

## SECTION VII

### FACULTY OF AGRICULTURE

#### General Information

#### Disciplines

- Animal Science Unit
- Agricultural Biotechnology
- Agricultural Meteorology
- Agronomy
- Entomology
- Extension Education
- Food Science & Technology
- Floriculture & Landscaping
- Forestry and Natural Resources
- Fruit Science
- Plant Breeding & Genetics
- Plant Pathology
- Soil Science
- Vegetable Science
- Course curriculum for B.Sc. (Hons) Agri. 4 year Programme
- Course curriculum for B.Sc. (Hons) Agri 2+4 year Programme for first two years
- Course curriculum for B.Tech.(Food Technology) 4 year Programme
- Course curriculum for B.Tech. (Biotechnology) 4 year Programme
- Course curriculum for Diploma in Agriculture 2-year Programme
- Course curriculum for Diploma in Hybrid Seed Production Technology (Two semesters)

## COLLEGE OF AGRICULTURE

Agricultural education on scientific lines was started in India in the beginning of twentieth century. The Punjab Agricultural College and Research Institute, Lyallpur, was established in 1906 and admission to a 3-year diploma course was started in 1909. Teaching was in the local language *Urdu* and the diploma awarded was called Licentiate in Agriculture (L. Ag.) This college was affiliated to Panjab University, Lahore, in 1917 and the diploma course was replaced by a 4-year degree course leading to B.Sc. in Agriculture. Admission to the degree programme was based on merit and the seats were allocated to different commissioneraries proportionate to the population. Subsequently the candidates were selected on merit according to the Communal Award.

During the first two years of 4-year degree programme, primarily courses on basic sciences and humanities were taught. However, agriculture with substantial emphasis on field practicals formed part of the instructions from first year of the degree programme. There was a university examination at the end of two years and a certificate was awarded to the successful candidates who passed as Fellows of Science in Agriculture (F.Sc. Agri.). Only those students who passed this examination were allowed to continue further studies for B.Sc. (Agri.) degree.

After independence in August 1947, a "Refugee College" was opened in November, 1947 in a part of the building of Khalsa College, Amritsar, for the migrated students and the staff appointed by the East Punjab Government. Different persons acted as Officers-in-Charge of the college. In the meantime, building of the Malwa Khalsa High School, Ludhiana, was rented by the Government to start the college as an independent institution. An advance team of four faculty members was sent to Ludhiana to take charge of the building. Dr Dalip Singh was appointed the first Principal of the college which opened at Ludhiana in September 1949 with 40 students.

One thousand and five hundred acres of evacuee land of Haibowal and the adjoining villages like Sunet, Rajpura, etc. near Ludhiana was allotted to the college by the Government for establishing a teaching and research institute at the present site of the Punjab Agricultural University. The foundation stone was laid by Sh Ajit Prasad Jain, Union Minister for Food and Agriculture, GOI on 23 September 1955 and the college started functioning in the new building in September 1958.

The Government Agricultural College, Ludhiana was headed by various principals, namely, Dr Dalip Singh (July 1949 to April 1952), Sh H. R. Saini (April to August 1952 and November 1952 to January 1953), Sh B. S. Sahney (August 1953 to July 1954), Dr M. R. Madhok (August to November 1952, January to August 1953 and August 1954 to October 1957), Dr S. S. Purewal (October 1957 to July 1960), Dr Kishan Singh Bedi (February to July 1960) and Dr Sardar Singh (November 1960 to June 1962).

With the establishment of Punjab Agricultural University in 1962, the college was headed by the Deans of the Faculty of Agriculture, namely, Dr Gursham Singh (June 1962 to September 1966), Dr A. S. Atwal (September 1966 to November 1973 and, again, from October 1975 to July 1979), Dr Sukhdev Singh (November 1973 to February 1974), Dr N. S. Randhawa (February 1974 to October 1975), Dr K.S. Gill (August 1979 to February 1983), Dr G.S. Gill (February 1983 to May 1984), Dr D.S. Dev (September 1985 to September 1989), Dr K.S. Aulakh (September 1989 to May 1994), Dr M.S. Bajwa (August 1994 to June 1998), Dr P. S. Sidhu (June 1998 to March 2001), Dr M.S. Tiwana (June 2001 to May 2005), Dr G. S. Chahal ( July 2005 to January 2008), Dr M. S. Aulakh (February 2008 to August 2010), Dr. D. S. Cheema (January 2011 to February 2013), Dr. H.S. Dhaliwal ( March 2013 to February 2017), Dr. S.S. Kukal ( May 2017 to August 2020).

Before the establishment of PAU, the B.Sc. (Agri.) programme was organized on the old annual system of the Panjab University, Lahore/Solan/Chandigarh. Under the new regulations of the Panjab University, Chandigarh, introduced in 1961, two concurrent programmes were offered viz. 5-year programme after matriculation and 4-year programme after pre-university or higher secondary. The number of students admitted to the two programmes was 80 and 170, respectively. The aggregate marks obtained in four years out of maximum were shown on the transcript of B.Sc. (Agri.) graduate in order to indicate the consistency of the performance of the students.

After the establishment of PAU, a new educational system was introduced with the collaboration of Ohio State University, Columbus (USA). The trimester system of education with complete internal assessment was introduced for M.Sc. and Ph.D. programmes in 1963 and for B.Sc. (Agri.) programme in 1964. The students who were already enrolled in these programmes were allowed to continue their studies according to the previous regulations in vogue. The number of students admitted was increased to approximately 250 per year but subsequently in 1974, the admission capacity was stabilized around 170 per year. A separate programme for admitting 25 inservice Nepalese students was also started.

At the time of independence in 1947, some M.Sc. and one Ph.D. student who were earlier registered with the Panjab University, Lahore, continued their research for the fulfilment of their degree requirements as private candidates. The Panjab University also framed rules for registering postgraduate students to complete their degrees based on thesis research. In 1961, new rules were framed which required such students to appear in three theory papers and practicals having a maximum of 400 marks, which they had to clear and the marks so obtained were added to the thesis marks which were awarded out of 300.

Under the ICAR programme of establishing centres of postgraduate education in the country, the College of Agriculture was also approved as one of such centres. Simultaneously, the regulations were modified by the Panjab University, Chandigarh and weightage to the thesis research was reduced. There were 450 maximum marks for theory and practicals, and 250 for thesis research. Another important feature introduced was the provision to admit regular students and the registered private candidates (only the teachers) were allowed to appear in the examinations and submit the thesis.

This system of education had just stabilized when the Formation of the Agricultural University Act was passed in October 1961. The previous system was continued for one year under the PAU, so that the already admitted students could complete their degrees. The new trimester system of education and the consequent rules and regulations became operative in July 1963 under the 'Statutes of the Punjab Agricultural University.' Regular admissions to M.Sc. and Ph.D. programmes in the existing departments of the College of Agriculture were made from August 1963.

In the Department of Agriculture, Punjab, the teaching and research was entrusted to various subject-matter Heads of Sections who were also designated as College Professors. With the establishment of PAU, these sections were upgraded as university departments and were headed by full professors. The chronological establishment of the Departments in the College of Agriculture was as under:

- Department of Agronomy (1963)
- Department of Animal Science (1963) Shifted to GADVASU in 2006]
- Department of Entomology (1963)

- Department of Extension Education (1963)
- Department of Horticulture (1963)
- Department of Plant Breeding (1963) [Now Department of Plant Breeding and Genetics]
- Department of Plant Pathology (1963)
- Department of Soil Science (1963)
- Department of Food Science and Technology (1969)
- Department of Vegetable Crops, Landscaping and Floriculture (1974)  
(Now department of Vegetable Science)
- Department of Forestry and Natural Resources (1979)
- Department of Agrometeorology (1981) [Now Department of Climate Change and Agricultural Meteorology (2012)]
- Department of Animal Nutrition and Forages (1991) [Shifted to GADVASU in 2006]
- Department of Seed Science and Technology (1991)
- Department of Floriculture and Landscaping (1994)
- School of Agricultural Biotechnology (2008)

In May 1998, the Departments of Animal Science and Animal Nutrition were shifted to the College of Veterinary Science. The Department of Seed Science and Technology was upgraded to Directorate of Seed Science and Technology under Director of Research in July 1999. The Department of Agrometeorology was merged with the Agronomy Department and a new Department of Agronomy and Agrometeorology was created in March 2002. The Department of Home Science Extension Education of the College of Home Science was shifted to the College of Agriculture and merged with Department of Extension Education in November 2002. Later, the Department of Genetics and Biotechnology from the College of Basic Sciences and Humanities was shifted to the College of Agriculture and merged with Department of Plant Breeding and the new Department of Plant Breeding, Genetics and Biotechnology was created in September 2003. The Department of Forestry and Natural Resources was merged with Department of Agronomy & Agrometeorology and new Department of Agronomy, Agrometeorology and Forestry was created in June 2006. The Department of Business Management of the College of Basic Sciences and Humanities was shifted to the College of Agriculture in November, 2006. The Department of Foods & Nutrition of the College of Home Science and Department of Processing & Food Engineering of the College of Agricultural Engineering were shifted to the College of Agriculture and merged with Department of Food Science & Technology and new Department of Food Science & Engineering was created in December, 2006. The Departments of Vegetable Crops and Floriculture & Landscaping were merged and a new department named as Vegetable Crops, Floriculture and Landscaping was created in April, 2007. The merger of Departments were again dissolved in 2007 and all these Departments were demerged for efficient working.

Due to inherent complexities of switching over from one system to another, the transitional period from the conventional annual system of external examinations to the trimester system, with complete internal assessment, was inevitably a difficult one. In fact, the College of Agriculture was the first in India to successfully adopt the new system. With the hard work of faculty and the patience and cooperation of students, complete switch over to the new system was accomplished by the academic year 1968-69. The innovations in agricultural education and the rules and regulations framed to suit local conditions were accepted by the students. Most of these rules were subsequently adopted by other State Agricultural Universities in India.

By way of background, in 1963-64, the existing subjects as taught under the old annual system were hurriedly sub-divided into trimester courses for undergraduate and postgraduate programmes. Based

on experience during the formative years, the course curriculum was rationally revised and operationalized in 1969. This revision was concurrent with the needs of the agricultural revolution which was already ushered in the state.

During seventies, agriculture in Punjab witnessed very rapid changes. The farmers became progressive and made heavy demands on agricultural education to meet the requirements of knowledge for intensive use of inputs, farm mechanization and diversification of agriculture. Hence the progressive agriculture in Punjab called for dynamic agricultural educational programme and the curricula. A critical revision of the various courses for B.Sc. (Agri.) programme was made which took almost one year. The new programme became operative in August 1973. The most significant feature of this programme was that the earlier concept of offering one major subject to the students in the final year, representing one of the thirteen departments, was changed and the disciplines were combined according to the professional specializations. The six new areas of elective subjects were: Crop Sciences; Animal Sciences; Soil Sciences; Plant Protection; Economics, Sociology and Extension Education; and Food Science, Technology and Nutrition. The new degree was renamed as B.Sc. (Agri.) with 'Honours' in one of these six specialized areas. The first batch students of B. Sc. (Agri.) Hons. were Graduated in 1976.

In 1974, "Earn While You Learn" schemes in the respective electives for the final year students were started. Revolving funds were created in various departments to meet the cost of inputs which were supplied to the students on loan from the common pool. When the produce was ready, they were encouraged to sell it in the market. The income from the saving of labour and innovative use of inputs was shared by the students. These activities included poultry farming, floriculture, food technology, nursery growing, dairy farming and vegetable growing. At present this scheme is operative only in Crop Production Courses (CPC) under the department of Agronomy.

The fourth revision of the course curricula for B.Sc. (Hons.) Agri. was made in 1982 by maintaining the essential features of the degree programme and incorporating the recommendations of the second Deans' Committee of the ICAR and the National Commission on Agriculture.

Consequent upon the decision of the university to switch over from the trimester to semester system of education from the academic session 1988-89, the course curricula for undergraduate and postgraduate programmes were revised, updated and reoriented. The practical component of the curricula was considerably strengthened. The minimum qualification for admission to B.Sc. (Hons) Agri. was raised to 10+2 with science group (medical or non-medical streams) and later on the agriculture stream was also included. The revised curricula in the light of the recommendations of third Deans' Committee of ICAR and the syllabi for National Eligibility Test conducted by ASRB (for PG Programmes) had been implemented with effect from academic session 1998-99. The recommendations of fourth Deans' Committee were implemented for all UG programmes with effect from academic session 2009-10. At present, the recommendations of fifth Deans' Committee have also been implemented for all UG programmes with effect from academic session 2016-17. The salient features of B.Sc. (Hons.) Agri. programme are:

- The component of basic sciences has been strengthened and new courses in the fields of Agri-business Management, Agrochemicals and Plant Products, Genetics, Biotechnology, Economics, Crop Physiology and Economic Zoology have been introduced.
- The Plant Clinic component which is a unique feature of the course curricula of this College, has been updated to provide hand-on experience to the students in the diagnosis and management of plant diseases, pests, nutrient deficiencies and phytotoxicities.

- More emphasis has been laid on modern information technology, computer applications, integrated pest management, environmental science and international trade. The physical facilities for imparting instructions effectively have been improved by equipping the classrooms with permanent fixtures of audio visual aids (Multimedia) during 2004.
- Smart class rooms have been developed for imparting effective lectures and quality education.
- Vocational training in specialized fields such as Apiculture, Sericulture, Fish Culture, Mushroom Production, etc. has been introduced so as to promote self-employment of agricultural graduates.
- The agricultural engineering component has been strengthened with increased emphasis on farm machinery and its maintenance, farm structures and irrigation engineering.
- Special emphasis has been laid on project planning and evaluation to train the students for working as consultants in private and public sector undertakings and organizations dealing with agribusiness enterprise.
- In the final year Rural Agricultural Work Experience (RAWE) and Experiential Learning Programme (ELP) has been introduced to focus on understanding and solving practical problems of agricultural production in rural settings and to get hands-on-experience and develop entrepreneurship skills among the students.

The latest revision of course curricula of M.Sc. and Ph. D. in the light of guidelines suggested by ICAR to bring about uniformity in syllabus at national level has been implemented from the academic session 2004-05, which has again been revised by National Core Group Chaired by Dr J. C. Katyal. It has been implemented with effect from academic session 2010-11.

One year degree programme in Bachelor of Education was started in 1977 for B.Sc. Agri.(Hons), B.Sc. (Home Science) and B.Tech. (Agri. Engg.) graduates of PAU. A two year Diploma in Dairy Technology was started in 1979 in order to provide technicians for the newly established Milk Chilling Centres and Milk Processing Plants in the state. This programme was discontinued in 1991 due to lack of employment opportunities. The one year certificate course for Agricultural Sub Inspectors was modified into a two year Diploma in Agriculture in 1983, with an option to the students to terminate studies at the end of one year certificate course or to complete the diploma course. With the establishment of an 'Institute of Agriculture' at Gurdaspur in 1993, this diploma course was shifted there. In 1985 four year B.Sc. (Forestry) programme was started but it was discontinued in 1987. One year 'Certificate Course in Pesticides and Fertilizers' was started in 1993. This was, however, discontinued in 1998 due to lack of employment opportunities for these students. Thereafter, the college started new Diploma programmes in Apiculture, Pest Management, Food Technology & Seed Production from the academic year 2005-06 which were discontinued from academic session 2007-08.

Apart from B.Sc. (Hons) Agri. the college now offers M.Sc. programme in 13 disciplines and Ph.D. programmes in 10 disciplines. Keeping in view the sustainability of agricultural production in Punjab, new programmes at undergraduate and postgraduate level were initiated as B Sc .(Hons) Agri 2+4 year programme after Matric (2008- 09) wherein the students attend first two years of their degree programme at Institutes of Agriculture located at Bathinda and Gurdaspur; B.Tech (Biotechnology) 4-year programme; B Tech. (Food Technology) 4-year programme (Both under self supporting system after 10+2 medical or non-medical streams); Two year Diploma Course in Agriculture at College of Agriculture, PAU campus, Ludhiana and Regional Research Station, Faridkot (2016-17); One year Diploma course in Hybrid Seed Production Technology (2013-14); PG programmes started were M.Sc Biotechnology (2008-09), Ph.D Biotechnology (2009-10), Ph D Floriculture & Landscaping (2010-11) .

Realising the tremendous potential of biotechnology in increasing agricultural productivity, the University established an independent 'School of Agricultural Biotechnology' on April 24, 2008. The School is equipped with basic infrastructural research facilities for carrying out research on various aspects of Agricultural Biotechnology. There is a separate building named after Food Laureate, Dr G. S. Khush, with 18 laboratories for conducting research on plant tissue culture, plant transformation, molecular biology, molecular cytogenetics, genomics laboratories and temperature, humidity and light controlled facility apart from a fully functional Bioinformatics Centre. A Super Computer has recently been installed in the University for conducting research related to Computational Biology in Biotechnology. The School has collaborations and funding from the John Innes Centre, Norwich, UK., University of Nottingham, England; University of Tokyo, Japan; IRRI, Philippines; Ohio State University, USA ; University of Zurich, Switzerland; Texas A & M University, USA; Kansas State University, USA; University of Sydney, Australia and ICGEB, New Delhi.

Wheat genome sequencing project is a globally ambitious research programme in which 16 countries are involved under the umbrella of IWGSC (International Wheat Genome Sequencing Consortium). India has been entrusted with the responsibility of sequencing of Chromosome 2A, which is about 900 Mbp and is 2.5 times larger than the whole rice genome. Dept. of Biotechnology (DBT), Ministry of Science and Technology, Government of India funded this collaborative programme to the PAU, National Research Centre on Plant Biotechnology (NRCPB) New Delhi and University of Delhi South Campus (UDSC), New Delhi with a total budget of Rs 34 crore for a period of three years. PAU is the lead centre with a total budget of Rs 18 crore.

School of Climate Change and Agricultural Meteorology has recently been established in 2012 upgrading the Department of Agricultural Meteorology with the objectives to undertake focused research on developing suitable technologies for sustaining natural resources and agricultural productivity under changing climate scenario and to impart quality education to undergraduate and postgraduate students on different aspects of agricultural meteorology. Scientists from allied disciplines of Agronomy, Soil Science, Entomology, Plant Pathology and Soil and Water Engineering have been associated to conduct the research work in field of climate change.

Punjab Agricultural University established with a grant from ICAR, a State-of-the-art facility named as Electron Microscopy & Nano-Science Laboratory (EMN Lab) in 2007 having Transmission Electron Microscope (TEM), Scanning Electron Microscope (SEM), Energy Dispersive X-ray Spectroscopy (EDS), and Scanning Probe Microscope (SPM), Optical Upright Research Microscope, Ultracut Microtome and Cryo Attachment, and Ion Sputter Coater facilities. The latest high resolution imaging tools in the EMN Lab for imaging particles as small as 1 nanometer (1 billionth of a meter) would enable scientists to develop technologies relevant to agriculture and food systems. It also facilitates research in basic biological, biomedical, chemical and material sciences to support the future needs of precision agricultural research.

The Old Boys' Association (renamed as Alumni Association) of the College was reactivated in 1968 when the regular students offered to contribute Rs.2/- per trimester. Directory of the alumni who graduated in various years was prepared for circulation and republished in 1990. The Association also started a quarterly magazine of its own under the name of "AGALUMNUS" This Association has published many books and Laboratory Manuals for improving the quality of agricultural teaching. A book bank was started in the college out of funds contributed by students. The books are issued to students on loan basis for a semester.

The student advisement which formed an essential and desirable feature of the trimester system of education has been considerably strengthened under the semester system. The advisors devote considerable time advising the students about curricular, co- curricular, social and emotional problems and serve as guides, mentors, role models and 'guardians-on-the-campus' for their advisees. With wise counselling and guidance by the faculty accompanied by receptive and proactive policies of the college, the defaults of the students have been considerably reduced facilitating timely completion of their degrees. The College has established a centrally located Placement and Counselling Cell, to provide the students with access to wide range of temporary and permanent jobs by organizing campus interviews or through building their competence to face interviews, personality development and coaching for various competitive examinations.

The students' interest are taken care of by providing them ample opportunities to exercise choice for courses in various fields of specialization. Within the confines of their limits, the autonomy of the teachers is assured, which is so essential under the system of internal evaluation. In order to ensure full coverage of the course contents, lecture outlines and references to the books and other relevant literature are distributed to the students in the beginning of the semester. The lesson plans and lectures of undergraduate courses on multimedia have been introduced for teaching from academic session 2004-05. Every student admitted to Bachelor's degree (w.e.f. academic session 2012-13) course is required to participate in any one of the three fold programmes namely NCC, NSO and NSS for first four semesters of their studies which was earlier for two semesters.



## ANIMAL SCIENCE

### Diploma courses

#### **LPM 51 Elementary Livestock and Poultry Production** **3+1** **Sem. II**

Importance of livestock and livestock farming. Important breeds of cattle, buffaloes, sheep, goat, swine and poultry. Judging. Selection and breeding of livestock for genetic improvement. Reproduction, reproductive behavior, estrous cycle, detection of estrous. Artificial insemination. Livestock feeding and ration formulation. Silage and hay making. Housing. Factors affecting milk yield and composition. Clean milk production. Care of young ones and adult animals. Composition and formation of an egg. Care and incubation of the eggs. Grading of eggs. Hatchery management. Preparing the animals for marketing. Transportation of animals. Common diseases, their prevention and control. Economics of livestock and poultry enterprises. Livestock development programmes of Govt. of India and State Govt.

Practical: Handling of various categories of livestock. Breed of livestock and poultry. Methods of restraint. External body parts of animals. Judging of animals. Milking. Feed formulation and mixing of concentrate. Management of young ones - feeding, tattooing and dehorning. Recording of body weight, temperature, and pulses and respiration rates. Study of reproductive organs. Artificial insemination. Cleaning and disinfection of houses. Selection and incubation of hatching eggs. Grading and handling of eggs. Visit to various livestock farms.

### Undergraduate Courses

#### **AS 201 Livestock and Poultry Management** **2+1** **Sem I / II**

(For students of B.Sc. (Hons) Agriculture and B.Tech. Biotechnology)

Livestock history in India Vedic, medieval and modern era. Demographic distribution of livestock and role in economy. Introductory animal husbandry. Breeds of livestock. Cattle, Buffalo, Sheep, Goat and Pig. Important traits of livestock. General management and feeding practices of animals. Handling and restraining of animals. Housing systems. Importance of grasslands and fodders in livestock production. Common farm management practices including disinfection, isolation, quarantine and disposal of carcass. Common vices of animals and their prevention. Diseases and parasite control & hygiene care. History and economic importance of poultry. Poultry breeds. Reproductive system of male and female birds. Formation and structure of eggs. Important economic traits of poultry. Egg production, Egg weight, Egg quality. Fertility and hatchability. Plumage characteristics and comb types. Care and management of chicks, grower and layers/broiler. Brooding management. Hatchery practices. Poultry diseases, control and hygiene care. Importance, advantages and limiting factors in fish farming. Common terms and species of fish. Scientific fish farming. Important diseases of fish along with their preventive measures.

Practical: Visit to livestock farms/demonstration centres. Breeds of cattle, buffalo, sheep, goat and Pigs. Familiarization with body parts of animals. Handling and restraining of cattle, buffalo, sheep, goat and swine. Male and female reproductive system and Artificial Insemination. Feeding of livestock. Methods of identification, marking, tattooing, branding and tagging. Milking methods. Record Keeping. Visit to the Poultry farm. Poultry breeds. Body parts of chicken, duck, quail and turkey. Housing, equipments, nesting and brooding requirements. Male and female reproductive system. Methods of identification and sexing. Hatchery layout and equipment. Identification of diseases and control of parasites. Vaccination. Maintenance of farm records. Fisheries: Pond designs and their management. Identification and management of different types of fish. Water and soil quality parameters for fish ponds.

## AGRICULTURAL BIOTECHNOLOGY

### PROGRAMMES

1. **M.Sc. Biotechnology**
2. **Ph.D. Biotechnology**

### COURSE REQUIREMENT

#### **M.Sc.**

Field of Specialization	Plant Tissue Culture and Transformation, Molecular Biotechnology
Required Courses	Biotech. 501, Biotech. 502, Biotech. 503, Biotech. 504, Biotech. 505
Supporting Courses	Stat. 421, PGS 501 and other courses from subject matter fields (other than minor) relating to area of special interest and research problem
Minor Fields	Plant Breeding & Genetics, Microbiology, Biochemistry, Botany, Plant Pathology, Entomology or any other as approved by Dean, Postgraduate Studies
Deficiency courses for students with elective other than Plant Breeding, Genetics and Biotechnology	As recommended by the Student's Advisory Committee and approved by the Dean, Postgraduate Studies

#### **Ph.D.**

Field of Specialization	Plant Tissue Culture and Transformation, Molecular Biotechnology
Required Courses	Biotech. 601, Biotech. 602, Biotech. 603, Biotech. 604
Supporting Courses	Courses from subject matter fields (other than minor) relating to area of special interest and research problem
Minor Fields	Plant Breeding & Genetics, Microbiology, Biochemistry, Botany, Plant Pathology, Entomology or any other as approved by Dean, Postgraduate Studies
Deficiency Courses for students with M.Sc. (Agri.) in discipline other than Biotechnology	Biotech. 501, Biotech. 502, Biotech. 503, Biotech. 504, Biotech. 505 and other courses as recommended by the Student's Advisory Committee.

## DESCRIPTION OF COURSE CONTENTS

### Diploma courses

**Biotech. 51 Elementary Plant Tissue Culture** **1+1** **Sem. II**  
History and development of plant tissue culture. Introduction, scope and importance of plant tissue culture. Advantages and disadvantages of *in vitro* propagation. Nutritional requirements of *in vitro* cultures. Mother plant selection, and collection, preparation, surface sterilization and inoculation of explants. *In-vitro* propagation via enhanced release of axillary buds. Organogenesis and somatic embryogenesis. Economics and commercial potential of *in-vitro* propagation. Progress in the *in-vitro* propagation of field, forestry and horticultural plants.  
Practical: Lay out of *in-vitro* propagation units. Working inside *in-vitro* propagation unit. Laboratory organization, equipment, tools and techniques. Laboratory contaminants - its control measures. Culture media preparation: major nutrients, minor nutrients, organics and other ingredients. Plant growth regulators. Solidifying agents, methods of sterilization, inoculation and incubation of cultures. *Ex-vitro* establishment of plantlets, their field testing, field planting and management of tissue culture plants.

### Undergraduate Courses

**Biotech. 101 Cell Biology** **2+0** **Sem. I**  
Origin and evolution of cell. Introduction to microscopy. Sub-cellular structure of prokaryotic and eukaryotic cells. Membrane structure and function: plasma membrane, cell wall and extracellular matrix. Structural organization and function of intracellular organelles and organelle biogenesis. Nucleus, mitochondria, endoplasmic reticulum, golgi apparatus, lysosomes, peroxisomes, plastids, vacuoles. Structure and function of cytoskeleton and its role in motility. Cell membrane transport. Introduction to cell signalling. Cell growth, cell cycle and its control. Cell death and cell renewal.

**Biotech. 102 Molecular Biology** **2+1** **Sem. II**  
History of molecular biology. Central dogma of life. Structure of DNA and RNA. Gene structure and function. DNA replication. Transcription. Genetic code and translation. Structure of prokaryotic and eukaryotic nuclear and organelle genomes. Gene regulation in prokaryotes: Lac operon concept, Tryp concept, Introduction to microbial genetics. Conjugation, transformation and transduction. Tools in molecular biology. Role of enzymes in molecular biology. Principles of Polymerase Chain Reaction. Electrophoresis. PCR and hybridization based molecular markers.  
Practical: Preparation of bacterial competent cells and transformation. Isolation and purification of plant and animal DNA. Measurement of nucleic acid concentration using spectrophotometer and gel electrophoresis. DNA amplification using RAPD, microsatellite primers and analysis. CAPS primers. Generation of linkage maps and mapping of qualitative genes. Estimation of genetic similarities and generation of dendrograms.

**Biotech. 103 Introduction to Biotechnology** **2+1** **Sem. I**  
History, definitions, concepts, scope and importance of Biotechnology - plant, microbial, animal, medical, environmental, industrial, marine, agricultural and food biotechnology. Nano biotechnology. Introduction to recombinant DNA technology and its applications-vectors, DNA restriction and modifying enzymes, gene cloning. Introduction to genomics and proteomics: Molecular markers, DNA sequencing. Genetic transformation and transgenic organisms. Bioinformatics. Biosafety guidelines.  
Practical: Orientation to the laboratories: glass houses, screen houses, transgenic facilities and field area. General guidelines for working in biotechnology laboratory. Familiarization with basic

equipments used in biotechnology. Selection of chemicals (different grade), buffer preparation, calculations and scientific notations used in laboratories.

#### **Biotech. 104 Plant Tissue Culture**

**2+1**

**Sem. II**

History of plant tissue culture. Concept of totipotency. Concept of aseptic culture practices. Components of *in vitro* culture media and role of different macro and micro nutrients, vitamins, plant growth regulators and growth supplements. Sterilization techniques. Various plant cell, tissue and organ culture techniques and uses. Somatic cell cultures. Morphogenesis - organogenesis and somatic embryogenesis. Micropropagation - *in vitro* grafting, meristem culture. Anther, pollen, embryo, ovule, ovary culture. Protoplast culture and somatic hybridization. Somaclonal variation.

Practical: Good laboratory practices. Media preparation and sterilization. Surface sterilization of explants. Establishment of callus/ cell suspension cultures. Micropropagation. Embryo culture. Anther and pollen culture. Induction of plant regeneration. Hardening and transfer to soil.

#### **Biotech. 106 Electronics and Instrumentation in Biotechnology**

**1+1**

**Sem. II**

Electronics, PN junction diode, diode forward and reverse characteristics. Diode as circuit element. Application of junction diode - half wave, full wave bridge rectifier, clipper, clamper, voltage multiplier circuit. Construction and working of bipolar transistor, load line concept, design of biasing methods of NPN transistor, AC model, analysis of small signal NPN transistor. Concept of instrumentation system. Transducers for temperature measurement, linear displacement measurement using LVDT. Force measurement using strain gauge. Principles, working of table top, refrigerated and ultra-centrifuges, laminar air flow, autoclaves, pH meter, fermenters, temperature control and BOD shakers, gel electrophoresis, 2-D gel electrophoresis, gel documentation, gel driers, ELISA readers, lyophilizers, spectrophotometers, gene pulser, particle gun, growth chambers, thermal cyclers, Real time PCR, DNA synthesizer and sequencer. Microscopes.

Practical: Familiarization with laboratory equipment and equipment working. Forward and reverse characteristics of a PN junction diode. Study of half wave, full wave, bridge rectifier using diode. Clipper, clamper and voltage multiplier circuit. Determination of input V-I characteristics of bipolar transistor for common emitter configuration. Determination of output V-I characteristics of bipolar transistor for common emitter configuration. Analysis of a biasing circuit for CE transistor. Design and test a biasing circuit for CE transistor. Study the measure of temperature using available sensor. Measurement of displacement with the available sensor. Study force with the available sensor.

#### **Biotech. 202 Introductory Bioinformatics**

**2+1**

**Sem. I**

Introduction to bioinformatics. Development and scope of bioinformatics. Applications of computers in bioinformatics. Operating systems, hardware, software, Internet, world wide web resources and FTP. Primary databases - nucleotide sequence databases (GenBank, EMBL), protein sequence databases. Secondary databases - SwissProt/TrEMBL, conserved domain database, Pfam. Structure databases - Protein Data Bank (PDB), MMDB, SCOP, CATH. File formats - Genbank, EMBL, Fasta, PDB, Flat file, ASN.1, XML. Introduction to sequence alignment and its applications - pair wise and multiple sequence alignment, concept of local and global alignment. Algorithms - Dot Matrix method, dynamic programming methods (Needleman-Wunsch and Smith-Waterman). Tools of MSA-ClustalW, Toffee. Phylogeny. Introduction to BLAST and FASTA.

Practical: Basic computing - Introduction to UNIX, LINUX. Nucleotide information resource - EMBL, GenBank, DDBJ, Unigene. Protein information resource - SwissProt, TrEMBL, Uniprot. Structure databases - PDB, MMDB. Search engines - Entrez, ARSA, SRS. Similarity searching - BLAST and interpreting results. Multiple sequence alignment - ClustalW. Structure visualization of DNA and proteins using Rasmol.

**Biotech. 201 Recombinant DNA Technology****2+1****Sem. II**

Recombinant DNA technology. Restriction endonucleases - types and uses. DNA ligases. Vectors - plasmids, cosmids, phagemids, bacterial artificial chromosomes (BACs), P1-derived artificial chromosomes (PACs), yeast artificial chromosomes (YACs), transposon vectors, expression vectors, shuttle vectors, binary plant vectors, co-integrating vectors. Construction and applications of chimeric DNA, Competent cells. Gene isolation and cloning. Genetic transformation of *E. coli*. Gel electrophoresis. Preparation of probes. Southern blotting. Northern blotting. Western blotting. PCR and *in vitro* gene amplification.

Practical: Orientation to recombinant DNA lab. Preparation of stock solutions and buffers. Plasmid DNA isolation. Genomic DNA isolation. Quality and quantity determination of DNA. Restriction digestion of DNA. Agarose gel electrophoresis, SDS-PAGE. PCR. Genetic transformation of *E. coli*. Screening of recombinant DNA clones in *E. coli*.

**Biotech. 203 Plant Genetic Transformation****2+1****Sem. II**

History of plant genetic transformation. Generation of gene construct and maintenance. Methods of genetic transformation - *Agrobacterium* mediated, biolistics, electroporation, liposome, Polyethylene glycol, *In planta* methods. Selection and characterization of transgenic plants using selectable and reportable markers. PCR, qRT-PCR, Southern, Northern, ELISA and Western techniques. Application of genetic transformation for developing transgenics for quality, yield, biotic and abiotic stresses. Biosafety aspects of transgenic plants and regulatory framework.

Practical: Preparation of stock solutions and buffers for genetic transformation. Preparation of competent cells of *Agrobacterium tumefaciens*. Restriction mapping of plasmid. Construction of binary vector and its transfer to an *Agrobacterium* strain. Confirmation of transformed bacterial colonies. *Agrobacterium tumefaciens* mediated and biolistic plant transformation. Colony hybridization.

**Biotech. 204 Classical and Molecular Cytogenetics****2+1****Sem. II**

Introduction and history. Mitosis and meiosis. Structure of chromatin. Chromosome structure and chromosome landmarks. Specialized chromosomes. Differential staining of the chromosomes - Q-banding, G-banding, C-banding and R banding. *In situ* hybridization - FISH, GISH. Changes in chromosome number. Aneuploidy - monosomy, trisomy and tetrasomy. Haploidy. Polyploidy - autopolyploidy and allopolyploidy. Methods of doubled haploid production. Structural aberrations of chromosomes - deletions, duplications, inversions and translocations. Locating genes on chromosomes. Genome analysis.

Practical: Preparation of chromosome stains. Testing of pollen fertility. Preparation of mitotic and meiotic slides of onion, pearl millet, wheat etc. Preparation of karyotypes. C/G banding of the chromosomes. Genomic *in situ* hybridization. Microphotography.

**Biotech. 206 Fundamentals of Plant Biotechnology****2+1****Sem. II**

(For students of B.Sc. (Hons) Agriculture)

Concepts and history. Various aspects of plant tissue culture. Somatic embryogenesis. Meristem culture. Micropropagation. Somaclonal variation. Anther and pollen culture. Embryo/ovule/ovary and endosperm culture. Protoplast culture and somatic hybridization. Cryopreservation of germplasm. Recombinant DNA technology. Gene cloning approaches. Methods of Genetic Transformation. Genetic Engineering. Southern, Northern and Western Hybridization. Polymerase Chain Reaction and its variants. Hybridization and PCR based DNA markers. Gene and QTL mapping. Marker assisted selection for precision plant breeding. Examples of marker assisted selection in commercial agriculture. Introduction to bioinformatics.

Practical: Culture media preparation. Surface sterilization of explants. Establishment of callus/cell suspension cultures. Induction of plant regeneration. Hardening and transfer to soil. Micropropagation.

Embryo culture. Demonstration of gene transfer techniques. Isolation of plant DNA. Measurement of nucleic acids concentration using photo spectrometer and gel electrophoresis. PCR. DNA amplification using microsatellite primers and its fractionation using agarose gels. Introduction to various databases.

**Biotech. 301 Molecular Genetics**

**2+0**

**Sem. I**

Structures, properties and modifications of DNA. Molecular mechanism of DNA replication, repair, mutation and recombination. Centromere and telomere sequences and DNA packaging. Synthesis and processing of RNA and proteins. Regulation of gene expression. Mutations and DNA repair. Repetitive DNA sequences and transposable elements. Promoters and their isolation. Transcription factors – their classification and role in gene expression. Epigenetic control of gene expression. Small RNAs, RNA interference and its applications.

**Biotech. 302 Nanobiotechnology**

**2+0**

**Sem. I**

Introduction to nanotechnology. Concepts and terminology. Types of nanomaterials and their synthesis approaches. Nano-bio interface. Factors affecting interactions at the nano-bio interface. Biological based nanosystems, molecular motors and their types, biosensors and other devices, applications of biosensors in agriculture. Self assembly of molecules for nanotechnology applications. Biomimetics, Biotemplating and *de novo* designed nanostructures and materials. DNA-Nanotechnology. DNA computers. Nanomanipulations, material design, synthesis and their applications.

**Biotech. 303 Molecular Marker Technology**

**2+0**

**Sem. I**

Types of molecular markers - RFLP. PCR based markers - RAPD, SCAR, SSR, STS, CAPS, AFLP, SNP and their variants. Uses of molecular markers - application as genetic tools for genotyping and gene mapping. Mapping populations -  $F_2$ , DH, RILs and NILs. Bulked segregant analysis. Linkage maps. Physical maps. Application of molecular markers - assessing genetic diversity, variety protection, Marker-assisted breeding for accelerated introgression of transgene, major genes and quantitative trait loci (QTLs). Human and animal health - association with genetic-based diseases. Paternity determination. Forensic studies.

**Biotech. 304 Genomics and Proteomics**

**3+0**

**Sem. I**

Introduction to genomics, functional genomics and proteomics. Structural genomics. Classical ways of genome analysis, BAC and YAC libraries. Physical mapping of genomes. Next generation sequencing. Genome analysis and gene annotation. Genome projects - *E. coli*, Arabidopsis, Bovine, Human. Comparative genomics - orthologous and paralogous sequences, synteny, gene order, phylogenetic foot printing. Functional genomics. Differential gene expression techniques - ESTs, cDNA-AFLP, microarray, differential display, SAGE, RNAseq, Real time PCREDIT. Introduction to proteomics. Analysis of proteome - native poly acrylamide gel electrophoresis (PAGE), sodium dodecyl sulphate-poly acrylamide gel electrophoresis (SDS PAGE), 2D poly acrylamide gel electrophoresis (PAGE). Edmann degradation. Chromatographic techniques – high performance liquid chromatography (HPLC), gas chromatography (GC). Mass spectrometry – matrix associated laser desorption/ionization-time of flight (MALDI-TOF), liquid chromatography mass spectrometry (LC-MS). Post translational modifications.

**Biotech. 305 Biosafety, Bioethics and IPR**

**2+0**

**Sem. I**

Biodiversity definition, importance and geographical causes for diversity. Species and population biodiversity, maintenance of ecological biodiversity hot spots in India. Convention on biological diversity. Cartagena protocol of bio-safety. Risk management for GMOs. Bio-safety guidelines, rules and regulations and regulatory frame work for GMOs in India. Introduction to Intellectual Property,

concepts and types. International treaties for protection of IPs. Indian legislations for the protection of various types of Intellectual Property. Patent search, filing process. Material transfer agreements.

**Biotech. 306 Computational Biology**

**2+1**

**Sem. II**

Introduction to computational biology. Web based servers and software for genome analysis: Ensembl, UCSC genome browser, MUMMER, BLASTZ. Sequence submission. Protein interaction databases: BIND, DIP, GRID, STRING, PRIDE. Principles of protein structure prediction. Fold recognition (threading). Homology modelling. SCOP, CATH, PDB, PROSITE, PFAM. Methods for comparison of 3D structures of proteins. Phylogenetic analysis: Evolutionary models, tree construction methods, statistical evaluation of tree methods. PHYLIP, dendroscope, MEGA. DNA barcoding database - BOLD.

Practical: Application of genome browsers in genomic research. Exploring protein-protein interaction databases. Working with protein structural classification databases. SCOP, CATH, PDB, PSD databases. SNP and SSR identification tools. PHYLIP. Genome browsers, microarray databases.

**Biotech. 307 Micropropagation Technologies**

**1+2**

**Sem. II**

Introduction to tissue culture and micropropagation techniques, their limitations and applications. Types of cultures - seed, embryo, organ, callus, cell. Stages of micropropagation. Axillary bud proliferation - shoot tip, meristem and bud cultures. Organogenesis - callus and direct organ formation. Somatic embryogenesis. Cell suspension cultures. Production of secondary metabolites. Somaclonal variation. Cryopreservation.

Practical: Nutrient media composition and preparation for specific cultures. Sterilization techniques for explants. Callus induction. Induction of somatic embryos. Regeneration of whole plants from different explants. Micropropagation of sugarcane, mentha, banana and citrus. Hardening procedures.

**Biotech. 308 Food Biotechnology**

**2+1**

**Sem. II**

(For students of B.Tech. Food Technology)

Chemical nature, properties and functions of the genetic material. Organization of the genetic material in prokaryotes and eukaryotes. DNA replication. Transcription and translation - types of RNA and genetic code. Mutation and DNA repair. Genetic recombination in bacteria, transformation, transduction, conjugation. Regulation of gene expression in prokaryotes. Recombinant DNA technology - Restriction enzymes, cloning vectors, cloning procedures, Gene cloning. Biosensors - classification, application in food industry. Application of biotechnology in food - immobilization of enzymes, arresting of cell in insoluble matrix, immobilized cell systems, cell attachment in a surface, aggregation, entrapment, containment, physical adsorption, covalent bonding, cross linking, entrapment into polymeric films, microencapsulation, large scale cell immobilization, uses and applications in industries. Ethical issues concerning GM foods. Testing for GMOs, bio-safety guidelines, risk assessment and risk management. Public perception of GM foods.

Practical: Study of auxotroph. Micro-propagation through tissue culture. Isolation and analysis of chromosomal/genomic DNA from *E. coli* and *Bacillus cereus*. Separation of protoplast using cellulytic enzymes. Production of biomass from fruit and vegetable waste. Introduction of ELISA, Southern blot. DNA finger printing. Agarose gel electrophoresis of plasmid DNA. Pesticide degradation by *Pseudomonas* spp.

**Biotech. 309 Nutrigenomics**

**3+0**

**Sem. II**

(For students of B. Sc. (Hons) Nutrition and Dietetics)

Genomics - Definition, scope and importance. Global impact of genomics. Genomics in health care, agriculture and environment. Processes and products of biotechnology. Application of genomics in development of nutritious foods. Genes - nature, concept and synthesis. Chemical nature of DNA,

nucleotides and nucleosides. Structure of RNA and RNA splicing. Units of gene, gene expression, regulation and transcription. Epigenetic changes in relation to diet. Genetic engineering for human health. Gene therapy and personalized medicine. Single cell protein. Role of genomics in enzymology and product development. Genetic improvement of food grade microorganisms. Nutritional significance of food products developed by biotechnological techniques. Scientific, technological and resource constraints on genomics. Factors affecting development in nutri genomics.

**Biotech. 310 Applications of Genomics and Proteomics**                      **2+1**                      **Sem. II**

Structure of genomes - *Arabidopsis*, pigeonpea, rice, tomato, wheat. DNA chips and their use in transcriptome analysis. Mutants and RNA interference (RNAi) in functional genomics. Site directed mutagenesis. Transposon tagging. Transient gene expression – virus induced gene silencing (VIGS) and fluorescence activated cell sorting (FACS) based targeted genome editing technologies. Bio-informatics in proteomics - protein 3D structure modelling (Homology modelling and crystallography). Proteome analysis. Protein-protein interaction - FRET, yeast two hybrid and co-immunoprecipitation. Applications of genomics and proteomics in agriculture, human health and industry. Metabolomics and ionomics for elucidating metabolic pathways.

Practical: SDS-PAGE. 2D electrophoresis. Protein characterization through HPLC. Specialized crop based genomic resources - TAIR, Gramene, Graingenes, Maizedb, Phytozome, Cerealdb, Citrusdb, miRbase.

**Biotech. 311 Molecular Breeding**    **2+1**    **Sem. II**

Principles of Plant Breeding. Breeding methods for self and cross-pollinated crops. Heterosis breeding. Limitations of conventional breeding. Methods of fruit crop improvement. Challenges in horticultural crop breeding, Pseudo test cross strategy for perennials with long juvenile period. Development of specific mapping populations.

QTL mapping using structured populations. Fine mapping of genes/QTL. Map based gene/QTL isolation and development of gene based markers. Marker assisted selection (MAS) - foreground and background selection. MAS for major and minor genes. Marker assisted pyramiding. Marker assisted recurrent selection. Transgenic breeding. MAS for specific traits with examples. Commercial applications of MAS.

Practical: Working on some genotyping and phenotyping datasets for Linkage mapping using Mapmaker, MapDisto and QTL mapping softwares - WinQTL cartographer. Use of gene based and closely linked markers for foreground selection for target traits in target crops. Marker assisted detection of the transgene.

**Biotech. 312 Epigenetics and Gene Regulation**    **3+0**    **Sem. II**

DNA methylation and histone modifications. DNA methylases, methyl binding proteins and histone modifiers. Epigenetic changes in response to external stimuli leading to changes in gene regulation. Role of DNA methylation in plant development. Mutant case studies. Introduction to small RNAs. History, biogenesis. *In silico* predictions of miRNAs, target gene identification, methylation of heterochromatin by het associated siRNAs. Small RNAs electrophoresis using PAGE. Blotting of small RNAs on nylon membrane. Detection of small RNAs using fluorescent labelled probes. Gene regulation by small RNA. Other classes of siRNAs. Bisulphite sequencing for methylation detection. Role of small RNAs in epigenetics. Jacob Monod model of gene regulation. RNA editing, Genome imprinting.

**Biotech. 313 Programming for Bioinformatics**    **2+2**    **Sem. II**

Introduction - operating systems, programming concepts, algorithms, flow chart, programming languages, compiler and interpreter; Computer number format - Decimal, Binary, Octal and



Hexadecimal. C-language: History, constant, variables and identifiers, character set, logical and relational operators, data input and output concepts; Decision making: if statement, if-else statement, for loop, while loop, do-while loop, arrays and functions, file handling. PERL-language - Introduction, variables, arrays, string, hash, sub-routines, file handling, conditional blocks, loops string operators and manipulators.

Practical: Constant, variables and identifiers, logical and relational operators, Programs related to arithmetic operations, arrays and file handling in C. Pattern matching and regular expressions in PERL, Sequence handling in PERL demonstrating string, array and hash. Shell programming - concepts and types of UNIX shell, Linux variables, if statements, control and iteration, arithmetic operations, concepts of awk, grep and sed. Sequence manipulations using shell scripting.

**Biotech. 314 Next Generation Sequencing and Data Analysis 2+1**

**Sem. II**

Introduction to first, second and third generation sequencing technologies; NGS Terminology; Applications of sequencing technologies. NGS Sequence file formats, data quality evaluation, pre-processing of data: quality control, adapter clipping, quality trimming; de-multiplexing. Bacterial genome assembly; Assessment of genome assembly, Tools for prokaryotic gene prediction (PROKKA); functional annotation (Blast, KEGG, BLAST2GO); domain and motif analysis (PFAM, interpro) Short read mapping tools (BWA, Bowtie); Visualization tools for genome assembly and mapped reads; data submission to SRA.

Practical: NGS sequence files format (FASTQ/BED/BAM/GFF), quality control (FastQC), adapter clipping (cutadapt), trimmomatic, Prokaryotic genome assembly (SPADES/soapdenovo), Gene prediction (PROKKA), Functional annotation (Blast/BLAST2GO/PFAM/interpro), Read mapping (BWA/Bowtie), Visualization of mapped reads (IGV/Tablet).

**Biotech. 491 In-house Skill Development in Plant Biotechnology 0+20/**

**Biotech. 492 In-house Skill Development in Bioinformatics 0+20**

**Sem. I**

B. Tech (Biotech.) students will register for either Biotech. 491 or Biotech. 492 in 7<sup>th</sup> semester. They will be demonstrated and imparted hands on training on different tissue culture, molecular biology and bioinformatics techniques at School of Agricultural Biotechnology.

**Biotech. 493 Project Formulation, Execution and Presentation 0+10**

**Sem. II**

The students (2 or 3) will be allotted to each faculty member of School of Agricultural Biotechnology and associated faculty member for Project Formulation, Execution and Presentation.

**Biotech. 494 Entrepreneurial Development in Biotechnology 0+10**

**Sem. II**

Modules:

- i. Micropropagation
- ii. DNA fingerprinting
- iii. Genetic purity for maintenance breeding
- iv. Marker assisted selection
- v. Database Management skills

**Postgraduate Courses**

**Biotech. 501 Plant Tissue Culture and Genetic Transformation 2+1**

**Sem. I**

Plant cell and tissue culture its importance and history. Culture media for callus, suspension, nurse, root, meristem, etc. In vitro differentiation. Plant growth regulators. Molecular basis of plant organ differentiation. Various aspects of plant tissue culture micropropagation, anther and microspore culture, somaclonal variation, embryo rescue, wide hybridization, in vitro mutagenesis, in vitro fertilization and in vitro germplasm

conservation. Production of secondary metabolites. Synthetic seeds. Protoplast culture and regeneration. Somatic hybridization: protoplast fusion etc. Vector and vector less methods of plant transformation. Genetic and molecular analyses of transgenics. Target traits and transgenic crops. Biosafety issues of transgenics, regulatory procedures for commercial approval.

**Practical:** Setting up a tissue culture and transformation laboratory. Preparation of nutrient media. Handling and sterilization of plant material. Inoculation, subculturing and plant regeneration. Anther and pollen culture. Embryo rescue. Suspension cultures and production of secondary metabolites. Protoplast isolation, culture and fusion. Gene cloning and vector construction. Gene transfer using vector and vectorless methods, reporter gene expression, selection of transformed tissues/plants, molecular analysis.

**Biotech. 502 Principles of Biotechnology**

**2+0**

**Sem. II**

History, scope and importance of recombinant DNA. Recombinant DNA, vectors and enzymes. Identification, isolation, characterization of genes and application of gene cloning. Generation of chimeric gene cassettes for producing genetically engineered transgenic plants. cDNA and genomic libraries, library screening. Molecular markers and their application. RFLP, PCR based markers. Construction of molecular maps. Marker assisted selection. Molecular mapping and tagging of agronomically important traits. Genomics and proteomics. DNA sequencing. Hybridization techniques. General application of biotechnology in agriculture. Biosafety, bioethics and intellectual property rights in biotechnology.

**Biotech. 503 Principles in Structural and Functional Genomics 3+0**

**Sem. I**

Development of sequence based molecular markers - SSRs and SNPs. Advanced methods of genotyping construction of high density linkage maps. Mapping genes for qualitative and quantitative traits. QTL mapping using structured populations, AB-QTL analysis, Association mapping of QTL. Fine mapping of genes/QTL. Map based gene/QTL isolation and development of gene based markers. Structural genomics: Classical ways of genome analysis, large fragment genomic libraries, Physical mapping of genomes, Genome sequencing, sequence assembly and annotation, comparative genomics. Allele mining by TILLING and Eco-TILLING and deep sequencing. Functional genomics: DNA chips and their use in transcriptome analysis. Mutants and RNAi in functional genomics. Metabolomics and ionomics for elucidating metabolic pathways. Use of markers in plant breeding. Marker assisted breeding including marker assisted back crossing, foreground and background selection, marker assisted alien introgression and transgenic breeding. Discussion on selected examples on MAS in India and global level. Applications of genomics in agriculture.

**Biotech. 504 Techniques in Structural and Functional Genomics 0+2**

**Sem. I**

Good lab practices. Biochemical techniques. Preparation of buffers and reagents, Principle of centrifugation, gel electrophoresis- agarose and PAGE (nucleic acids and proteins). Growth of bacterial culture and preparation of growth curve. Isolation of plasmid DNA from bacteria, restriction digestion of plasmid DNA. Isolation of high molecular weight DNA and analysis. Gene cloning - Recombinant DNA construction, transformation and selection of transformants. PCR and optimization of factors affecting PCR. Dot blot analysis. Southern hybridization, Northern hybridization, Western blotting and ELISA. Radiation safety and non-radio isotopic procedure. Molecular markers (RAPD, SSR, AFLP etc) and their analysis. Case study of SSR markers (linkage map, QTL analysis etc). SNP identification and Analysis. Microarray studies and use of relevant software. Construction of gene libraries. Synthesis and cloning of cDNA and RTPCR Analysis. Real time PCR and interpretation of data.

**Biotech. 505 Techniques in Molecular Biology-II**

**0+2 Sem. II**

Construction of gene libraries. Synthesis and cloning of cDNA and RTPCR analysis. Real time PCR and interpretation of data. Molecular markers (RAPD, SSR, AFLP etc) and their analysis. Case study of SSR markers (linkage map, QTL analysis etc). SNP identification and analysis. Microarray studies and use of relevant software. Proteomics (2D gels, mass spectrometry, etc.). RNAi (right from designing of construct

to the phenotyping of the plant). Yeast 1 and 2-hybrid interaction. Generation and screening of mutants. Transposon mediated mutagenesis.

### **Biotech. 506 Molecular Cell Biology**

**3+0 Sem. I**

General structure and constituents of cell. Similarities and distinction between plant and animal cells. Cell wall, cell membrane, structure and composition of biomembranes, cell surface related functions. Structure and function of major organelles i.e. Nucleus, Chloroplasts, Mitochondria, Ribosomes, Lysosomes, Peroxisomes, Endoplasmic reticulum, Microbodies, Golgi apparatus, Vacuoles, etc. Organellar genomes and their manipulation. Ribosomes in relation to cell growth and division. Cyto-skeletal elements. Cell division and regulation of cell cycle. Membrane transport. Transport of water, ion and biomolecules. Signal transduction mechanisms. Protein targeting.

### **Biotech. 507/ Micro. 504 Industrial Microbiology**

**2+1 Sem. II**

History, scope and development of industrial microbiology. Isolation, maintenance and genetic improvement of industrially and biotechnologically important microorganisms. Substrates for industrial fermentations. Bioreactor types. Concepts of industrial fermentations - batch and continuous. Scaling up, downstream processing and product recovery. Microbial production of ethanol, beer, wine, organic acids, enzymes, growth factors and vitamins, vinegar, low alcoholic beverages, antibiotics, lactic acid, biofuels, vaccines, Single cell protein, biogas and hydrogen production, biofertilizers, bioinsecticides biopesticides, biodegradable plastics. Biosensors: to detect food contamination and environmental pollution. Biomining, Steroid transformation, Immobilization of cells/enzymes, Silage production, Waste disposal and treatment .Use of genetically-engineered microorganisms, Microbiologically produced food colours, pigments and flavours. Retting of flax.

Practical: Isolation, maintenance and improvement of industrial important organisms. Production of alcohol, beer, citric acid, lactic acid and their recovery; Study of bio-reactors. Production of biofertilizers and biogas. Demonstration of activity of immobilized enzymes/cells.

### **Biotech. 508 Nanobiotechnology**

**3+0 Sem. II**

Introduction to Biomacromolecule. The modern concepts to describe the conformation and dynamics of biological macromolecules using scattering techniques, micromanipulation techniques, drug delivery applications etc. Cellular engineering. Signal transduction in biological systems, feedback control signaling pathways, cell-cell interactions etc. Effects of physical, chemical and electrical stimuli on cell function and gene regulation. Chemical, physical and biological properties of biomaterials and bioresponse. Biomineralization, biosynthesis, and properties of natural materials (proteins, DNA, and polysaccharides), structure-property relationships in polymeric materials (synthetic polymers and structural proteins). Aerosol properties, application and dynamics. Statistical Mechanics in Biological Systems, Preparation and characterization of nanoparticles. Nanoparticulate carrier systems. Micro- and Nanofluidics. Drug and gene delivery system. Microfabrication, Biosensors, Chip technologies, Nano-imaging, Metabolic engineering and Gene therapy.

### **Biotech. 509 Bioinformatic Tools and their Applications in Agriculture**

**2+1 Sem. I & II**

Introduction to Bioinformatics, HTML, CGI, web services, databases - primary, secondary and structural. Protein and Gene Information Resources - PIR, SWISSPROT, PDB, Genbank including NCBI, DDBJ, EMBL. Specialized crop based genomic resources. Structure of DNA, RNA, DNA sequencing, Structure of common amino acids, peptide, polypeptide, Primary, secondary and tertiary structure of proteins, biological functions of proteins, 1D and 2D- Electrophoresis and protein sequencing. DNA sequence analysis. cDNA libraries and EST, EST analysis. Pairwise alignment techniques. database searching. multiple sequence alignment. Secondary database searching. building search protocol. Introduction to softwares for SNP identification. Gene finder. Primer design. SSR finder and Phylogenetic analysis. Hidden Markov Models, Bayesian estimation and Gibbs sampling. Comparing two sequences

using PAM and BLOSUM, Needleman and Wunsch algorithm, Smith-Waterman algorithm, BLAST. Solution of transcendental and polynomial equations by bisection, iteration, secant and Newton-Raphson methods, solution of system of linear algebraic equations by Gauss elimination method, Jacobi's and Gauss- Siedel iteration methods; numerical differentiation, numerical integration- Trapezoidal rule, Simpson's 1/3 and 3/8 rules.

Practical: HTML, Biological databases, Protein and Gene Information Resources, Hidden Markov Models, Bayesian estimation and Gibbs sampling. PAM and BLOSUM matrices, Needleman and Wunsch algorithm. Tutorials on bisection, iteration, secant and Newton - Raphson methods, Gauss elimination, Jacobi's and Gauss-Siedel iteration methods, numerical differentiation and numerical integration.

**Biotech. 601 Advances in Genetic Engineering and Transformation** **2+0 Sem. II**

Overview of transgenic plants. Genetic engineering for herbicide, insects/pests resistance, abiotic stress tolerance and quality. Genetically engineered pollination control and induction of male sterility in plants. Molecular farming of plants for applications in veterinary and human medicine systems. Rapid production of specific vaccines. Recent developments in plant transformation and marker free strategies. Role of antisense and RNAi-based gene silencing in crop improvement. Regulated and tissue-specific expression of transgenes for crop improvement. Gene stacking. High throughput phenotyping of transgenic plants. Environmental issues associated with transgenic crops. Food and feed safety issues associated with transgenic crops. Risk assessment of transgenic food crops. Discussions on application of genetic transformation in some major field and horticultural crops such as rice, wheat, cotton, maize, soybean, oilseeds, sugarcane, citrus, papaya, banana etc.

**Biotech. 602 Advances in Plant Molecular Biology** **2+0 Sem. I**

Arabidopsis in molecular biology, Forward and Reverse Genetic approaches. Transcriptional and post-transcriptional regulation of gene expression. Isolation of promoters and other regulatory elements. RNA interference. Transcriptional gene silencing. Transcript and protein analysis. Use of transcript profiling to study biological systems. Floral Development. Molecular basis of self incompatibility. Molecular basis of heterosis. Regulation of flowering. Molecular biology of abiotic stress responses. Molecular Biology of plant-pathogen interactions. Molecular biology of Agrobacterium infection. Molecular biology of Rhizobium infection (molecular mechanisms in symbiosis). Programmed cell death in development and defense. Molecular biology of Rhizobium infection (molecular mechanisms in symbiosis). Recent topics in plant molecular biology.

**Biotech. 603 Advances in Crop Biotechnology** **2+0 Sem. II**

Conventional versus non-conventional methods for crop improvement. Present status and recent developments on molecular marker systems. Transformation and genomic tools for crop improvement. Genetic Engineering for increasing crop productivity by manipulation of photosynthesis, nitrogen fixation, nutrient uptake efficiency, quality improvement (protein, essential amino acids, vitamins, mineral nutrients, etc). Edible vaccines. Molecular breeding- constructing molecular map. Integrating genetic, physical and molecular maps. Diversity assessment and phylogenetic analysis. Molecular tagging of genes/traits. Selected examples on marker assisted selection of qualitative and quantitative traits. Discussions on application of molecular markers and genomic tools for the genetic enhancement in some major field and horticultural crops such as rice, wheat, cotton, maize, soybean, oilseeds, sugarcane, banana, grapes and papaya etc.

**Biotech. 604 Advances in Functional Genomics and Proteomics** **2+0 Sem. I**

Genome sequencing and functional genomics in some model plants and major field crops. Advances in genome sequence technologies. Genome annotation. Gene discovery. Functional annotation and gene family clusters. Functional analysis of genes. RNA-mediated interference. Gene knockoffs. Gene traps/ T-DNA insertion lines. Homologous recombination. Microarray profiling. SAGE, SNPs/variation. Yeast- two hybrid screening. Gene expression and transcript profiling. EST contigs. EcoTILLING. Allele/gene

mining. Synteny and comparative genomics. Genome evolution, speciation and domestication. Proteomics- protein annotation; protein separation and 2D PAGE. Mass spectroscopy. Protein microarrays. Protein interactive maps. Structural proteomics including protein structure determination, prediction and threading, software and data analysis/ management. Discussions on recent topics in functional genomics, proteomics and integrative genomics.

**Biotech. 605/Micro. 605 Advances in Microbial Genetics and Biotechnology** **2+0 Sem. II**

Organization of genetic material in prokaryotic and Eukaryotic cell. Gene expression-DNA- protein interaction. Genetic recombination-General and specific recombination following gene transfer-transformation, transduction and conjugation. Bacterial plasmids-replication, maintenance and functions. Bacteriophages-structure, lytic and lysogenic cycle, molecular mechanism and adsorption and infection. Insertion sequences and transposons-structure, replication and application in improvement of microbial expression with respect to industry and agriculture. Molecular mechanism of site mutagenesis. Protein engineering, recombinant DNA technology-DNA isolation, vector designing, cloning, PCR amplification, expression of genes and its application in industry and agriculture. Concepts of proteomics and genomics.

**Biotech. 606 Commercial Plant Tissue Culture** **2+0 Sem. I**

Micropropagation of commercially important plant species. Plant multiplication, hardening, and transplantation, genetic fidelity, scaling up and cost reduction. Bioreactors. Synthetic seeds. Management and marketing. Production of useful compounds via biotransformation and secondary metabolite production. Suspension cultures. Immobilization. Examples of chemicals being produced for use in pharmacy, medicine and industry. Value-addition by transformation. Development, production and release of transgenic plants. Patent, bio-safety, regulatory, environmental and ethic issues. Management and commercialization. Some case studies on success stories on commercial applications of plant tissue culture.

**Biotech. 607 Advances in Bioinformatics** **0+2 Sem. I**

Linux and Unix Operating Systems. C + +, Perl Script. Importance of Biological Databases. Searching NCBI Database using Entrez. Multiple sequence alignment using ClustalW and ClustalX. Using repeat Masker to identify repetitive elements in Genome Sequences. Finding genes using various algorithms. Finding SSRs and Designing Primers. Viewing and editing assembled sequences using Consed. Assembling Genome Sequences using PHRAP. Aligning large sequences sets. Generating Contigs using FPC. Gene Annotation. Inferring evolutionary relationships based on DNA and protein data.

**Biotech. 591 Seminar**

**Biotech. 600 Master's Research**

**Biotech. 700 Ph.D. Research**

## AGRICULTURAL METEOROLOGY

### PROGRAMMES

1. **M.Sc. Agricultural Meteorology**
2. **Ph.D Agricultural Meteorology**

### COURSE REQUIREMENT

#### **M.Sc.**

Field of Specialization	Climate Change, Microclimate Modifications, Crop Modeling, Crop-weather-pests interactions.
Required Courses	Agromet. 501, Agromet. 502, Agromet. 503, Agromet. 504, Agromet.505
Supporting Courses	Stat. 421, PGS 501 and other courses from subject matter fields (other than minor) relating to area of special interest and research problem
Minor Fields	Agronomy, Entomology, Plant Pathology, Soil Science, Math., Vegetable Science or any other as approved by the Dean, PostgraduateStudies
Deficiency courses for students the with elective other than Agronomy, Soil Sceicne, Forestry	As recommended by Student's Advisory Committee and approved by the Dean, Postgraduate Studies

#### **Ph.D.**

Field of Specialization	Climate Change, Microclimate Modifications, Crop Modeling, Crop- weather-pests interactions.
Required Courses	Agromet.601, Agromet. 602, Agromet.603
Supporting Courses	Stat. 515 and other courses from subject matter fields (other than minor) relating to area of special interest and research problem
Minor Fields	Agronomy, Entomology, Plant Pathology, Soil Science, Math., Vegetable Science or any other as approved by the Dean, PostgraduateStudies
Deficiency courses for students with M.Sc.(Agri.) in a discipline other than Agricultural Meteorology	Agromet. 501, Agromet. 502, Agromet. 503, Agromet. 504, Agromet.505 and other courses as recommended by Student's Advisory Committee



## DESCRIPTION OF COURSE CONTENTS

### Diploma courses

#### **Agromet. 51 Elementary Agro-climatology**

**1+1**

**Sem. II**

General Climatology. Agrometeorology. Elements and factors of climate. Earth's atmosphere. Effect of climate on crops, and livestock distribution and production. Weather hazards in agriculture. Introduction to monsoons. Basics of weather forecasting. Agro-climatic regions of Punjab. Effects of climate change on agriculture.

Practical: Introduction to Agrometeorology. Instruments installed in observatory. Recording data in Meteorological Observatory. Preparation of Ergograph. Computation of atmosphere humidity. Analysis of wind using Wind Rose. Study of weather systems. Analysis of weather charts. Preparation and dissemination of weather forecast. Agro advisories.

### Undergraduate Courses

#### **Agromet. 102 Introductory Agrometeorology and Climate Change**

**1+1**

**Sem. II**

Agrometeorology – definition, scope. Earth atmosphere - its composition, extent and structure. Atmospheric weather variables. Elements and factors of weather and climate. Atmospheric pressure. Wind, types, daily and seasonal variation. Cyclone, anticyclone. Land and sea breeze. Solar radiation-solar constant, depletion, short and long wave, thermal radiation, net radiation, albedo. Atmospheric temperature, inversion, lapse rate, daily and seasonal variations, vertical profile. Energy balance of earth. Atmospheric humidity, saturation vapor pressure, condensation. Dew, fog, mist, frost. Precipitation, process, types. Cloud formation and classification. Artificial rainmaking. Monsoon-mechanism and importance in Indian agriculture. Weather hazards. Agriculture and weather relations. Modifications of microclimate. Climatic normals for crop and livestock production. Weather forecasting – types and applications. Climate change and impacts on agriculture.

Practical: Visit to Agrometeorological observatory. Site selection of observatory and exposure of instruments and weather data recording. Measurement of total, short and long wave radiations and their estimation using Planck's intensity law. Measurement of albedo and sunshine duration, computation of radiation intensity using BSS. Measurement of maximum and minimum air temperatures, tabulation, trend and variation analysis. Measurement of soil temperature and computation of soil heat flux. Determination of vapor pressure and relative humidity. Determination of dew point temperature. Measurement of atmospheric pressure and analysis of atmospheric conditions. Measurement of wind speed and wind direction, preparation of wind rose. Measurement, tabulation and critical analysis of rainfall. Computation of drought indices. Measurement of open pan evaporation and evapotranspiration. Computation of PET and AET.

#### **Agromet. 301 System Simulation and Agroadvisory**

**2+1**

**Sem. II**

System approach for representing soil-plant- atmospheric continuum, system boundaries. Crop models-concepts, types, techniques, basic data requirements, relational diagrams. Evaluation of crop responses to weather elements. Elementary crop growth model. Calibration, validation, verification and sensitivity analysis. Potential and achievable crop production-concept and modeling techniques for their estimation. Crop production in moisture and nutrient limited conditions. Components of soil water and nutrient balance. Insect and disease forecasting models. Weather forecasting, types methods, tools and techniques, forecast verification. Value added weather forecast; ITK for weather forecast and its validity. Crop weather calendars. Preparation of agro-advisory bulletins based on weather forecast and crop simulation models and its effective dissemination.





**Agromet. 504 Agrometeorological Measurements and Instrumentation      2+1    Sem. I**

Fundamentals of measurement techniques. Theory and working principles of barometers, thermometers, psychrometers, hair hygrometer, thermohygrograph, radiation and temperature instruments, pressure bomb apparatus, precipitation and dew instruments, wind instruments, porometer, photosynthesis system, leaf area meter, soil thermometers and soil heat flux plates. Automatic weather station. Computation and interpretation of data.

Practical: Working with the above instruments in the meteorological observatory, taking observations of relevant parameters. Exposure and operation of meteorological instruments/equipments in agromet observatories. Computation and interpretation of the data.

**Agromet. 505 Soil Water Balance Climatology****2+1 Sem.II**

Basic laws of radiation, radiation interaction with plant environment. Energy balance in atmosphere and crop canopy. Fundamentals of soil water movement and fluid flow. Soil heat concepts. Theories and methods of ET estimation. Concepts of potential, reference and actual evapotranspiration - modified techniques. Influence of microclimatic, plant, soil and cultural factors on ET. Techniques of lysimetry in measuring actual ET. Yield functions, water use efficiency and scheduling of irrigation based on ET. Water use efficiency and anti-transpirants. Dry matter yield, ET functions. Advanced techniques for measurement of radiation and energy balance; computation of KC values and their use. Modeling for potential ET & reference ET and ET through remote sensing.

Practical: Measurement and evaluation of radiation components. Computation and comparison of evapotranspiration by different methods - energy balance method, aerodynamic method, Penman method, remote sensing and other methods. Measurement of wind and temperature profiles near the ground

**Agromet. 506 Crop Weather Models****2+1 Sem. I**

Basic concepts and definitions related to modelling. Principles of crop production. Evaluation of crop responses to weather elements. Impact of natural and induced variability of climate on crop production. Empirical and statistical crop weather models, their application with examples. Regression models-incorporating weather, soil, plant and other environmental related parameters and remote sensing inputs. Growth and yield prediction models. Crop simulation models-DSSAT models, WOFOST, SPAW, INFOCROP etc. Yield forecasting models, insect forecasting and disease forecasting models. Testing of models- Verification, calibration, sensitivity analysis and validation of models.

Practical: Working with statistical and simulation models, DSSAT models, BRASSICA etc.

**Agromet. 507 Weather Modification and Risk Management Strategies****2+0 Sem. II**

Weather modification- historical review, present status and theories. Atmospheric composition and green house effect. Scientific advances in clouds and electrical behaviour of clouds. Modification of weather hazards. Modification of field microclimate. Protection of plants against climatic hazards. Meteorological conditions in artificial and controlled climates. Risks in agricultural production, history, trends and strategies, preparedness for weather and climate risks. Risk characterization - definitions and classification in agriculture. Risks related with water, radiation/heat, air, biomass, social and economic risk factors related to weather and climate. Methods for risk assessment and application to agricultural systems. Application of risk management approaches to weather and climate problems. Application of methods that permit the incorporation of seasonal and long-term forecasts into the risk assessment models.

**Agromet. 508 Principles of Remote Sensing and their Applications in Agriculture 2+1 Sem. I**

Basic components of remote sensing. Characteristics of electromagnetic radiation and its interaction with matter. Spectral features of earth's surface. Sensor Systems. Data acquisition system, data pre-processing, storage and dissemination. Digital image processing and information extraction. Fundamental of aerial photographs. Microwave remote sensing. Visual and digital image interpretation. Introduction to GIS and GPS. Application of Remote Sensing Techniques-crop identification, crop stress detection, yield forecasting, soil moisture, air temperature assessment, drought monitoring, wasteland identification, management & monitoring of crop disease and pest infestation. Analysis of spatial & temporal variability in soils, agroclimatic regionalization.

Practical: Field data collection. Map and imagery scales. S/W and H/W requirements and specifications. Data products, their specifications, media types, data inputs, transformation, display types, image enhancement. Image classification methods. Evaluation of classification errors. Crop discrimination and acreage estimations. Differentiation of different degraded soils. Time domain reflectometry. Use of spectrometer and computation of vegetation indices. Demonstration of case studies. Hands on training.

**Agromet. 509 Applied Agricultural Climatology****2+1 Sem. II**

Climatic statistics. Assessment of frequency of disastrous events. Hydrological cycle. Climatic water budget. Potential and actual ET. Calculation of water surplus and deficit. Computation of daily and monthly water budget and their applications. Assessment of dry and wet spells, available soil moisture, moisture adequacy index and their applications. Thermal indices and phenology. Cardinal temperatures. Growing degree day concept and applications. Crop weather calendars. Agroclimatic requirements of crops. Bioclimatic concepts- evaluation of human comfort, indices and clothing insulation. Climate housing and site orientation. Climatic normals for animal production.

Practical: Statistical approaches in data analysis. Preparation of climatic water budget. Estimation of agro-meteorological variables using historical records. Degree day concept and phenology forecasting, crop calendar and climograph. Weather-pest-disease interactions, calculation of continentality factors and comfort indices.

**Agromet. 601 Advanced Weather Forecasting 3+0 Sem. I**

Weather forecasting - definition, importance, scope and types. Study of synoptic charts, jet streams, synoptic features and weather anomalies and zones of thermal advection and interpretation of satellite pictures of clouds. Weather forecasting network. Approaches of weather forecasts. Indigenous Technical Knowledge. Weather based advisories. Interpretation of weather forecasts for soil moisture, farm operations, pest and disease development and epidemics, crops and livestock production. Special forecasts for natural calamities. Modification of weather hazards, weather modification for agriculture. Scientific advances in artificial rain making, hail suppression, dissipation of fog and stratus clouds, modification of severe storms and electric behaviour of clouds. Synoptic chart analysis. The kinematics of the pressure field. The atmospheric scales of motion. Global circulations. Perturbation theories of instability. Jet streams. Cloud identification and characterization from satellites.

**Agromet. 602 Analytical Tools and Methods for Agricultural Meteorology 3+0 Sem. II**

Review of agro-climatic methods. Characterization of agroclimatic elements. Sampling of atmosphere - temporal and spatial considerations. Micro, meso and macro climates. Network spacing-spatial and temporal methods. GIS fundamentals and applications. Numerical characterization of climatic features. Crop response to climate, time lags, time and distance constants. Hysteresis effects. Influence of climate on stress-response relations. Thermal time approach in agroclimatology- heat and radiation use efficiency in crop plants, applications to insect-pest development and prediction. Comfort indices for human and animals. Impact of natural and induced variability and change of climate on crop production. Instrumentation and sampling problems. Design of agro-meteorological experiments. Basic knowledge of applications of computers in agriculture. Empirical and statistical crop weather models and their application with examples. Incorporating weather, soil, plants and other environment related parameters as subroutine and remote sensing inputs in models. Growth and yield prediction models, crop simulation models and forecasting models for insects and diseases.

**Agromet. 603 Strategic Use of Climate Information****3+0 Sem. II**

Awareness and history of climate-related disasters. Hazards and their relation to agricultural production risks and their mitigation. Selection of appropriate land use and cropping patterns- history and environmental issues, success and difficulties experienced by farmers and outlook for possible alternatives. Agro-meteorological aspects for making more efficient use of agricultural inputs. Selection of livestock management- history related to environmental issues. Adoption of microclimate modification techniques. Protection measures against extreme climate- history of protection measures against extreme climate in the continent/region/country/sub region concerned, successes and difficulties experienced by

farmers with present protection measures, outlook for present protection measures and possible alternatives. Trends in protection methods against extreme climate.

**Agromet. 604 Climate Change and Sustainable Development 2+0 Sem.I**

Climate change and variability. Driving forces and patterns in climatic changes. Green house effect. Green house gases and global warming. Types of air pollutants. Role of air pollutants in climate change. Meteorological factors in the movement of dispersion of air pollutants & biochemical smog. Natural and human caused climate change. Induced climate change due to change in land use pattern. Implications of climate change for agriculture. Global strategy to minimize climate change process. Role of climate change models. Effects of climate change on agriculture, biodiversity etc. Mitigation and adaptation strategies in agriculture. Advances in climate change. Mitigation strategies in agriculture to counteract climate change. Models for climate change studies.

**Agromet. 605 Advanced Micrometeorology 2+0 Sem.II**

Energy flow in the plant environment system. Momentum, heat and mass transfer in the biosphere. Soil heat flux. Aerial and crop resistance affecting energy transport. The movement of particles in plant communities. Derivations of crop growth processes based on micrometeorological data. Energy balance over different crops. Microclimate in fields, forests, glass house and net houses/plastic houses. Field climate modification-methods of modification in crops. Risk analysis in environmental modifications. Recent advances in field climate modifications.

**Agromet. 606 Agrometeorological Data Base Management and e-Services 2+1Sem. I**

Data, information and types of data-climate, soil and crop data. Importance of database management, data requirements, collection and recording. Data structure/format and quality control of data. Techniques of climatic data generation and missing data. Introduction to different software for database management. Processing and analysis of data and data products. Value addition of data and data products- data users, public, commercial, academic / research. Availability, accessibility and security of data. Evaluating the cost of data.

Practical: Types of instruments and data recording. AWS data retrieval, storage and transfer. Exposure to different software for Agromet data analysis; exposure to Statistical software. Temporal and spatial analysis of data; exposure to GIS. Value addition to data. Uploading and downloading data, password and security of data. E-management of data.

**Agromet. 591 Seminar**

**Agromet. 600 Master's Research**

**Agromet. 700 Ph.D. Research**

## AGRONOMY

### PROGRAMMES

#### 1. M.Sc.

#### 2. Ph.D.

#### COURSE REQUIREMENT M.Sc.

Field of Specialization	Agrostology, Crop Ecology, Crop Nutrition, Crop Physiology, Crop Production, Water Management, Weed Science
Required Courses	Agron.501, Agron. 502, Agron. 503, Agron. 504, Agron.505
Supporting Courses	Stat.421, PGS 501 and other courses from subject matter fields (other than minor) relating to area of special interest and research problem
Minor Fields	Agrometeorology, Chemistry, Botany, Soil Science, Forestry & Natural Resources, Microbiology or any other as approved by the Dean, Postgraduate Studies
Deficiency courses for the students with elective other than Agronomy, Soil Science and Forestry	As recommended by Student's Advisory Committee and approved by the Dean, Postgraduate Studies

#### Ph.D.

Field of Specialization	Agrostology, Crop Ecology, Crop Nutrition, Crop Physiology, Crop Production, Water Management, Weed Science
Required Courses	Agron. 601, Agron. 602, Agron. 603, Agron. 604
Supporting Courses	Courses from subject matter fields (other than minor) relating to area of special interest and research problem
Minor Fields	Agrometeorology, Chemistry, Botany, Soil Science, Forestry & Natural Resources, Microbiology or any other as approved by the Dean, Postgraduate Studies
Deficiency courses for students with M.Sc.(Agri.) in a discipline other than Agronomy	Agron.501, Agron. 502, Agron. 503, Agron. 504, Agron.505 and other courses as recommended by Student's Advisory Committee

## DESCRIPTION OF COURSE CONTENTS

### Diploma courses

**Agron. 51 Elementary Agriculture** **1+1** **Sem. I**

Agriculture and its component sciences. Classification of crops. Seed, its structure, germination, phases of growth, factors affecting growth. Seed bed preparation. Nutrients for plant growth. Fertilizers and manures. Importance of water to plants, its uptake and losses. Weeds and their control. Practical: Identification of various crops and seed. Study of germination of different types of crop seeds. Familiarization of important agricultural implements and hand tools, weeds, fertilizers.

**Agron. 52 Elementary Agronomy** **2+1** **Sem. I**

Agronomy - its importance and relation with other sciences. Classification of crops. Tillage - principles and practices. Different methods of sowing. Common manures and fertilizers and their time and method of application. Green manuring. Methods of irrigation. Weeds and their control. Cropping systems, crop rotations and inter-cropping. Harvesting and threshing. Conservation agriculture. Practical: Land measurements. Use of common hand tools and farm implements. Identification of different fertilizers. Computation of fertilizer doses. Methods of fertilizer application. Germination and purity test. Use of spray pumps. Practice in harvesting and threshing. Farm visit for familiarization with field problems.

**Agron. 53 Crop Production – I** **2+1** **Sem. I**

Important *kharif* crops – rice, maize, bajra, cotton, sugarcane, moong, mash, red gram, soybean, groundnut, sesamum, mentha, turmeric and fodder crops, their importance, improved varieties, cultural practices, harvesting and threshing. Practical: Identification of important *kharif* crops, their seeds and weeds. Field practices like seedbed preparation, seed treatment, preparation of sugarcane seed sets, sowing, transplanting, thinning, earthing up, hoeing, fertilizer and herbicide application, propping, maturity indexing and harvesting.

**Agron. 54 Crop Production – II** **2+1** **Sem. II**

Important *Rabi* crops – wheat, winter maize, gram, lentil, rapeseed and mustard, sunflower, safflower, celery and fodder crops, their importance, improved varieties, cultural practices, harvesting and threshing. Practical: Identification of important *rabi* crops, their seeds and weeds. Field practices like seedbed preparation, seed treatment, sowing, transplanting, thinning, earthing up, hoeing, fertilizer and herbicide application, maturity indexing and harvesting.

### Undergraduate Courses

**Agron. 101 Fundamentals of Agronomy** **3+1** **Sem. I**

Agronomy and its scope. History of agriculture and impact of green revolution on Indian agriculture. Seeds and sowing, tillage and tith. Crop density and geometry. Crop nutrition, manures and fertilizers, nutrient use efficiency. Water resources. Soil-plant-water relationship, crop water requirement, water use efficiency. Irrigation- scheduling criteria and methods, quality of irrigation water, water logging. Weeds-importance, classification, crop weed competition, concepts of weed management-principles and methods, herbicides- classification, selectivity and resistance, allelopathy. Growth and development of crops. Cropping system and its diversification in present day agriculture. Factors affecting growth and development. Plant ideotypes. Crop rotation and its principles. Adaptation and

distribution of crops. Crop management technologies in problematic areas. Harvesting and threshing of crops.

Practical: Identification of crops, seeds, fertilizers, pesticides and tillage implements. Study of agro-climatic zones of India. Identification of weeds in crops, methods of herbicide and fertilizer application. Study of yield contributing characters and yield estimation. Seed germination and viability test. Numerical exercises on fertilizer requirement, plant population, herbicides and water requirement. Use of tillage implements-reversible plough, one way plough, harrow, leveller, seed drill. Study of soil moisture measuring devices, measurement of field capacity, bulk density and infiltration rate. Measurement of irrigation water.

**Agron. 102 Principles of Agronomy**

**1+1**

**Sem. II**

(For students of B. Tech. Agri. Engineering)

Introduction and scope of Agronomy. Classification of crops. Effect of different weather parameters on crop growth and development. Principles of tillage, tillth and its characteristics. Modern concepts of tillage. Crop seasons. Varieties, methods, time and depth of sowing, weed control, irrigation and fertilizer management of major field crops. Methods and time of application of manures and fertilizers. Precision agriculture. Organic farming. Sustainable agriculture. Soil water plant relationship, methods of irrigation, water requirement of crops and critical stages for irrigation. Weeds and their control. Crop rotation, cropping systems, relay cropping and mixed cropping.

Practical: Land measurement. Identification of crops, seeds, hand tools, implements, fertilizers and weeds. Calculation of fertilizer doses, fertilizer application methods. Different weed control methods. Practice of ploughing, practice of puddling, practice of sowing.

**Agron. 103 Crop Production Technology**

**2+1**

**Sem. I**

(For students of B.Tech. Biotechnology - In collaboration with Department of Soil Science)

Soil and its components. Soil morphological, physical, chemical and biological properties. Acidic, saline and alkali soils and their reclamation. Essential plant nutrients-functions and deficiency symptoms. Soil micro-organisms. Rhizosphere and its domain in soil. Organic manures and inorganic fertilizers. Agriculture, Agronomy and its relation with other sciences. Classification of crops. Tillage and tillage practices, concepts of tillage and objectives. Seed, its characteristics and different sowing methods. Weed management-definition of weed, losses and benefits of weeds, different weed control methods and their suitability under different conditions. Irrigation-Soil water classification, methods of irrigation, approaches for scheduling irrigation. Soil fertility and productivity. Concept of essentiality of plant nutrients. Fertilizers, manures and their types, methods of fertilizer application. Concepts of crop rotation, multiple cropping and intercropping - their principles, advantages and limitations. Cropping intensity. Production technology of major crops: Rice, maize, cotton, soybean, mung bean, mash, wheat, rapeseed and mustard, gram and Egyptian clover.

Practical: Study of soil profile and its characteristics. Determination of soil particle size distribution, particle density and bulk density. Determination of soil pH, electrical conductivity and organic carbon. Isolation of soil micro-flora (bacteria, fungus and actinomycetes). Land measurement. Practice in seedbed preparation and seeding methods. Identification of crop seeds, crops, weeds and fertilizers. Identification and use of hand tools and implements. Computation of fertilizer doses and their method of application.

**Agron. 105 Crop Production Practices**

**2+1**

**Sem. I**

(For students of B. Tech. Food Technology - In collaboration with Department of Fruit Science & Vegetable Science)

Classification of crops. Effect of different weather parameters on crop growth and development. Principles of tillage. Soil-water-plant relationship. Crop rotation, cropping systems, relay cropping and



mixed cropping. Crop production technology for major cereal crops viz., paddy, wheat, maize, pearl millet, sorghum, etc. Major varieties, sowing time, method of sowing, spacing, inter-culturing, fertilizer and water requirement, time of harvest, maturity index, yield potential, etc. Crop production technology for major oilseed crops viz., groundnut, sesame, rapeseed, mustard, castor, etc. Major varieties, sowing time, method of sowing, spacing, inter-culturing, fertilizer and water requirement, time of harvest, maturity index, yield potential, etc. Crop production technology for major pulse crops viz., pigeon pea, cowpea, gram, green gram, black gram, etc. Major varieties, sowing time, method of sowing, spacing, inter-culturing, fertilizer and water requirement, time of harvest, maturity index, yield potential etc. Crop production technology for major spices and cash crops viz., cumin, coriander, fennel, ginger, garlic, sugarcane etc. Major varieties, sowing time, method of sowing, spacing, inter-culturing, fertilizer and water requirement, time of harvest, maturity index, yield potential, cost of cultivation, income from production, etc. Horticulture - Scope of horticultural crops. Soil and climatic requirements for fruits and vegetables, nursery raising and management. Crop production technology for major fruit crops viz., mango, banana, sapota, aonla, pomegranate, guava, etc., Major varieties, time of transplanting, spacing, inter-culturing, fertilizer and water requirement, time and method of harvest, maturity index, yield potential, cost of cultivation, income from production, etc. Crop production technology for major vegetable crops viz., potato, onion, tomato, chilli and other green and leafy vegetables: Major varieties, sowing time, method of sowing, spacing, inter-culturing, fertilizer and water requirement, time of harvest, maturity index, yield potential, cost of cultivation, income from production, etc.

Practical: Examination of soil profile in the field, Introduction to different equipments utilized in a weather observatory. Identification of seed of different agricultural crops and their varieties. Study of seed viability and germination test. Identification of different weeds and methods of their control. Use of different inter-culturing equipments. Study of water requirement of different crops. Fertilizer application methods and equipments. Judging maturity time for harvesting of crop. Identification and description of important fruit and vegetable crops. Preparation of nursery. Study of different garden tools. Practices of pruning and training in some important fruit crops.

**Agron. 201 Production Technology for *Kharif* Crops** **1+1** **Sem. I**

Origin, geographical distribution, economic importance, soil and climatic requirements, varieties, cultural practices and yield of *kharif* crops. Cereals- rice, maize, sorghum, pearl millet and finger millet; pulses- pigeon pea, mung bean and urdbean; oilseeds- groundnut and soybean; fibre crops- cotton and jute; forage crops- maize, sorghum, bajra, cowpea, cluster bean and Napier-bajra hybrid.

Practical: Rice nursery preparation and transplanting. Sowing of cotton, maize, soybean, pigeon pea, mung bean, groundnut and forage crops. Effect of seed size and sowing depth on germination and seedling vigour of *kharif* crops. Identification of weeds in *kharif* crops. Top dressing and foliar application of fertilizers. Morphological description of *kharif* crops. Yield calculation of *kharif* crops. Visit to experiments at Agronomy farm and research centres.

**Agron. 202 Production Technology for *Rabi* Crops** **1+1** **Sem. II**

Origin, geographical distribution, economic importance, soil and climatic requirements, varieties, cultural practices and yield of *rabi* crops. Cereals - wheat and barley; pulses- chickpea, lentil, peas; oilseeds - rapeseed, mustard and sunflower; sugar crops- sugarcane; medicinal and aromatic crops- lemon grass and citronella; forage crops-*berseem*, lucerne and oat.

Practical: Sowing methods of wheat and sugarcane. Identification of weeds in *rabi* season crops. Study of morphological characteristics of *rabi* crops. Study of yield contributing characters of *rabi* season crops and their yield. Study of important agronomic experiments of *rabi* crops at experimental farms. Study of *rabi* forage experiments. Oil extraction of medicinal crops. Visit to research stations of related crops.

**Agron. 203 Farming System and Sustainable Agriculture** **1+0** **Sem. II**  
Farming System-scope, importance, and concept. Types and systems of farming system and factors affecting types of farming. Farming system components and their maintenance. Cropping system and pattern. Multiple cropping system. Efficient cropping system and their evaluation. Allied enterprises and their importance. Tools for determining production and efficiencies in cropping and farming system. Sustainable agriculture-problems and its impact on agriculture. Indicators of sustainability. Adaptation and mitigation. Conservation agriculture strategies in agriculture. HEIA, LEIA and LEISA and its techniques for sustainability. Integrated farming system-historical background, objectives and characteristics. Components of IFS and its advantages. Site specific development of IFS model for different agro-climatic zones, resource use efficiency and optimization techniques. Resource cycling and flow of energy in different farming system, farming system and environment, Visit of IFS model in different agro-climatic zones of nearby states University/ institutes and farmers field.

**Agron. 301 Practical Crop Production-I (Kharif Crops)** **0+2** **Sem. I**  
Crop planning. Raising field crops in multiple cropping system- field preparation, seed treatment, nursery raising, sowing, nutrient, water, weed, insect-pest and disease management of crops, harvesting, threshing, drying, winnowing, storage and marketing of produce with emphasis on seed production, mechanization, resource conservation and integrated nutrient, weed, insect-pest and disease management technologies. Preparation of balance sheet including cost of cultivation and net returns per student and as well as per team of 8-10 students.

**Agron. 302 Practical Crop Production-II (Rabi Crops)** **0+2** **Sem. II**  
Crop planning. Raising field crops in multiple cropping system-field preparation, seed treatment, nursery raising, sowing, nutrient, water, weed, insect-pest and disease management of crops, harvesting, threshing, drying, winnowing, storage and marketing of produce with emphasis on seed production, mechanization, resource conservation and integrated nutrient, weed, insect-pest and disease management technologies. Preparation of balance sheet including cost of cultivation and net returns per student and as well as per team of 8-10 students.

**Agron. 303 Rainfed Agriculture and Watershed Management** **1+1** **Sem. I**  
Rainfed agriculture-introduction and types. History of rainfed agriculture and watershed concept in India. Problems and prospects of rainfed agriculture in India. Soil and climatic conditions in rainfed areas. Drought - types, effect of water deficit on physio-morphological characteristics of the plants. Crop adaptation to drought and mitigation of its effects. Soil and water conservation techniques. Water harvesting- importance and its techniques. Efficient utilization of water through soil and crop management practices. Management of crops in rainfed areas. Contingent crop planning for aberrant weather conditions. Concept, objectives, principles and components of watershed management. Factors affecting watershed management.  
Practical: Climate classification. Rainfall pattern in rainfed areas of the country. Pattern of onset and withdrawal of monsoons. Calculations of effective rainfall. Cropping pattern of different rainfed areas in the country and their mapping. Interpretation of meteorological data. Scheduling of supplemental irrigation on the basis of evapo-transpiration demand of crops. Cultural practices for mitigation of moisture stress. Characterization and delineation of model watershed. Field demonstration on soil and moisture conservation measures. Field demonstration of water harvesting structures. Visit to rainfed research station/ watershed.

**Agron. 304 Principles of Organic Farming** **1+1** **Sem. II**  
(In collaboration with Department of Soil Science, Entomology and Plant Pathology)

Organic farming - principles and its scope in India. Initiatives taken by Government (central/state), NGOs and other organizations for promotion of organic agriculture. Organic ecosystem and their concepts. Organic nutrient resources and its fortification. Restrictions to nutrient use in organic farming. Choice of crops and varieties in organic farming. Fundamentals of insect, pest, disease and weed management under organic mode of production. Operational structure of NPOP. Certification process and standards of organic farming. Processing, labelling, economic considerations and viability, marketing and export potential of organic products.

Practical: Visit to organic farms for studying various components and their utilization. Preparation and analysis of enriched compost, vermicompost and bio-fertilizers/bio-inoculants. Indigenous Technical Knowledge (ITK) for nutrient, insect, pest, disease and weed management. Cost calculation of organic production systems. Post harvest management- quality aspect, grading, packaging and handling.

**Agron. 305 Weed Management  
(Optional course)**

**2+1**

**Sem. II**

Weeds - introduction, characteristics and their harmful effects. Classification, reproduction and dissemination of weeds. Herbicide classification. Concept of adjuvant, surfactant, herbicide formulation and their use. Introduction to mode of action of herbicide and selectivity. Allelopathy and its application for weed management. Bio-herbicides and their application in agriculture. Concept of herbicide mixture and utility in agriculture. Herbicide compatibility with agro-chemicals and their application. Integration of herbicides with non-chemical methods of weed management. Herbicide resistance and its management.

Practical: Weed identification and techniques of weed preservation. Losses caused by weeds. Biology of important weeds. Study of herbicides– their formulations and mixtures. Shift of weed flora study in long term experiments. Methods of herbicide application. Spraying equipments and their calibration. Calculation of herbicide doses, weed control efficiency and weed index.

**Agron.491 Agro-industrial Attachment: Seed Industries/Herbicide Formulations 0+4 Sem. I**

**Agron. 492 Experiential Learning in Organic Production Technology 0+20**

**Sem. II**

**Postgraduate Courses**

**Agron. 501 Modern Concepts in Crop Production 3+0**

**Sem. I**

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 and crop response production functions. Concept of soil plant relations. Yield and environmental stress. Integrated farming systems. Organic farming. Resource conservation technology including modern concept of tillage, dry farming. Determining the nutrient needs for yield potentiality of crop plants. Concept of balanced nutrition and integrated nutrient management. Crop residue management-recycling and its effective utilization. Remote sensing for yield forecasting. Precision agriculture.

**Agron. 502 Fertilizer Use in Crop Production**

**2+0**

**Sem. I**

Crop response to fertilizer-effect on germination, growth and nutrient removal. Problems of supply and availability of nutrients, relation between nutrient supply and crop growth. Organic farming - basic concepts

and definitions. Preparation and use of farmyard manure, compost, green manures, vermin-compost, bio-fertilizers 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 fertilizer application and its concept. Relative performance of organic and inorganic manures. Economics of fertilizer use. Integrated nutrient management. Site specific nutrient management. Effect of fertilizers on environment, Nutrient cycling integrated farming systems, Long effects of fertilizers use on crop yield and soil productivity.

**Agron. 503 Principles and Practices of Weed Management** **2+1 Sem.II**

Weed biology, ecology and crop-weed competition including allelopathy. Principles and methods of weed control. Weed indices. History and development of herbicide. Classification and selectivity of herbicides based on chemical, physiological application and selectivity. Mode and mechanism of action of important herbicides. Herbicide structure- activity relationship and factors affecting the efficiency of herbicides. Herbicide formulations and mixtures. Weed control through bio-herbicides, myco-herbicides and allelochemicals, Degradation of herbicides in soil and plants. Herbicide resistance in weeds and crops herbicide rotations. Weed management in major crops and cropping systems. Management of parasitic weeds and special weed problems. Weed shifts in cropping systems. Aquatic and perennial weed control. Integrated weed management. Cost: benefit analysis of weed management.

Practical: Identification of important crop weeds. Preparation of a weed herbarium. Weed survey in crops and cropping systems. Crop-weed competition studies. Weed indices. Preparation of spray solutions of herbicides for high and low-volume sprayers. Use of various types of spray pumps and nozzles and calculation of swath width. Economics of weed control. Herbicide residue analysis in plant and soil. Bioassay of herbicide residue. Calculation of herbicidal requirement.

**Agron. 504 Principles and Practices of Water Management** **2+1 Sem. I**

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 and water absorption by plants. Plant response to water stress. Soil, plant and meteorological factors determining water needs of crops, scheduling, depth and methods of irrigation, micro irrigation 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, methods of field drainage, their layout and spacing.

Practical: Measurement of soil water potential by using tensiometer, pressure plate and membrane 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. Determination of Consumptive use, water requirement of a given cropping pattern.

**Agron. 505 Field Plot Techniques** **2+1 Sem.II**

Planning field experiments-objectives, selection of field and treatment. Conduct of the experiment, precautions during sowing, management, harvesting and threshing. Sampling. Recording biometrical observations. Sources of error in the field experiments and methods of reducing it. Optimum plot size and number of replications. Selection of experimental designs. Rotational experiments. Experiments to study the effect of years and locations. Compilation, presentation and interpretation of the data. Factorial experiments and interaction effects. Different tests of significance. Correlation and response functions.

Transformation of data. Practical: Actual layout of field experiments. Critical examination of experiments scientific journals. Compilation and interpretation of the given data. Missing plots and analysis of variance results. Use of computers for analysis of data.

**Agron. 506 Agronomy of Major Cereals and Pulses**

**2+1 Sem.II**

Origin, history, area, production, classification, morphology, phenology, physiology, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition, quality components, handling and processing of the produce for maximum production of kharif and rabi cereals and pulses (rice, maize, sorghum, millets, wheat, barley), important grain legumes (pigeonpea, mungbean, urdbean, chickpea and lentil).

Practical: Phenological studies at different growth stages of crop. Estimation of crop yield on the basis of yield attributes. Formulation of cropping schemes for various farm sizes and calculation of cropping and rotational intensities. Working out growth indices of prominent intercropping systems of different crops. Estimation of protein content in pulses. Planning and layout of field experiments. Intercultural operations in different crops. Determination of cost of cultivation of different crops. Working out harvest index of various crops. Study of seed production techniques in various crops. Visit of field experiments.

**Agron. 507 Agronomy of Oilseed, Fibre and Sugar Crops**

**2+1 Sem.I**

Origin and history, area and production, classification, morphology, phenology, physiology, improved varieties, adaptability, climate, soil, water and cultural requirements, nutrition quality component, handling and processing of the produce for maximum production of kharif and rabi oilseed crops (Groundnut, sesame, castor, sunflower, soybean, rapeseed and mustard, linseed, etc.), fibre crops (Cotton, jute, sunhemp etc.) and sugar crops (Sugar-beet and sugarcane etc.).

Practical: Planning and layout of field experiments. Cultivation of sugarcane crop and estimation of its quality parameters. Intercultural operations in different crops. Cotton seed treatment. Working out growth indices of prominent intercropping systems. 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.

**Agron. 508 Agronomy of Medicinal, Aromatic and Under-utilized Crops**

**2+1 Sem.I**

Importance of medicinal, aromatic, plantation and under-utilized crops in national economy and their classification. Description, distribution, climate, soil requirements, cultural practices, processing and important constituents/quality of medicinal, aromatic, plantation and under-utilized crops, viz. Aloe, Satavar, Stevia, Safed musli, Kalmegh, Asaphoetida, Amla, Bael, Vanilla, Isabgol, Mentha, Basil, Lemongrass, Citronella, Palmarosa, Rose, Patchuli, Geranium, Rice bean, Lathyrus, Sesbania, Clusterbean, French bean, Celery, Fenugreek, Grain Amaranth, Coffee, Tea and Tobacco.

Practical: Identification of crops based on morphological and seed characteristics. Raising of herbarium of medicinal, aromatic and under-utilized plants. Quality characters in medicinal and aromatic plants. Methods of analysis of essential oil and other chemicals of importance in medicinal and aromatic plants.

**Agron. 509 Agronomy of Fodder and Forage Crops**

**2+1 Sem.II**

Adaptation, distribution, varietal improvement, agro-techniques and quality aspects including anti-quality factors of important fodder crops like maize, bajra, guar, cowpea, oats, barley, berseem, senji, lucerne etc. and forage crops like, napier grass, panicum, lasiurus, cenchrus etc. Year-round fodder production and management, preservation and utilization of forage and pasture crops. Principles and methods of hay and silage making; chemical and biochemical changes, nutrient losses and factors affecting

quality of hay and silage. Use of physical and chemical enrichments and biological methods for improving nutrition. Value addition of poor quality fodder. Economics of forage cultivation uses and seed production techniques.

Practical: Farm operations in raising fodder crops. Canopy measurement, yield and quality estimation, viz. crude protein, NDF, ADF, lignin, silica, cellulose etc. of various fodder and forage crops. Anti-quality components like HCN in sorghum and such factors in other crops. Hay and silage making and economics of their preparation

### **Agron. 510 Cropping Systems and Organic Farming**

**3+0 Sem. II**

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, scope and objectives. Production potential under monoculture cropping, multiple cropping, alley cropping, sequential cropping and intercropping. Mechanism of yield advantage in intercropping systems. 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. Organic farming - concept and definition, its relevance to India and global agriculture and future prospects. Soil fertility- nutrient recycling, organic residues, organic manures, composting, soil biota and decomposition of organic residues, earthworms and vermicompost, green manures and biofertilizers. Farming systems, crop rotations, intercropping in relation to maintenance of soil productivity. Control of weeds, diseases and insect pests- management biological agents, pheromones and biopesticides. Socio-economic impacts. Marketing and export potential, Organic standards, certification, labeling and accreditation procedures. Organic farming and national economy.

### **Agron. 511 Dryland Farming and Watershed Management**

**2+1 Sem II**

Definition, concept and characteristics of dry land farming. Dry land versus rainfed farming. Significance and dimensions of dry land farming in Indian agriculture. 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 resistance to drought, adaptation of crop plants to drought and drought management strategies. Preparation of appropriate crop plans for dry land areas, mid contingent plan for aberrant weather conditions. Tillage, till, 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). Anti-transpirants, soil and crop management techniques, seeding and efficient fertilizer use. Concept of watershed resource management, problems, approach and components. Plant ideotypes for drylands.

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 and 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 and soil conservation research stations and watershed projects.

### **Agron. 512 Conservation Agriculture**

**2+0 Sem. II**

Conservation agriculture definition, status and prospects. Its role towards natural resources management and sustainability concerns. Concept of conservation agriculture and their fulfillment using tillage and crop residue management, efficient cropping systems, water and nutrients management, and integrated pest management. Relevance of conservation agriculture under changing climatic conditions.

Impact of conservation agriculture on soil health and crop productivity. Conservation agriculture under rainfed / dry land farming.

**Agron. 601 Advanced Trends in Agronomy**

**2+0 Sem. I**

Agro-physiological basis of variation in yield. Recent advances in soil- plant- water relationship. Globalization of agriculture and WTO. Precision agriculture. Contract farming. Organic farming, marketing and export potential of organic products, certification, labeling and accreditation procedures. Crop residue management in multiple cropping systems. Latest developments in plant management, weed management, cropping systems, grassland management and allelopathy. GIS, GPS and remote sensing for crop management. Global warming. GM crops. Seed production technology. Seed certification, seed multiplication, hybrid seed production etc. Concepts of system agriculture, holistic approach of farming systems, dryland farming, sustainable agriculture and research methodology in Agronomy.

**Agron. 602 Advanced Crop Ecology**

**2+0 Sem.I**

Concept of crop ecology, agricultural systems and ecology of cropping systems. Principles of plant distribution and adaptation. Crop and world food supply. Ecosystem characteristics, types and functions, terrestrial ecology, flow of energy in ecosystem, ecosystem productivity and biomass. Succession and climax concept. Physiological response of crop plants to light, temperature, CO<sub>2</sub>, moisture and solar radiation; influence of climate on photosynthesis and productivity of crops. Effect of global climate change on crop production. Exploitation of solar energy in crops; vertical distribution of temperature; efficiency in crop production. Competition in crop plants. Environmental pollution, ecological basis of environmental management and environment manipulation through agronomic practices. Improvement of unproductive lands through crop selection and management.

**Agron. 603 Advanced Irrigation Management**

**2+0 Sem.II**

Water resources of India, irrigation projects, irrigation needs. Atmospheric, soil, agronomic, plant and water factors affecting irrigation need, water deficits and crop growth. Transpiration, evapo-transpiration, significance, energy utilization of transpiration, physiological processes and crop productivity. Infiltration, water movement under saturated and unsaturated conditions. Management practices for improving water use efficiency of crops. Application of irrigation water, conveyance and distribution system, irrigation efficiency. Agronomic considerations in the design and operation of irrigation projects. Characteristics of irrigation and farming systems affecting irrigation management. Strategies of using limited water supply. Factors affecting ET, control of ET by mulching and use of anti-transpirants. Fertilizer use in relation to irrigation. Land suitability for irrigation, land irrigability classification. Integrated water management, institution and farmer's participation in command areas and irrigation legislation.

**Agron. 604 Advanced Weed Management**

**2+0 Sem.II**

History of herbicide development and registration procedures. Crop-weed competition in different cropping situations. Changes in weed flora, various causes and effects. Physiological and biological aspects of herbicides, their absorption, translocation, metabolism and mode of action, selectivity of herbicides and factors affecting them. Classification, selectivity, chemical structures of different group of herbicides. Bioherbicides, biological agents and allelochemicals for weed control. Absorption, translocation, metabolism and mode of action of herbicides. Climatic factors and phytotoxicity of herbicides. Fate of herbicides in soil and plants and factors affecting them, residue management of herbicides and adjuvants. Advances in herbicide application techniques. Herbicide resistance and shift in weed flora. Antidotes and crop protection compatibility of herbicides of different groups with other pesticides. Development of transgenic herbicide resistant crops. Relationship of herbicides with tillage, fertilizer and irrigation. Hazards of herbicide use and environment pollution. Bioassay and analytical techniques for herbicide residue. bioherbicides, allelochemical herbicide bioassays.

**Agron. 605 Advanced Crop Growth and Productivity****2+0 Sem.I**

Physiological limitations to crop yield. Growth analysis- concept, indices, validity and limitations. Growth curves, sigmoid, polynomial and asymptotic. Root systems, root-shoot relationship. Principles involved. Concept and differentiation of inter and mixed cropping, criteria in assessing the yield advantages. Competitive relationship and competition functions, biological and agronomic basis of yield advantage. Physiological principles of dry land crop production, constraints and remedial measures. Heat unit concept of crop maturity, and its types. Concept of plant ideotypes, crop physiological and new ideotypes, characteristics of ideotype for wheat, rice, maize, etc. Concept and types of growth hormones, their role in crop production.

**Agron. 606 Integrated Farming Systems for Sustainable Agriculture****2+0 Sem. II**

Farming systems- concept, classification of farming systems according to type of rotation, intensity of rotation, degree of commercialization, water supply, enterprises. Concept of sustainability in farming systems, efficient farming systems, natural resources - identification and management. Production potential of different components of farming systems; interaction and mechanism of different production factors, stability in different systems through research. Eco-physiological approaches to intercropping. Simulation models for intercropping, soil nutrient in intercropping, preparation of different farming system models. Evaluation of different farming systems. New concepts and approaches of farming systems and cropping systems and organic farming, case studies on different farming systems. Role of organic matter in maintenance of soil fertility; crop residue management; fertilizer use efficiency and concept of fertilizer use in intensive cropping system for sustainable agriculture.

**Agron. 607 Stress Crop Production****2+0 Sem. I**

Stress and strain terminology, nature and stress injury and resistance, causes of stress. Low and high temperature stress- freezing, heat injury and resistance in plants, measurement of freezing tolerance, chilling injury and resistance in plants, practical ways to overcome the effect of low temperature stress through soil and crop manipulations. Water deficit stress and its effect on growth and development, water deficit injury and resistance, practical ways to overcome effect of water deficit stress through soil and crop, manipulations. Excess water and salt stress, its effects on crop plants and practical ways to overcome these through soil and crop manipulations. Mechanical impedance of soil and its impact on plant growth, measures to overcome soil mechanical impedance. Environmental pollution-air, soil and water pollution, and their effect on crop growth and quality of produce, ways and means to prevent environmental pollution.

**Agron. 591 Seminar****Agron. 600 Master's Research****Agron. 700 Ph.D. Research**



## ENTOMOLOGY

### PROGRAMMES

1. M.Sc.
2. Ph.D.

### COURSE REQUIREMENTS

#### M.Sc.

Field of Specialization	Economic Entomology, Insect Ecology, Insect Physiology, Insect Taxonomy, Insect Toxicology
Required Courses	Ent.501, Ent.502, Ent.503, Ent. 504, Ent.505
Supporting Courses	Stat. 421, PGS 501 and other courses from subject matter fields (other than minor) relating to area of special interest and research problem
Minor Fields	Biochemistry, Biotechnology, Chemistry, Nematology, Plant Breeding & Genetics, Plant Pathology or any other as approved by Dean, Postgraduate Studies
Deficiency Courses for students with the elective other than Crop Protection	As recommended by Student's Advisory Committee and approved by the Dean, Postgraduate Studies

#### Ph.D.

Field of Specialization	Economic Entomology, Insect Ecology, Insect Physiology, Insect Taxonomy, Insect Toxicology,
Required Courses	Ent. 601, Ent.602, Ent.603
Supporting Courses	Courses from subject matter fields (other than minor) relating to area of special interest and research problem.
Minor Fields	Biochemistry, Biotechnology, Chemistry, Nematology, Plant Breeding & Genetics, Plant Pathology, or any other as approved by Dean, Postgraduate Studies
Deficiency Courses for students with M.Sc. (Agri.) in a discipline other than Entomology	Ent.501, Ent.502, Ent.503, Ent.504, Ent.505, and other courses as recommended by student's Advisory Committee



## DESCRIPTION OF COURSE CONTENTS

### Diploma Courses

#### Ent. 51 Elementary Agricultural Entomology

2+1 Sem. I

Insects, their distinguishing characteristics. Insects' dominance. Importance of insects in Agriculture. General body structure. Growth and development. Feeding stages and adaptations. Pests – definitions. Population build-up and causes of outbreak. Principles and methods of insect-pests management. Integrated Pest Management. Important insect-pests of crops - cereals, cotton, sugarcane, oilseeds, pulses, fruit and vegetables, nature of damage and management. Stored grain insect-pests and safe storage of grains. Insecticides classification and formulations. Safe use of insecticides. Plant protection equipment.

Practical: Insect's body structure and anatomy. Modifications of appendages. Development stages. Identification of important insect-pests of crops - cereals, cotton, sugarcane, oilseeds, pulses, fruit and vegetables, and symptoms of attack. Storage insect-pests and symptoms of damage. Working of commonly used plant protection equipment, common troubles and remedies. Insecticidal formulations. Preparation of spray fluid. Grain storage structures. Seed treatment and fumigation.

#### Ent. 52 Useful Insects

2+1 Sem. II

Insects of commercial importance. Apiculture, sericulture and lac culture. Pollinators. Predators, parasitoids and scavengers. Insects as food; Medicinal and aesthetic value of insects.

Practical: Identification of honey bee species and castes. Colony examination. Bee hive and equipment. Bee flora. Seasonal bee management. Colony multiplication. Bee enemies - identification, nature of damage and management. Bee diseases – symptoms and management. Bee products. Identification of silk worm species. Sericulture equipment. Silk worms' rearing. Pests and diseases of silk worms. Lac insect and lac culture. Bee pollinators. Important parasitoids and predators – identification and rearing. Insects collection and display

### Undergraduate Courses

#### Ent. 201 Fundamentals of Entomology

3+1

Sem. I

Definitions - Insect, Entomology. History of Entomology in India. Factors for dominance of Class Insecta in animal kingdom. Classification of phylum Arthropoda upto classes with examples and importance. Body segmentation, Structure of head, thorax and abdomen. Morphology - structure and functions of insect cuticle and molting. Structure and modifications of insect mouth parts, antennae, legs. Wing venation, modifications and wing coupling apparatus. Structure of male and female genital organs. Metamorphosis and diapause in insects. Types of larvae and pupae. Structure and functions of digestive, circulatory, excretory, respiratory, nervous, endocrine and reproductive system in insects. Types of reproduction in insects. Major sensory organs - simple and compound eyes, chemoreceptors. Insect Ecology - Introduction, environment and its components. Effect of abiotic factors - temperature, moisture, humidity, rainfall, light, atmospheric pressure and air currents. Effect of biotic factors - inter-specific competition (food, space, predation and parasitism) and intra-specific (food and space) competition. Insecticides - classification, toxicity and formulations. Repellents, antifeedants, hormone analogues, attractants, gamma radiation. Taxonomy - importance, history and development and binomial nomenclature. Definitions - biotype, sub-species, species, genus, family and order. Classification of Class Insecta up to orders and suborders. Basic groups of present-day insects with special emphasis on orders and 48 families of agricultural importance.

Practical: Collection and preservation of insects including immature stages. Morphology and anatomy of Grasshopper/Blister beetle. Different types of antennae, mouthparts, legs and wings. Wings venation and wing coupling apparatus. Types of larvae and pupae. Study of characters of orders -

Odonata, Orthoptera, Dictyoptera, Isoptera, Thysanoptera, Hemiptera, Lepidoptera, Neuroptera, Coleoptera, Hymenoptera, Diptera and their families of agricultural importance.

**Ent.-Pl. Path. 202 Principles of Integrated Insect-pest and Disease Management 2+1 Sem. II**

Categories of insect pests and diseases. IPM - Introduction, history, importance, concepts, principles and tools. Economic importance of insect pests, diseases and pest risk analysis. Methods of detection and diagnosis of insect pests and diseases. Importance, calculation and dynamics of EIL and ETL. Methods of pest control - host plant resistance, cultural, mechanical, physical, legislative, biological and chemical control. Recent technologies for pest management. Pesticides and their misuse; first aid and antidotes. Insecticides Act 1968. Spray technology. Ecological management of crop environment. Survey, surveillance and forecasting of insect pests and diseases. Development and validation of IPM module. Implementation and impact of IPM. IPM modules for insect pests and diseases. Safety issues in pesticide uses. Political, social and legal implications of IPM. Case histories of important IPM programs.

Practical: Methods of diagnosis and detection of various insect pests and plant diseases. Sampling techniques for estimation of insect-pest and disease indices. Measurement of incidence of insect pests and diseases. Assessment of crop yield losses. Working out economics of IPM. Identification of biocontrol agents and natural enemies. Mass multiplication of *Beauveria bassiana*, *Bacillus thuringiensis*, *Trichoderma*, *Pseudomonas*, NPV and various parasitoids and predators. Pesticide appliances and their maintenance. Calculation of pesticide quantity for preparing spray material. Plan and assess preventive strategies (IPM module) and decision making. Monitoring of crop attacked by insect pests and diseases. Awareness campaign at farmers' fields.

**Ent.-Pl. Path. 203 Fundamentals of Crop Protection**

**2+1**

**Sem. I**

(For students of B. Tech. Biotechnology)

Insects- their general body structure and modifications. Importance of insects in agriculture. Insect metamorphosis and development stages. Insect diversity. Feeding stages of insects and kinds (modifications) of mouth parts. Concepts in population build-up of insects – GEP, DB, EIL, ETH and pest status. Categories of insect-pests. Causes of insect-pests outbreak. General symptoms of insect attack. Principles and methods of insect-pests management. Integrated Pest Management concept. Bioecology and management of important pests of major crops and storage products. Importance and scope of plant pathology. Concept of disease in plants. Nature and classification of plant diseases. Importance and general characters of fungi, bacteria, fastidious bacteria, nematodes, phytoplasmas, spiro-plasmas, viruses, viroids, algae, protozoa and phanerogamic parasites. Pathogenesis due to obligate and facultative parasites. Variability in plant pathogens. Conditions necessary for development of disease epidemics. Survival and dispersal of plant pathogens. Management of key diseases and nematodes of major crops.

Practical: Familiarization with generalized insect's body structure and appendages. Life stages. Acquaintance with insect diversity. Identification of important insect-pests of cereals, cotton, oilseeds, pulses, sugarcane, fruit and vegetables crops and stored-grains, and their symptoms of damage. Acquaintance with useful insects: predators, parasitoids, pollinators, honey bees and silk worms. Acquaintance to plant pathology laboratory equipment. Preparation of culture media for fungi and bacteria. Demonstration of Koch's postulates. Study of different groups of fungicides and antibiotics and methods of their evaluation. Diagnosis and identification of important diseases of cereals, cotton, oilseeds, pulses, sugarcane, fruit and vegetables crops and their characteristic symptoms. Acquaintance with various pesticidal formulations. Principles and working of common plant protection appliances. Calculation for preparing spray material.

**Ent. 301 Pests of Crops and Stored Grains and their Management**

**2+1**

**Sem. I**

Scientific name, order, family, host range, distribution, biology, ecology, nature of damage and management of major arthropod pests of various field, vegetable, fruit, plantation and ornamental crops, and spices and condiments. Stored grain losses -role of physical, biological, mechanical and chemical factors. Insects, mites, rodents, birds and microorganisms associated with stored grains and their management. Principles of grain store management. Storage structures and methods of grain storage. Warehousing Development and Regulatory Authority; Warehousing (Development and Regulation) Act.

Practical: Identification of life stages and damage symptoms, Study of seasonal history of insect pests of field crops, vegetable crops, fruit crops, ornamental crops, spices and condiments. Identification of insect- pests and mites associated with stored grains and their damage symptoms. Determination of insect infestation by different methods. Assessment of losses due to insects. Calculations of insecticide doses. Fumigation of grain store/godown. Identification of rodents and their control in godowns. Birds identification and their management. Grain moisture measurement. Grain sampling methods under storage conditions. Visit to godowns of Food Corporation of India and Central/ State Warehousing Corporation. Visit to field station of Indian Grain Storage Management and Research Institute (IGMRI).

**Ent. 302 Management of Beneficial Insects**

**2+1**

**Sem. II**

Importance of beneficial insects. Beekeeping and its characteristic features. Bee species, castes and biology. Hive and apicultural equipment. Starting beekeeping. Bee pasturage. Seasonal management. Bee foraging and communication. Pests and diseases of honey bees and their management. Hive products and their production. Role of honey bees in crop pollination. Silkworm species, voltinism and biology. Rearing appliances of mulberry silkworm. Mulberry cultivation. Methods of harvesting and preservation of mulberry leaves. Silkworm rearing. Mounting and harvesting of cocoons. Pests and diseases of silkworms and their management. Lac insect – species, morphology, biology and host plants. Lac production – brood lac, stick lac, seed lac, button lac, shellac, lac-products. Important insect pollinators, weed killers and scavengers and their significance.

Practical: Identification of honey bee species and their combs. Identification of immature and mature stages of various castes of honey bees. Brood and food distribution in honey bee colony. Hive and beekeeping appliances. Examination of honey bee colonies. Seasonal management of honey bee colonies. Identification of bee enemies and diseases and their management. Bee pasturage, foraging and communication. Honey extraction, processing and packaging. Collection of other hive products. Identification of silkworm species. Biology of silkworm. Silkworm rearing appliances. Methods of harvesting and preservation of mulberry leaves. Biology and host plants of lac insect. Identification of important pollinators, weed killers and scavengers. Visit to research and training institutions devoted to beekeeping, sericulture and lac culture.

**Ent. 491 Agro-industrial Attachment**

**0+4**

**Sem. I**

(i) Commercial Honey Production, Hive and Apicultural Equipment and Honey Processing Manufacturing Units; Honey Trading, Processing, Packaging, Exporting and Marketing Units.

**Ent. 492 Experiential Learning in Commercial Apiculture**

**0+20**

**Sem. II**

**Ent-PI.Path. 491 Agro-Industrial Attachment**

**0+4**

**Sem I**

- i. Pesticide and Biopesticide Industries
- ii. Biocontrol Agents Production Units
- iii. Plant Quarantine Station
- iv. Virus free Potato Tuber Production Units

**Ent-PI.Path.492:Experiential Learning in Production Technology for Bioagents 0+20 Sem II**

## Postgraduate Courses

### Ent. 501 Insect Morphology and Systematics

2+1 Sem.I

Evolution of insect body form. Primary and secondary segmentation, structure of typical secondary segment. Different theories regarding segmentation of insect head. Comparative morphological characteristics of insects and their bearing in insect classification. Insect sense organs. Mechanism of flight. Insect Systematics - history and importance. Taxonomic categories. Taxonomic keys. Important rules of Zoological nomenclature. Ethics in taxonomy. Zoogeographical regions of world.

Practical: Comparative study of morphological characteristics of representative type of insects. Collection and preservation of insects and their identification with the help of taxonomic keys. Preparation of taxonomic keys.

### Ent. 502 Insect Anatomy and Physiology

2+1 Sem.I

Importance and scope of insect anatomy and physiology. Structure and physiology of insect integument. Comparative study of anatomy and physiology of digestive, circulatory, respiratory, excretory, reproductive, nervous, sensory, endocrine and exocrine systems. Embryonic and post-embryonic developments. Diapause. Insect nutrition, inter- and intracellular micro organisms. Artificial diets.

Practical: Study of comparative anatomy of various organ systems of insects through dissection and preparation of mounts of internal organs. Experiments to highlight physiological significance of cuticle, digestive, circulatory, respiratory, excretory, endocrine and exocrine systems. Formulation and preparation of artificial diets for rearing of insects.

### Ent. 503 Classification of Insects

2+1 Sem. I

History of insect classification and its importance. Introduction to phylogeny of insects. Classification of Superclass Hexapoda including all the classes with special emphasis on Class Insecta. Distinguishing morphological characters alongwith the habits and habitats of insects belonging to economically important families of all the orders of Class Insecta.

Practical: Collection and preservation of insects. Identification of insects upto family level. Field visits to collect insects of different orders.

### Ent. 504 Insect Ecology

2+1 Sem.II

Basic concepts of ecology. Organization levels. Ecosystem concept. Food chain. Characteristics of insect populations. Physical environment, its influence on abundance, distribution, rate of increase and diapause in insects. Concept of intrinsic rate of increase. Biotic factors, intraspecific competition, logistic theory. Interspecific relationships, prey/predator models, effect of food and space on insects. Natural balance, population dynamics and regulation. Defense mechanisms against predators/parasitoids. Estimation of dispersal, migration and mortality factors. Life-tables and their application. Systems approach to ecology. Abundance and diversity of insects, its causes and estimates. Pest outbreaks and forecasting. Sampling considerations for population estimates of insects in different habitats. Pest management as applied ecology.

Practical: Measurement of microenvironment- maintenance of physical factors, calculation of rate of increase ( $r_m$ ), stable age distribution and fitting of logistic curve for population growth. Determination of distribution pattern, and size and number of samples. Estimation of population of different groups of insect pests. Measurement of insect diversity. Life-tables for determining mortality factors.

### Ent. 505 Toxicology of Insecticides

2+1 Sem. II

Definition, importance, scope, basic principle of insecticide toxicology and its relationship with other disciplines. Structure and mode of action of organochlorines, organophosphates, carbamates, pyrethroids,

neonicotinoids, oxadiazines, phenylpyrozoles, botanicals and new promising compounds etc. Criteria, methods, problems and solutions of bioassay. Evaluation of insecticide toxicity, joint action of insecticides, synergism, potentiation and antagonism, factors affecting toxicity of insecticides, selectivity and phytotoxicity. Insecticide metabolism, pest resistance to insecticides, mechanisms and types of resistance, insecticide resistance management and pest resurgence. Insecticide residues, their significance and environmental implications. Insecticide Act, registration and quality control of insecticides, safe use of insecticides, diagnosis and treatment of insecticide poisoning.

Practical: Insecticide formulation and mixtures, quality control of pesticide formulations. Working out doses and concentrations of pesticides for laboratory and field evaluation for their bioefficacy, bioassay techniques, probit analysis, evaluation of insecticide toxicity and joint action. Toxicity to beneficial insects. Preparation of working standard solutions of pesticides, Sampling, extraction, clean-up and estimation of insecticide residues by various methods, calculations and interpretation of data, visit to toxicology laboratories, good laboratory practices.

#### **Ent. 506 Biological Control of Insect Pests**

**2+1 Sem. I**

Principles and scope of biological control. Techniques in biological control. Biology and host seeking behaviour of predatory and parasitic groups of insects. Role of insect pathogens and their mode of action. Biological control of weeds using insects. Techniques for mass production of quality biocontrol agents. Various formulations and economics of bioagents. Field application and evaluation. Analysis of successful biological control projects. Trends and future possibilities of biological control. Importation of natural enemies and quarantine regulations. Biotechnology in biological control. Semiochemicals in biological control

Practical: Identification of common natural enemies of crop pests and weed killers. Techniques for rearing of natural enemies. Visits (only where logistically feasible) to bio-control laboratories to learn rearing and mass production of natural enemies of crop pests and weeds and their laboratory hosts. Field collection of parasitoids and predators. Hands-on training in culturing and identification of common insect pathogens. Quality control and registration standards for biocontrol agents.

#### **Ent. 507 Plant Resistance to Insects**

**2+1 Sem. II**

History and importance of host plant resistance. Principles, classification, components, types and mechanisms of resistance. Insect-host plant relationships. Theories and bases of host-plant selection. Chemical ecology. Tritrophic relations. Volatiles and secondary plant substances. Basis of resistance. Factors affecting plant resistance including biotypes and measures to combat them. Screening techniques. Breeding for insect resistance in crop plants. Exploitation of wild plant species and gene transfer. Successful examples of resistant crop varieties in India and world. Role of biotechnology in plant resistance to insects.

Practical: Screening techniques for measuring resistance. Measurement of plant characters and working out their correlations with plant resistance. Testing of resistance in important crops. Demonstration of antibiosis, tolerance and antixenosis.

#### **Ent. 508 Integrated Pest Management**

**2+1 Sem. I**

History and origin. Definition and evolution of various related terminologies. Concept and philosophy of IPM. Ecological principles. Determination of crop losses and economic thresholds. Integration of different pest management methods. Pest survey and surveillance, forecasting, types of surveys including remote sensing methods, factors affecting surveys. Political, social and legal implications of IPM. Pest risk analysis, pesticide risk analysis and cost-benefit ratios. Case studies of successful IPM programmes. National and international set-ups for integrated pest management.

Practical: Characterization of agro-ecosystems. Sampling methods and factors affecting sampling. Population estimation methods. Crop loss assessments, potential losses, avoidable losses, unavoidable losses. Computation of EIL and ETL. Crop modelling, designing and implementing IPM system.

**Ent. 509/PI.Path.509/Nem. 509 Molecular Approaches in Plant Protection 2+1 Sem.II**

Recent concepts of molecular biology and techniques used in plant protection. Genes of interest in plant protection. Identification, characterization and isolation of novel genes involved in pest resistance. Molecular bases of host plant-insect and pathogen interactions. PR-proteins and G-proteins. Molecular characterization of biodiversity-insects and pathogens. Molecular biology of baculoviruses. Molecular mechanisms of genetically engineered plants for pest resistance and pesticide resistance. Improvement of biocontrol agents and useful insects using molecular techniques. Bio-safety related issues.

Practical: Molecular characterization of pest populations. Detection of biotypes/races. Establishment of phylogenetic relationships/dendrograms. Detection of Cry-gene and estimation of cry-toxin; characterization of capsid proteins of insect viruses. Detection of disease induced biochemical changes at molecular level.

**Ent.510/PI.Path.510/ Nem. 510 Quarantine in Plant Protection 2+0 Sem.II**

Definition of pest and pesticides and transgenics as per Govt. notification. Relative importance and quarantine for domestic and international. Quarantine restrictions in the movement of agricultural produce including seeds and planting material. Case histories of exotic pests and diseases and their status. Plant protection organization in India. Acts related to registration of pesticides and transgenics. History of quarantine legislations. PQ Order 2003. Environmental Acts and APEDA. Industrial registration. Import and Export of bio-control agents. Special requirements for biopesticide registration. Identification of pest and disease free areas. Contamination of food with toxigens of micro-organisms and their elimination. Symptomatic diagnosis and other techniques to detect pest/pathogen infestations. Vapor Heat Treatment (VHT) and other safer techniques of disinfection and salvaging of infected material. WTO regulations. Non-tariff barriers. Pest risk analysis and good laboratory practices for pesticide laboratories. Pesticide industry. Sanitary and phytosanitary measures.



**Ent. 511 Insect Vectors of Plant Pathogens**  
**Sem.II**

**2+1**

History of developments in the area of insects as vectors of plant pathogens. Important insect vectors and their characteristics. Mouth parts and feeding processes of important insect vectors. Efficiency of transmission. Transmission of plant viruses and fungal pathogens. Relation between viruses and their vectors. Transmission of plant viruses by insect vectors and mites. Transmission of mycoplasma and bacteria by leaf hoppers and plant hoppers. Epidemiology and management of insect transmitted diseases through vector management. Paratransgenesis.

Practical : Identification of common vectors of plant pathogens- culturing and handling of vectors. Demonstration of virus transmission through vectors. Vector virus relationship studies.

**Ent. 512 Commercial Entomology**

**2+1 Sem.II**

Development of apiculture. Classification of bees and distribution of genus Apis. Morphological adaptations. Behaviour and activities of honey bees. Honey bee nutrition. Artificial queen bee rearing and bee breeding. Sex and caste determination. Honey bee ecology. Bee pheromones. Pests and diseases of honey bees. Bee poisoning. Hive products. Planned crop pollination using bees. Silkworm species and their characteristics. Moriculture. Silk seed production. Rearing and management of silkworms. Pests and diseases of silkworms. Silk and its uses. Lac insect's management. Economic importance of insect-pests of human health and habitation. Biology, damage and management strategies for mosquitoes, house flies, bed bugs, ants, termites, cockroaches and wasps.

Practical: Morphological adaptations in different castes of honey bees. Recording of colony data. Selection and breeding of honey bees. Latest techniques in mass queen bee rearing. Artificial diets and feeding. Production and extraction of hive products. Preparation of beekeeping projects. Recording pollination behaviour and determining pollination requirements. Identification of different species of silkworms. Silkworm rearing equipment. Silkworm rearing and management. Diseases of silkworms. Lac insect and host management. Lac collection and processing. Management of insect-pests of public health importance and human dwellings.

**Ent. 513 Storage Entomology**

**2+1 Sem. II**

Introduction, history and concepts of storage entomology. Post-harvest losses. Factors responsible for grain losses. Important pests namely insects, mites, rodents, birds and micro-organisms associated with stored grains and agricultural products. Association of stored grain insects with fungi and mites, their systematic position, identification, distribution, host range, biology, nature and extent of damage. Sources of infestation. Type of losses in stored grains and their effect on quality including biochemical changes. Ecology of insect pests of stored commodities. Stored grain deterioration process. Type of storage structures. Ideal storage conditions. Management of rodent and bird pests. Preventive and curative measures for the management of insect pests of stored grains. Characteristics of pesticides, their use and precautions in their handling with special emphasis on fumigants. Integrated approaches to stored grain pest management.

Practical: Collection and identification of stored grains insect pests and their nature of damage. Detection of insect infestation in stored food grains and estimation of stored losses. Determination of micro flora of grains. Determination of grain moisture. Familiarization of storage structures. Laboratory culturing of stored grain pests. Demonstration of preventive and curative measures including fumigation techniques. Field visits to grain markets, central and FCI warehouses, IGSMRI and commercial silos.

**Ent. 514 General Acarology**

**1+1 Sem.II**

History of acarology. Importance of mites and ticks as a group. Introduction to morphology and biology of mites and ticks. Broad classification of major orders and important families of Acari including diagnostic characteristics. Economic importance of mites. Seasonal occurrence and nature of damage of mite

pests on different crops. Mite pests in polyhouses, stored products and honey bees. Management of mites using acaricides and natural enemies. Culturing of phytophagous, predatory and parasitic mites. Practical: Collection and extraction of mites from different habitats. Preparation of mounting media and slide mounts. External morphology of mites. Identification of mites up to family level using keys. Studying different rearing techniques for mites.

**Ent. 601 Advanced Insect Systematics**

**2+0 Sem.II**

Study of International Code of Zoological Nomenclature in detail. Phylogenetics and Classification. Development of cladograms. Molecular approaches for the classification of organisms. Homology. Species concepts and speciation processes and evidences. Zoogeography. Study of different views on the evolution of insects. Fossil insects and evolution of insect diversity over geological times. Concept of Phylocode and alternative naming systems for animals. Molecular Taxonomy. Barcoding species. Websites related to insect taxonomy and databases.

**Ent. 602 Advanced Insect Physiology**

**2+0 Sem.II**

Physiology and biochemistry of insect cuticle and moulting process. Advances in physiology of digestive, circulatory, respiratory, excretory, reproductive, nervous and sensory organ systems of insects. Source, chemistry and physiology of insect hormones as regards their growth and development. Biosynthesis of chitin and physiology of chitin synthesis inhibitors. Biochemistry and mode of action of behaviour modifying compounds. Nutrients and their physiological influences in insects. Defence mechanisms in plants against insects.

**Ent. 603 Advanced Insect Pest Management**

**2+0 Sem.II**

Database management and computer programming, simulation techniques and system analysis and modelling. Case histories of national and international programmes, their implementation, adoption and criticisms, global trade and risk of invasive pests. Advances in application of behavior modifying chemicals, insect growth regulators, genetic engineering and other biotechnological strategies for management of insect pests. Strategies for pesticide resistance management and resurgence in insects. Scope and limitations of bio-intensive and ecological based IPM programmes. Applications of IPM to farmers' real time situations. Dynamism of IPM under changing cropping systems and climate; insect pest management under protected cultivation. Advances in pesticide application technology.

**Ent. 604 Advanced Insect Ecology**

**2+0 Sem. I**

Influence of changing environment and pest populations. Life-system approach to the study of insect populations, case studies. Key factors in population dynamics and their manipulation. Numerical changes in insect population, causes and estimation. Modes of insect-plant interactions, tritrophic interactions. Evolution of diversity, diversity indices, biodiversity and conservation. Foraging ecology. Reproductive ecology. Disruption of diversity and stability of insect species due to pesticide application. Predictive models and forecasting of pest outbreaks. Systems ecology, modelling. Sequential sampling. Characteristics of distribution of insects- indices of dispersion, Taylor's power law. Ecological aspects of pest management.

**Ent.605 Advanced Biological Control**

**2+0 Sem.II**

(Pre-requisite Ent.506)

Effect of abiotic and biotic factors on natural enemies of crop pests. Nutrition of entomophagous insects and their hosts. Dynamics of biocontrol agents vis-à-vis target pest populations. Insectary facilities and equipments. Basic standards of insectary and viable mass-production unit. Colonization of natural enemies. Techniques for release of natural enemies and their recovery. Evaluation of effectiveness of natural enemies. Importance of biotypes in biological control. Survivorship analysis and ecological manipulations. Modification of chemical control practices to preserve natural enemies. Scope of genetically engineered microbes

and parasitoids in biological control. Genetics of ideal traits in biocontrol agents for introgressing and for progeny selections. Breeding techniques of biocontrol agents

**Ent. 606 Advanced Insecticide Toxicology**

**2+1**

**Sem. I**

Penetration, binding and distribution of insecticides in insect systems, insecticide selectivity, biochemical and physiological basis of selectivity, toxicodynamics of insecticides. Biochemical and physiological target sites of insecticides in insects, developments in biorationals, biopesticides and newer molecules, their modes of action and structural - activity relationships, metabolism of insecticides. Joint action of insecticides, activation, synergism and potentiation. Pesticide resistance- mechanisms and resistant management strategies. Contribution of genetics to resistance, monogenic and polygenic resistance. Bound and conjugated residues, persistence and pollution, health hazards and other side effects of insecticides. Analysis of insecticidal residues - sampling, extraction, clean-up and estimation by various methods, maximum residue limits (MRLs) and their fixation. Insecticide laws and standards.

Practical: Sampling, extraction, clean-up and estimation of insecticide residues by various methods, calculations and interpretation of data, biochemical and biological techniques for detection on insecticides resistance in insects.

**Ent. 607 Advanced Host Plant Resistance**

**2+0**

**Sem.II**

(Pre-requisite Ent.507)

Insect herbivory and plant defense. Genes for plant defense against herbivory. Factors affecting expression of genes. Constitutive and inductive resistance. Biochemistry of induction of resistance. Biotechnological approaches in host plant resistance- genetic manipulations and incorporation of resistant gene(s) in crop varieties. Genetics of host plant resistance. Inheritance of resistance and its estimation Techniques and determination of categories of plant resistance. Breakdown of resistance in crop varieties.

**Ent. 608 Insect Behaviour**

**2+0**

**Sem. II**

Evolution and inheritance of insect behaviour. Innate and learned behaviour patterns. Orientation - forms of primary and secondary orientation including taxes and kinesis. Responses to environmental stimuli; role of visual, olfactory and auditory signals. Biological functions of insect behaviour such as locomotion, feeding, host selection and location, escape, defense, reproduction, dispersal and migration. Activity rhythms and biological clocks. Genetic and hormonal control of insect behaviour. Regulation of insect population through behavioural manipulations. Inter- and intra-specific communication. Insect societies. Nest founding and construction, brood care, defense and caste determination in social insects.

**Ent.591 Seminar**

**Ent. 600 Master's Research**

**Ent.700 Ph.D. Research**

## EXTENSION EDUCATION

### PROGRAMMES

1. M.Sc.
2. Ph.D.

### COURSE REQUIREMENTS

#### M.Sc.

Field of Specialization	Communication and Adoption of Innovations, Farmers' Training and Education, Extension Administration.
Required Courses:	Ext.501, Ext.502, Ext.503, Ext.504, Ext.505, Ext.506
Supporting Courses:	Stat.421, Stat.522, PGS 501 and other courses from subject-matter fields (other than minor) relating to area of special interest and research problem.
Minor Fields:	Any agricultural subject depending upon the student's interest and researchproblem.
Deficiency courses for students with elective other than Agri-Business Management, Economics and Extension Education	As recommended by the Student's Advisory Committee and approved by the Dean, Postgraduate Studies

#### Ph.D.

Field of Specialization	Communication and Adoption of Innovations, Farmers' Training and Education, Extension Administration.
Required Courses	Ext.601, Ext.602, Ext.603
Supporting Courses	Stat.526 and other courses from subject matter fields (other than minor) relating to area of special interest and research problem.
Minor Fields	Any agricultural subject depending upon the student's interest and researchproblem.
Deficiency courses for students with M.Sc. (Agri.) in a discipline other than Extension Education	Ext.501, Ext.502, Ext.503, Ext.504, Ext.505, Ext.506, Stat.522 and other courses as recommended by Student's Advisory Committee..

## DESCRIPTION OF COURSE CONTENTS

### Diploma Courses

#### Ext. 51 Elementary Extension Education

2+2

Sem. II

Meaning and principles of Extension Education. Elements of communication process. Classification, selection and use of extension teaching methods. Audio visual aids. Principles and procedure of extension programme planning and evaluation. Qualities and abilities of good extension worker, Interpersonal perception and social behavior. Group - meaning, type and functioning.

Practical: Conducting individual contact. Method demonstration. Group meeting and campaign. Skill in preparation and use of graphic aids. Speaking to group and mass. Visits to agro-based industries and agricultural development organizations of Punjab.

### Undergraduate Courses

#### Ext. 101 Agricultural Heritage

1+0

Sem. I

Introduction of Indian agricultural heritage, status of farmers in society; advice by sages to kings on their duties towards farmers, soil management in ancient, medieval & pre-modern India and its relevance in modern day sustainable agriculture, heritage of crop & water management, plant growth and development & plant protection through vrikshayurveda and traditional knowledge. Heritage of medicinal plants and their relevance today, seed health in ancient & medieval history and its relevance to present day agriculture, description of Indian civilization and agriculture by travellers from China, Europe and United States, our journey in agriculture, green revolution and its impact and concerns, vision for the future.

#### Ext. 201 Fundamentals of Agricultural Extension Education

2+1

Sem. I

Education - definition and types. Extension Education - definition, scope, process, objectives and principles. Extension programme planning - meaning, process, principles and steps. Extension systems in India - extension efforts in pre-independence (Sriniketan, Marthandam, Firka Development Scheme, Gurgaon Experiment) and post-independence era (Etawah Pilot Project, Nilokheri Experiment). Various extension/ agricultural development programmes of ICAR and Govt. of India (IADP, IAAP, HYVP, KVK, IVLP, ORP, ND, NATP, NAIP). New trends in agricultural extension - privatization of extension, cyber extension/ e-extension, market-led extension, farmer-led extension, expert systems. Rural development - concept and programmes. Community development - concept, definition, principles and philosophy. Rural leadership - concept and definition, types of leaders in rural context. Extension administration – meaning, concept, principles, functions. Monitoring and evaluation of extension programmes. Transfer of technology - concept, models and capacity building of extension personnel. Extension teaching methods - meaning, classification, individual, group and mass contact methods, ICT applications in TOT (new and social media), media mix strategies. Communication - definition, principles and functions, models and barriers. Agricultural journalism. Diffusion and adoption of innovation – concept, meaning, process and stages of adoption, adopter categories.

Practical: Acquaintance with university extension system. Group discussion exercise. Handling and use of audio-visual equipment - digital camera and LCD projector. Preparation and use of AV aids. Preparation of extension literature - leaflet, booklet, folder, pamphlet, news stories and success stories. Presentation skills and microteaching exercises. Visit to village to understand the problems of villagers/farmers. Understanding PRA techniques and their application in village development planning. Study of organization and functioning of DRDA and other development departments at district level. Visit to NGOs and learning from their experience in rural development. Exposure to mass media - visit to community radio and television studio for understanding the process of programme

production. Script writing, writing for print and electronic media, developing script for radio and television.

<b>RAWE 401 (General Orientation and On-campus training)</b>	<b>0+1</b>	<b>Sem I</b>
<b>RAWE 402 (Village Attachment)</b>	<b>0+8</b>	<b>Sem I</b>
<b>RAWE 403 (KVK and Research Station Attachment)</b>	<b>0+5</b>	<b>Sem I</b>
<b>RAWE 404 (Plant Clinic)</b>	<b>0+2</b>	<b>Sem I</b>

### **Postgraduate Courses**

**Ext. 501 Development Perspectives of Extension Education** **1+1 Sem.I**

Objectives, principles and philosophy of extension education. Adult education and distance education. Pioneering extension efforts and their implications in Indian agricultural extension system. Analysis of extension systems of ICAR, SAU, State departments and non-government organizations. Poverty alleviation, employment generation and women development programmes. Problems in rural development. Decentralised decision making, bottom-up planning. Farming system approach. Farming situation based extension. Market led extension. Farm field school. Agricultural Technology Information Centre. Kisan Call Centres, National Agricultural Innovation Project.

Practical: Studying on-going rural development programmes. Visits to KVK, NGO and extension centers of State Agricultural University and state development departments to study their objectives, organizational set up and activities. Report preparation and presentation.

**Ext. 502/HECM 502 Development Communication and Information Management** **2+1 Sem.II**

Communication-concept, meaning, importance, models, theories and types. Communication delity, credibility, empathy, feedback and factors affecting communication process. Communication skills. Characteristics and role of key communicators in development. Expert system in selected enterprises. Role of ICT in communication. Social networks and development. Effective oral communication, public speaking, non-verbal communication, writing skills and soft skills. Participative communication-meaning, importance, process and determinants. Development communication-concept, nature and significance. Recent advances in communication- print and electronic, internet, e-mail, fax, mobile, interactive video and teleconferencing, computer and computer networking (PAN, LAN, CAN, MAN, WAN), AGRINET, e- Governance.

Practical: Exercises in oral and written communication. Planning and use of different communication approaches. Practical hands on experience in recent advances in print and electronic media.

**Ext.503/HECM 503 Participatory Programme Management** **1+1 Sem.II**

Conceptual framework of extension programme. Planning - key concepts and importance in planned change. Participatory planning - concept, importance, process. Techniques of participatory planning- RRA, PRA and PLA and their application in extension. Approaches of participatory planning - cooperative, democratic, bottom up and down. Project management techniques - PERT, CPM, SWOT analysis, obtaining technical and monetary support from GOs and NGOs. Importance and ways of people's participation in programme planning. Concept and formation of farmers and women SHGs. Implementation and evaluation - concept, importance and techniques.

Practical: Application of PRA methods. Critical review of evaluation studies related with farmers, women and rural development programmes. Critical analysis of monitoring and evaluation of developmental programmes. Preparation and implementation of home improvement / agriculture development work plans. Critical evaluation of work plans with specific evaluation techniques. Organizing and evaluating programmes related to farmers, women and children at village level.

**Ext. 504 Diffusion and Adoption of Innovations**

**1+1 Sem.I**

Concept and elements of diffusion, innovation generation and development process in application of research. Concept and stages of adoption and innovation-decision process. Innovativeness, adopter categories and their characteristics. Attributes of an innovation and factors influencing the rate of adoption. Concept of over adoption. Role of change agents in diffusion and adoption. Meaning, characteristics and types of opinion leaders. Multi-step flow of innovation. Concepts of homophily, heterophily and their influence on flow of innovations. Types and consequences of innovation-decisions. Meaning, theories, process, steps and factors influencing decision making.

Practical: Case studies in individual and community adoption process. Content analysis of adoption studies. Identification of adopter categories of a selected technology. Studying attributes of current farm technologies. Identification of opinion leaders. Sources of information at different stages of adoption. Studying factors affecting rate of adoption. Presentation of reports on adoption and diffusion of innovations.

**Ext.505/Econ.506/Soc.506/HECM 501 Research Methodology for Social Sciences 2+1 Sem.I**

Importance and scope of research in social sciences. Concept and characteristics of social research. Types of research. Fundamental vs Applied. Concept of researchable problem - research prioritization, research process. Hypothesis-meaning, characteristics, types and testing. Review of literature. Development of theoretical orientation of the research problem. Concept, construct, variables and their measurement. Sampling design, sampling error and methods of sampling. Research design and techniques. Types of data collection tools and testing their reliability and validity. Scaling techniques. Coding, editing, tabulation and validation of data. Tools of data analysis. Statistical package for social sciences, interpretation of results, writing research report / thesis. Writing of articles. Universal procedures for preparation of bibliography.

Practical: Selection and formulation of research problem, objectives and hypothesis. Selection of variables and their operationalisation. Developing conceptual framework of research. Development of data collection tools and measuring their validity and reliability. Data processing, tabulation and analysis. Formulation of secondary tables. Writing of thesis and research articles. Presentation of reports.

**Ext. 506 Human Resource Development**

**2+1 Sem.II**

Importance and scope of human resource development (HRD). Inter disciplinary approach, functions, systems and case studies in HRD. Different experiences of HRD interventions. Social and organizational culture. Organizational and managerial values and ethics. Motivation and productivity. Collective bargaining and negotiation skills for human resource management. Information management and measurement. Inter and intra personal processes. Stress and coping mechanisms. Organizational communication. Team building process. Human resource development and supervision. Tasks and responsibilities of a professional manager. Skills required for extension workers. Decision making, management by objectives, behavioural dynamics, leadership styles, group dynamics. Types, models, methods and evaluation of training. Determining training needs and development strategies. Facilities for trainers training and techniques for trainees participation. Research studies in training extension personnel. Main issues and emerging trends in human resource development, culture and climate.

Practical: Visits to different training organizations to review their on going activities and facilities. Analysis of training methods used for imparting training to farmers and extension personnel. Evaluation of a training programme. Studying human resource development in an organization in terms of performance, organizational development, employee's welfare and improving quality of work life and human resource information.

**Ext.507 Entrepreneurship Development and Management in Extension** **2+1 Sem.II**

Agri-entrepreneurship. Traits and types of entrepreneurs. Establishing an enterprise, project management and appraisal. Profitable micro agri-enterprises in India. Agro processing, Khadi and Village Industries Commission. Sources of micro finance. Marketing for enterprises. Gender issues in entrepreneurship development. Nature, importance, approaches and levels of management. Extension management. Making planning effective. Decision-making process. Principles and elements of an organization. Interpersonal relations in the organization. Training and development. Methods of performance appraisal. Functions and approaches to leadership. Leadership styles. Organizational communication. Work motivation and performance. Approaches to motivation. Qualities, functions and essentials of effective supervision. Nature, process, types and techniques of managerial control, budgeting, observation, PERT, CPM and MIS.

Practical: Field visits to successful enterprises, financial institutions and extension organizations. Studying characteristics of successful entrepreneurs. Development of project proposal. Case studies of successful/failed enterprises. Exercises on market survey. Simulated exercises to understand management process. Techniques of decision making and designing organizational structure. Group activity on leadership development skills. Development of short and long term plans.

**Ext.508 Perspectives of Distance Education** **2+0 Sem.I**

Concept, evolution, philosophy, work ethics and characteristics of distance education. Theory, methodology, epistemology, dimensions, scope and problems of distance education. Scope of non-formal, continuing and correspondence education. Forms and systems of distance and open education. Methods and modes of teaching and learning in distance education. Systems approach, course planning, target groups and barriers to learning in distance education. Planning and management of network learning. Application of information and educational technologies in distance education. Development of course, course material and management of resources. Video classroom strategy in distance education. Strategies for maximizing services to students and programme evaluation.

**Ext. 509 Market Led Extension Management** **1+1 Sem.II**

(In collaboration with Deptt. of Economics and Sociology, COBSc.&H)

Present scenario of agricultural extension at the national level. Emerging perspectives, challenges and dimensions of market led extension. An overview of agricultural marketing. Consumer behaviour, marketing communication and promotional strategies. Marketing research process. Agricultural trade liberalization and its impact. International marketing opportunities. Implications of Agreement on Agriculture, TRIPS and Intellectual Property Rights. Role of self help groups and public private linkages in market led extension. Information technology enabled approaches for market led extension and communication.

Practical: Identification and analysis of different marketing sources for agricultural commodities. Developing strategy for an effective market intelligence system and marketing plan to suit rural situation. Visits to APEDA and Apni Mandi to study their processes and procedures related to market-led extension.

**Ext. 510 Visual Communication** **1+1 Sem.I**

Role, characteristics and functions of visuals and graphics in communication. Theories of visual perception. Classification and selection of visuals. Designing message for visuals, graphic formats and devices. Presentation of scientific data. Principles and production of low cost visuals. Photographs, reprographic



and computer based visuals. Digitized video material in multimedia production. Designing visuals for print, TV and video. Scanning, pre-testing and evaluation of visuals.

Practical: Preparation of low cost projected and non-projected visuals. Designing and layout of charts, posters, flash cards, power point presentations. Generating computer aided presentation graphics. Scanning and evaluation of visuals.

**Ext.511 / HECM 506 Gender Sensitization for Empowerment** **2+0 Sem.I**

Gender sensitization-meaning, need and importance of empowering women. Gender in community diversity and its implication for empowerment. Gender perspectives in development of women, social characteristics, desegregated roles, responsibilities, resources, constraints and opportunities. Economical, educational and anthropological parameters in gender perspectives. Gender dimensions and methodologies for empowerment. Gender analysis framework-context, activities, resources, tools and programme action profile. Training aids for gender sensitization. Empowerment through gender specific technologies, household technology interface. Socio-cultural interface and women as consumer of technologies. Gender issues and development-health and nutrition, violence, governance, educational media.

**Ext. 601 Advances in Agricultural Extension** **2+0 Sem.II**

A critical analysis of different agricultural extension approaches. Importance, relevance, identification and documentation of indigenous knowledge system and its integration in research formulation. Concept of agricultural knowledge and information system and training of stakeholders. Concept of cyber extension. Alternative methods of financing agricultural extension. Importance, scope, implications of Research-Extension - Farmer - Market linkage. Market - led extension. Farmer - led extension. Farm field school. Public - private partnership in extension. Stakeholder's analysis in extension. Gender issues in extension. Implications of WTO and AOA for extension services. Re-orientation of extension services for agri-business and marketing activities. Govt. organisations / institutes / non-govt. organizations collaboration to improve efficiency of extension. Issues related to rural poverty and privatization of extension. Intellectual property rights. Extension reforms in India. Organization innovations in extension. Agricultural technology information centre. Institutional village linkage programme. Kisan call centres.

**Ext. 602/HECM 602 Scaling Techniques for Behavioural Research** **2+1 Sem.II**

Meaning, types, principles and steps of scaling. Techniques of attitude scale construction - Paired comparison, Equal appearing intervals, Successive intervals, Summated ratings, Scalogram analysis, Scale discrimination technique, Sociometrics, Q-sort technique, Semantic differential technique, Projective and Semi projective techniques, Critical incident technique. Reliability and Validity of Scales. Knowledge measurement. Participatory tools and techniques in behavioural research. Data collection and evaluation. Impact analysis. The e-data collection and information analysis. Use of computer in analysis of data.

Practical: Practice in construction of different scales and their use under various situations. Testing reliability and validity of constructed scales. Application of semi projective and projective techniques. Practicing participatory tools and techniques. Preparation of data collection instruments. Use of e-data collection methods. Review of previous studies.

**Ext.603 Advances in Training Technology** **3+0 Sem.I**

Paradigm shift in training and learning scenario. Training need assessment, approaches, designs and models. Designing an effective training programme and training session. Harmonizing training needs, course objectives, content and methods. Designing experiential training sessions, simulation exercises and openness in training transaction, managing dilemmas, ambivalence, conflicts and confusion for trainers and trainees. Recent training techniques for understanding and facilitation of team building. Group dynamics, motivation and empowerment. Laboratory methods, micro-lab process work and sensitivity training. Thematic Appreciation Test, inventories, cases as training tools. Participatory training techniques.

Trainer's roles and competencies. Factors affecting training effectiveness. Monitoring, evaluation and follow-up of training.

**Ext.604 Organizational Development**

**2+0 Sem.II**

Concept, characteristics, types and levels of organization. Human relations and organizational behaviour. Theories of organization. Systems approach to study organization needs. Motives, attitude, values and ethical behaviour, alienation and work, work motivation, communication and interpersonal behaviour, organizational communication, leadership behaviour, group behaviour, decision-making, problem solving techniques. Organizational climate and structure. Dimensions of motivational climate. Elements and principles of organizational management. Organisational culture and performance. Management by objectives. Transactional analysis. Stress management. Conflict management. Expert system. Forecasting techniques - time series analysis and delphi. Management information system.

**Ext.605 Advanced Instructional Technology**

**2+0 Sem.I**

Scope of instructional technology. Guidelines for curriculum development in agricultural universities. Development of course outlines, lesson plans for theory and practicals. Teaching and learning styles. Theories of learning. Taxonomy of educational objectives. Instructional course objectives. Motivation of students. Instructional methods. Experiential learning cycle. Innovative instructional aids. Identification of innovative low cost instructional aids. Computer assisted instruction (CAI). Preparation of lesson plans for theory and practical with CAI design. Programmed instruction technique. Team teaching. e - Learning. Art of effective communication. Distance education. Student evaluation and question bank. Parameters for appraisal of teacher performance. Review of research in instructional technology.

**Ext.606 Theory Construction in Social Sciences**

**2+0 Sem.I**

Meaning, elements, ideal criteria, functions and types of theory. Importance of theory construction in social sciences. Meaning, types and rules of definitions. Meaning and classification of generalizations. Meaning and types of relationships. Terminologies used in theory construction. Steps in theory building. Axiomatic techniques and historical approaches. Scientific application of theoretical concept in social sciences. Applying appropriate statistical tests for testing of theory.

**Ext.607 Transfer of Technology in Agriculture**

**2+0 Sem.II**

Transfer of technology (TOT) and transfer of technology systems. Knowledge generating system. Knowledge disseminating and consuming system. Input supplying agencies system. Appropriateness of communication media in the system of technology transfer. New communication strategy for transfer and adoption of agricultural technology. Extension training in transfer of technology. Analysis of constraints in transfer of technology. Agencies or departments involved in TOT. Role of extension professionals in TOT. Attributes of technology in relation to TOT process. TOT to resource poor farmers. Role of key communicators or local leaders in TOT. Private and public partnership in TOT. TOT system in USA, Asian and European countries.

**Ext.608/HECM 606 Advanced Media Management**

**2+1 Sem.I**

(In collaboration with Deptt. of Agril. Journalism, Languages & Culture, COBSc.&H)

Principles of management - managing the media organization, managerial functions in the media organization, introduction to media organization. History, functions, uses and theories of media. Editorial and circulation management, need and importance, marketing concept/circulation, affecting factors, circulation manager, functions of circulation department, difficulties in circulation, promoting circulation. Need and concept of personnel management - role of personnel management, integration of interests, functions, human resource planning. Advertising management. Financial management- importance of finance, financial problems, production and printing management. Significant issues in the management of broadcast media-

organizational structure of radio and television in public and private sectors. Concept, history and role of FM radio, community radio and TV in transfer of technology. Functions of various departments and personnel - production, marketing, financial, managing the station/channel.

Practical: Visit to print, electronic and new media organizations to understand the designing, media development, organizational management, functions, problems etc.

**Ext.591 Seminar**

**Ext.600 Master's Research**

**Ext.700 Ph.D. Research**

## FLORICULTURE AND LANDSCAPING

### PROGRAMMES

1. M.Sc.
2. Ph. D.

### COURSE REQUIREMENTS

#### M.Sc.

Field of Specialization:	Floriculture, Landscaping
Required Courses:	Flori. 501, Flori. 502, Flori. 503, Flori. 504
Supporting Courses:	Stat. 421, PGS 501 and other courses from subject matter fields (other than minor) relating to the area of special interest and research problem.
Minor Fields:	Plant Breeding & Genetics, Biotechnology, Horticulture, Soil Science, Botany or any other as approved by Dean, Postgraduate Studies.
Deficiency courses for the students with elective other than Horticulture	As recommended by Student's Advisory Committee and approved by the Dean, Postgraduate Studies

#### Ph.D.

Field of Specialization:	Floriculture, Landscaping
Required Courses:	Flori. 601, Flori. 602, Flori. 603
Supporting Courses:	Courses from subject matter fields (other than minor) relating to area of special interest and research problem
Minor Fields:	Plant Breeding & Genetics, Biotechnology, Horticulture, Soil Science, Botany or any other as approved by Dean, Postgraduate Studies.
Deficiency courses for other students with M. Sc. (Agri.) in a discipline other than Floriculture and Landscaping	Flori. 501, Flori. 502, Flori. 503, Flori. 504 and courses as recommended by Student's Advisory Committee.

## DESCRIPTION OF COURSE CONTENTS

### Diploma Courses

#### **Flori. 51 Landscaping and Floriculture**

**1+1**

**Sem. II**

Importance of floriculture in Punjab. Landscape use of ornamental trees, shrubs, climbers and pot plants. Cultivation of seasonal flowers, chrysanthemum, gladiolus. Marigold and rose. Preparation and maintenance of lawn. Art principles of landscaping. Landscaping of home garden and public parks. Practical: Identification of important trees, shrubs, climbers, annuals and pot plants. Raising and transplanting of seedlings of seasonal flowers. Hands-on training for cultivation of chrysanthemum, gladiolus, marigold and rose. Potting and repotting of indoor plants. Propagation of ornamental plants. Establishment of lawn. Visit to landscape nursery.

### Undergraduate Courses

#### **Flori. 202 Production Technology for Ornamental Crops and Landscaping**

**1+1**

**Sem. II**

Importance and scope of ornamental plants and landscaping. Art principles of landscaping. Landscape uses of trees, shrubs and climbers. Production technology of important cut flowers- rose, gerbera, carnation, liliun and orchids under protected conditions and gladiolus, tuberose, chrysanthemum under open conditions. Package of practices for loose flowers - marigold and jasmine. Processing and value addition in ornamental crops. Practical: Identification of ornamental plants. Nursery bed preparation and seed sowing. Training and pruning of ornamental plants. Planning and layout of garden. Protected structures– care and maintenance. Intercultural operations in flowers. Harvesting and post-harvest handling of cut and loose flowers. Visit to commercial flower unit.

#### **Flori. 301 Landscape Gardening**

**2+1**

**Sem. II**

Importance and scope of landscaping. Principles of landscaping. Garden styles and types. Water, terrace, vertical and sunken gardens. Garden components- rockery, adornments, walk-paths, bridges and other constructed features etc. Trees, shrubs climbers, pot plants and annuals - selection, propagation, planting schemes, canopy management. Other garden plants - palms, ferns, cacti and succulents. Bio-aesthetic planning - definition, importance and planning. Landscaping of urban and rural areas. Peri-urban landscaping. Preparation of landscape plans for home, schools and public places like townships, river banks, hospitals, play grounds, industries, institutions. Bonsai - principles, types, techniques and management. Lawn - establishment and maintenance. CAD application. Practical: Identification of trees, shrubs, climbers, pot plants and annuals. Care, propagation and maintenance of plants. Potting and repotting of plants. Identification of tools and implements used in landscape gardening. Training and pruning of plants for special effects. Lawn establishment and maintenance. Layout of formal and informal gardens. Types of gardens – sunken, terrace and rock gardens. Designing of conservatory and lathe house. Use of computer software. Visit to important gardens/parks/ institutes.

#### **Flori. 491 Agro-industrial Attachment**

**0+4**

**Sem. I**

- (i) Commercial Flower Nurseries
- (ii) Flower Marketing Firms
- (iii) Flower Seed Production and Landscaping Units

#### **Flori. 492 Experiential Learning in Commercial Floriculture and Landscaping**

**0+20 Sem.II**

## Postgraduate Courses

### Flori. 501 Production Technology of Flowers

3+1 Sem.I

Status of Floriculture in India and its potential in global trade. Nursery management. Propagation structures. Media for nursery production. Special nursery practices. Growing environment. Open and protected cultivation - Plant morphology, Soil requirements, artificial growing media, soil decontamination, planting methods, water and nutrient management, fertigation, weed management, ratooning, training and pruning, disbudding, special horticultural practices in rose, chrysanthemum, carnation, gerbera, gladiolus, tuberose, orchids, anthurium, aster, lilliums, tulip, bird of paradise, alstroemeria, dahlia, gypsophilla, limonium, stock, Jasmine, marigold, geranium, crossandra, non-traditional flowers (Nyctanthes, Tabernaemontana, ixora, lotus, gardenia, pandanus), annual flowers and cut foliages. Influence of environmental parameters on growth and flowering. Production for exhibition purposes. Use of growth regulators. Flower forcing and year round flowering through physiological interventions, chemical regulation, and environmental manipulation. Flower seed production. Post-harvest handling of flowers. Physiological disorders and remedies. IPM and IDM. Marketing, export potential. Institutional support. Agri Export Zones.

Practical: Description of varieties. Propagation techniques. Mist chamber operation. Training and pruning techniques. Practices in manuring, drip and fertigation, foliar nutrition, growth regulator application, pinching, disbudding, staking. Harvesting techniques. Post-harvest handling. Project preparation for regionally important cut flowers. Visit to commercial cut flower units and case study.

### Flori. 502 Breeding of Flower Crops and Ornamental Plants

2+1 Sem.II

Origin, distribution, genetic resources, genetic divergence and evolution of varieties. Genetic inheritance of flower colour, doubleness, flower size, fragrance, post harvest life. Breeding methods suitable for sexually and asexually propagated ornamental plants. Introduction, selection, domestication, polyploidy and mutation breeding for varietal development. Role of heterosis. Production of hybrids. Male sterility and self-incompatibility. Breeding of commercial flowers - rose, chrysanthemum, marigold, tuberose, carnation, dahlia, gerbera, gladiolus, orchids, anthurium, lilliums, nerium. Breeding of annuals (zinnia, petunia, cosmos, dianthus, snapdragon, pansy), ornamental plants (hibiscus, bougainvillea, Jasminum). Introduction and selection of plants for waterscaping and xeriscaping.

Practical: Description of botanical features. Cataloguing of cultivars, varieties and species in flowers. Floral biology. Selfing and crossing. Evaluation of hybrid progenies. Seed production. Induction of mutation through physical and chemical mutagens. Induction of polyploidy. Screening of plants for biotic, abiotic stresses and environmental pollution. In vitro breeding in ornamental plants.

### Flori. 503 Landscaping and Ornamental Gardening

2+1 Sem.I

Principles of art and their application in landscape compositions and interior decoration. Types and styles of gardens. Natural and man-made forms and features. Organization of spaces. Visual aspects of plan arrangement-view, vista and axis. Principles of circulation. Structures in landscape. Factors affecting growth and distribution of plants. Classification of plant material and identification. Principle groups of plants and their analysis from design view point. Nursery production of ornamentals. Maintenance of plant material. Growth habits and physiological requirements for growing of plants for interior decoration.

Practical: Study of violation of art and landscape principles. Identification and analysis of plant material for their use in landscaping. Propagation techniques of ornamentals. Maintenance of plant material including indoor plants. Study tours to gardens and arboretums.

**Flori. 504 Landscape Designs (Pre-requisite: Flori. 503)****2+2 Sem.II**

Analysis of various types of sites and their landscape treatment. Application of Landscape principles for various types of houses, educational institutions, religious places, fair grounds, industrial sites, rural habitat, farm complexes, embassies, hotels and other buildings. Special problems of landscaping of terrace and roof gardens and multistory buildings. Water scaping, xeriscaping, hardscaping. Landscaping of various categories of roads. Concepts and significance of planning cities and open spaces. Master plan of cities in relation to open spaces. Types of parks and other recreational areas. Maintenance of parks. Factors affecting outdoor recreation.

Practical: Site analysis of various landscape projects. Use of drawing scale, lettering, plotting, reading and interpretation of maps on different scales. Preparation of landscape designs of various types of buildings, roads, parks, sport centers, picnic spots, and camping grounds. Display of plants for interior decoration. Preparation of cost estimates for landscaping and maintenance. Study tours. Introduction to CAD.

**Flori. 505 Protected Floriculture****2+1****Sem.II**

(Collaboration: Deptt. of Soil and Water Engineering)

Prospects of protected floriculture in India. Types of protected structures. Designing and erection of protected structures. Economics of cultivation. Location specific designs. Structural components. Flower crops for protected cultivation. Environment control. Containers and substrates, soil decontamination. Layout of drip and fertigation system. Water and nutrient management. Weed management. Physiological disorders. IPM and IDM. Crop regulation by chemical methods and special horticultural practices. Staking and netting. Photoperiod regulation. Harvest indices, harvesting techniques and Post-harvest handling.

Practical: Study of protected structures. Soil preparation and sterilization. Practices in environmental control systems. Drip and fertigation techniques. Special horticultural practices. Determination of harvest indices, harvesting methods and postharvest handling. Packing methods. Project preparation. Visit to commercial greenhouses.

**Flori. 506 Value Addition in Flowers****2+1 Sem.I**

Status and prospects of value addition. Types of value added products. Value addition in loose flowers - garlands, veni, floral decorations. Value addition in cut flowers- types of flower arrangement, bouquets, button-holes, flower baskets, floral wreaths. Selection of containers and accessories for floral products and decorations. Terrariums. Dry flowers- Identification and selection of flowers and plant parts, raw material procurement, preservation and storage. Techniques in dry flower making - Drying, bleaching, dyeing, embedding, pressing. Accessories. Designing and arrangement - dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths. Packing and storage. Concrete and essential oils - selection of species and varieties (including non-conventional species). Extraction methods. Packing and storage. Selection of species and varieties for pigment extraction. Types of pigments - carotenoids, anthocyanin, chlorophyll, betalains. Significance of natural pigments.

Practical: Practices in preparation of bouquets, button-holes, flower baskets, corsages, floral wreaths, garlands with fresh flowers. Techniques in flower arrangement and floral decoration. Identification of plants for dry flower making. Practices in dry flower making. Preparation of dry flower baskets, bouquets, pot-pourri, wall hangings, button holes, greeting cards, wreaths. Visit to dry flower units, concrete and essential oil extraction units.

**Flori. 507 Turfing and Turf Management****2+1 Sem.I**

Status and prospects of turf grass. Site selection and evaluation. Physical, chemical and biological properties of soil for turf grass establishment. Turf grasses - Types, species, varieties, hybrids. Selection of

grasses for different locations. Grouping according to climatic requirement- adaptation. Turfing for roof gardens. Preparatory operations. Growing media used for turf grasses. Turf establishment methods, seeding, sprigging/dibbling, plugging, sodding/turfing, turf plastering, hydro-seeding. Turf management - Irrigation, nutrition, special practices - aerating, rolling, soil top dressing. Use of plant growth regulators (PGRs) and micronutrients. Turf mowing- mowing equipments, weed control. Biotic and abiotic stress management in turfs. Establishment and maintenance of turfs for playgrounds, viz. golf, football, hockey, cricket, tennis, etc.

Practical: Identification of turf grasses. Preparatory operations in turf making. Practices in turf establishment. Layout of irrigation systems. Water and nutrient management. Special practices - mowing, raking, rolling, soil top dressing. Weed management. Biotic and abiotic stress management. Project preparation for turf establishment. Visit to IT parks, model cricket and golf grounds, corporates, Govt. organizations. Renovation of lawns.

### **Flori. 508 CAD for Outdoor and Indoor Landscaping**

**1+2 Sem I**

Applications of CAD in landscape garden designing, 2D drawing by AUTOCAD, Basics of Photoshop software in garden designing. Toolbars and Icons, File handling functions, Modifying tools. Dimension concepts, Hyper linking, Making layout. Dimensioning and detailing of designs, Visualization tools for landscape preview, Data management, plotting and accessories for designing.

Practical: Practices in point picking methods. Using tool bars and icons. Using modifying tools and modifying comments. Isometric drawings. Using productivity tools. Drawing designs by AUTOCAD for home garden, institutional gardens, interior garden design, IT parks, corporates, theme parks and ecotourism spots. Using Photoshop for 3D picture insertion.

### **Flori. 601 Advances in Flower Production Technology**

**3+0 Sem.II**

Commercial flower production. Global scenario in cut flower production and trade, varietal wealth and diversity. Soil and Environment. Special characteristics and requirements. Cut flower, loose flowers, dry flowers and floral oil trade. Propagation and multiplication. IPR issues related to propagation of materials. Greenhouse management. Soil/media decontamination techniques. Microirrigation. Nutrition and fertigation. Slow release fertilizers and biofertilizers. Influence of environmental parameters on growth and flowering. Regulation for quality flowers. Flower forcing and year-round flowering through physiological interventions, chemical regulation and environmental manipulation. Harvest indices, Harvesting techniques and Post-harvest handling. Export potential. Agri Export Zones. Crop specific practices - rose, anthurium, orchids, carnation, gladiolus, gerbera, liliiums, heliconia, bird of paradise, Jasminum sp., marigold, tuberose, crossandra. Floral oil industry - floral concrete production, extraction methods and recent advances.

### **Flori. 602 Advances in Breeding of Flower Crops**

**3+0 Sem. I**

Origin, evolution and distribution of varieties. Plant introduction, selection and domestication. Inheritance of important characters. Genetic mechanisms associated with flower colour, flower size, doubleness, fragrance and post-harvest life. Plant Variety Protection Act. Specific objectives of breeding in flower crops. Methods of breeding suited to seed and vegetatively propagated flower crops. Introduction, selection, polyploidy and mutation breeding in the evolution of new varieties. Exploitation of heterosis. Utilization of male sterility. Incompatibility problems. In Vitro breeding. Breeding for resistance to pests, diseases, nematodes and other biotic and abiotic stresses in flower crops. Specific breeding problems and achievements made in rose, jasmine, chrysanthemum, marigold, tuberose, crossandra, carnation, gerbera, gladiolus, orchids, anthurium, aster, petunia, liliiums, heliconia, bird of paradise, hibiscus and bougainvillea.

### **Flori. 603 Advances in Landscape Architecture**

**1+2 Sem.I**



Commercial landscape gardening- History, Plant identification and ecology. Materials of garden design. Design making by different garden styles and types. Expenses to model landscaping units of all category. Creativity and communication skills for landscape architect. Assessing site and plants adaptability for different locations. Landscape engineering (Topographical) survey and designing concept. Special techniques in garden landscaping (Waterscaping, hardscaping, topiary styles specializing). Computer Aided Design (CAD) for developing a garden landscape plan. Handling soft landscape materials (AUTOCAD & ARCHICAD). GIS as a tool for spatial designing. Case study with the successful landscapist. Budget/Project cost estimating. Execution strategies. Assessing a successful design in site.

Practical: Commercial landscaping. Plant identification. Materials of garden design. Design making by different garden styles and types. Way of designing a commercial landscape project. Visit to model ornamental nursery. Assessing site and plants adaptability for different locations. Landscape engineering. Special techniques in garden landscaping. Preparing drawing for site plan. Computer Aided Design (CAD) for developing a garden landscape plan. Handling soft landscape materials. GIS as a tool for spatial designing. Contemporary, Environmental, Industrial and institutional landscaping. Public and private garden making. Play ground landscaping. Case study with the successful landscapist. Budget/Project cost estimating and execution.

**Flori. 604 Advances in Pre and Post-harvest Management of Ornamentals 3+0 Sem.II**

Recent advances in plant growth regulation in relation to photoperiodism, temperature and other environmental factor. Bulb culture, dormancy and storage of bulbs. Flower forcing in bulbous ornamentals. Physiology of flowering. Plant hormones-biosynthesis, signal transduction and role in floriculture. Factors influencing juvenility and strategies to overcome. Physiological disorders of ornamental plants. Biochemistry of flowers: Principles involved in the formation of pigments - chlorophyll, xanthophyll, carotenoids, flavonoids and anthocyanins. Recent trends- Extraction of biocolours and their value addition, uses in food and textile industries. Effects of pre-harvest environments on post harvest quality of cut flowers. Harvesting of flowers and florist greens. Factors affecting decline in vase life. Importance of cool chain. Floral preservatives, storage, grading, packing and transportation of cut flowers. Functional and ultrastructural changes during petal senescence. Molecular basis of flower senescence. Biotechnological approaches to improve vase life.

**Flori. 605 Advances in Nursery Production and Management 2+0 Sem.I**

Planning and establishment of a landscape nursery-selection of site and lay out. Propagation structures-Greenhouse, glasshouse, lathhouse, mist chambers, net houses etc. Soil sterilization, raising seedlings, Plug production, grading, packing, storing, merchandizing and inventory making of ornamentals. Weed management. Media and containers for propagation of plants. Maintenance of stock plants. Advances in the principles underlying sexual and asexual propagation of different ornamentals. Factors influencing germination of seeds. Physiology of rooting, graft union, Stock scion incompatibility. Use of growth regulators in propagation. In vitro techniques of mass multiplication. Integrated management of important insect-pests and diseases in nursery. Customer services.

**Flori. 606 Advances in Protected and Precision Floriculture 2+0 Sem.II**

Prospects of protected floriculture in India. Growing structures. Basic considerations in establishment and operation of green houses, functioning and maintenance. Environmental control systems in greenhouse. Containers, substrate culture, soil decontamination techniques. Water and nutrient management. Crop regulation. Protected cultivation of rose, chrysanthemum, carnation, orchids, anthurium, gerbera, liliiums, cut foliage. Marketing and export potential. Precision floriculture. Principles and concepts. Enabling technologies of precision farming, GPS, GIS, Remote sensing, sensors. Variability management in precision farming, mapping, variable rate technology. Precision equipments - computers and robotics in precision farming. Post-harvest process management in floriculture using precision farming.

**Flori. 607 Planning and Management of Parks****2+0 Sem.II**

Recreational parks - history, importance, scope and their role in outdoor recreation and nature conservation. Biotic regions of the world. Types of distribution of vegetation in India. Bio- aesthetic planning, lanning and designing of Botanical gardens, amusement and zoological parks. Maintenance of historical and archeological sites, recreational gardens, Wet lands, National parks, and wild life sanctuaries.

**Flori. 591 Seminar****Flori. 600 Master's Research****Flori. 700 Ph.D. Research**

## FOOD SCIENCE AND TECHNOLOGY

### PROGRAMMES

1. **B.Tech. (Food Technology)**
2. **M.Sc.**
3. **Ph.D.**

### COURSE REQUIREMENTS

#### **M.Sc.**

Field of Specialization	Cereal Technology, Fruit and Vegetable Technology, Dairy Technology, Egg and Meat Technology
Required Courses	FT 501, FT 502, FT 503, FT 504, FT 505, FT 506
Supporting Courses	Stat. 421, PGS 501 and other courses from subject matter fields (other than minor) relating to the area of special interest and research problem
Minor Fields	Microbiology, Biochemistry, Processing and Food Engineering, Food and Nutrition or any other as approved by the Dean, Postgraduate Studies
Deficiency courses for students with elective field other than Post Harvest Technology and Value Addition	As recommended by the students Advisory Committee and approved by the Dean, Postgraduate Studies

#### **Ph.D.**

Field of Specialization	Cereal Technology, Fruit and Vegetable Technology, Dairy Technology, Egg and Meat Technology
Required Courses	FT 601, FT 602, FT 603, FT 604
Supporting Courses	Courses from subject matter fields (other than minor) relating to area of special interest and research problem
Minor Fields	Microbiology, Biochemistry, Processing and Food Engineering, Food and Nutrition or any other as approved by the Dean, Postgraduate Studies
Deficiency courses for Students with M.Sc. (Agri.) in a discipline other than Food Science and Technology	FT 501, FT 502, FT 503, FT 504, FT 505, FT 506 and other courses as recommended by Student's Advisory Committee

## DESCRIPTION OF COURSE CONTENTS

### Diploma Courses

#### **FT 51 Elementary Food Technology**

**1+1**

**Sem. II**

Causes of food spoilage. Principles of processing and preservation of food by heat, low temperature, chemicals and fermentation. Preservation through ultraviolet and ionizing radiations. Post harvest handling and technology of fruits, vegetables, cereals, oilseeds, milk, meat and poultry. Food safety, adulteration and food laws. Status of food industry in India.

Practical: Quality assessment of cereals, fruits, vegetables, egg, meat and poultry. Value added products from cereals, fruits, vegetables, milk, egg and meat. Visit to local food processing units.

### Undergraduate Courses

#### **FT 101 Food Science and Processing**

**1+1**

**Sem. I**

Definition: Food and nutrition; Food production and consumption trends in India; Major deficiencies of calories, proteins, vitamins and micronutrients; food groups and concept of balanced diet; RDA. Causes of food spoilage; principles of processing and preservation of food by heat, low temperature, drying and dehydration, chemicals and fermentation; preservation through ultraviolet and ionizing radiations. Post-harvest handling and technology of fruits, vegetables, cereals, oilseeds, milk, meat and poultry; food safety, adulteration and food laws; status of food industry in India.

Practical: Quality assessment of cereals, fruits, vegetables, egg, meat and poultry. Value added products from cereals, fruits, vegetables, milk, egg and meat. Visit to local processing units.

#### **FT 102 Food Chemistry of Macroconstituents**

**2+1**

**Sem. II**

Nature, scope and development of food chemistry. Moisture in foods. Role and type of water in foods, functional properties of water, water activity and sorption isotherm. Molecular mobility and food stability. Dispersed systems of foods, physicochemical aspects of food dispersion system (sol, gel, foam, emulsions). Rheology of diphase systems. Carbohydrates, changes of carbohydrates on cooking, modification of carbohydrates, dietary fibres and carbohydrate digestibility, enzymatic and chemical reactions of carbohydrates. Proteins in foods. Processing induced physical, chemical and nutritional changes in protein, chemical and enzymatic modification of protein. Lipids in foods, role and use of lipids/fat, crystallization and consistency, chemical aspects of lipids, lipolysis, auto-oxidation, thermal decomposition. Chemistry of frying technology of fat and oil. Oil processing, refining, hydrogenation, inter esterification. Safe use of oils and fats in food formulation. Enzymatic and chemical reactions of fats. Rancidity and its types, detection techniques, chemical aspects of lipids. Antioxidants.

Practical: Determination of moisture content of foods using different methods. Studies of sorption isotherms of different foods. Swelling and solubility characteristics of starches. Rheological properties of food systems. Determination of crude proteins by micro-Kjeldhal method. Determination of essential amino acids - lysine, tryptophan, methionine etc. Isolation of egg and milk protein. Preparation of protein isolates and concentrates. Determination of acid value, saponification value and iodine number of fat/oil. Assay of amylases, papain and lipases.

#### **FT 201 Fundamentals of Food Processing**

**1+1**

**Sem. I**

Scope and importance of food processing. Sources, types and perishability of foods. Causes and types of food spoilage. Food preservation - principles, methods, benefits, effects on food quality and

equipments. Methods of preservation: salt and sugar, heat treatment, low temperature, drying, dehydration, concentration, fermentation, irradiation, chemicals - acidulants, antioxidants, mold inhibitors and antibodies. Principles, methods and equipments for thermal processes - blanching, canning, pasteurization and sterilization. Principles and equipments for non-thermal processes - pulsed electric field and pulsed intense light, ultrasound, dielectric heating, ohmic heating, infrared heating, high pressure processing and microwave processing. Quality tests and shelf-life of preserved foods.

Practical: Demonstration of various perishable food items and assessment of degree of spoilage. Blanching of selected food items. Preservation of food by heat treatment- pasteurization and sterilization. Preservation of food using high concentration of sugar (jam), salt (pickle), acidulants (pickling by vinegar or acetic acid) and chemical preservatives. Preservation of bread and cake using mold inhibitors. Drying of foods - fruit slices (pineapple and apple) and green leafy vegetables in cabinet dryer, mango/other pulp by foam-mat dryer, semisolid foods by roller dryers and vegetable slices by freeze dryer. Preserving foods under cold and freezing process. Processing of foods using fermentation technique - sauerkraut. Effect of high pressure on microbes. Effect of pulse electric field on food.

### **FT 202 Processing Technology of Liquid Milk**

**1+1**

**Sem. I**

Dairy development in India. Production, utilization, composition and properties of milk. Milk-collection, preservation, processing, packaging and storage. Standardized, skim, sterilized, reconstituted/rehydrated, recombined, flavoured milk. Cream - definition, classification, manufacture and processing. Fermented milk - types, processing, manufacture, storage, packaging, biochemical changes, factors affecting these changes and their effects on the quality. Milk adulteration and detection. Quality defects in milk - causes and prevention. Processing equipments - Bulk milk coolers, chilling units, reception equipment, tanks/silos, pasteurizers, sterilizers, centrifuges, clarifiers, filtration units, homogenizers, packaging and filling machines and CIP units. Hygienic design concepts, corrosion process and control.

Practical: Platform tests of raw milk - clot on boiling and alcohol tests. Determination of physico-chemical and microbiological properties of milk. Detection of adulterants in milk. Identification and demonstration of liquid milk processing equipment, pipes and fittings. Standardization, separation, pasteurization, homogenization and packaging of liquid milk. Preparation of fermented milk. Visit to chilling centre and dairy plant.

### **FT 203 Food Additives and Preservatives**

**1+1**

**Sem. I**

Intentional and unintentional food additives, their toxicology and safety evaluation. Naturally occurring food additives. Food colours and dyes. Regulatory aspects of dyes, food colours (natural and artificial). Pigments and utilization as food colour. Processing of natural and artificial food colorants. Food preservatives and their chemical action. Role and mode of action of salts, chelating agents, stabilizers, thickeners, humectants/polyhydric alcohol, anti-caking agent, firming agent, flour bleaching and maturing agents, antioxidants, acidity regulators, emulsifiers, nutritional and non-nutritional sweeteners, Production of enzymes, leavening agents and fat substitutes. Flavor and taste enhancers in food processing.

Practical: Evaluation of GRAS aspect of food additives. Estimation of chemical preservatives by TLC (organic and inorganic). Identification of food colour by TLC (organic and inorganic). Quantitative estimation of added dyes. Isolation and identification of naturally occurring food pigments by paper and TLC. Role and mode of action of chelating agent in fruit juice, stabilizer and thickener in frozen dairy products, clarifying agent in fruit juices, antioxidant in frozen fish and leavening agent in baked food product. Preservation of coconut shreds using humectants.

**FT 204 Food Chemistry of Microconstituents****2+1 Sem. I**

Chemistry of food flavour. Philosophy and definitions of flavour, flavourmatics/ flavouring compounds. Sensory assessment of flavour. Technology for flavour retention. Pigments in animal and plants kingdom - Heme pigments, chlorophyll, carotenoids, phenolics, flavonoids and betalains. Effect of processing on pigment behaviour. Technology for retention of natural colours of food stuffs. Colour losses during thermal processing. Vitamins and minerals - requirements, allowances, enrichment, restorations, fortifications, losses, optimization and retention. Chemistry of anti-nutritional factors. Enzymes in food industry- carbohydrases, proteases and lipases. Modification of food using enzymes. Role of endogenous enzymes in food quality. Use of enzymes as processing aid and ingredients. Practical: Preparation of mineral solution by using ash and tri-acid method (dry and wet oxidations). Estimation of calcium, phosphorus, iron and magnesium. Estimation of tannins and phytic acid from food. Determination of vitamin A (total carotenoids), ascorbic acid, thiamine and riboflavin. Determination of food colours. Assessment of hydrocolloids as food additives. Assessment of various pectinases from fruits and vegetables.

**FT 205 Processing Technology of Meat and Poultry Products 2+1 Sem. II**

Sources and importance of meat and poultry. Status of meat and poultry industry in India. Pre-slaughter and slaughtering operations for animals and poultry. Evaluation of animal carcasses. Factors affecting post-mortem changes, properties and shelf life of meat. Mechanical deboning, grading and aging. Eating and cooking quality of meat. Preservation of meat by chilling, freezing, pickling, curing, cooking, smoking, dehydration, radiation, chemical and biological preservatives. Meat tenderization. Meat emulsions. Meat cutting and handling. Preparation, preservation and equipment for manufacture of smoked meat, dehydrated meat, meat sausages and their quality evaluation. Abattoir design and layout. Eggs - structure, composition, quality characteristics, processing and preservation. Processing and preservation of meat and poultry products. Meat plant sanitation and safety. By-products of meat, poultry and eggs and their utilization. Safety standards in meat industry. HACCP/ ISO/ MFPO/ FSSAI/ Kosher/ Halal.

Practical: Pre-slaughter operations of meat animals and poultry birds. Slaughtering and dressing of meat animals. Study of post-mortem changes. Meat cutting and handling. Preservation of meat by freezing, curing, pickling and dehydration. Evaluation of quality and grading of eggs. Preservation of shell eggs. Preparation of value added meat, poultry and egg products. Visit to abattoir.

**FT 206 Technology of Bakery, Confectionery and Snack Foods 2+1 Sem. II**

Bakery products - types, specifications, compositions, ingredients, formulations, processing, equipment, packaging, storage and quality testing. Confectionery and chocolate products - types, specifications, compositions, ingredients, formulations, processing, equipment, packaging, storage and quality testing. Product quality characteristics, defects, causes and corrective measures. Snack foods - types, specifications, compositions, ingredients, formulations, processing, equipment, packaging, storage and quality testing. Snack food seasonings. Breakfast cereals, macaroni products and malts - specifications, compositions, ingredients, formulations, processing, equipment, packaging, storage and quality testing.

Practical: Identification and composition of various ingredients for snacks, bakery and confectionery products. Flours, their classifications and characterization. Preparation, packaging and quality evaluation of selected snack items, bakery items, confectionery items, selected chocolates, traditional Indian confection. Visit to bakery, confectionary and snack units (industry).

**FT 207 Processing Technology of Legumes and Oilseeds 2+1 Sem. II**

Present status and future prospects of legumes and oilseeds. Morphology, classification, types, chemical composition, nutritional value and anti-nutritional compounds in legumes and oilseeds.

Methods of removal of anti-nutritional compounds. Pulse milling - home, cottage and modern milling methods, machines, milling quality, milling efficiency, factors affecting milling quality and quantity. Problems in dhal milling industry. Nutritional changes during soaking and sprouting of pulses. Cooking quality of dhal, methods and factors affecting cooking of dhal. Quick cooking and instant dhal. Soybean milk processing and value addition. Fermented products of legumes. Oil seed milling - ghanis, hydraulic presses, expellers, solvent extraction methods, machines, milling quality, milling efficiency, factors affecting milling quality and quantity. Problems in oil milling industry. Desolventization, refining, degumming, neutralization, bleaching, filtration, deodorization and hydrogenation - their principles and process controls. New technologies in oilseed processing. Utilization of oil seed meals. High protein products like protein concentrates and isolates. By-products of pulse and oil milling and their value addition.

Practical: Determination of physical properties of legumes and oil seeds. Determination of proximate composition and nutritional quality of selected pulses and oilseeds. Study of mini dhal mill and mini oil mill. Preconditioning of pulses and oilseeds before milling. Removal of anti-nutritional compounds from selected pulses and oilseeds. Laboratory milling of selected pulses, oilseeds and its quality evaluation. Laboratory refining of selected oils. Laboratory hydrogenation of selected oils. Study of cooking quality of dhal. Processing of composite legume mix and preparation of value added products. Visit to commercial dhal and oil mills.

### **FT 208 Processing Technology of Spices and Plantation Crops                    1+1 Sem. II**

Production and processing scenario and scope of spices and plantation crops. Major (Ginger, chilli, turmeric, onion, garlic, pepper and cardamom) and minor spices, (Herbs, leaves and spartan seasonings, allspice, annie seed, sweet basil, caraway seed, cassia, cinnamon. clove, coriander, cumin, dill seed, fennel seed, nutmeg, mace, mint marjoram, rosemary, saffron, sage, Savory, thyme, ajwain, Asafoetida and curry leaves) their post harvest technologies, composition and processed products. Post harvest technology and processing for tea, coffee, cocoa, vanilla and annatto. Post harvest technology and processing of areca nut, cashew nut and oil palm. Flavours of major and minor spices. Extraction techniques for spice oil and oleoresins. Standards and specifications of spices. Functional packaging of spices and spice products. By-products of plantation crops and spices.

Practical: Identification and characterization of flavouring compounds of spices. Valuable oil determination. Extraction of oil from clove, pepper, cardamom and chilli. Extraction of oleoresins from turmeric, ginger, pepper and cloves. Peperine estimation in pepper oleoresin. Steam distillation of spices. Determination of curcumin content in turmeric. Chemical analysis of spices-moisture, valuable oil, specific gravity, refractive index and acid value. Packaging study of spices. Preparation of curry powder. Visit to spice industry.

### **FT 301 Processing Technology of Fruits and Vegetables    2 +1 Sem. I**

Production and processing scenario of fruits and vegetables in India and world. Scope of fruit and vegetable processing industry in India. Overview of principles and preservation methods of fruits and vegetables. Supply chain of fresh fruits and vegetables. Primary processing and pack house handling of fruits and vegetables. Peeling, slicing, cubing, cutting and other size reduction operations for fruits and vegetables. Minimal processing of fruits and vegetables. Blanching operations and equipment. Canning-definition, processing steps, equipment, cans and containers, quality assurance and defects in canned products. FSSAI specifications, preparation, preservation and equipments used for juices, squashes, syrups, sherbets, nectars, cordials, crystallized fruits preserves, jam, jelly, marmalades, candies, chutney, pickles, sauce, puree, paste, ketchup, toffee, fruit cheese, leather, dehydrated products, wafers, papads and soup powders. Production of pectin and vinegar. Commercial processing technology of selected fruits and vegetables for production of various value added processed products.

Practical: Primary processing of seasonal fruits and vegetables. Canning of Mango/Guava/Papaya/sarson ka saag/peas. Preparation of jam, jelly and marmalade from selected fruits. Preparation of RTS, beverages, squash and syrup, Preparation of raisins, dried fig, dried banana, anardana. Dehydration of ginger, onion, garlic, leafy and other vegetables. Preparation of banana and potato wafers. Preparation of papain. Preparation of pickles. Visit to fruits and vegetables pack house, canning plant and vegetable dehydration plant.

### **FT 302 Processing Technology of Cereals**

**2+1**

**Sem. I**

Present status and future prospects of cereals and millets. Morphology, physico-chemical properties and nutritive value of cereals, major and minor millets. Paddy processing and rice milling- conventional and modern methods. Quality characteristics influencing final milled product. Parboiling. Rice bran stabilization and its methods. Wheat milling- break, purification and reduction system. Extraction rate and its effect on flour composition. Quality characteristics of flour and its suitability for baking. Corn/Maize milling - dry and wet, starch separation, milling fractions and modified starches. Barley - malting and milling. Oat - processing and milling. Sorghum - milling, malting and pearling. Millets - processing for food uses. Secondary, tertiary and byproduct processing of cereals and millets. Processing of cereals and millets for infant and baby foods. Breakfast cereal foods- flaked, puffed, expanded, extruded and shredded.

Practical: Morphological, physical and chemical properties of cereals. Milling and cooking quality of rice. Parboiling of paddy. Conditioning and milling of wheat into different products and their evaluation. Production of sorghum flakes, popcorns, flaked rice, puffed rice and noodles. Preparation of barley malt. Determination of gelatinization temperature by amylograph. Processing of value added products from millets. Visit to cereal processing unit.

### **FT 303 Processing Technology of Dairy Products**

**2+1**

**Sem. I**

Classification of dairy products. Butter - definition, composition, processing, equipment, overrun, quality testing, defects - causes and their prevention, packaging and storage. Butter oil and ghee - definition, composition, processing, equipment and quality tests. Paneer and cheese - definitions, composition, types, processing, equipment, quality defects- causes and prevention, packaging and storage. Ice cream and frozen desserts - definition, composition, types, processing, equipment, quality testing, defects - causes and prevention, packaging and storage. Condensed and dried milk - definition, composition, role of milk constituents in condensed milk, manufacture of condensed milk, types of standards for dried milk, manufacture of skim milk powder (SMP) and whole milk powder (WMP) using roller and spray drying, instantization, recent developments in drying, quality testing, defects- causes and prevention, packaging and storage. Traditional Indian dairy products - definitions, composition, processing, packaging, storage, equipment and quality testing. Byproducts of dairy industry and their utilization (lassi, whey and ghee residue).

Practical: Preparation of butter / table butter, *ghee*, *paneer*, selected type of cheese, ice-cream, selected frozen desserts, condensed milk, milk powder, selected Indian dairy products. Determination of quality parameters of dairy products. Visit to dairy plant.

### **FT 304 Sensory Evaluation of Food Products**

**2+1**

**Sem. I**

Introduction, definition and importance of sensory evaluation in relation to consumer acceptability and economic aspects. Factors affecting food acceptance. Terminology related to sensory evaluation. Principles of good practice. Sensory testing environment, test protocol considerations and their basic principles. Senses and sensory perception. Physiology of sensory organs, classification of tastes and odours, threshold value factors affecting senses - visual, auditory, tactile and other responses. Discrimination tests. Types of tests – difference tests (paired comparison, duo-trio, triangle), ranking, scoring, Hedonic scale and descriptive tests. Panel selection - screening and training of judges.



Requirements of sensory evaluation. Sampling procedures. Factors influencing sensory measurements. Consumer research – effective tests, objectives, methods, types and development of questionnaires. Comparison of laboratory testing and consumer studies along with their limitations. Interrelationship between sensory properties of food products and various instrumental and physico-chemical tests. Application of sensory testing. Sensory evaluation in food product development and quality control.

Practical: Determination of threshold value for basic tastes and odours. Selection of judging panel. Training of judges, for recognition of certain common flavour and texture defects using different types of sensory tests- difference test (Paired Comparison (PC), Duo-trio, triangle). Descriptive analysis methodology. Sensory evaluation of various food products using different scales, score cards and tests. Texture profile methodology. Estimation of colour. Relationship between objective and subjective methods. Designing a sensory laboratory.

### **FT 305 Techniques and Instruments for Food Analysis                  1+2                  Sem. I**

Concepts of food analysis. Rules and regulations of food analysis. Principles and methodology involved in food analysis, rheological, textural profile, proximate and mineral analysis of foods. Adulteration analysis. Principles and methodology in analytical techniques- Ion selective electrodes, spectroscopy, ultraviolet, visible, fluorescence, infrared spectroscopy, atomic absorption and emission mass spectroscopy, nuclear magnetic resonance (NMR) and electron spin resonance. Chromatography- Adsorption, column, partition, gel-filtration, affinity, ion - exchange, size-exclusion, gas-liquid chromatography (GLC), high performance liquid chromatography (HPLC). Separation techniques - dialysis, electrophoresis, sedimentation, ultra-filtration, ultracentrifugation, iso-electric focusing, isotopic techniques, manometric techniques. Immuno assay techniques in food analysis by IR and NIR. Principles, measurement, instrumentation for food analysis including statistical evaluation of analytical data. Rapid microbiological methods. Principles of food sensing techniques and sensors for flavour and freshness. Electronic nose and tongue.

Practical: Sampling plan, sample collection and preparation for analyses. Sensory evaluation of products. Quality evaluation of raw material, fruits, vegetables, cereals, dairy products, meat and poultry products. Quality evaluation of market food products for colour and taste. Analysis of heavy metals using atomic absorption spectrophotometer. Estimation of phytic acid using spectrophotometer. Separation of amino acids by paper chromatography. Identification of sugars in fruit juice using TLC. Gel electrophoresis - quantitative determination of sugars and fatty acid profile. Quantitative make-up of water and fat soluble vitamins using HPLC. Separation of sugars by paper chromatography. Analysis of wheat flour. Analysis of foods for pesticide and drug residues. Study of colourimetry and spectrophotometry. Spectrophotometric method for total chlorophyll (A & B).

### **FT 306 Food Plant Sanitation    1+1                  Sem. II**

Good manufacturing practices, standard operating procedures and good laboratory practices. Sanitation and food industry - laws, regulations and guidelines. Relationship of microorganisms to sanitation. Allergens and their control. Food contamination and protection. Personal hygiene and sanitary food handling. Role of HACCP in sanitation and quality assurance. Cleaning compounds, sanitizers, sanitizing methods, sanitation equipment, waste product handling, solid waste disposal and liquid waste disposal. Pests' infestation in food and integrated pest management. Sanitary design for construction for food processing unit. Low-moisture food manufacturing and storage sanitation. Sanitation in dairy, meat, poultry, seafood, fruit and vegetables, beverage, brewery and wine processing plants. Potential risks of bioterrorism due to food and other items.

Practical: Determination of BOD (Biological Oxygen Demand) and COD (Chemical Oxygen Demand) of industrial effluents. Determination of hardness of water. Good Manufacturing Practices (GMPs) and personal hygiene. Primary, secondary, tertiary and quaternary aerobic and anaerobic sludge

treatment. Lab demonstration on state of water. CIP plant. Isolation and identification of actinomycetes. Enrichment and isolation of cellulose degrading bacteria. Biodegradation of phenol compounds. Bacteriological examination of water. Coliform MPN test. Sampling of airborne microorganisms. Sampling from surfaces, equipment and plant. Aerosol sampling and measurement guidelines.

**FT 307 Processing Technology of Fish and Marine Products**                      **1+1**                      **Sem. II**

Fisheries resources-global and Indian scenario. Types of fish and other marine products. Classification, composition and characteristics of fresh water and marine fish. Spoilage of fish - microbiological, physiological and biochemical. Relationship between chilling and storage life, fish freezing, changes in quality during chilled and frozen storage. Canning of fish pre and post process cannery operations, storage of canned fish. Fish products - muscle proteins, fish protein concentrates (FPC), fish protein extracts (FPE) and fish protein hydrolysates (FPH), surimi process (traditional and modern production lines, quality and comparison with other fish mince products). Preparation of protocols for indigenous products. Fish sauce and paste. Novel methods - low dose irradiation, high pressure treatment, MAP, Vacuum & gas packaging, hurdle barrier concept. Value added fish products and their packaging. Sea food quality assurance - HACCP, EU hygienic regulations and ISO 9000 standards. New kinds of quality and safety problems emerging in sea food processing and preservation.

Practical: Study of anatomy and dressing of fish, prawn and other marine products. Identification of different types of fish, prawn and other marine products - selection and grading. Quality evaluation of fish. Preservation of fish by drying, canning, pickling, chilling and freezing. Preparation of sun dried, salt cured, sauce, protein concentrate, meal, oils and various other products from fish. Utilization of fish byproducts. Preparation of marine algal products. Determination of iodine value. Protein estimation by Folin-Lowrey's method. Visit to fish and prawn processing industry.

**FT 308 Processing Technology of Beverages**                      **2+1**                      **Sem. II**

History, importance and status of beverages industry. Packaged drinking water, juice based beverages, synthetic beverages, still, carbonated, low-calorie and dry beverages, isotonic and sports drinks, dairy based beverages, alcoholic beverages, fruit beverages, speciality beverages, tea, coffee, cocoa, spices, plant extracts, etc. FSSAI (Food Safety and Standards Authority of India) specifications for beverages. Ingredients, manufacturing, packaging processes and equipment for different beverages. Water treatment and quality of process water. Sweeteners, colourants, acidulants, clouding, clarifying and flavouring agents for beverages. Carbon dioxide and carbonation. Quality tests and control in beverages. Miscellaneous beverages - sugar cane juice, coconut beverages and flavoured syrups.

Practical: Quality analysis of water. Determination of density and viscosity of caramel. Determination of colours in soft drinks by wool technique. Preparation of iced and flavoured tea. Preparation of carbonated and non-carbonated beverages. Determination of caffeine in beverages. Determination of brix value, gas content, pH and acidity of beverages. Quality analysis of tea and coffee. Preparation of miscellaneous beverages. Visit to carbonation unit and mineral water plant.

**FT 309 Food Quality, Safety Standards and Certification**                      **2+0**                      **Sem. II**

Food quality-definition and its role in food industry. Quality attributes, classification. Physical properties of food. Defects - classification and measurement. Colour and gloss - definition, different colours, colour measurement by spectrophotometer, Munsell colour system and Lovibond tintometer. Role of viscosity and consistency in food quality. Flavour - definition and its role in food quality. Taste and Odor - definition, classification and its role in food quality. Factors influencing sensory measurements. Correlation of sensory and instrumental analysis. Descriptive sensory analysis by contour and other

procedures. Consumer measurement - factors influencing acceptance and preference, objectives of consumer preference and information obtained from consumer study. Development of the questionnaire, types of questionnaires and serving procedures. Laboratory panels versus consumer panels. Limitations of consumer survey. Physical, chemical and microbial quality of raw material and processed products. Colour, taste, texture, flavor and appearance. Factors influencing the food quality - soil, field practices, harvesting practices, procedures, packaging, transportation, storage, conditions, processing conditions, packaging and storage conditions of finished products. Recording and reporting of quality. Quality - inspection and control. Quality management and quality assurance- total quality management (TQM), good manufacturing practices (GMP), good agricultural practices (GAP), and good laboratory practices (GLP). Quality management systems - quality services and solutions (QSS). Quality circles and statistical quality control (SQC). ISO system. HACCP - principles, implementation, plan documentation and record keeping. Auditing - surveillance, audit, mock audit, third party quality certifying audit, auditors and lead auditors. Certification - procedures, certifying bodies, accrediting bodies and international bodies.

**FT 310 Food Packaging Technology and Equipment** **2+1** **Sem. II**

Packaging situations in India and world. Packaging requirements, functions and material classification. Paper- manufacture, types and advantages of corrugated and paper board boxes, etc. Glass- manufacture, advantages and disadvantages. Metal (Aluminum / tin/ SS) - manufacture, advantages, disadvantages. Plastic- classification, properties and uses. Lamination. Moulding- injection, blow and extrusion. Coating on paper and films. Aseptic packaging – need, advantages, process, comparison of conventional and aseptic packaging, Permeability in relation to packaging requirement of foods. Transport properties of barriers. Simulations of product. Package environment interaction. Packaging of specific foods. Mechanical and functional tests on package.

Practical: Classification of various packages based on material and rigidity. Measurement of thickness, basic weight, grammage, water absorption, bursting strength, tear resistance, puncture resistance, tensile strength and grease resistance of paper and paper boards. Determination of gas and water transmission rate of package films. Determination of laquer integrity, drop test and box compression test. Identification of plastic films. Determination of seal integrity and ink adhesion. Packaging practices for fruits and vegetables. Shelf life calculations for food products. Head space analysis of packaged food. Study of vacuum packaging, bottle filling and form-fill-seal machines.

**FT 313 Principles of Food Science and Nutrition** **2+0** **Sem. I**

Concepts of Food Science - definitions, measurements, density, phase change, pH, osmosis, surface tension, colloidal systems etc. Food composition and chemistry - water, carbohydrates, proteins, fats, vitamins, minerals, flavours, colours, bioactives and important reactions. Food microbiology - bacteria, yeast, moulds, spoilage of fresh and processed foods. Production of fermented foods. Principles and methods of food processing and preservation - use of heat, low temperature, chemicals, radiation, drying, etc. Food and nutrition - Malnutrition (over and under nutrition). Nutritional disorders - energy metabolism (carbohydrate, fat and proteins). Balanced and modified diets. Menu planning. New trends in Food Science and Nutrition.

**FT 314 Food Safety and Standards** **2+1** **Sem. II**

Food safety - definition and importance. Scope and factors affecting food safety. Hazards and risks. Types of hazards - biological, chemical, physical hazards and management. Control of parameters - temperature, pH etc. Food storage. Product design. Hygiene, sanitation in food service. Establishments - introduction. Sources of contamination and their control, waste disposal, pest and rodent control. Personnel hygiene, food safety measures. Food safety management tools - basic concepts, PRPs, GHPs, GMPs, SSO'Ps, etc. HACCP. ISO series. TQM - concept and need for quality,

components of TQM, Kaizen. Risk analysis. Accreditation and auditing. Water analysis, surface sanitation and personal hygiene. Food laws and standards- Indian Food Regulatory Regime and FSSAI. Global scenario and CAC. Other laws and standards related to food. Recent concerns - new and emerging pathogens. Packaging, product labeling and nutritional labeling. Genetically modified foods, transgenics. Organic foods. Newer approaches to food safety. Recent outbreaks related to food safety. Indian and International standards for food products.

Practical: Water quality analysis - physico-chemical and microbiological. Preparation of different types of media. Microbiological examination of different food samples. Assessment of surface sanitation by swab/rinse method. Assessment of personal hygiene. Biochemical tests for identification of bacteria. Scheme for the detection of food borne pathogens. Preparation of plans for Implementation of FSMS - HACCP, ISO: 22000.

**FT 491 Agro-industrial Attachment** **0+4** **Sem. I**

- i. Fruits and Vegetables Industry
- ii. Beverages Industry
- iii. Cereal Industry
- iv. Milk Industry

**FT 492 Experiential Learning in Food Technologies** **0+20** **Sem. II**

Experiential Learning in processing of Cereals, Fruits and Vegetables in pilot plants. This shall include development of detailed project report on setting up of enterprise in the selected areas of product manufacture and evaluation of the module. The experiential learning is intended to build practical skills and entrepreneurship attributes among the students with an aim to deal with work situations and for better employability and self-employment.

**FT/ Mgt 493 Entrepreneurship Development** **2+1** **Sem. I**

Entrepreneurship- importance and growth, characteristics and qualities of entrepreneur, role of entrepreneurship, ethics and social responsibilities, entrepreneurship development. Assessing overall business environment in the Indian economy. Overview of Indian social, political and economic systems and their implications for decision making by individual entrepreneurs. Globalization and the emerging business/entrepreneurial environment. Concept of entrepreneurship, entrepreneurial and managerial characteristics, managing an enterprise, motivation and entrepreneurship development, importance of planning, monitoring, evaluation and follow up, managing competition, entrepreneurship development programs, SWOT analysis, generation, incubation and commercialization of ideas and innovations. Women entrepreneurship- role, importance and problems. Corporate entrepreneurship. Role, mobility of entrepreneur. Entrepreneurial motivation. Planning and evaluation of projects. Growth of firm, project identification and selection, factors inducing growth. Project feasibility study. Post planning of project, project planning and control. New venture management. Creativity. Government schemes and incentives for promotion of entrepreneurship. Government policy on small and medium enterprises (SMEs)/SSIs. Export and import policies relevant to food processing sector. Venture capital. Contract farming and joint ventures, public-private partnerships. Overview of food industry inputs. Characteristics of Indian food processing industries and export. Social responsibility of business.

Practical: Visit to public enterprise. Visit to private enterprise. Visit to agro-processing/food business centres. SWOT analysis of public and private enterprises. Project proposals as entrepreneur - individual and group. Presentation of project proposals in the class.

**FT 494 Student READY-Experiential Learning Programme - I** **0+7** **Sem. I**

Student READY - Experiential Learning in processing of fruits and vegetables in pilot plants. This shall include development of detailed project report on setting up of enterprise in the selected areas of product manufacture and evaluation of the module. The experiential learning is intended to build practical skills and entrepreneurship attributes among the students with an aim to deal with work situations and for better employability and self-employment.

**FT 495 Student READY- Experiential Learning Programme - II      0+7      Sem. I**

Student READY - Experiential learning in processing of grains in value added food products in pilot plants. This shall include development of detailed project report on setting up of enterprise in the selected areas of product manufacture and evaluation of the module. The experiential learning is intended to build practical skills and entrepreneurship attributes among the students with an aim to deal with work situations and for better employability and self-employment.

**FT 496 Student READY - Research Project      0+3      Sem. I**

**FT 497 Student READY - Seminar      0+1      Sem. I**

A power point presentation on any topic chosen from the subjects studied from vocational package to be prepared and delivered to the group of staff and students of department. Organization of topic. Presentation of data. Oral presentation. Delivery, language, explanation of figures. Ability to grasp and understand the subject and depth of understanding the topic.

**FT 498 Student READY- Industrial cum Educational Tour      0+2      Sem. I**

Student READY - Educational tour of two-three industries within and outside the state of the university and submission of report on industrial tour carrying a weightage of 0+2 credit hours.

**FT 499 Student READY - In-Plant Training      0+20      Sem. II**

Student READY - In-plant training of one semester duration with a credit load of 0+20 credit hours at relevant food processing industry, machinery manufacturer, marketing or other agencies. The In-plant training is intended to expose the students to an environment in which they are expected to be associated in their future career. The students will be required to have hands-on-experience in one or more commercial establishment.

**Postgraduate Courses**

**FT 501/FN 512 Principles of Food Processing      2+1      Sem. I**

Scope of food processing and historical developments. Principles and methods of food processing and preservation - blanching, pasteurization, sterilization and UHT processing, aseptic processing, canning, extrusion, baking, roasting, frying, drying, concentration and evaporation dielectric and microwave heating, refrigeration, freezing, controlled atmosphere (CA), modified atmosphere (MA), and dehydro-freezing. Non-thermal methods- irradiation, high pressure, pulsed electric field, hurdle technology, minimal processing and membrane technology. Food fermentations, pickling, smoking and chemical preservation. Practical: Canning, freeze drying, dehydration, concentration, refrigeration and freezing of foods. Determination of thermal inactivation time of enzymes. Use of chemicals in preservation of foods. Extrusion cooking. Preparation of intermediate moisture and fermented foods. Visit to a food processing plant.

**FT 502 Food Additives and Ingredients      2+1      Sem. I**

Food additives - definition, classification and functions. Preservatives, antioxidants, colours, flavours, emulsifiers, sequesterants, humectants, hydrocolloids, sweeteners, acidulants, buffering salts, anticaking agents - their food uses and functions in formulations. Toxicological evaluation of food additives. Flavours-types, generation during processing and reactions. Flavour composites. Stability of flavours during food

processing. Analysis and extraction techniques of flavours. Flavour emulsions. Essential oils and oleoresins, authentication of flavours. Proteins, starch and lipids as functional ingredients. Functional properties of nutraceuticals and fibre - their application in food.

Practical: Estimation of preservatives, sweeteners, fibre, colours, antioxidants, flavour enhancers. Functional properties of native and modified proteins, starch and lipids. Extraction of essential oil and oleoresins. Applications of additives and ingredients in foods.

### **FT 503 Food Quality Systems and Management**

**2+1 Sem. II**

Concept of quality. Quality attributes of raw and processed food- physical, chemical, nutritional, microbial, and sensory evaluation. Quality management systems- TQM, GMP/GHP, GLP, GAP, HACCP, ISO, Food Codex and Indian food standards. Statistical quality control. Sampling procedures and plans. Food Laws, Food Safety and Standards Act, 2006. Labelling issues. International food standards. Quality manual, documentation and audit Export - import policy and export documentation. Laboratory quality procedures and assessment of laboratory performance. Applications in different food industries. Food adulteration and food safety. IPR and Patents.

Practical: Assessment of quality attributes of raw and processed foods. Detection and estimation of food additives and adulterants. Quality assurance procedure, Preparation of quality policy & documentation. Implementation of HACCP. Visit to Units with ISO systems and with HACCP certification. Sensory & instrumental method for measuring food attributes, aflatoxins, pesticides & insecticide residues.

### **FT 504 Enzymes in Food Processing**

**2+1 Sem. II**

Enzymes- classification, properties, nature and mode of action. Sources and production of enzymes. Natural enzymes in foods - their significance in food processing. Commercial enzymes and their application in fruits (cell wall degrading enzymes for liquefaction, clarification, debittering, decolourization of very dark coloured juices), vegetables, milk (cheese making, whey processing), meat, poultry (tenderization) and egg, malting, brewing, baking (fungal ?- amylase for bread making, maltogenic?-amylases for anti-staling, xylanases, pentosanases and lipases as dough conditioners, oxidases as replacers of chemical oxidants) and confectionery. Enzymes for corn syrup solids (liquefaction, saccharification, isomerization for production of high-fructose-corn-syrup), fructose and fructo-oligosaccharides. Enzyme processing for flavours. Enzymatic approach to tailor- made fats.

Practical: Assay of enzymes in raw and processed foods. Applications of commercial enzymes in food product preparation- baking, starch hydrolysis, meat tenderization, cheese making and juice clarification.

### **FT 505 Nutraceuticals and Health Foods**

**2+1 Sem. I**

Introduction to nutraceuticals-definition, basis of claims for a compound as a nutraceutical, regulatory issues for nutraceuticals. Concept of angiogenesis and the role of nutraceuticals/functional foods. Nutraceuticals for various disorders and diseases- compounds and their mechanism of action and dosage level. Manufacturing aspects of selected nutraceuticals. Formulation of functional foods containing nutraceuticals- stability and analytical labelling issues. Clinical testing of nutraceuticals and health foods. Interactions of prescription drugs and nutraceuticals, adverse effects and toxicity of nutraceuticals. Nutrigenomics - an introduction and its relation to nutraceuticals.

Practical: Market survey of existing health foods. Identification and estimation of selected nutraceuticals. Production and quality evaluation of foods containing nutraceuticals. Development of labels for health foods. Visit to relevant processing Units.

### **FT 506 Inplant Training**

**0+1 (NC) Sem. I & II**

After the completion of theory, and research work, M.Sc. students would undergo compulsory inplant training in a food industry for a duration of six weeks. On completion of industrial inplant training the

students will be required to submit a written training report. The students will be evaluated for awarding the grade on the basis of project report, industry manager's report, oral presentation and viva-voce.

### **FT 507 Technology of Fruit and Vegetable Processing**

**2+1 Sem.I**

Indian and global scenario on production and processing of fruits and vegetables. Quality requirements of raw materials for processing. Post harvest handling, grading and treatments. Storage of fruits and vegetables-controlled atmosphere (CA) and modified atmosphere (MA) storages. Physiological and enzymological aspects of juice extraction. Fruit and vegetable processing for pulp, puree and concentrates using aseptic packaging, canning, RTS fruit beverages, IQF and frozen fruits and vegetables. Technology for processed products - pickles, chutneys, sauces. Processing of fruits for candies, bars, toffees, jams and jellies, squashes, syrups, cordials, nectars, vinegar and tomato products. Dehydration of fruits and vegetables using various drying technologies. Intermediate moisture fruits and vegetables. Food ingredients and chemicals from fruits, vegetables and their wastes. Effluent treatment. Trends in health aspects related to fruits and vegetables.

Practical: Equipment for fruits and vegetables processing. Plant layout. Grading, refrigeration and freezing of fruits and vegetables. Evaluation of pectin grade. Canning of fruits and vegetables. Preparation and quality evaluation of fruit jam, fruit jelly, marmalade, preserve and candy, fruit RTS, squash, syrups. Processing of tomato products. Preparation of guava cheese, pickles and chutneys. Preparation of dehydrated vegetables and fruits. Visit to fruits and vegetables processing factories.

### **FT 508 Technology of Cereals, Pulses and Oil seeds**

**2+1 Sem. I**

Production and utilization trends of different cereal grains. Structure and composition of common cereals, pulses and oil seeds. Wheat- evaluation of varieties, principles of milling, products and by-products, flour treatment, dough rheology, role of enzymes in wheat processing and technology of different bakery products. Rice- classification, milling technology, physico- chemical and cooking quality, accelerated ageing, milled rice products and by-product utilization, parboiling of rice and processed products from rice. Corn- types, milling, manufacture of value added products. Processing of barley, oats, sorghum and millets. Pulses- composition, anti nutritional factors, processing and utilisation. Importance of oil seeds processing industry in India. Processing of edible oils, protein isolates, concentrates and their uses. Extrusion cooking technology. Fermented foods and health foods from grains.

Practical: Physico-chemical analysis of grains and resultant flours. Experimental milling, Rheological properties of dough. Test baking. Milling of rice. Physicochemical and cooking quality of rice. Parboiling of rice. Malting of barley. Corn processing. Dehusking of pulses. Preparation of protein concentrates and isolates. Extraction of oil using expeller and solvent extraction methods. Preparation of extruded snacks and pasta products. Visit to related processing industries.

### **FT 509 Technology of Milk and Milk Products**

**2+1 Sem. I**

Present status of dairy industry in India and Abroad. Market milk-composition, quality evaluation and testing, procurement, transportation and processing. Cleaning & sanitization of dairy equipments. Fermented and special milks. Probiotic milk products. Technology of commercial manufacture, evaluation and defects of cream, butter, condensed milk, evaporated milk, skim & whole milk powder, ice cream, softy, cheese and yoghurt. Indigenous milk products - khoa, chhana, paneer, dahi and their products, and ghee. Milk by-products. Milk and whey protein concentrates, Lactose and health related other dairy ingredients.

Practical: Study on basics of reception of milk at the plant. Platform tests in milk. Estimation of fat and solid not fat (SNF) in milk. Operation of LTLT & HTST pasteurizer. Preparation of special milks. Cream separation & standardization of milk. Preparation and evaluation of table butter, ice-cream, cheese, yoghurt and indigenous milk products. Visit to dairy plants

**FT 510 Technology of Meat, Poultry and Fish****2+1 Sem. I**

Poultry and fish industry in India-Present status and scope. Structure and chemical composition of meat, Poultry and fish. Transportation of animals and birds. Modern abattoirs and poultry processing plants-lairage, facilities and procedures. Ante-mortem and post-mortem inspections. Conditioning of carcasses. Meat tenderization. Preservation, packaging, microbiology and recent advances in meat, fish and poultry processing and their products. Comminuted products. Hygiene and sanitation in meat, poultry and fish processing plants.. Evaluation of quality characteristics of fresh meat, poultry and their products. Quality evaluation of eggs. Manufacture of egg powder and other products. By-products of meat, fish and poultry industry. Preparation of fish oils, fish protein concentrate and other by-products.

Practical: Slaughtering and dressing of meat animals. Study of post-mortem changes. Meat cutting and handling. Evaluation of meat quality. Preservation by dehydration, freezing, canning, curing, smoking and pickling of fish and meat. Shelf-life studies on processed meat products. Evaluation of quality of eggs. Preservation of shell eggs. Estimation of meat: bone ratios. Preparation of meat products- barbecued sausages, loaves, burger and fish finger. Visit to meat processing plants.

**FT 511/PFE 510 Food Packaging****2+1 Sem. II**

Objectives and functions of packaging and packaging materials. Packaging requirements and selection of packaging materials. Types of packaging materials -paper, glass, metals, plastics- their properties and methods of testing and evaluation. Barrier properties of packaging materials- Theory of permeability and its measurement. Prediction of shelf life of foods, selection and design of packaging material for different foods. Packaging systems for different foods. Packaging equipment and machinery-vacuum, controlled atmosphere and modified atmosphere. Seal and shrink packaging, form and fill sealing, aseptic packaging systems, bottling and carton making equipments. Biodegradable packaging. Recent advances in packaging.

Practical: Identification and testing of packaging materials. Determination of wax from wax paper. Measurement of tin coating weight. Sulphide stain test. Thickness, substance weight, water absorption, capability of flexible packaging materials. Determination of equilibrium moisture content. Grading of glass bottles for alkalinity. Determination of water vapour and gas transmission rate of packaging material. Vacuum .and shrink packaging. Testing the compression strength of the boxes. Testing the strength of glass containers. Testing the strength of filled pouches by drop tester. Visit to packaging institute/industry.

**FT 601 Advances in Food Technology****2+0 Sem.II**

Membrane technology- micro-filtration, ultra-filtration, nano-filtration, reverse osmosis and their applications in food industry. Supercritical fluid extraction- concept and extraction methods. Microwave and radio frequency processing-mechanism and application in food processing. Hurdle technology- concept and its applications. High Pressure processing-concept, equipments for HPP treatment, mechanism and its application. Ultrasonic processing- properties and applications. New techniques-high intensity light, pulse electric field, ohmic heating, infra red heating, inductive heating and pulsed X-rays and nanotechnology in food processing. Techniques in fortification and stability of nutrients in relation to processing. Flavour stabilization.

**FT 602 Advanced Food Analysis****0+2 Sem. I**

Sample preparation for food analysis. Measurement of colour, viscosity/texture and water activity of raw and processed foods. Rheological techniques and instrumentation in food. Determination of browning reaction, food additives, residues and deleterious factors in raw and processed foods. Enzymatic, Thermal and Chromatographic methods in food analysis. Microscopic, Fluorimetric and polarimetric techniques in food analysis. Application and operating parameters of spectrophotometer, AAS (Atomic absorption spectroscopy), GC (Gas chromatography), HPLC (high performance liquid



chromatography), NMR (nuclear magnetic resonance), FTIR (Fourier transform infrared spectroscopy), GC-MS (gas chromatography-mass spectroscopy), LC-MS (liquid chromatography-mass spectroscopy).

### **FT 603 Product Design and Development**

**2+0 Sem.II**

Product development. Innovation strategy. Product development programme. Product development process - strategy, design, development, commercialization, launch and evaluation. Development of new product, technological knowledge, raw material properties, processing, product qualities, packaging requirements, distribution and marketing. Role of consumers in product development - consumer behavior and food preferences. Managing and improving the product development process. Market exploration and acquisition. Legal aspects of new product launch.

### **FT 604 Carbohydrate Technology**

**2+1 Sem. II**

Different carbohydrates in food products such as starch, cellulose, sugars, pectin, fibres (significance in diet, isolation from natural sources, and changes therein during processing). Chemical & enzymatic modification of carbohydrates especially starches and celluloses, manufacture of maltodextrins and corn syrups, Cyclodextrins - chemistry, technology and food applications. Interactions with other food constituents and their implications; Newer carbohydrates for food applications such as xanthan, dextran, pullulan, gellan, curdlan and  $\beta$ -glucans (nutraceutical and functional properties) Stabilization of food systems, simulated and low-fat foods, Fat-substitutes based on carbohydrates, Carbohydrate-based biodegradable packaging.

Practical: Isolation and assay of food carbohydrates; analysis of modified carbohydrates such as starches and celluloses; evaluating gelling abilities of different polysaccharides, their blends and the effect of food ingredients such as salts, sugars and acids; development of food products with newer carbohydrates in relevant food systems.

### **FT 605 Lipid Technology**

**2+1 Sem. I**

Nutritional aspects of food lipids and their sources- omega-3 and omega-6 fatty acids and their significance, Phytosterols and their nutraceutical significance. Measurement of lipid degradation parameters during deep-fat frying and storage of foods. Flavor emulsions and their stability. Fat powders like cream, butter, cod-liver oil etc. and techniques involved such as micro encapsulation, Fat substitutes based on carbohydrates and proteins. Formulation and characterization of low-fat spreads, whipped creams, margarines, mayonnaise, salad dressings etc. Bakery shortenings chemistry, formulation and technology. Trans-fatty acids- formation during processing and nutritional aspects, Enzymatic approach to tailor made fats.

Practical: Assay of lipid degradation and polymerization products in fried foods and fried oils; analysis of phytosterols, trans-fatty acids and omega fatty acids; preparation of fat and cream powders; formulation and stabilization of low fat spreads, margarines and mayonnaise based on locally available fats; applications of emulsifiers in industrially produced foods.

### **FT 606 Protein Technology**

**2+1 Sem. I**

Protein structure and chemistry; protein-protein interactions, methods of evaluation of protein quality and amount, Conventional and novel sources of protein. Production of proteins, protein concentrates/isolates from legumes, oilseeds, fish, seafood, leaf, microbes. Functional properties of proteins and their applications; Structure-function relationships of different food proteins, textured vegetable proteins and different methods of texturization. High protein food formulations, Modification of proteins by enzymic (manufacture of protein hydrolysates, their characterization and applications), chemical and physical methods. Interactions of proteins with flavours, polysaccharides, lipids and their technological effects, Protein-based fat substitutes, Protein engineering.

Practical: Isolation of proteins from different raw materials such as soybeans, oilseed meals, fish, leaves, milk; preparation of protein isolates, concentrates and hydrolysates and evaluation of their nutritional and functional properties; development of high-protein food formulations; visits to industrial units manufacturing protein-based products.

**FT 591 Seminar**

**FT 600 Master's Research FT 700 Ph.D. Research**

## FORESTRY AND NATURAL RESOURCES

### PROGRAMMES

M. Sc.

### COURSE REQUIREMENTS

Field of Specialization	Silviculture and Forest Management, Tree Improvement, Agroforestry, Forest Ecology and Wildlife.
Required Courses	Forst. 501, Forst. 502, Forst. 503, Forst. 504, Forst.505, Forst. 506
Supporting Courses	Stat. 421, PGS 501 and other courses from subject matter fields (other than minor) relating to area of special interest and research problem.
Minor Fields	Agronomy, Biotechnology, Botany, Economics, Plant Breeding and Genetics, Vegetable Science, Fruit Science, Floriculture and Landscaping, Soil Science or any other as approved by the Dean, Postgraduate Studies
Deficiency courses for students with elective other than Agronomy, Soil Science and Forestry	As recommended by the, Student's Advisory Committee and approved by the Dean, Postgraduate Studies

### DESCRIPTION OF COURSE CONTENTS

#### Diploma Courses

##### **Forst. 51 Elementary Agroforestry**

**1+1**

**Sem. I**

Introduction and importance of forests. State of forest cover and tree cover. Forestry, farm forestry, social forestry and agroforestry. Overview of national and global agro-forestry systems. Methods of growing trees with crops - boundary/block planting, alley cropping, windbreak/ shelter belts and homestead gardens. Agroforestry benefits/ limitations, and ecological and economic interactions. Choice of trees and crops for combined culture. Fodder, fuel, timber and other multipurpose trees for agroforestry. Environmental services of agroforestry plantations. Methods of regeneration, cultural practices and tending operations for agroforestry trees. People participation and role of national/international agencies. Agroforestry policy.

Practical: Identification of various agroforestry and other important forest trees. D & D exercise. Field layout of boundary/block plantations. Measurements of tree and crop parameters. Propagation and nursery practices for forest trees. Seed collection and handling. Agroforestry farm visits.

#### Undergraduate Courses

##### **Forst. 102 Introduction to Forestry**

**1+1**

**Sem. II**

Forestry - Introduction, related definitions. Objective of silviculture. Forest classification. Indian Forest Policies. Artificial and natural regeneration – objectives, choice between natural and artificial regeneration. Coppicing, pollarding, root suckers. Tending operations – weeding, cleaning and thinning methods. Forest mensuration – objectives, instruments for diameter, height and age measurement. Non instrumental and instrumental height measurement methods - shadow and single pole method, geometric and trigonometric principles. Tree stem form, form factor, form quotient. Measurement of volume of felled and standing trees. Agroforestry – definitions, importance, systems prevalent in the country and criteria of tree selection. Shifting cultivation. Taungya. Alley cropping. Home gardens. Wind breaks and shelter belts. Cultivation practices of two important fast growing tree species of the region.

Practical: Identification of tree-species. Diameter measurements of forked, buttressed, fluted and leaning trees. Height measurement of standing trees by shadow method, single pole method and hypsometer. Volume measurement of logs using various formulae. Nursery lay out, seed sowing, vegetative propagation techniques. Nursery raising practices of important tree species. Forest plantations and their management. Visits to nearby forest-based industries.

### **Forst. 103 Forest Resource Management**

**1+1**

**Sem. II**

(For students of COBS & H)

Forestry - Definition, scope and important terminology. Status of forests in India. Principles of forest management; scope, objectives and peculiarities of forest management with other land-use systems. History of forest development in India. Salient features of Forest Policies and Acts. National and International Forestry Organizations. Choice of species. Progressive yield. Growing stock (even and uneven aged forest), concept of normal forest, increment and rotation. Principle and concept of Sustainable Forest Management (SFM). Prerequisite, Criteria and indicators for SFM. Thinning and other intermediate treatments. Preparation of Management Plan Maps and Working Plan Maps. Forest based industries. Inter-regional and international trade in forest products. Financial criteria of forest project evaluation - NPV, IRR, B/C and Land Expectation Value (LEV). Natural and environmental resource accounting - methods and implications. Forest valuation of timber and non-timber forest products.

Practical: Identification of trees. Measurement of volume and biomass. Marketing channels of major and minor forest produce Methods of sale of forest produces in different forest timber depots. Estimation of demand and supply functions. Financial and economic appraisal of forestry projects. Discounting concepts and measures (Financial criteria - NPV, IRR, and B/C ratio). Environment Impact Assessment. Model project preparation of plantation establishment of any tree species. Methods of valuation of timber and non-timber forest products. Computer applications for using programming techniques in evaluating forest management. Visits to different forest-based industries.

### **Forst.491 Agro-industrial Attachment**

**(0+4)**

**Sem. I**

The students opting for this module under 491 series courses as Agroindustrial attachment will be attached for hands on training at either of the following locations/industries:

- i. Forest based Industry (Ply wood/ Furniture/Paper & Pulp, etc.)
- ii. High-tech Nursery (Tree Planting Stock Production) in public/private nurseries/farms

### **Forst.492 Experiential Learning in Nursery Production of Agro-forestry trees (0+20) Sem. II**

The students opting for this module under Experiential Learning Modules shall raise the nursery of assigned agro-forestry tree(s) as per the recommended PAU Packages of Practices for Forest Trees.

## **Postgraduate Courses**

### **Forst. 501 Silviculture**

**2+0 Sem. I**

Forest ecosystem concept, stand dynamics-forest succession, competition and tolerance, classification of world's forest vegetation. Productivity and vegetation forms of India, forest composition and structure. Ecophysiology of tree growth, effect of radiation and water relationship, mineral nutrients and temperature. Stem cambium, shoot and crown development and root growth. Natural regeneration of species and types including uneven aged silviculture. Intermediate treatments. Plantation in arid, coastal, hilly regions, water logged and salt affected sites. Silviculture of pure and mixed stands. Advanced and modern nursery tools and techniques. Silvics and silviculture of important conifers and broadleaved tree species.

### **Forst. 502 Forest Biometry and Management**

**3+1 Sem. II**

Definition, importance and scope. Measurement of tree parameters. Estimation of volume, growth and yield of individual tree and forest stands. Preparation of volume, yield and stand tables and their application. Forest inventory, sampling methods adopted in forestry, use of GPS in forest inventory and computer analysis of inventory data. Measurement of stand density. Simulation techniques. Growth and yield prediction models - their preparation and applications. Principles of forest management; scope and objective of forest management, development of forest management in India. Need for man-made forests. Site quality evaluation and importance. Stand growth, classical approaches to yield regulation in forest management, salient features and strategies. Forest valuation and appraisal in regulated forests. Forests and its importance, forest societies, interactions between forests and people, social and cultural factors of forest management. Gender dimension of forest management, tribal economy and forests. Forests and food security, eco-tourism and local development, land use change and forestry.

Practical: Measuring instruments and procedures for tree and stand measurement. Calculations of volume of felled as well as standing trees. Volume table preparation. Application of sampling procedures. Handling of GPS. Preparation of yield and stand table. Visits to plantations of different age gradation, record the actual growing stock and increment.

### **Forst. 503 Forest Ecology and Biodiversity Conservation**

**2+1 Sem. I**

Advances in forest ecology including forest population, forest community dynamics, forest community structure and analysis, forest productivity on a global scale, ecology of forest landscapes spatial heterogeneity. Hierarchy issues in ecology. Conservation of natural resources (hotspot areas, wildlife sanctuaries, national parks, biosphere reserves). Global warming and forests. Green House Effect and its consequences. Ozone depletion. Conservation laws and acts. Forest genetic resources of India, timber and non-timber species. Survey exploration and sampling strategies. Documentation and evaluation of forest genetical resources (FGR), in situ and ex situ conservation of gene resources. Biological diversity and its significance to sustainable use. Handling and storage of FGR. Intellectual property rights. Quarantine laws and FGR exchange.

Practical: Study of forest community structure and its successional status. Estimation of productivity of forest ecosystem. Trip to different regions of the state to study forest vegetation. Collection and preservation of specimen. Methods of vegetation analysis. Measurement of biomass and productivity. Quantification of litter production and decomposition. Visit to national parks, wildlife sanctuaries, botanical gardens and arboreta.

### **Forst. 504 Forest Protection and Conservation**

**2+1 Sem. II**

(In collaboration with Deptts. of Entomology, Plant Pathology and Zoology) Important pests of forest nurseries and plantations. Management strategies for control of pests. Breeding trees for resistance against key insects-pests and diseases. Mycoflora of tree seeds and management; role of mycorrhiza in tree health. Assessment of losses by diseases, insects, vertebrates; deterioration of timber; microclimate

influence on pests. Habitat management of vertebrate pests. Climatic factors, acid rain and air pollutants in relation to forest tree health. Forest fires and management. Wildlife damage in nurseries. Wildlife as important component of forest ecosystem. Importance and use of wildlife. Threats to wildlife. Role of people in wildlife conservation and awareness. Principles of wildlife conservation. Endangered species. Protected areas, zoos and wildlife conservation. Conservation acts. Extension and public participation. Minimum viable population size. General management plan for wild animals and special requirements. Management of zoos, wildlife sanctuaries and national parks. Management of harmful wildlife species. Climate change and wildlife.

Practical: Collection, identification and preservation of important insect-pests and disease specimens of forest trees, extraction of spores of VAM from soil and assessment of mycorrhizal root infestation, detection of insect infestation and seed borne mycoflora; estimation of losses caused by insects and diseases, laboratory tests for estimating decay resistance in wood, demonstration of power operated sprayer, spray technology for trees, fire control methods and devices.

### **Forst. 505 Tree Improvement**

**1+1 Sem. I**

General concepts. Reproduction, dimorphism pollination mechanisms. Pollen dispersion and pollen handling. Pollination mechanisms. Variation in trees: importance and its causes. Natural variation as a basis for tree improvement. Geographic variations - Ecotypes, clines and land races. Selective breeding methods- mass, family, within family, family plus within family. Plus tree selection for wood quality, disease resistance and agroforestry objectives. Selection strategies and choice of breeding methods. Indirect selection for biotic and abiotic stresses.

Practical: Floral biology, modes of reproduction and modes of pollination. Estimating pollen viability. Controlled pollination and pollen handling. Manipulation of flowering through hormones. Selection of superior phenotypes. Marking of candidate trees, plus trees and elite trees. Visit to species, provenance and progeny trials. Visit to seed orchards. Induction of polyploidy through colchicines treatment.

### **Forst. 506 Agroforestry**

**1+1 Sem. II**

Agroforestry objectives, importance and potential. Farming system. Community forestry and social forestry. Agroforestry systems - perspectives, national and global importance. Choice and management of agroforestry. Practices for live fences, hedge rows, alley- cropping, windbreaks and shelter belts, hill-slope and terrace farming, and wood-lots. Diagnostic and design methodology. Tree-crop interface and resource utilization. Nutrient budgeting and soil productivity in agroforestry systems. Agroforestry under different productivity levels. Yield optimization and economics of agroforestry enterprise.

Practical: Field visits to agroforestry and farm forestry sites. Methods of planting trees with crops. Lay out of agroforestry trials. Measurement of growth and yield parameters of agroforestry components, and data analysis. Marketing and economic appraisal of agroforestry projects. Determination of litter fall. Root studies in agroforestry system.

### **Forst. 507/ Econ 520 Forest Resource Management and Economics**

**1+1 Sem. I**

Importance of Forests, use of economic principles in forest resources problems. Forest products, demand and supply analysis, forest products marketing, forest capital theory. Inter-regional and international trade in forest products. Impact of economics and physical variables upon forest appraisal and management decisions. Externalities and property rights. Natural and environmental resource accounting –methods and implications. Application of operations research tools in evaluating forest management alternatives in public and private forest planning.

Practical: Exercises on estimation of demand and supply functions; biodiversity valuation, valuation of non-marketed forest products. Exercises on financial and economic appraisal of forestry projects. Exercises on marketing of forest products and international trade competitiveness. Computer applications for using programming techniques in evaluating forest management alternatives.

**Forst. 508 Forest Policy, Laws and International Conventions****2+0 Sem. I**

Forest policy - Relevance and scope; National Forest Policy - 1894, 1952 and 1988. General principles of criminal law; Indian Penal Code, criminal procedure code; Indian evidence act applied to forestry matters. Forest laws; Indian Forest Act -1927, the state amendments - Punjab and Haryana general provision and detailed study; Forest Conservation Act 1980, Forest (conservation) Rule 2003, The Biological Diversity Act.2002. The Cattle Trespass Act 1871. The wildlife (protection) Licensing (additional matters for consideration) rules 1983. Declaration of wildlife stock rules 2003. Wildlife Protection Act 1972. Other important forest rules and guidelines. Important case studies and landmark judgments.

**Forst. 509 Forests and People****2+0 Sem. I**

Forest societies, people and forests interactions between forests and people. Importance of forests in traditional farming systems, livestock economy and forests, social and cultural factors of forest management. Afforestation programmes and forest conflicts, wildlife and human conflicts, important forest movements like Chipko movement. Gender dimension of forest management. Pastoralists and their dependence on forests. Forests and economic security of tribals. Forests and food security, eco-tourism and local development, land use change and forestry. Forest rights, customary rights of people, community participation, ethnobotany, Joint Forest Management, global environmental change and land use, dams, forests and resettlement of tribals and non-tribals - case study. Poverty alleviation and forests, role of NGOs and other community based organizations in forest management.

**Forst. 510 Forest Products - Chemistry and Industries****2+1 Sem. II**

(Collaboration: Deptt. of Chemistry)

Importance of forest based industries in relation to Indian economy. Chemistry in relation to forest products. Description of different forest based industries - paper and pulp, furniture, bamboo, sports goods, pencil making, match box and splint making, use of wood of lesser known forest species for commercial purposes. Minor forest products- gums, resins, essential oils and tannins, fibres, bamboos and canes. Cell wall constituents. Chemistry of cellulose, starch, hemicelluloses and lignin. Extraneous components of wood-water and organic solvent soluble. Chemical composition of oleoresin from major pine species. Structural difference among different gums (arabic, ghatti, tragacanth). Chemical nature and uses of volatile oils, tannins, katha and cutch. Chemical nature and uses of important forest based dyes and pigments.

Practical: Estimation of cell wall contents - Hemicellulose and lignin, extraction of essential oils, resins, tannins, acetylation of wood. Moisture content, specific gravity and calorific value determination of wood samples. Determination of strength properties of wood. Visit to nearby forest based industries. Visit to State Forest Corporation's saw mill and wood fabrication unit.

**Forst. 591 Seminar****Forst. 600 Master's Research**

## FRUIT SCIENCE

### PROGRAMMES

1. M. Sc.
2. Ph. D.

### COURSE REQUIREMENTS

#### M. Sc.

Field of Specialization	Fruit Breeding, Fruit Production, Orchard Management, Horti-Agro Techniques, Nursery Production, Post-harvest Handling
Required Courses	Hort. 501, Hort. 502, Hort. 503, Hort. 504, Hort. 505
Supporting Courses	Stat. 421, PGS 501 and other courses from subject matter fields (other than minor) relating to area of special interest and research problem.
Minor Fields	Botany, Biochemistry, Biotechnology, Plant Breeding and Genetics, Soil Science, Vegetable Science or any other as approved by Dean, postgraduate Studies.
Deficiency Courses for the Student's with elective other than Horticulture	As recommended by Student's Advisory Committee and approved by the Dean, Postgraduate Studies

#### Ph. D.

Field of Specialization	Fruit Breeding, Fruit production, Orchard Management, Horti-Agro Techniques, Nursery Production, Post-harvest Handling
Required Courses	Hort. 601, Hort. 602, Hort. 603
Supporting Courses	Courses from subject matter fields (other than minor) relating to area of special interest and research problem.
Minor Fields	Botany, Biochemistry, Biotechnology, Plant Breeding and Genetics, Soil Science, Vegetable Science or any other as approved by Dean, postgraduate Studies.
Deficiency courses for students with M. Sc. (Agri.) in a discipline other than Pomology	Hort. 501, Hort. 502, Hort. 503, Hort. 504, Hort. 505 and other courses as recommended by Student's Advisory Committee

### DESCRIPTION OF COURSE CONTENTS

#### Diploma Courses



**Hort. 51 Elementary Fruit Cultivation****2+1 Sem. I**

Fruits: Importance, scope and their role in human nutrition. Fruit zones of Punjab. Planning, planting and after-care of fruit plants. Important hints (varieties, soil, irrigation, manuring and fertilization, weed management, training and pruning, harvesting, post-harvest handling, insect-pests and diseases) for the cultivation of fruit plants such as citrus, mango, pear, peach, plum, guava, grapes, litchi, loquat, ber, amla and papaya.

Practical: Identification of different fruit plants. Layout, digging and filling of pits. Planting of young plants and protection from adverse weather conditions. Training and pruning, manuring and fertilization, and methods of irrigation to different fruit plants. Identification and management of important diseases and pests of fruit plants.

**Hort. 52 Nursery Production of Fruit Crops****0+1 Sem. II**

Layout of a nursery. Extraction and storage of healthy seeds. Seed bed preparation. Raising of rootstock for different fruit plants. Soil solarization. Preparation of potting mixture. Selection of healthy scion wood. Practices in different methods of plant propagation like cuttings, layering, budding and grafting in fruit plants. Management practices i.e weed control, irrigation, nutrition, removal of sprouts, etc. Diagnosis and control of important diseases and pests in the nursery. Lifting and packing of nursery plants.

**Undergraduate Courses****Hort. 101 Fundamentals of Horticulture****1+1 Sem. I**

Horticulture - Definitions and branches, importance and scope. Horticultural and botanical classification. Climate and soil for horticultural crops. Plant propagation-methods and propagation structures. Seed dormancy, seed germination, principles of orchard establishment. Principles and methods of training and pruning, juvenility and flower bud differentiation. Unfruitfulness. Pollination, pollinizers and pollinators. Fertilization and parthenocarpy. Importance of plant bio-regulators in horticulture, irrigation-methods. Fertilizers application in horticultural crops.

Practical: Identification of garden tools. Identification of horticultural crops. Preparation of seed bed/nursery bed. Practice of sexual and asexual methods of propagation including micro-propagation. Layout and planting of orchard. Training and pruning of fruit trees. Preparation of potting mixture. Fertilizers application in different crops. Visits to commercial nurseries/orchard.

**Hort. 201 Production Technologies of Horticultural Crops****2+1 Sem. I**

(For students of B.Tech. (Biotechnology) : Importance and scope of fruit, vegetable and flower crops. Classification and climatic requirements for cultivation of horticultural crops. Importance of fruits and vegetables for nutritional security. Selection of site, fencing, wind break, layout and planting systems for orchards. Sexual and asexual methods of plant propagation. Production technology of important fruit crops: tropical - guava, mango, banana, papaya, pineapple and sapota; Sub-tropical-citrus, litchi, ber and grapes; temperate - apple, pear, peach, plum, almond and walnut. Production technology of important vegetable crops-potato, peas, tomato, chilli, onion, brinjal, okra, cabbage, cauliflower, muskmelon, watermelon, cucumber, carrot, radish and leafy vegetables. Production technology of important flower crops-rose, chrysanthemum, gladiolus, marigold, gerbera, carnation, liliium, jasmine, anthurium and orchids.

Practical: Identification of important fruit, vegetable and flower crops. Layout and planning for planting orchards. Preparation of seed beds. Raising of seedlings, rootstocks. Propagation techniques of major fruit, vegetable and flower crops. Visit to commercial nurseries and orchards

**Hort. 202 Production Technology for Fruit and Plantation Crops****1+1 Sem. II**

Horticulture-Definitions, Importance and scope of fruit and plantation crop industry in India, Selection

of site, layout and planting methods, Training and pruning of fruit and plantation crops, Importance of rootstocks. Propagation methods. Production technologies for the cultivation of major fruits - mango, banana, citrus, grape, guava, litchi, papaya, sapota, apple, pear, peach, plum, ber, walnut and almond. Minor fruits- date, pineapple, pomegranate, jackfruit, strawberry and plantation crops - coconut, arecanut, cashew, tea, coffee and rubber

Practical: Horticultural tools and their uses. Containers and potting mixtures. Sexual and asexual methods of propagation, Scarification and stratification of seeds, Identification and description of fruits/ plantation crops, Layout and planting systems. Methods of training and pruning of commercial fruits, Preparation of plant bioregulators and their uses, Important pests, diseases and physiological disorders of fruit and plantation crops. Visit to local commercial orchards.

**Hort. 301 Post-harvest Management and Value Addition of Fruits & Vegetable 1+1 Sem. I**

Importance of post-harvest management and processing of fruits and vegetables, extent and possible causes of post-harvest losses; pre and post-harvest factors affecting storage life and quality. Maturity, ripening and changes occurring during ripening; Harvesting, grading, pre-cooling, packing and transport, Storage (ZECC, cold storage, CA, MA, and hypobaric); Value addition concept; Principles and methods of preservation; Concepts and standards of intermediate moisture food - jam, jelly, marmalade, preserve, candy; tomato products, drying/ dehydration of fruits & vegetables, osmotic drying and canning. Fermented and non-fermented beverages, packaging of products.

Practical: Identification of equipment used in post-harvest handling. Applications of different types of packaging, containers for enhancing shelf life. Effect of temperature on shelf life and quality of produce. Demonstration of chilling and freezing injury in vegetables and fruits. Extraction and preservation of pulps and juices. Preparation of jam, jelly, marmalade, RTS, nectar, squash, osmotically dried products, fruit bar, candy, tomato and canned products. Quality evaluation of products - physico-chemical and sensory. Visit to processing unit/ industry.

**Hort. 302 Hi-tech Horticulture**

**2+1**

**Sem. II**

Introduction and importance, Containerized nursery production and mechanization, Micro-propagation of horticultural crops, Field preparation and improved planting methods, Protected cultivation-advantages, controlled conditions, methods and techniques, Micro-irrigation systems and their components, Fertigation EC and pH-based fertilizer scheduling, Canopy management, high density planting, Components of precision farming-remote sensing, Geographical Information System (GIS), Differential Geo-positioning System (DGPS), Variable Rate Applicators (VRA), Application of precision farming in fruit, vegetables and ornamental crops, Mechanized harvesting.

Practical: Types of polyhouses and shade net houses. Intercultural operations. Tools and equipment - identification and application. Micro-propagation. Nursery pro-trays. Micro-irrigation. Fertigation - EC and pH based fertilizer scheduling. Canopy management. Visit to hi-tech orchard/nursery.

**Hort. 491 Agro-industrial Attachment**

**0+4**

**Sem. I**

(i) Commercial Fruit Nurseries

**Hort. 492 Experiential Learning in Commercial Horticulture**

**0+20**

**Sem. II**

**Postgraduate Courses**

**Hort. 501 Tropical and Dry Land Fruit Production**

**2+1**

**Sem. I**

Origin, distribution, commercial importance and export potential. Ecophysiological requirements. Species and varieties. Rootstocks and propagation. Planting, root zone, training and pruning. Nutrition and water requirements, fertigation, role of bio- regulators, major pests, diseases, physiological disorders and their control measures. Abiotic factors limiting fruit production. Flowering, pollination and fruit set.

Quality improvement. Storage and ripening techniques. Industrial and export potential, Agri. Export Zones (AEZ) and industrial support. Fruit crops- citrus, mango, papaya, pineapple, banana, avocado, sapota, guava, ber, amla, Jack fruit, annonas and minor fruits of tropics.

Practical: Description and identification of species and varieties. Growth and development. Growth regulation. Nutritional and physiological disorders and their control. Rejuvenation of old and unproductive trees. Visit to commercial orchards. Project preparation for establishing commercial orchards.

### **Hort. 502 Sub-tropical and Temperate Fruit Production**

**2+1 Sem. II**

Origin, distribution, commercial importance and export potential. Ecophysiological requirements. Species and varieties. Rootstocks and propagation. Planting, root zone, training and pruning. Nutrition and water requirements, fertigation, role of bio- regulators, major pests, diseases, physiological disorders and their control measures. Abiotic factors limiting fruit production. Flowering, pollination and fruit set. Quality improvement. Storage and ripening techniques. Industrial and export potential, Agri. Export Zones (AEZ) and industrial support. Fruit crops- Apple, pear, quince, grapes, plum, peach, apricot, cherries, hazelnut, litchi, loquat, persimmon, kiwifruit, strawberry, walnut, almond, pistachio, pecan, mangosteen, carambola, bael, wood apple, fig, jamun, rambutan and pomegranate.

Practical: Description and identification of species and varieties. Growth and development. Growth regulation. Nutritional and physiological disorders and their control. Rejuvenation of old and unproductive trees. Visit to commercial orchards. Project preparation for establishing commercial orchards.

### **Hort. 503 Nutrient and Canopy Management in Fruit Crops**

**2+1 Sem. II**

Essential elements, criteria of essentiality. Natural sources and fertilizers. Role of essential elements in fruit plants. Interaction of nutrients. Canopy management, importance and advantages. Factors affecting canopy development. Canopy types and structures. Light interception and distribution in different types of tree canopies. Spacing and utilization of land area. Canopy management through the use of rootstock and scion, plant growth inhibitors, training and pruning and management practices. Canopy development in relation to growth, flowering, fruiting and fruit quality in temperate fruits, grapes, pomegranate, mango, sapota, guava, citrus and ber.

Practical: Leaf sampling techniques, Determination of nutrient status through soil and plant analysis. Study of different types of canopies. Training of plants for different canopy types. Canopy development through pruning, use of plant growth inhibitors and, geometry of planting. Effect of canopy types on production and quality of fruits.

### **Hort. 504 Principles and Practices of Plant Propagation.**

**2+1 Sem. II**

Introduction, life cycles in plants, cellular basis for propagation. Sexual propagation- apomixis, polyembryony, chimeras. Factors influencing seed germination, hormonal regulation of germination and seedling growth. Seed quality, treatment, packing, storage, certification and testing. Rooting of cuttings under mist and hot beds. Physiological, anatomical and biochemical aspects of root induction in cuttings. Selection of elite mother plants. Establishment of bud wood bank. Stock, scion and inter stock relationship and Incompatibility. Physiology of dwarfing rootstocks. Rejuvenation. Progeny orchard and scion bank. Micro-propagation - in vitro clonal propagation, direct organogenesis, embryogenesis, micrografting and meristem culture. Hardening, packing and transport of micro-propagules. Nursery structures.

Practical: Anatomical studies in rooting of cutting and graft union. Propagation structures. Use of media and PGR. Micropropagation and hardening of plants. Explant preparation, media preparation, culturing invitro,

clonal propagation, meristem culture, shoot tip culture, axillary bud culture., Micro grafting and hardening. Visit to TC labs and nurseries.

### **Hort. 505 Breeding of Fruit Crops**

**2+1 Sem. I**

Origin and distribution, taxonomical status of species and cultivars. Cytogenetics and genetic resources. Blossom biology, breeding objectives, systems and ideotypes. Crop improvement through introduction, selection, hybridization, mutation breeding, polyploid breeding and rootstock breeding. Improvement of quality traits. Resistance breeding for biotic and abiotic stresses. Biotechnological interventions, achievements and future thrust. The important temperate, sub-tropical and tropical fruit crops will be covered.

Practical: Characterization of germplasm. Blossom biology and anthesis. Estimating fertility status. Practices in hybridization, ploidy breeding, mutation breeding, evaluation of biometrical and quality traits. Screening for resistance, developing breeding programme for specific traits. Visit to research stations.

### **Hort. 506 Post-harvest Technology for Fruit Crops**

**2+1 Sem. II**

Importance and scope. Maturity indices, harvesting practices and grading for specific market requirements. Influence of pre-harvest practices, enzymatic and textural changes, respiration and transpiration. Physiology and biochemistry of fruit ripening, ethylene evolution and its management. Pre-cooling. Factors leading to post-harvest losses. Treatments prior to transportation viz. chlorination, waxing, chemicals, bio-control agents, natural plant products fungicides, hot-water, vapour heat treatment, sulphur fumigation and irradiation. Methods of storage. Physical injuries and disorders during storage. Packing methods and transport. Quality evaluation.

Practical: Analyzing maturity stages of commercially important fruit crops, harvesting methods, pre-cooling methods, grading. Pre-harvest and post-harvest application of growth substances, fungicides, nutrients, waxes and hot water treatments, sulphuring. Improved packing and storage of important horticultural commodities. Physiological loss in weight of fruits. Estimation of transpiration, respiration rate, ethylene release. Estimation of quality characteristics in stored fruits. Cold chain management - visit to cold storage and CA storage units. .

### **Hort. 507 Growth and Development of Horticultural Crops**

**2+1 Sem. I**

(In collaboration with Department of Botany)

Parameters of growth and development. Growth dynamics and morphogenesis. Annual, semi-perennial and perennial fruit crops. Effect of light and temperature. Assimilate partitioning during growth and development. Effect of water and mineral nutrition. Biosynthesis and role of growth promoters and inhibitors. Physiology of dormancy, bud break, juvenility, vegetative to reproductive inter phase, flowering, pollination, fertilization, fruit set, fruit drop, fruit growth, ripening and seed development. Growth and developmental processes during stress. Impact of pruning, training and chemical manipulations in fruit crops.

Practical: Dormancy mechanisms and stratification of seeds. Visit to different fruit zones to identify growth and development patterns. Techniques of growth analysis. Evaluation of photosynthetic efficiency. Study of growth regulator functions, hormone assays and ripening phenomenon in fruits. Stress impact on growth and development.

### **Hort. 508 Orchard Management and Organic Horticulture**

**2+1 Sem. I**

Soil quality and its management for orchard plantation. Effect of soil organic matter on physico-chemical characteristics of the soil. Moisture conservation and water requirement for fruit crops. Principles, methods

and scheduling of irrigation. Principles and status of organic horticulture. Organic farming systems. Organic inputs and their role. EM technology and its impact. Indigenous practices of organic farming, sustainable soil fertility, weed management and biological/natural control of pests and diseases. Fruit quality improvement. Good Agricultural Practices (GAP), HACCP and certification of organic products. Standards evolved by different agencies. Constraints in certification, organic horticulture and export.

Practical: Different methods of irrigation. Mulching and weed control in orchards. Determination of soil organic matter. Inter-cropping exercises. Input analysis of manures. Bio-composting, biofertilizers and their application. Methods of preparation of organic manures. EM technology and products. Biological/natural control of pests and diseases. soil solarization. Case studies. Residue analysis in organic products and documentation.

**Hort. 601 Advances in Breeding of Fruit Crops (pre- requisite Hort. 505) 3+0 Sem. I**

Evolutionary mechanisms, adaptation and domestication. Genetic resources, cytogenetics, cytomorphology, chemotaxonomy, genetics of important traits and their inheritance pattern. Variations and natural selection, spontaneous mutations, incompatibility systems in fruits. Recent advances in crop improvement through introduction and selection, chimeras, apomixis, clonal selections, intergeneric, interspecific and intervarietal hybridization, mutation and polyploid breeding, resistance breeding to biotic and abiotic stresses. Breeding for improving quality. Molecular and transgenic approaches in improvement of selected fruit crops: Mango, banana, papaya, grapes, citrus fruits, guava, sapota, pineapple, avocado, apple, pear, plums, peaches, apricot, cherries and strawberry.

**Hort. 602 Advances in Production of Fruit Crops 3+0 Sem. II**

National and international scenario. Advances in propagation, root stock problems and their influence, planting systems, High density planting and crop modeling. Precision farming. Aspects of crop regulation. Influence of stress factors, strategies to overcome stress effects. Integrated water and nutrient management. Total quality management of mango, banana, papaya, grapes, citrus. guava, sapota, pomegranate, amla, pineapple, avocado, jack fruit , fig, apple, pear, plum, strawberry, peach, apricot, cherries and nut crops.

**Hort. 603 Advances in Growth Regulation of Fruit Crops 3+0 Sem. II**

Ecophysiological influences on growth and development like flowering, fruit set, crop load and assimilate partitioning and distribution. Root and canopy regulation. Biosynthesis, metabolic and morphogenetic effects of different plant growth promoters and growth retardants. Absorption, translocation and degradation of phyto-hormones, internal and external factors influencing hormonal synthesis, biochemical action, growth promotion and inhibition. Canopy management for fertigated orchards. Growth regulation aspects of propagation, embryogenesis, seed and bud dormancy. Fruit bud initiation, flowering, off season production. Flower drop and thinning, fruit set and development, fruit drop, parthenocarp, fruit maturity, ripening and storage. Molecular approaches in crop growth regulation.

**Hort. 604 Advances in Nutrition of Fruit Crops 3+0 Sem. I**

Historical background. Organic and inorganic sources. Nutrition and plant health - role of macro, secondary and micro nutrients. Nutrient status of different types of soils. Mineral uptake and translocation - theories and mechanisms. Nutritional problems of saline, sodic and water logged soils and their solutions. Inter-relationships of elements of fruit plants. Deficiency and toxic nutrient symptoms. Nutritional disorders in fruits. Fertilizer needs, scheduling, foliar feeding and fertigation. Bio fertilizers- role and classification. Integrated nutrient management in fruit crops.

**Hort. 605 Biotic and Abiotic Stress Management in Fruit Crops. 3+0 Sem. I**

Stress-definition and classification. Biotic stress due to pathogens like fungi, bacteria, viruses and nematodes. Stresses due to water, temperature, radiation, wind and soil conditions. Impact of stress on horticultural crop production. Stress due to physiological and biochemical factors. Fruit crops suitable for different stress situations. Crop modeling for stress situations. Interaction among different stress and their impact on crop growth and productivity. Greenhouse effect and methane emission and its relevance to abiotic stresses, use of anti transpirants and PGRs. Soil moisture conservation, mulching, hydrophilic polymers. Rain water harvesting, increasing water use efficiency. Contingency planning to mitigate different stress situations, cropping systems, stability and sustainability indices.

**Hort. 591 Seminar**

**Hort. 600 Master's Research**

**Hort. 700 Ph.D. Research**

## PLANT BREEDING AND GENETICS

### PROGRAMMES:

1. M. Sc.
2. Ph. D.

### COURSE REQUIREMENT

#### M. Sc.

Field of Specialization	Plant Breeding, Genetics, Cytogenetics
Required Courses	PBG 501, PBG 502, PBG 503, PBG 504 and PBG 505
Supporting Courses	Stat. 421, PGS 501 and other courses from subject matter fields (other than minor) related to area of special interest and research problem.
Minor Fields	Biotechnology, Statistics, Plant Pathology, Entomology, Botany, Biochemistry, Microbiology, Agronomy or any other as approved by the Dean, postgraduate Studies
Deficiency courses for students with elective other than Plant Breeding, Genetics Studies and Biotechnology	As recommended by the Student's Advisory Committee and approved by the Dean, Postgraduate

#### Ph.D.

Field of Specialization	Plant Breeding, Genetics, Cytogenetics
Required courses	PBG 601, PBG 602, PBG 603
Supporting Courses	Courses from subject matter fields (other than minor) related to area of special interest and research problem.
Minor Fields	Biotechnology, Statistics, Plant Pathology, Entomology, Botany, Biochemistry, Microbiology, Agronomy or any other as approved by the Dean, postgraduate Studies.
Deficiency courses for with M. Sc. in discipline other than Plant Breeding and Genetics	PBG 501, PBG 502, PBG 503, PBG 504, PBG 505 and other courses students as recommended by Student's Advisory Committee





## DESCRIPTION OF COURSE CONTENTS

### Diploma Courses

#### **PBG 51 Hybrid Seed Production – I**

**2+2 Sem. I**

Hybrid seed production – history, importance, types of hybrids, development of inbred lines, single cross, double cross, three way cross etc. Concept of heterosis and advantages of hybrid cultivars. Systems of pollination control. Male sterility – inheritance, maintenance and utilization of genetic, cytoplasmic and cytoplasmic genetic of male sterility in seed production, sources of male sterility in different crops. Foundation and certified seed production in inbreds, hybrids, synthetics and composites in maize and bajra.

Practical: Handling hybrid production programme in maize hybrids - climate, soil, seed source, seed rate and spacing, isolation distance, border rows, planting ratios, methods of planting and earthing up, non-synchronization of flowering, manures, fertilizers and micronutrients, field inspections, weeding, irrigation, pests and diseases, precautions to be taken while detasseling, rouging, harvesting of seed crop, post harvest operations, grading, seed treatment, storage, field standards, seed standards for hybrids, standards for germination test. Hybrid seed production of vegetable crops.

#### **PBG 52 Seed testing and Quality Control**

**2+2 Sem. I**

Deterioration of crop varieties/hybrids. Factors responsible for loss of genetic purity, maintenance of genetic purity during seed production, safeguards for maintenance of genetic purity. Seed quality standards - Importance of good quality seed, characters of good quality seed, factors affecting seed quality, seed quality components and field standards. Seed sampling. Receipt and registration of samples, Physical purity analysis. Moisture test, Quick viability test. Testing for coated/pelleted seeds. Grow-out test. Seed health including pathogen and insect damage. Seed dormancy, types and methods to break it. Weed seed identification.. Seed Act and seed rules and law enforcement. Role of Punjab State Seed certification Authority (PSSCA), Inspection procedures and equipments required.

Practical: Sampling and submission of samples to seed testing laboratory, Obtaining working sample, physical purity analysis and reporting results. Germination test Methods of breaking dormancy, Tetrazolium test. Moisture testing. Visit to state seed testing laboratory. Field inspection at different crop growth stages for off types, pollen shedders, designated seed borne diseases, counts of the male and female plants in hybrid seed production, field inspection report for different crops, isolation distances. Seed priming treatment.

#### **PBG 53 Visits to Seed Production and Processing Units-I**

**0+2 Sem. I**

In order to give a practical exposure to the students and make them aware of the seed production techniques, the visits will be conducted to:

-University Seed production Farms at Ladhowal.

-Private seed growers/progressive farmers.

-Various organizations in both private/public sectors

in order to make them aware of working of seed industry and its problems.

#### **PBG 54 Project on Seed Production**

**0+4 Sem. I/ II**

The class will be divided into groups of 4-5 students each. Each group will be allotted a project(s) on seed production in the hybrids of field and vegetable crops. These groups will be raising the seed crop on their own by practically doing all the operations from the seed treatment, sowing, inspection, rouging, harvesting, processing, testing and packaging of the seed and finally they will submit a detailed report of the work done. Their performance will be closely monitored and assessed for final evaluation.

**PBG 55 Hybrid Seed Production – II****2+2 Sem. II**

Self-incompatibility and its utilization in hybrid seed production. Effect of planting designs on honey bee movements. Variety maintenance. Field inspection, Minimum Field and Seed Certification Standards. Grow-out test. Seed lots, Certified seed label, Certification tag. Validity period of certification.

Practical: Handling of Seed production planning in sunflower and summer vegetables with special reference to agronomic practices such as selection of field, seed rate and seed treatment, season and time of sowing, nursery raising, transplanting, optimum stage of harvesting, land and isolation requirements, rouging, harvesting, post harvest operations, grading. Seed treatment, storage, field standards, seed standards for hybrids, standards for germination test. Seed certifications procedures, seed drying, processing, cleaning, testing packaging, storage and marketing.

**PBG 56 Seed health****2+2 Sem. II**

Important storage pests namely seedborne plant pathogens (fungi, bacteria, viruses, viroids, nematodes), insects, mites, rodents and birds. Detection of seedborne pathogens and insects. Deterioration of seed due to storage fungi, insects, rodents, birds. Detection 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. Practices for safe storage, examination of seeds for infection with various tests.

Practical: Collection and identification of storage insect pests. Fumigation, fumigants, its safe handling and use, plant protection equipments and their use. Examination of seeds for infections. Washing test. Incubation methods. Seedling symptomatology test. Histopathology. NaOH seed-soak method. Collection and identification of storage pests. Dose estimation of various seed protectants. Methods of fumigation, fumigants, its safe handling and use. Plant protection equipment and their use.

**PBG 57 Seed processing and Storage****2+2 Sem. II**

Introduction and importance of seed processing. Seed drying, including dehumidification. Seed treatments. Cleaning, grading and processing. Seed storage: Thumb rule and its relevance for seed storage. Seed deterioration. Conservation of orthodox and recalcitrant seeds. Methods to minimize the loss of seed vigour and viability. Storage losses due to pests. Storage methods and godown sanitation. Storage structure. Storage pests and their control.

Practical: Operation and handling of mechanical drying equipments. Effect of drying on seed quality during storage. Seed processing equipment. Seed treating equipments. Seed extraction.

**PBG 58 Visits to Seed Production and Processing Units-II****0+2 Sem. II**

In order to give a practical exposure to the students and make them aware of the seed production techniques, the visits will be conducted to:

- Vegetable Seed Production Programmes under contract growing by NSC in Saparoon valley of Solan or Katrain valley of Kullu.
- Various processing plants at University Seed Farms/State processing Units and ICAR Regional Research Station, Karnal.

**PBG 59 Elementary Plant Breeding and Seed Production****2+1 Sem. I**

Classification of plants, botanical description and floral biology. Emasculation and pollination techniques in cereals, millets, pulses, oilseeds, cotton, sugarcane. Aims and objectives of plant breeding. Modes of reproduction, modes of pollination and their consequences. Mendel's laws of inheritance, qualitative and quantitative traits, genotype and phenotype, cytoplasmic inheritance. Methods of breeding - introduction, selection in self and cross pollinated crops. Hybridization and selection in self pollinated crops. Recurrent selection. Heterosis and inbreeding; hybrid breeding.

Methods of breeding asexually propagated crops. Male sterility and its utilization. Importance of seed production. Deterioration of crop varieties and its prevention. Different classes of seed. Production of nucleus and breeder seed. Foundation and certified seed production in self and cross pollinated crops. Seed certification. Seed act. Grow out test. Seed drying. Seed testing for quality assessment. Seed health. Seed treatment. Seed storage. Seed marketing.

Practical: Botanical description and floral biology of major crops. Hybridization kit. Hybridization techniques in different crops. Study of male sterility and hybrid seed production. Seed sampling. Tests for seed moisture, seed health, seed viability. Test of germination percentage. Grow out test. Varietal identification in seed production plots. Visit to seed processing plant.

## **Undergraduate Courses**

### **PBG 102 Fundamentals of Genetics**

**2+1 Sem. II**

Pre and Post Mendelian concepts of heredity. Mendelian principles of heredity. Architecture of chromosome - morphology, karyotype and ideogram. Special types of chromosomes. Chromosomal theory of inheritance. Cell cycle and cell division (mitosis and meiosis). Probability and Chi-square test. Dominance relationships. Epistatic interactions with example. Multiple alleles - blood group genetics, pleiotropism and pseudoalleles. Sex determination, sex linkage, sex limited and sex influenced traits. Linkage and its estimation. Crossing over mechanisms. Chromosome mapping. Structural and numerical variations in chromosome and their implications (genetic disorders). Use of haploids, dihaploids and doubled haploids in genetics. Mutation - classification, methods of inducing mutations, CIB technique, mutagenic agents. Qualitative and quantitative traits - polygenes and continuous variations, multiple factor hypothesis. Cytoplasmic inheritance. Nature, structure and replication of genetic material. Protein synthesis, transcription and translational mechanism of genetic material. Gene concept - gene structure, function and regulation, *Lac* and *Trp* operons.

Practical: Use of microscope. Study of cell structure. Mitosis and meiosis. Experiments on monohybrid, dihybrid, test cross and back cross. Experiments on epistatic interactions including test cross and back cross. Practice on mitotic and meiotic cell division. Experiments on probability and Chi-square test. Determination of linkage and cross-over analysis (through two point test cross and three point test cross data). Study on sex linked inheritance in *Drosophila*. Study of models on DNA and RNA structures.

### **PBG 201 Fundamentals of Plant Breeding**

**2+1**

**Sem. I**

Historical development, concept, nature and role of plant breeding. Major achievements and future prospects. Genetics in relation to plant breeding. Modes of reproduction. Male sterility - genetic consequences and cultivar options. Domestication, acclimatization and introduction. Centres of origin/diversity. Components of genetic variation, heritability and genetic advance. Genetic basis and breeding methods in self-pollinated crops - mass and pure line selection, hybridization techniques and handling of segregating population. Multiline concept. Concepts of population genetics and Hardy-Weinberg Law. Genetic basis and methods of breeding

cross - pollinated crops. Modes of selection. Population improvement schemes - ear to row method, modified ear to row, recurrent selection schemes. Heterosis and inbreeding depression. Development of inbred lines and hybrids, composite and synthetic varieties. Breeding methods in asexually propagated crops - clonal selection. Wide hybridization and pre-breeding. Polyploidy in relation to plant breeding. Mutation breeding - methods and uses. Breeding for important biotic and abiotic stresses. Introduction to biotechnological tools - DNA markers and marker assisted selection. Participatory plant breeding. Plant Breeders' and Farmers' Rights.

Practical: Plant breeder's kit. Study of germplasm of various crops. Study of floral structure of self-pollinated and cross-pollinated crops. Emasculation and hybridization techniques in self and cross-

pollinated crops. Consequences of inbreeding on genetic structure of resulting populations. Study of male sterility system. Handling of segregation populations. Maintenance of breeding records and data collection. Methods of calculating mean, range, variance, standard deviation, heritability. Designs used in plant breeding experiments, analysis of Randomized Block Design. Working out the mode of pollination in a given crop and extent of natural out-crossing. Prediction of performance of double cross hybrids.

**PBG 301 Crop Improvement – I (*Kharif* Crops)**

**1+1**

**Sem. I**

(For students of B.Sc. (Hons) Agri. and B. Tech. Biotechnology - In collaboration with Department of Fruit Science & Vegetable Science)

Centre of origin, distribution of species, wild relatives, utilization and conservation of plant genetic resources, major breeding objectives and procedures, study of genetics of qualitative and quantitative characters, innovative approaches for development of hybrids and varieties for yield, adaptability, stability, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional) in rice, maize, pigeonpea, mungbean, soybean, groundnut, castor, cotton, jute, sorghum, pearl millet, tobacco, brinjal, okra, muskmelon, guava and banana. Ideotype concept and climate resilient crop varieties for future.

Practical: Floral biology and crossing techniques in rice, maize, cotton, pearl millet, pigeonpea, mungbean, soybean, groundnut, brinjal, okra, muskmelon/bottle gourd, guava and banana. Maintenance breeding in different *kharif* crops. Study of field techniques for seed production. Hybrid seed production technologies in maize, cotton, rice and brinjal. Estimation of heterosis and inbreeding depression. Layout of field experiments. Study of quality traits. Important donors for different characters. Visit to seed production farms and research experiments.

**PBG 302 Crop Improvement – II (*Rabi* Crops)**

**1+1**

**Sem. II**

(For students of B.Sc. (Hons) Agri. and B. Tech. Biotechnology - In collaboration with Department of Fruit Science & Vegetable Science)

Centre of origin, distribution of species, wild relatives, utilization and conservation of plant genetic resources, study of genetics of qualitative and quantitative characters, major breeding objectives and procedures, innovative approaches for development of hybrids and varieties for yield, adaptability, stability, abiotic and biotic stress tolerance and quality (physical, chemical, nutritional) in wheat, barley, chickpea, lentil, rapeseed mustard, sunflower, sugarcane, oat, berseem, potato, chilli, onion, mango and citrus. Ideotype concept and climate resilient crop varieties for future.

Practical: Floral biology and crossing techniques in wheat, barley, rapeseed mustard, sunflower, sugarcane, chickpea, lentil, oat, berseem, potato, tomato chilli and onion. Maintenance breeding in different *rabi* crops. Study of field techniques for seed production. Hybrid seed production technologies in sunflower, mustard and chilli. Estimation of heritability. Layout of field experiments. Study of quality traits. Important donor parents for different characters. Visit to seed production farms and research experiments.

**PBG 303 Intellectual Property Rights**

**1+0**

**Sem. I**

Introduction to IP, GATT, WTO, TRIPs and WIPO. Treaties for IPR protection- Madrid protocol, Berne Convention, Budapest treaty, etc. Types of IP and legislations covering IPR in India- patents, copyrights, trademark, industrial design, geographical indications, integrated circuits, trade secrets. Patent Act 1970 and patent system in India. Convention on Biological Diversity, International treaty on plant genetic resources for food and agriculture (ITPGRFA). Indian Biological Diversity Act, 2002 and its salient features, access and benefit sharing. Introduction to UPOV and PPV & FR Act 2001, access and benefit sharing. Breeders, researchers and farmers rights along with protection of plant varieties. Traditional knowledge-meaning and rights of TK holders.

**PBG 304 Principles of Seed Technology****1+1****Sem. II**

Seed and seed technology - Introduction and importance. Causes of deterioration of crop varieties and their control. Maintenance of genetic purity during seed production. Seed quality - definition, characters of good quality seed. Different classes of seed. Foundation and certified seed production of important crops. DUS testing. Seed certification - phases, procedure and field inspection. Seed laws and its enforcement. Duties and powers of seed inspector, offences and penalties. Seed Control Order 1983. Seed production of non-GM crops. GM crops and organic seed production. Contamination by transgenes. Seed drying and processing. Seed testing for quality assessment. Seed treatment - importance, method of application and seed packing. Seed storage - general principles, stages and factors affecting seed longevity, measures for pest control. Seed marketing - structure and organization, sales generation activities, promotional media, factors affecting seed marketing, role of WTO and OECD. Private and public sectors - production and marketing strategies.

Practical: Seed production in wheat, maize, mungbean, chickpea, rapeseed-mustard, sunflower, chilli and onion. Seed sampling and testing - physical purity, moisture content, germination, viability, seedling vigour. Genetic purity test - grow out test and DNA fingerprinting. Seed certification - procedure, field inspections and preparation of reports. Visit to seed production farms and seed testing laboratories.

**PBG 305 Molecular Breeding Technologies****2+1****Sem. II**

In collaboration with School of Agricultural Biotechnology)  
(Optional course)

Limitations of conventional breeding strategies. Conventional and advanced Mapping populations - F<sub>2</sub>, DH, RILs, BC, NILs, NAM, MAGIC. Molecular markers- RFLP, RAPD, SCAR, SSR, STS, CAPS, AFLP, SNP and their applications. Development of linkage maps. Bulk Segregant Analysis and mapping genes for qualitative traits. Quantitative traits and mapping QTLs. Marker assisted selection and pyramiding. Commercial applications and success stories of Marker Assisted Selection. Introduction to genome sequencing platforms. Impact of genome sequencing on plant breeding. Genome editing and future of plant breeding. Doubled haploid breeding in cereals. Speed breeding in cereals.

Practical: DNA extraction. Assessing quality and quantity of DNA. Polymerase chain reaction, Agarose gel electrophoresis. DNA fingerprinting-hybrid purity and variety protection. Assessment of genetic diversity using SSR markers. Development of linkage maps using MapMaker. QTL mapping using WinQTL cartographer. Visit to genome sequencing facilities at other institutes. Introduction to Linux terminal. BLAST. Primer designing.

**PBG 491 Agro-industrial Attachment****0+4****Sem. I**

- Commercial Hybrid Seed Production Units

**PBG 492 Experiential Learning in Seed Production And Technology****0+20****Sem. II****Postgraduate Courses****PBG 501 Principles of Genetics****2+1****Sem.I**

History of genetics. Multiple alleles and Gene interactions. Sex determination, differentiation and sex-linkage. Linkage-detection. Recombination and genetic mapping in eukaryotes. Extra chromosomal inheritance. Hardy-Weinberg equilibrium. Nature, structure and replication of the genetic material. Genetic code. Protein biosynthesis. Genetic fine structure analysis, allelic complementation, split genes, transposable elements, overlapping genes, pseudogenes, oncogenes, gene families and clusters. Regulation of

gene activity in prokaryotes and eukaryotes. Molecular mechanisms of mutation, repair and suppression. Bacterial plasmids. Molecular chaperones. Gene isolation, synthesis and cloning. Genomic and cDNA libraries, nucleic acid hybridization and immunochemical detection. DNA sequencing. DNA restriction and modification, Anti-sense RNA and ribozymes. Micro-RNAs. Genomics and proteomics. Functional and pharmaco genomics. Metagenomics. Study of polymorphism at biochemical and DNA level. Transgenics and bioethics. Gene silencing. 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. 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.

### **PBG 502 Principles of Cytogenetics**

**2+1 Sem. II**

Architecture of chromosome in prokaryotes and eukaryotes. Artificial chromosomes and special types of chromosomes. Cell Cycle, synaptonemal complex, recombination models. Karyotyping. Chromosome banding and in situ hybridization. Structural variations of chromosomes and their implications. Variation in chromosome behaviour. Evolutionary significance of chromosomal aberrations. Polyploidy and its role in crop breeding. Aneuploidy and its role in basic and applied aspects of crop breeding. Apomixis. Genome mapping. Wide hybridization, Chromosome manipulations. Alien addition and substitution lines. Production and use of haploids and doubled haploids in genetics and plant breeding.

Practical: Learning the cytogenetics laboratory. Microscopy. Use of Electron microscope. Fixatives and fixing specimens. Studies on mitosis and meiosis in selected crops. Use of micrometers. Pollen germination in vivo and in vitro. Microtomy. Induction of polyploidy and identification in different crops. Induction and identification of haploids. Morphological and cytological observations on synthesized autopolyploids and allopolyploids. Morphological and cytological observations on aneuploids. Cytogenetic analysis of interspecific and intergeneric crosses. Maintenance of Cytogenetic stocks. Fluorescent in situ hybridization (FISH), Genomic in situ hybridization (GISH).

### **PBG 503 Principles of Plant Breeding**

**2+1 Sem. I**

History of Plant Breeding, objectives and achievements. Centres of origin, biodiversity and its significance. Plant introduction and role of plant genetic resources in plant breeding. Genetic basis of breeding self- and cross-pollinated crops, Mating systems and response to selection. Pure line theory. Breeding methods in self-, cross-pollinated and asexually reproducing crops. Heterosis and inbreeding. Concept of plant ideotype. Transgressive breeding. Hybrid breeding. Self-incompatibility and male sterility in crop plants and their commercial exploitation. Mutation breeding. Breeding for abiotic and biotic stresses. Testing, release and notification of varieties. Maintenance breeding. Participatory Plant Breeding. Plant Breeders' Rights and regulations for plant variety protection and farmers' rights.

Practical: Floral biology of self- and cross-pollinated species. Selfing and crossing techniques. Selection methods in segregating populations and evaluation of breeding material. Maintenance of experimental records. Estimation of heterosis and inbreeding depression. Techniques in hybrid seed production using male-sterility in field crops.

### **PBG 504 Principles of Quantitative Genetics**

**2+1 Sem. II**

Mendelian traits vs polygenic traits. Quantitative traits and their inheritance. Multiple factor hypothesis. Nature of gene action, epistatic and linkage effects. Analysis of Variance and variance components. MANOVA. Biplot analysis. Comparison of means and variances for significance. Designs for experiments. Genetic diversity analysis. Association analysis. Path analysis and parent-progeny regression analysis. Discriminant function and principal component analyses. Selection indices.

Heritability and genetic advance. Generation mean analysis. Mating designs. Genotype x environment interaction. Stability parameters. AMMI analysis - principles and interpretation. QTL mapping. Marker assisted selection (MAS).

Practical: Multiple factors inheritance. Partitioning of variance. Heritability and genetic advance. Covariance analysis. Metroglyph analysis.  $D^2$  analysis, cluster diagrams and dendrograms. Correlation analysis. Path analysis. Parent-progeny regression analysis. Diallel analysis. NCD. Line x tester analysis. Generation mean analysis. QTL mapping. Bi-parental mating and Triple Test Cross Stability analysis. AMMI model. Principal component analysis. Biplots and mapping genotypes. Construction of saturated linkage maps.

### **PBG 505 Heterosis Breeding**

**2+1 Sem. II**

Historical aspect of heterosis. Genetic theories of heterosis. Physiological, biochemical and molecular factors underlining heterosis. Prediction of heterosis. Development of heterotic pools in germplasm and inbreds. Male sterility and its use in heterosis breeding. Use of self- incompatibility in development of hybrids. Hybrid seed production system. Male sterile line development and diversification. Apomixis and heterosis. Genetically engineered male-sterility. Heterosis breeding in wheat, rice, cotton, maize, pearl millet, sorghum and oilseed crops. Hybrid breeding at National and International level.

Practical: Male sterile line development and characterization in different crops. Restorer line identification and diversification of male sterile sources. Breeding apomicts. Estimation of heterotic parameters in self-, cross- and asexually propagated crops. Hybrid seed production in field crops. Future prospects.

### **PBG 506 Mutagenesis and Mutation Breeding**

**1+1 Sem. I**

History of mutation breeding. Nature and classification of mutations. Spontaneous mutations. Detection of mutations in lower and higher organisms. Para-mutations. Physical and chemical mutagens and mode of action. Dose determination and factors influencing mutagenesis. Effect of mutations on DNA and repair mechanisms. Treatment methods. Observing mutagen effects in.  $M_1, M_2, M_3$  generation Factors influencing the mutant spectrum. Comparative evaluation of physical and chemical mutagens. Use of mutagens in creating oligogenic and polygenic variations - case studies. In vitro mutagenesis. Validation of mutants. Mutation breeding for various traits in different crops. Achievements of mutation breeding. Problems associated with mutation breeding. Use of mutagens in genomics. Allele mining and TILLING.

Practical: Mutagenic agents. Visit to radio isotope laboratory. Treating the plant propagules at different doses of physical and chemical mutagens. Raising the crop for observation- Study of  $M_1, M_2$  generation - Parameters to be observed. Mutation breeding in cereals, pulses, oilseeds, cotton, forage crops and vegetatively propagated crops. Procedure for detection of mutations for polygenic traits in  $M_2$  and  $M_3$  generations

### **PBG 507 Population Genetics**

**2+1 Sem. II**

Properties of population. Genetic constitution of a population. Mating systems. Frequencies of genes and genotypes and causes of changes. Hardy-Weinberg law and its applications. Multiple alleles. Sex linked genes. Use of gene and genotypic frequencies. Recurrent and non-recurrent selection. Selection favouring heterozygotes - overdominance for fitness. Non random mating. Selfing, sibmating, assortative and disassortative mating. Pedigreed populations. Estimation of selection, disequilibrium and linkage. Gene substitution and average effect. Genetic drift. Co- adapted gene complexes. Homeostasis. Adaptive organization of gene pools: polymorphism, heterozygous advantage - survival of recessive and deleterious alleles in populations.

Practical: Genetic exercise on probability. Estimation of gene frequencies. Factors affecting gene frequencies. Estimation of average effect of gene substitution and breeding value. Inbreeding and linkage disequilibrium. Cavalli's joint scaling test. Mating designs. Estimation of different population parameters from experimental data. Measurement of genotype x environment interaction. Genetic divergence.

### **PBG 508 Cell Biology and Molecular Genetics**

**2+1 Sem. II**

Ultrastructure of eukaryotic, prokaryotic cells and cellular organelles. Interphase nucleus- structure and chemical composition. Physiology of cell division. Historical background of molecular genetics. Structure and properties of nucleic acids. DNA transcription and its regulation. Genetic code. Regulation of protein synthesis in prokaryotes and eukaryotes. Transposable elements. Mechanisms of recombination in prokaryote. DNA organization in eukaryotic chromosomes. 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.

### **PBG 509 Breeding for Biotic and Abiotic Stress Resistance**

**2+1 Sem. II**

Plant breeding with reference to biotic and abiotic stress resistance. Biotic stresses in economically important crops. Host defense responses to pathogen invasions. Biochemical and molecular mechanisms. Host-pathogen interactions. Gene-for-gene hypothesis. Acquired and induced immunity. Systemic acquired resistance (SAR). Concept of signal transduction and other host-defense mechanisms against viruses and bacteria. Types and genetic mechanisms of resistance to biotic stresses. Phenotypic screening methods for major pests and diseases. Gene pyramiding. Classification of abiotic stresses - moisture stress/drought, water logging and submergence, wind, acidity, salinity/alkalinity/sodicity, temperature etc. Stress due to soil factors and mineral toxicity. Physiological and phenological responses. Genetics of abiotic stress resistance. Genes and genomics in breeding for abiotic stresses. Utilizing MAS procedures. Breeding for resistance to abiotic stresses. Exploitation of wild relatives as a source of resistance to biotic and abiotic factors in major field crops. Transgenics in management of biotic and abiotic stresses.

Practical: Phenotypic screening techniques for sucking pests, chewing pests, nematodes and borers. Use of standard MAS procedures. Phenotypic screening methods for diseases caused by fungi and bacteria. Screening crops for drought, flood resistance, acidity, alkalinity and temperature etc.

### **PBG 510 Breeding Field Crops**

**3+1 Sem. II**

Evolution and distribution of species and forms, wild relatives and germplasm, genetics, cytogenetics, genome relationship, breeding objectives, achievements and hybrid breeding in wheat, rice, maize, sugarcane, forage legumes, chickpea, other pulses, groundnut, rapeseed and mustard, sunflower, soybean and cotton. Distinguishing features of popular released varieties in rice, wheat, maize, sugarcane, pulses, oilseeds and cotton and their application to DUS testing. Maintenance of seed purity and seed production.

Practical: Floral biology. Emasculation - pollination techniques. Study of variation for yield and yield components. Study of segregating populations and their evaluation. Trait based screening for stress resistance in crops of importance. Use of descriptors for cataloguing. Germplasm maintenance. Standard evaluation system (SES) and descriptors. Use of softwares for database management and retrieval. Laboratory analysis of forage crops for crude protein, palatability, digestibility percent and other quality attributes. Wide hybridization in different crops. Visit to animal feed producing factories.

### **PBG 511 Breeding for Quality Traits**

**2+1 Sem. II**

Developmental biochemistry and genetics of carbohydrates, proteins, fats, vitamins, amino acids and anti-nutritional factors. Nutritional improvement. Breeding for grain quality parameters in rice, golden rice and aromatic rice, wheat, barley, oats, maize, forage crops, pulses, cotton, groundnut, rapeseed mustard,



sesame and sunflower. Breeding strategies for quality traits. Molecular and cytogenetic manipulation for quality. Post harvest manipulations. Molecular basis of fat formation and manipulation to achieve more PUFA in oil crops. Genetic engineering protocols for quality improvement. Nutritional genomics. Second generation transgenics and achievements.

Practical: Grain quality evaluation in rice. Correlating ageing and quality improvement in rice. Quality analysis in millets. Estimation of anti-nutritional factors. Quality parameters evaluation in wheat, cotton, pulses and oilseeds. Value addition in crop plants. Post harvest processing of major field crops. Quality improvement in crops through tissue culture techniques. Evaluating the available populations like RIL, NIL etc. for quality improvement using MAS procedures.

### **PBG 512 Gene Regulation and Expression**

**2+0 Sem. I**

Gene regulation in prokaryotes and eukaryotes. Levels of gene controls. Coordinated genetic regulation. Genetic and molecular basis depending on tissue specificity. Gene expression. Light regulated gene expression. Para-mutations and imprinting of genes and genomes. Transgene expression and gene silencing mechanisms. Regulatory genes. Transformation. Reporter systems. Combinatorial gene control. Eukaryotic transcriptional control. Translational and post-translational regulation. Signal transduction. Stress-induced gene expression. Gene traps and enhancer traps.

### **PBG 513 Maintenance Breeding and Concepts of Variety Release and Seed Production 1+1 Sem. I**

Variety development and maintenance. Defining variety, cultivar, extant variety, derived variety, reference variety, farmers' variety, hybrid and population. Variety testing, release and notification systems in India and abroad. US testing. Genetic deterioration of varieties. Maintenance of varieties. Principles of seed production. Generation system of seed multiplication. Quality seed production of cereals and millets, pulses, oilseeds, cotton and forages. Seed certification. Seed laws and plant variety protection regulations in India and international systems.

Practical: Identification of suitable areas for seed production. Ear-to-row method and nucleus seed production. Main characteristics of released and notified varieties, hybrids and parental lines. Identification of important weeds/objectable weeds. Determination of isolation distance and planting ratios in different crops. Seed production techniques of varieties in different crops. Hybrid seed production technology of important crops.

### **PBG 514 Collection, Management and Utilization of Plant Genetic Resources 3+1 Sem. II**

Germplasm exploration, collection and preservation. Ecological zones and genetic diversity. Post-exploration handling. Present status and future strategies in collection of crops such as rice, maize, sorghum, sesame, Brassica, cotton, etc. National and international legislations on germplasm collection and exchange. Database management system, statistical softwares, pictorial and graphical representation of data. Introduction of binomial, normal and negative cumulative normal. Use of probit scales, viability equations and nomograms. Germplasm documentation. Germplasm management system, global scenario. Management and utilization of germplasm collection. Predictive methods for identification of germplasm. Pest risk analysis, pest and pathogen information database. Quarantine in relation to integrated pest management. Detection and identification of pests including use of recent techniques like ELISA, PCR etc. International linkages in plant quarantine. GMOs or GEPs: concepts of biosafety and risk analysis, treaties and multilateral agreements governing trans-boundary movement of GEPs or GMOs and Indian regulatory system for biosafety. Concept of core collection. Pre-breeding. Harmonizing agrobiodiversity and agricultural development. Crop diversification. Participatory plant breeding.

Practical: Plant exploration and collection. Introductions. Techniques of coarse and fine grid surveys. Identification of wild relatives of crop plants. Estimation of sample size during plant explorations, impact of sampling, sequential sampling. Sample size for storage and viability testing. Test cases to understand quarantine regulations. Techniques for the detection of insects, mites, nematodes, bacteria, weeds,

pathogens and viruses on seed and planting materials and salvaging. Use of visual, qualitative, quantitative, microscopic, molecular and plant growth related techniques (controlled green houses/growth chambers, etc). Detection of GMOs and GEPs. Study of post-entry quarantine operation, seed treatment and other prophylactic treatments and preparation of herbarium specimens. Analysis of genetic diversity. Information management

**PGS 502 Intellectual Property Management, Biodiversity and Biosafety 2+0 Sem. I & II**

Introduction to Intellectual Property: history, concepts and types. International treaties and conventions for protection of IP'S. Role of intellectual property in growth, development, trade and commerce; Indian legislations for the protection of various types of Intellectual Property with a special reference to history and evolution of the concepts of geographical indicators, variety protection and patents. R & D expenditure vis-à-vis patents. PPVFRA: Process for protection of plant varieties, issues related to compliance and infringements. GI: Process for protection of goods, community involvement and benefit sharing. Patents: Search, process of filing patents, infringement and compliances. Biodiversity: Definition, importance, historical and geographical causes for diversity. Species and population biodiversity. Maintenance of ecological biodiversity. Biodiversity hot spots in India, Collection, conservation, documentation and characterization of biodiversity, development and maintenance of live repositories, community gene banks. Convention on biological diversity. National biodiversity protection initiatives; sustainable use of bio-diversity, benefit sharing, Bio-safety guidelines for the development and protection of genetically modified organisms; Cartagena Protocol of Bio-safety, its objective, salient features, risk assessment and risk management for GMO's, Bio-safety guidelines, rules and regulations and regulatory frame work for GMO in India; institutional arrangements at national level, procedure for direct use of GMO's in India. Licensing of technologies, Material transfer agreements, Research collaboration agreement, License Agreement.

**PBG 601 Genomics in Plant Breeding**

**2+1 Sem. II**

Introduction to the plant genome. Chloroplast and mitochondrial genomes. Genome size and complexity. Establishment of plant genome mapping projects. Genome mapping and use of molecular markers in plant breeding. Approaches for mapping quantitative trait loci. Map based cloning of plant genes. Regulation of plant gene expression. Functional genomics. Expression Analysis using Microarrays. Transposon tagging and insertional mutagenesis. Diversity array technology. Principles, techniques and applications of genome sequencing in plants. Comparative genomics: techniques and approaches. Detection of single nucleotide polymorphism. TILLING and Eco-TILLING. Role of transcriptomics, proteomics and metabolomics in linking genome and phenome. Knock out mutant studies and high throughput phenotyping. Concept of database development, management and bioinformatics.

Practical: Chromosome analysis. FISH. Comparative genomic hybridization. Comparative analysis of genomes using molecular markers. Genetic map construction. Mapping major genes. QTL mapping in plants. Plant genome databases. Computational tools to explore plant genome databases. Comparative genomics. Comparison of genome sequences using tools of bioinformatics. TILLING and Eco-TILLING. DNA array technology. Tools of transcriptomics, proteomics and metabolomics.

**PBG 602 Molecular and Chromosomal Manipulations for Crop Breeding 2+0 Sem. II**

Organization and structure of genome. Transcriptional and translational changes. Inheritance and expression of organellar DNA. Karyotyping. Tracking introgressions using FISH and GISH. Distant hybridization. Role of polyploids in crop evolution and breeding. Applications of cytogenetical methods for crop improvement. Totipotency of cells. Molecular Breeding: constructing molecular maps, integrating genetic, physical and molecular maps. diversity assessment and phylogenetic analysis. Gene tagging. Marker assisted selection of qualitative and quantitative traits. Genome structure and organization: cytogenetic and molecular analysis. Recent techniques of chromosome engineering. Crop genome evolution: progenitors and related species, comparative mapping, synteny. Gene expression in polyploids and wide hybrids. Alien gene

introgression in crop improvement. Recent advances, analysis and manipulation of crop genomes in wheat, rice, pearl millet, maize, cotton, oilseed, Brassicas, sunflower, soybean, pigeon pea, Vigna species and sugarcane. Current research topics in cytogenetics.

**PBG 603 Advances In Plant Breeding Systems**

**2+0 Sem. I**

Evolutionary concepts. Flower development, whorls formation and proposed models. Mating systems. Pollination mechanisms. Populations, gene pool, composites and synthetics. Complex population. Population improvement. Selection in self fertilizing crops. Genetic variability. Mass selection, pureline selection, pedigree method. Backcross, polycross and test cross. Selection in cross fertilizing crops. Polycross, topcross, mass and recurrent selection. Convergent and divergent selection. Recurrent selection, GCA and SCA. Selection in clonally propagated crops. Self-incompatibility and sterility. Male sterility and genetic engineering to create male sterility. Case studies: fertility restoration, conversion of agronomically ideal genotypes into male steriles, new cytonuclear interaction system for diversification of male steriles, photo and thermo sensitive genetic male sterility. Apomixis and its use in heterosis breeding. Incongruity.

**PBG 604 Breeding Designer Crops**

**2+1 Sem. II**

Breeding of crop ideotypes. Genetic manipulations through recombination breeding, genomics and transgenics for physiological efficiency, nutritional enhancement: proteins, vaccines, gums, starch and fats. Physiological efficiency, parametric and whole plant physiology for improvement in nutrient use efficiency, water use efficiency, osmotic adjustment, photosynthetic efficiency, stay green trait and its significance in crop improvement. Improvement in yield potential under sub-optimal conditions by manipulating source and sink, canopy architecture, plant-water relationships. Enhancing input use efficiency through genetic manipulations. Breeding for special traits viz., oil, protein, vitamins, amino acids etc. Biopharming and development of varieties producing vaccines, modified sugars, gums and starch. Biosafety management, segregation and isolation requirements in designer crop production and post-harvest management.

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

**PBG 605 Plant Genetic Resources and Crop Evolution**

**2+0 Sem. I**

Historical perspective and need for PGR conservation. Domestication. Gene pools. Basic genetic resources and transgenes. Exploration and collection of PGR-national and international protocols. Plant quarantine and phytosanitary certification. Germplasm exchange. Cryopreservation. Germplasm conservation. Orthodox seeds and vegetatively propagated crops. Registration of plant genetic resources. PGR database management. Multivariate and clustering analysis, descriptors. PGR for food and agriculture (PGRFA). PGR access and benefit sharing. Role of CGIAR system in the germplasm exchange. Geographical indicators. Genetics enhancement. Distant hybridization and introgression. Pre breeding. Utilization of genetic resources, concept of core and minicore collections. Origin and evolution of crop species. Patterns of evolution. Selection and genetic drift. Speciation and extinction. Stabilization of polyploids. Multifactorial design. Intragenomic and intergenomic interactions. Protein and DNA based methods to study crop evolution. Genome analysis and comparative genomics.

**PBG 606 Advanced Biometrical and Quantitative Genetics**

**2+1 Sem. I**

Principles of Biometrical genetics. Selection of parents. Advanced biometrical models for combining ability analysis. Simultaneous selection models. Multiple regression analysis. Designs and systems. Models in stability analysis. Pattern analysis. Additive Main Effect and Multiplicative Interaction (AMMI) analysis.

Principal component analysis. Additive and multiplicative model. Biplots and mapping genotypes. Genetic architecture of quantitative traits. Conventional analyses to detect gene actions. Partitioning of phenotypic/genotypic variance. Construction of saturated linkage maps. QTL mapping. Marker assisted selection (MAS). Practical : Working out efficiency of selection methods in different populations and interpretation. Biparental mating. Triple Test Cross (TTC). Advanced biometrical models for combining ability analysis. Stability analysis. Additive Main Effect and Multiplicative Interaction (AMMI) model. Principal Component Analysis model. Biplots and mapping genotypes. Construction of linkage maps and QTL mapping and statistical methods in QTL mapping. Phenotype and marker linkage studies.

**PBG 607 Advances in Breeding of Major Field Crops**

**3+0 Sem. I**

History, description, classification, origin and phylogenetic relationship, genome status in cultivated and alien species of major cereals and millets like rice, wheat, maize, pearl millet, sorghum, pulses, oilseeds, cotton, sugarcane, arid legumes and other forage crops etc. Breeding objectives of major crops. Genetic resources and their utilization. Genetics of quantitative and qualitative traits. Breeding for value addition and resistance to abiotic and biotic stresses. Conventional (line breeding, population improvement, hybrids) and other approaches (DH Populations, Marker Assisted Breeding, Development of new male sterility systems and transgenics). National and International accomplishments in genetic improvement of major field crops and their seed production.

**PBG 608 Microbial Genetics**

**2+1 Sem. I**

Nature of bacterial variation. Molecular aspects of mutation. Episomes and plasmids. Gene mapping in bacteria. Life cycle of bacteriophages. Genetic fine analysis of rII locus. Circular genetic map of phage T4. Transposable elements. Gene manipulation. Biochemical genetics of *Neurospora* and *Sacharomyces*. One gene - one enzyme hypothesis. Regulation of gene activity in prokaryotes. Molecular mechanisms of mutation, repair and suppression. Molecular chaperones and gene expression. Genetic basis of apoptosis. Transgenic bacteria and bioethics. Genetic basis of nodulation, nitrogen fixation and competition by rhizobia, genetic regulation of nitrogen fixation and quorum sensing in rhizobia. Genetics of mitochondria and chloroplasts.

Practical: Preparation of bacterial nutrient media. Assessment of generation time in the log-phage bacterial cultures. Handling of microorganisms. Isolation of rhizobia. Gram staining. Examination of polyhydroxy butyrate (PHB) production in rhizobia. Demonstration of N<sub>2</sub>-fixing nodules/bacterial inoculation in the legume-Rhizobium symbiotic system. Induction, isolation and characterization of auxotrophic and drug resistant mutants in bacteria. Determination of spontaneous and induced mutation frequencies. Discrete bacterial colony counts for the preparation of survival curves and determination of LD<sub>50</sub> of a mutagen. Tn-mediated mutagenesis. Analysis and isolation of plasmid DNA. Curing of plasmids.

**PBG 609 *In Situ* and *Ex Situ* Conservation of Germplasm**

**2+1 Sem. II**

Natural reserves and gene banks. *In situ* conservation of wild species. *In situ* conservation components, factors influencing conservation value, national plan for *in situ* conservation. *In situ* conservation of agrobiodiversity on-farm. *Ex situ* conservation: components, plant genetic resources conservation in gene banks, national gene banks, gene repositories, preservation of genetic materials under natural conditions, permafrost conservation, guidelines for sending seeds to network of active/ working collections, orthodox, recalcitrant seeds, clonal repositories, genetic stability under long term storage condition. *In vitro* storage. Cryopreservation. Cryoprotectants, desiccation, rapid and slow freezing, vitrification techniques, encapsulation/dehydration techniques, national facilities, achievements, application of cryopreservation in agriculture. Problems and prospects. Challenges ahead.

Practical: *In situ* conservation of wild species - case studies at National and International levels- *ex situ* techniques for active and long-term conservation of collections. Preparation and handling of materials, packaging, documentation. Design of cold storage modules. Conservation protocols for recalcitrant and

orthodox seeds. Cytological studies for assessing genetic stability, in vitro cultures-embryo, cell/suspension cultures, pollen cultures, study of cryotank facility and vitrification techniques. Visit to NBPGR/NBAGR.

**PBG 591 Seminar**

**PBG 600 Master's Research**

**PBG 700 Ph. D. Research**

## PLANT PATHOLOGY

### A. PLANT PATHOLOGY PROGRAMME

1. **M.Sc.**
2. **Ph.D**

### COURSE REQUIREMENTS

#### **M. Sc.**

Field of Specialization	Fungal Pathology, Plant Bacteriology, Plant Virology.
Required Courses	PI.Path.501, PI. Path. 502, PI.Path.503, PI.Path.504, PI.Path.505.
Supporting Courses	Stat.421, PGS 501 and other courses from subject matter fields (other than minor) relating to area of special interest and research problem.
Minor Fields	Agrometeorology, Biochemistry, Entomology, Fruit Science, Nematology, Plant Breeding and Genetics, Biotechnology, Vegetable Science, or any other as approved by the Dean, Postgraduate Studies.
Deficiency courses for students with the elective other than Crop Protection	As recommended by Student's Advisory Committee and approved by the Dean, Postgraduate Studies.

#### **Ph.D.**

Field of Specialization	Fungal Pathology, Plant Bacteriology, Plant Virology.
Required Courses	PI. Path. 601, PI. Path. 602, PI.Path.603, PI.Path. 604, PI. Path. 605.
Supporting Courses	Courses from subject matter fields (other than minor) relating to area of special interest and research problem.
Minor Fields	Agrometeorology, Biochemistry, Entomology, Fruit Science, Nematology, Plant Breeding and Genetics, Biotechnology, Vegetable Science, or any other as approved by the Dean, Postgraduate Studies.
Deficiency courses for students with M. Sc. (Agri.) in a discipline other than Plant Pathology	PI.Path.501, PI.Path.502, PI.Path.503, PI.Path.504, PI. Path. 505, and other courses as recommended by Student's Advisory Committee.

## DESCRIPTION OF COURSE CONTENTS

### Diploma Courses

#### PI. Path. 51 Diseases of Field Crops

1+1 Sem. I

Importance and concept of plant diseases. Symptoms and causes of diseases. Study of important diseases of wheat, rice, maize, barley, cotton, sugarcane, sorghum, gram, moong, mash, red gram, rapeseed and mustard and groundnut. Economic aspects of disease control.

**Practical:** Diagnosis by studying symptoms of important diseases of field crops. Demonstration of important methods of plant disease management. Practical field training in the use and operation of plant protection equipments.

#### PI. Path. 52 Diseases of Fruit and Vegetable Crops

1+1 Sem. II

Symptomatology, etiology and management of diseases of citrus, guava, mango, peach, pear, plum, ber, papaya, grapes, potato, tomato, brinjal, chillies, okra, cabbage, cauliflower, carrot, radish, turnip, onion, garlic and cucurbitaceous vegetables.

**Practical:** Diagnosis by studying symptoms of important diseases of fruit and vegetable crops. Preparation of fungicidal formulations.

### Undergraduate Courses

#### PI. Path.102 Fundamentals of Plant Pathology

3+1 Sem. II

Plant Pathology-concepts, terms, scope, objectives, causes and importance of plant diseases. History of plant pathology with special reference to Indian work. Pathogenesis, disease triangle, tetrahedron. Classification of plant diseases. Plant pathogens- fungi, bacteria, fastidious vascular bacteria, nematodes, phytoplasmas, spiroplasmas, viruses, viroids, algae, protozoa and phanerogamic parasites with examples of diseases caused by them. Symptoms due to diseases and abiotic stresses. Fungi- definition, characters, somatic structures, type of thalli, fungal tissues, modifications of thallus, reproduction. Nomenclature- binomial system and rules. Classification of fungi- key to divisions, sub-divisions, orders and classes. Bacteria and molliutes- morphological characters, methods of classification and reproduction. Viruses- nature, structure, replication and transmission. Phanerogamic plant parasites. Nematodes- morphology, reproduction, classification, symptoms and nature of damage. Growth and reproduction of plant pathogens. Liberation/ dispersal and survival of plant pathogens. Types of parasitism and variability in plant pathogens. Role of enzymes/toxins and growth regulators in disease development. Defence mechanisms in plants. Epidemiology and factors affecting disease development. Principles and methods of plant disease management. Fungicides/antibiotics- formulations, classification, mode of action, resistance development and management.

**Practical:** Acquaintance with laboratory equipment. Microscopy. Collection and preservation of plant disease specimens. Preparation of culture media, isolation and Koch's postulates. Structures of fungi. Symptoms of various plant diseases. Study of representative fungal genera. Staining and identification of plant pathogenic bacteria. Transmission of plant viruses. Study of phanerogamic plant parasites. Morphological features and identification of plant parasitic nematodes. Sampling and extraction of nematodes for soil and plant material. Preparation of nematode mounting. Fungicides and their formulations. Methods of pesticide application and their safe use. Calculation of fungicide sprays concentration.

#### PI. Path. 301 Diseases of Field and Horticultural Crops & their Management – I 2+1 Sem. I

Symptoms, etiology, disease cycle and management of diseases of following crops:

i). Field crops: Rice - blast, brown spot, bacterial blight, sheath blight, false smut, foot rot, khaira, tungro; Maize - stalk rots, downy mildews, leaf spots; Sorghum - smuts, grain mold, anthracnose; Bajra - downy mildew, ergot; Cotton - anthracnose, vascular wilt, black arm, leaf curl; Groundnut - early and late leaf spots, wilt, collar rot, peanut bud necrosis; Soybean - Rhizoctonia blight, bacterial spot, seed and seedling rot, mosaic; Pigeonpea - Phytophthora blight, wilt, sterility mosaic; Finger millet – blast, leaf spot; Black gram and Green gram - Cercospora leaf spot, anthracnose, web blight, yellow mosaic; Castor - Phytophthora blight; Tobacco - black shank, black root rot, mosaic.

ii) Horticultural crops: Guava - wilt, anthracnose; Banana - Panama wilt, bacterial wilt, Sigatoka, bunchy top; Papaya - foot rot, leaf curl, mosaic; Pomegranate - bacterial blight; Brinjal - Phomopsis blight and fruit rot, Sclerotinia blight, little leaf, root knot nematode; Tomato - damping off, wilt, early and late blight, buck eye rot, leaf curl, mosaic; Okra - yellow vein mosaic; Beans - anthracnose, bacterial blight; Ginger - soft rot; Turmeric - leaf spots; Colocasia - Phytophthora blight; Coconut - wilt, bud rot; Tea - blister blight; Coffee - rust.

Practical: General symptoms of plant diseases. Identification of symptoms and pathogens of selected diseases of rice, maize, sorghum, bajra, finger millet, cotton, groundnut, soybean, pigeonpea, black gram, green gram, castor, tobacco, guava, banana, papaya, pomegranate, brinjal, tomato, okra, ginger, turmeric, colocasia, coconut, coffee and tea. Field visits for the diagnosis of field problems. Collection and preservation of plant diseased specimens for herbarium.

### **Pl. Path. 302 Diseases of Field and Horticultural Crops & their Management - II 2+1 Sem. II**

Symptoms, etiology, disease cycle and management of diseases of following crops:

i). Field crops: Wheat - rusts, smuts, bunts, powdery mildew, Alternaria blight, ear cockle; Barley – smuts, stripe disease; Sugarcane - red rot, smut, wilt, grassy shoot, ratoon stunting, Pokkah boeng; Sunflower - Sclerotinia stem rot, Alternaria blight; Mustard - Alternaria blight, white rust, downy mildew, Sclerotinia stem rot; Gram - wilt, grey mould, Ascochyta blight; Lentil – rust, wilt; Pea - downy mildew, powdery mildew, rust; Berseem- stem rot.

ii). Horticultural crops: Mango - anthracnose, malformation, bacterial blight, powdery mildew, black tip; Citrus-gummosis, scab, die back, canker, greening; Grape vine - downy mildew, powdery mildew, anthracnose; Apple - scab, powdery mildew, fire blight; Peach - leaf curl, crown gall; Strawberry - leaf spot; Potato - early & late blight, black scurf, common scab, leaf roll, mosaic; Cruciferous vegetables- Alternaria leaf spot, black rot; Cucurbits - downy mildew, powdery mildew, wilt, mosaic; Onion and garlic - purple blotch, Stemphylium blight, downy mildew; Chillies -anthracnose and fruit rot, wilt, leaf curl; Coriander - stem gall; Marigold- Botrytis blight; Rose - dieback, powdery mildew, black leaf spot; Gladiolus - Botrytis blight

Practical: Identification of symptoms and pathogens of selected diseases of wheat, barley, sugarcane, sunflower, mustard, gram, lentil, peas, berseem, mango, citrus, grapevine, apple, peach, strawberry, potato, cruciferous vegetables, cucurbits, onion, garlic, chilli, coriander, marigold, rose and gladiolus. Field visits for the diagnosis of field problems. Collection and preservation of plant diseased specimens for herbarium.

### **Ent.-Pl. Path. 202 Principles of Integrated Pest and Disease Management 2+1 Sem. II**

Categories of insect pests and diseases. IPM - Introduction, history, importance, concepts, principles and tools. Economic importance of insect pests, diseases and pest risk analysis. Methods of detection and diagnosis of insect pests and diseases. Importance, calculation and dynamics of EIL and ETL. Methods of pest control - host plant resistance, cultural, mechanical, physical, legislative, biological and chemical control. Recent technologies for pest management. Pesticides and their misuse; first aid and antidotes. Insecticides Act 1968. Spray technology. Ecological management of crop environment. Survey, surveillance and forecasting of insect pests and diseases. Development



and validation of IPM module. Implementation and impact of IPM. IPM modules for insect pests and diseases. Safety issues in pesticide uses. Political, social and legal implications of IPM. Case histories of important IPM programmes.

Practical: Methods of diagnosis and detection of various insect pests and plant diseases. Sampling techniques for estimation of insect-pest and disease indices. Measurement of incidence of insect pests and diseases. Assessment of crop yield losses. Working out economics of IPM. Identification of biocontrol agents and natural enemies. Mass multiplication of *Beauveria bassiana*, *Bacillus thuringiensis*, *Trichoderma*, *Pseudomonas*, NPV and various parasitoids and predators. Pesticide appliances and their maintenance. Calculation of pesticide quantity for preparing spray material. Plan and assess preventive strategies (IPM module) and decision making. Monitoring of crop attacked by insect pests and diseases. Awareness campaign at farmers' fields.

**Ent.-PI. Path. 203 Fundamentals of Crop Protection**

**2+1**

**Sem. I**

(For students of B. Tech. Biotechnology)

Insects - their general body structure and modifications. Importance of insects in agriculture. Insect metamorphosis and development stages. Insect diversity. Feeding stages of insects and kinds (modifications) of mouth parts. Concepts in population build-up of insects - GEP, DB, EIL, ETH and pest status. Categories of insect-pests. Causes of insect-pests outbreak. General symptoms of insects attack. Principles and methods of insect-pests management. Integrated Pest Management concept. Bioecology and management of important pests of major crops and storage products. Importance and scope of plant pathology. Concept of disease in plants. Nature and classification of plant diseases. Importance and general characters of fungi, bacteria, fastidious bacteria, nematodes, phytoplasmas, spiroplasmas, viruses, viroids, algae, protozoa and phanerogamic parasites. Pathogenesis due to obligate and facultative parasites. Variability in plant pathogens. Conditions necessary for development of disease epidemics. Survival and dispersal of plant pathogens. Management of key diseases and nematodes of major crops.

Practical: Familiarization with generalized insect's body structure and appendages. Life stages. Acquaintance with insect diversity. Identification of important insect-pests of cereals, cotton, oilseeds, pulses, sugarcane, fruit and vegetables crops and stored-grains, and their symptoms of damage. Acquaintance with useful insects: predators, parasitoids, pollinators, honey bees and silk worms. Acquaintance to plant pathology laboratory equipment. Preparation of culture media for fungi and bacteria. Demonstration of Koch's postulates. Study of different groups of fungicides and antibiotics and methods of their evaluation. Diagnosis and identification of important diseases of cereals, cotton, oilseeds, pulses, sugarcane, fruit and vegetables crops and their characteristic symptoms. Acquaintance with various pesticidal formulations. Principles and working of common plant protection appliances. Calculation for preparing spray material.

**Ent-PI.Path. 491 Agro-Industrial Attachment**

**0+4**

**Sem I**

- i. Pesticide and Biopesticide Industries
- ii. Biocontrol Agents Production Units
- iii. Plant Quarantine Station
- iv. Virus free Potato Tuber Production Units

**Ent-PI.Path.492:Experiential Learning in Production Technology for Bioagents 0+20 Sem II**

## Postgraduate Courses

### PI. Path. 501 Mycology

2+1 Sem.I

Introduction, basic concepts and terminology. Mycology in relation to agriculture and mankind. History of mycology. Concepts of nomenclature and classification. Fungal biodiversity. Reproduction in fungi. Comparative morphology, ultrastructure and characters of different groups of fungi up to generic level of Divisions Myxomycota and Eumycota emphasizing sub- divisions Mastigomycotina Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina. Types of Lichens and importance, fungal genetics and variability in fungi.

Practical: Comparative study of different groups of fungi up to generic level of Divisions Myxomycota and Eumycota emphasizing sub-divisions Mastigomycotina, Zygomycotina, Ascomycotina, Basidiomycotina and Deuteromycotina. Collection, identification and preservation of specimens. Isolation and identification of plant pathogenic fungi.

### PI. Path. 502 Plant Virology

2+1 Sem. II

History of plant viruses, their composition and structure. Symptomatology of important plant viral diseases, transmission, chemical and physical properties. Host virus interaction and virus vector relationship. Virus nomenclature and classification, genome organization, replication and movement. Isolation, purification, electron microscopy, protein and nucleic acid based diagnostics. Mycoviruses, phytoplasma arbo and baculoviruses, satellite viruses, satellite RNAs, phages, viroids, and prions. Origin and evolution, mechanism of resistance and genetic engineering of plant viruses. Study of representative viral/mycoplasmal diseases, emphasizing their distribution, symptomatology, etiology, epidemiology and principles of plant viral disease control.

Practical: Study of symptoms caused by viruses, transmission, assay of viruses, physical properties, isolation and purification, method of raising antisera, serological tests, electron microscopy and ultratome, molecular diagnostics. Diagnosis of representative viral diseases.

### PI. Path. 503 Plant Bacteriology

2+1 Sem. II

History of bacteriology and introduction to phytopathogenic procarya. Importance of phytopathogenic bacteria. Evolution, classification and nomenclature of phytopathogenic procarya. Survival and dissemination of phytopathogenic bacteria. Important diseases caused by procarya. Growth, nutrition requirements, reproduction, preservation of bacterial cultures and variability among phytopathogenic procarya. General biology of bacteriophages, L- form bacteria, plasmids and bdellovibrios. Procaryotic inhibitors and their mode of action against phytopathogenic bacteria.

Practical: Isolation, purification, identification and host inoculation of phytopathogenic bacteria. Staining methods, biochemical and serological characterization. Isolation of plasmid and use of antibacterial chemicals/antibiotics.

### PI. Path. 504 Principles of Plant Pathology

3+0 Sem. I

Importance, terminology and concepts of plant diseases. History and growth of plant pathology. Biotic and abiotic causes of plant diseases. Growth, reproduction, survival and dispersal of important plant pathogens. Role of environment and host nutrition on disease development. Host parasite interaction, recognition concept and infection. Symptomatology, disease development. Role of enzymes, toxins, growth regulators. Defense strategies, oxidative burst, phenolics, phytoalexins, PR proteins and elicitors. Altered plant metabolism as affected by plant pathogens. Genetics of resistance, 'R' genes, mechanism of genetic variation in pathogens, molecular basis for resistance, marker-assisted selection and genetic engineering for disease resistance. Disease management strategies.

### PI. Path. 505 Principles of Plant Disease Management

2+1 Sem.I

Principles of plant disease management by cultural, physical, biological, chemical, organic amendments

and botanicals. Integrated control measures of plant diseases. Disease resistance and molecular approach for disease management. Foliage, seed and soil application of chemicals. Role of stickers, spreaders and other adjuvants. History of fungicides, bactericides, antibiotics, antivirals. Concepts of pathogen, immobilization, chemical protection and chemotherapy. Nature, properties and mode of action of antifungal, antibacterial and antiviral chemicals. Recent trends in the development of fungitoxicants, antibiotics and antiviral agents and relationships between their structures and activity. Environmental hazards, residual effects and safety measures.

Practical: *In vitro* and *in vivo* evaluation of chemicals against plant pathogens. Foliage, seed and soil application of chemicals. Role of stickers, spreaders and other adjuvants. ED and MIC values. Study of structural details of sprayers and dusters. Environmental hazards, residual effects and safety measures.

**PI. Path. 506 Detection and Diagnosis of Plant Diseases 0+2 Sem. II**

Isolation of pathogens using selective media, pure culture techniques. Methods to prove Koch's postulates with biotroph and necrotroph pathogens. Preservation of plant pathogens and disease specimens, use of haemocytometer, micrometer, centrifuge, pH meter, camera lucida. Microscopic techniques and staining methods, chromatography, phase contrast and electron microscopy, spectrophotometer, ultracentrifuge and electrophoretic apparatus. Serological and molecular techniques for detection of plant pathogens. Evaluation of fungicides and bactericides. Data collection and preparation of reports.

**PI. Path. 507 Integrated Disease Management 2+1 Sem. I**

Introduction, definition, concept and tools of disease management. Components of integrated disease management, their limitations and implications. Development of IDM and its adaptation in important crops, rice, wheat, cotton, sugarcane, chickpea, rapeseed mustard, pearl millet, Kharif pulses, vegetable and fruit crops.

Practical: Application of biological, cultural, chemical and biocontrol agents, their compatibility and integration in IDM. Demonstration of IDM in certain crops as project work.

**PI. Path. 508 Epidemiology and Forecasting of Plant Diseases 2+0 Sem. II**

Epidemic concept and historical development, pathometry and crop growth stages, epidemic growth and analysis. Common and natural logarithms, function fitting area under disease progress curve and correction factors, inoculum dynamics, population biology of pathogens, temporal spatial variability in plant pathogens. Survey, surveillance and vigilance, crop loss assessment and models. Principles and pre-requisites of forecasting, systems and factors affecting various components of forecastings, some early forecasting, procedures based on weather and inoculum potential, modelling disease growth and disease prediction.

**PI. Path. 509/Ent. 509/Nem. 509 Molecular Approaches in Plant Protection 2+1 Sem. II**

Recent concepts of molecular biology and techniques used in plant protection. Genes of interest in plant protection. Identification, characterization and isolation of novel genes involved in pest resistance. Molecular basis of host plant-insect and pathogen interactions. PR-proteins and G-proteins. Molecular characterization of biodiversity-insects and pathogens. Molecular biology of baculoviruses. Molecular mechanisms of genetically engineered plants for pest resistance and pesticide resistance. Improvement of biocontrol agents and useful insects using molecular techniques. Bio-safety related issues.

Practical: Molecular characterization of pest populations. Detection of biotypes/races. Establishment of phylogenetic relationships/dendrograms. Detection of Cry-gene and estimation of cry-toxin; characterization of capsid proteins of insect viruses. Detection of disease induced biochemical changes at molecular level.

**PI.Path.510/ Ent.510/ Nem. 510 Quarantine in Plant Protection****2+0 Sem.II**

Definition of pest and pesticides and transgenics as per Govt. notification. Relative importance and domestic & international quarantine. Quarantine restrictions in the movement of agricultural produce including seeds and planting material. Case histories of exotic pests and diseases and their status. Plant protection organization in India. Acts related to registration of pesticides and transgenics. History of quarantine legislations. PQ Order 2003. Environmental Acts and APEDA. Industrial registration. Import and Export of bio-control agents. Special requirements for biopesticide registration. Identification of pest and disease free areas. Contamination of food with toxins of micro-organisms and their elimination. Symptomatic diagnosis and other techniques to detect pest/pathogen infestations. VHT and other safer techniques of disinfestations and salvaging of infected material. WTO regulations. Non-tariff barriers. Pest risk analysis and good laboratory practices for pesticide laboratories. Pesticide industry. Sanitary and phytosanitary measures.

**PI. Path. 511 Post Harvest Diseases****2+1 Sem. II**

Concept of post harvest diseases, definitions, importance with reference to environment and health. Post-harvest diseases of fruits and vegetables. Factors governing post-harvest problems. Role of physical environment, agro-ecosystem leading to quiescent infection. Concept of microbial associations, rhizosphere/ rhizoplane colonization, competitive saprophytic ability, antibiosis, induced resistance. Operational mechanisms and cultural practices in perpetuation of pathogens. Operational mechanisms, handling and its relevance in control. Management of aflatoxigenic and mycotoxigenic fungi. Antagonists, their relationship and role as biocontrol agents. Chemicals in controlling post-harvest diseases. Merits and demerits of phyto-extracts in controlling post-harvest diseases. Integrated approach in controlling diseases and improving the shelf life of produce. Codex Alimentarius for agro-product and commodity.

Practical: Isolation, characterization and maintenance of important post-harvest pathogens. Role of different storage conditions for disease development. Application of antagonists against pathogens under *in vitro* and *in vivo* conditions. Comparative efficacy of different chemicals, fungicides, phyto-extracts and bioagents.

**PI. Path. 512 Fungal Diseases of Plants****2+1 Sem. I**

Nomenclature, classification and general characterization of fungi. Description of important phytopathogenic genera. Study of representative fungal diseases with emphasis on their distribution, symptomatology, etiology, epidemiology and control. Post harvest diseases in transit and storage and their management.

Practical: Characteristics of important phytopathogenic genera of fungi and their identification. Macro and microscopic diagnosis of representative diseases of various crops.

**PI.Path. 601 Ecology of Plant Pathogens****2+0 Sem.II**

Soil as an environment for plant pathogens, nature and importance of rhizosphere and rhizoplane, host exudates, soil and root inhabiting fungi. Dispersal, survival and dormancy of plant pathogens. Types of biocontrol agents. Inoculum potential and density in relation to host and soil variables, competition, predation, antibiosis and fungistasis. Role of rhizosphere, phyllosphere and spermosphere in disease development in relation to crop sequences. Suppressing soils, biological control, concepts and potentialities for managing soil borne pathogens.

**PI. Path. 602 Molecular Basis of Host-Pathogen Interaction****2+0 Sem.II**

Importance and role of biotechnological tools in Plant Pathology. Basic concepts and principles to study host pathogen relationship. Molecular basis of host-pathogen interaction, fungi, bacteria and viruses. Recognition system and signal transduction. Induction of defense responses, pathogenesis

related proteins, HR, reactive oxygen species, phytoalexins and systemic acquired resistance. Programmed Cell Death. Viral induced gene silencing. Molecular basis of gene-for-gene hypothesis. R-gene expression, transcription profiling, mapping and cloning of resistance genes, marker-aided selection and pyramiding of R genes. Biotechnology and disease management, development of disease resistant plants using genetic engineering approaches. Different methods of gene transfer.

**PI. Path. 603 Principles and Procedures of Certification**

**2+0 Sem.II**

Introduction to certification. International scenario of certification and role of ISTA, EPPO, OECD etc. in certification and quality control. Case studies of certification systems of USA and Europe. National regulatory mechanism and certification system including seed certification, minimum seed certification standards. National status of seed health in seed certification. Methods for testing vegetative propagules and *in vitro* cultures and genetic identity, physical purity, germination percentage, seed health etc. Fixing tolerance limits for diseases and insect pests in certification and quality control programmes. Accreditation of seed testing laboratories. Role of seed/ planting material health certification in national and international trade.

**PI. Path. 604 Advanced Systematic Mycology**

**3+0 Sem.I**

General introduction, historical development and advances in mycology. Recent taxonomic and morphological criteria for classification. Serological, chemical, molecular and numerical taxonomy. Interaction between groups and their phylogeny. Micro conidiation, conidiogenesis and sporulating structures of *fungi imperfecti*. Morphology and reproduction of representative plant pathogenic genera. Sexual reproduction in different groups of fungi. Population biology. Pathogenic variability. Heterokaryosis and parasexual cycle. Sex hormones in fungi. Pleomorphism and speciation in fungi. Mechanism of nuclear inheritance. Mechanism of extra- nuclear inheritance. Biodegradation.

**PI. Path. 605 Advanced Plant Virology**

**2+0 Sem. II**

Replication, assembly and architecture of plant viruses. Ultrastructural changes due to virus infection. Variation, mutation and virus strains. Mechanism of virus transmission by vectors, virus- vector relationship. Bimodal transmission and taxonomy of vectors and viruses, vector specificity for classes of viruses. Molecular mechanism of vector transmission, symptom expression, viroids and prions. Immunoglobulin structure and functions of various domains. Methods of immunodiagnosis, hybridoma technology, use of monoclonal antibodies. Polymerase Chain Reaction in identification of viruses and their strains. Genome organization, replication, transcription and translational strategies of pararetro viruses and gemini viruses. Satellite viruses and satellite RNA genome organization in tobamo, poty, bromo, cucummo, ilar and tospoviruses. Gene expression and regulation, viral promoters. Molecular mechanism of host virus interactions. Virus induced gene. Genetic engineering with plant viruses, viral suppressors, a RNAi dynamics, resistant genes. Viruses as potential vectors. Genetically engineered resistant and transgenic plants. Techniques and application of tissue culture. Origin, evolution and interrelationship with animal viruses.

**PI. Path. 606 Advanced Plant Bacteriology**

**2+0 Sem.I**

Current approaches for the characterization and identification of phytopathogenic bacteria. Ultrastructures and biology of bacteria. Role of enzyme, toxin, exopolysaccharide, polypeptide signals in disease development. Mechanism of wilt (*Ralstonia solanacearum*) development, mechanism of soft rot (*Erwinia* spp.) development, mechanism of crown gall formation (*Agrobacterium tumefaciens*). Host-bacterial pathogen interaction, quorum-sensing phenomenon, Type III secretion system, HR/SR reactions, R- genes, Avr-genes, hrp genes, Effector protein. Molecular variability among phytopathogenic procarya and possible host defense mechanism(s). Genetic engineering for management of bacterial plant pathogens, gene silencing and RNAi technology. Epidemiology in

relation to bacterial plant pathogens. Development of diagnostic kit. Beneficial prokaryotes. Endophytes, PGPR, phylloplane bacteria and their role in disease management. Endosymbionts for host defence.

**PI. Path. 591 Seminar**

**PI. Path. 600 Master's Research**

**PI. Path. 700 Ph. D. Research**

## B. NEMATODOLOGY PROGRAMME

### M.Sc.

#### COURSE REQUIREMENTS

Field of Specialization	Nematode Taxonomy, Host -parasite Relationships, Nematode Management, Nematode Ecology, Nematode Biology.
Required Courses	Nem. 501 , Nem. 502, Nem. 503 , Nem. 504, Nem. 505.
Supporting Courses	Stat. 421, PGS 501 and other courses from subject matter fields (other than minor) relating to area of special interest and research problem.
Minor Fields	Entomology, Fruit Science, Microbiology, Plant Pathology and Vegetable Science or any other as approved by the Dean, Postgraduate Studies.
Deficiency courses for students with elective other than Crop Protection	As recommended by the Student's Advisory Committee and approved by the Dean, Postgraduate Studies.

#### Postgraduate Courses

##### **Nem. 501 Structural and Functional Organization of Nematodes** **2+1 Sem.I**

General organization of nematode body. Morphology and anatomy of nematode cuticle, hypodermis, musculature and pseudocoelom. Structural variations of stoma, esophagus, intestine and rectum in nematodes. Reproductive system, its variations, terminology, nemic eggs and sperms and types of reproduction, spermatogenesis and oogenesis. Types and structure of excretory systems. Nervous system and associated sense organs.

Practical: Studies on variation in nematode shapes and sizes, morphological details of cuticle, cuticular markings and ornamentation, variations in stoma, esophagus, rectum; types and parts of female and male reproductive systems, sense organs, and excretory system.

##### **Nem. 502 Classification of Nematodes** **2+1 Sem.I**

Nematode systematics and comparison with its allies. Comparative study of morphological and allometric variations and evaluation of characters of classification. Classification of Phylum Nematoda. Orders of class Adenophorea and Secernentea. Diagnosis of order Tylenchida- Suborder Tylenchina, Hoplolaimina and Criconematina, their families and genera. Diagnosis of genera and families of orders Aphelenchida, Dorylaimida, Enoplida, Rhabditida with emphasis on economically important taxa.

Practical: Identification of common plant parasitic nematodes belonging to orders Tylenchida, Dorylaimida, Aphelenchida and Enoplida up to generic level and up to species level for major nematode pests of crops with the help of keys and illustrations. Identification of Entomopathogenic nematodes belonging to Order Rhabditida.

##### **Nem. 503 Nematological Techniques** **1+2 Sem.I**

Methods of survey and surveillance. Soil and plant sampling for characterizing nematode communities. Techniques for extraction of nematodes from soil and plant material. Sterilization of soil and culture media. Killing, fixing, clearing and mounting nematodes; Nematode measurements, *in vitro* and *in vivo* culturing techniques of plant parasitic, bacteriophagous, mycophagous and omnivorous nematodes. Staining nematodes in plant tissues. Microtomy for histopathological studies. Collection of plant root exudates and their bioassay. Principles and use of light, scanning and transmission electron microscopes, and other laboratory equipments. Application of molecular techniques in Nematology.

Practical: Collection of soil and plant samples. Extraction of nematodes from soil and plant material. Estimation of population densities. Staining plant material for nematodes. Mounting nematodes by slow and Seinhorst's methods; preparation of temporary and permanent mounts. Preparation of perineal pattern, vulval cone, en-face views and body section of nematodes. Measurements, drawing, microphotography. Collection of root exudates, preparation of exhibits of nematode diseased plant material, *in vitro* culturing techniques of nematodes- callous culture, excised root and carrot disc techniques.

### **Nem. 504 Nematode Diseases of Crops**

**2+1 Sem.II**

Diagnosis of Nematode diseases, their causal organisms, distribution, host range, biology, life cycle, nature of damage, symptoms and management in different crops. Nematode parasites as primary or secondary pathogens. Disease concept terminology. Interaction of nematodes with other organisms. Detailed account of ear-cockle, tundu and molya diseases of wheat. Cyst, rice root nematode, ufra and white tip diseases of rice. Lesion and cyst nematodes of maize and sorghum. Root knot, reniform, lesion, lance nematode, sugarbeet cyst, pigeon pea cyst and soybean cyst nematode problems on pulses, sugar cane, fibre, fodder and oilseed crops. Root-knot, reniform, stem and bulb nematode, potato cyst nematode on vegetable crops. Nematode problems of protected cultivation. Root-knot and reniform nematode on fruit crops. Slow decline of citrus. Mushroom nematode problems. Burrowing nematode problem of banana, spices and condiments, root-knot and lesion nematode diseases of coffee and tea. Red ring disease of coconut and pine wilt disease.

Practical: Diagnosis of causal organisms. Identification of different life cycle stages. Study of symptoms and histopathology of nematode damage in different crops and field diagnosis of nematode problems.

### **Nem. 505 Nematode Management**

**2+1 Sem.II**

Concepts and history of nematode management. Crop loss estimation. Nematicides, their types, classification, mode of action, applicators, application methods, and antidotes. Cultural practices including sanitation, crop rotations and cropping sequences, fallowing, flooding, soil solarisation, time of sowing, organic amendments of soil, biofumigation and trap crops. Use of heat, hot water treatment and other methods of disinfestations of planting material. Biocontrol methods, concept and terminology, use of predators and parasites as biological control agents, their mass multiplication and field use. Antagonistic plants and antinemic plant products. Plant resistance. Host defence system, morphological and anatomical resistance. Chemicals in host defence, post infectious chemicals, phytoalexins, hypersensitivity and its mechanisms. Quarantine regulations and pest risk analysis; integrated nematode management- concepts and applications. Pest risk analysis. Pesticide risks, cost-benefit ratios and partial budgeting; case studies of successful IPM programmes.

Practical: *In vitro* screening of synthetic chemicals and plant products for nematicidal activity, and their application methods. Methods for screening of crop germplasm for resistance against nematodes. Laboratory exercises on biocontrol potential of fungal, bacterial parasites, predaceous fungi and nematodes.

### **Nem. 506 Principles of Taxonomy**

**2+0 Sem.I**



History and principles of systematics and its importance. Levels and functions of systematics. Identification methods, character matrix and taxonomic keys. Taxonomic characters. Analogy vs homology, parallel vs convergent evolution, intraspecific variation in characters. Polythetic and polymorphic taxa. Sexual dimorphism. phenetics, cladistics and evolutionary classification. Components of biological classification: hierarchy, rank, category and taxon. Species concepts, cryptic, sibling and etho-species, infra-specific categories. Speciation, anagenesis vs cladogenesis, allopatric, sympatric and parapatric processes. Introduction to numerical, biological and cytogenetical taxonomy. Common vs Scientific names. International Code of Zoological Nomenclature (ICZN), criteria for availability and validity of names. Categories of names under consideration of ICZN. Principles of priority, and homonymy, synonymy, type concept in zoological nomenclature.

**Nem. 507 Nematode Biology and Physiology**

**1+1 Sem.I**

Host finding, invasion, feeding, hatching, moulting and life cycle patterns in different types of nematodes. Types of reproduction, gametogenesis, embryogenesis and post embryogenesis in nematodes. Physiology of body wall and chemical composition of nematodes. Hydrolytic enzymes, pseudocoelom and function of transport in nematodes. Physiology of digestive system. Respiration and intermediary metabolism. Osmoregulation. Physiology of nutrition, excretory-secretory and neuromuscular systems in nematodes.

Practical: Studies on embryogenesis and post-embryogenesis, hatching, moulting, life cycle development, feeding, enzymatic assay by electrophoresis.

**Nem. 508 Nematode Ecology**

**1+1 Sem.II**

Definition and scope. Components of environment. Evolution of nematodes. Ecological classification. Prevalence, distribution and dispersal of nematodes. Role of nematodes in the food web. Community analysis and population estimation models. Effects of abiotic and biotic factors on nematodes. Environmental extremes and nematode behaviour. Survival strategies of nematodes in adverse environment. Modeling population dynamics and relations with crop performance; ecological considerations in nematode management, data interpretation and systems simulation.

Practical: Study of nematode fauna in varied agro-ecological systems, community analysis of nematode populations, laboratory exercises on influence of abiotic factors on movement and hatching, green-house experiments on effect of abiotic factors on nematode populations and plant growth. Pathogenicity of nematodes alone or in association with other organisms.

**Nem. 509/Ent.509/PI.Path.509 Molecular Approaches in Plant Protection**

**2+1 Sem.II**

Recent concepts of molecular biology and techniques used in plant protection. Genes of interest in plant protection. Identification, characterization and isolation of novel genes involved in pest resistance. Molecular basis of host plant-insect and pathogen interactions. PR-proteins and G- proteins. Molecular characterization of biodiversity-insects and pathogens. Molecular biology of baculoviruses. Molecular mechanisms of genetically engineered plants for pest resistance and pesticide resistance. Improvement of biocontrol agents and useful insects using molecular techniques. Bio-safety related issues.

Practical: Molecular characterization of pest populations. Detection of biotypes/races. Establishment of phylogenetic relationships/dendrograms. Detection of cry-gene and estimation of cry-toxin; characterization of capsid proteins of insect viruses. Detection of disease induced biochemical changes at molecular level.

**Nem. 510/Ent.510/PI.Path.510 Quarantine in Plant Protection**

**2+0 Sem.II**

Definition of pest and pesticides and transgenics as per Government notification. Relative importance and domestic & international quarantine. Quarantine restrictions in the movement of agricultural produce

including seeds and planting material. Case histories of exotic pests and diseases and their status. Plant protection organization in India. Acts related to registration of pesticides and transgenics. History of quarantine legislations. PQ Order 2003. Environmental Acts and APEDA. Industrial registration. Import and export of bio-control agents. Special requirements for biopesticide registration. Identification of pest and disease free areas. Contamination of food with toxins of micro-organisms and their elimination. Symptomatic diagnosis and other techniques to detect pest/pathogen infestations. VHT and other safer techniques of disinfestations and salvaging of infected material. WTO regulations. Non-tariff barriers. Pest risk analysis and good laboratory practices for pesticide laboratories. Pesticide industry. Sanitary and phytosanitary measures.

### **Nem.511 Nematode Interaction with Other Organisms**

**1+1 Sem.II**

Concept of interaction, its importance in disease complexes and their management involving nematode and other organisms. Interaction of plant parasitic nematodes with wilt causing fungal pathogens. Interaction of plant parasitic nematodes with root rot and other fungal pathogens. Interaction of plant parasitic nematodes with bacterial pathogens, other nematodes and arthropods. Virus transmission by nematodes.

Practical: Green-house experiments to study the role of plant parasitic nematodes in wilt or rot causing fungal and bacterial pathogens.

### **Nem. 512 Beneficial Nematodes**

**1+1 Sem.II**

Beneficial nematode fauna, predators, parasites of insects, molluscs and other pests; Entomophilic nematodes, their important groups and types of associations. Taxonomic characteristics of nematode parasites of insects. Host-parasite relations and life cycle of mermithids, entaphelenchids, thelastomids, sphaerularids and tylenchids. *Steinernema* and *Heterorhabditis*, their morphological characteristics, taxonomic status, biology and mode of action. Entomopathogenic nematodes- mass multiplication techniques, formulations, field applications and efficacy, and commercial products. Nematodes as biological models and as indicators of pollution. Role of nematodes in organic matter recycling.

Practical: Isolation, identification, mass rearing and application methods of entomopathogenic nematodes. Evaluating *in vitro* survival and on other culture media.

### **Nem. 591 Seminar**

### **Nem. 600 Master's Research**

## SOIL SCIENCE

### PROGRAMMES

1. M.Sc.
2. Ph.D.

### COURSE REQUIREMENTS

#### M.Sc.

Field of Specialization	Pedology, Soil Chemistry, Soil Conservation, Soil Fertility, Soil Microbiology, Soil Physics
Required Courses	Soils 501, Soils 502, Soils 503, Soils 504, Soils 505,
Supporting Courses	Stat. 421, PGS 501 and other courses from subject matter fields (other than minor) relating to special interest and research problem
Minor Fields	Agronomy, Biochemistry, Botany, Chemistry, Microbiology, Soil and Water Engineering, Vegetable Science or any other as approved by Dean, postgraduate Studies
Deficiency courses for the students with elective other than Soil Science, Agronomy Studies and Agroforestry	As recommended by Student's Advisory Committee and approved by the Dean, Postgraduate

#### Ph.D.

Field of Specialization	Pedology, Soil Chemistry, Soil Conservation, Soil Fertility, Soil Microbiology, Soil Physics
Required Courses	Soils 601, Soils 602, Soils 603
Supporting Courses	Courses from subject matter fields (other than minor) relating to area of special interest and research problem
Minor Fields	Agronomy, Biochemistry, Botany, Chemistry, Microbiology, Soil and Water Engineering, Vegetable Science or any other as approved by Dean, postgraduate Studies
Deficiency Courses for other students with M.Sc. (Agri.) in a discipline other than Soil Science	Soils 501, Soils 502, Soils 503, Soils 504, Soils 505 and courses as recommended by Student's Advisory Committee

## DESCRIPTION OF COURSE CONTENTS

### Diploma Courses

#### **Soils 51 Elementary Soil Fertility**

**2+1**

**Sem. I**

Components of soil. Function of soil for plant growth. Rocks and minerals. Weathering. Soil forming factors and processes. Soil profile. Soils of Punjab. Essential nutrients - criteria of essentiality, form present in soil, functions and deficiency symptoms. Soil colloids - properties, types and importance. Ion exchange - CEC and AEC. Organic matter and its mineralization. Soil organisms and their beneficial and harmful roles. Soil reaction, saline and sodic soils and their reclamation. Fertilizer and manures. Time and method of fertilizer application.

Practical: Identification of rocks and minerals. Study of soil profile. Visit to soil testing lab. Determination of pH, EC and organic carbon. Gypsum requirement of sodic soils. Identification of fertilizer. Diagnosis of nutrient deficiency symptoms in the field. Collection of soil samples for different purposes. Preparation of farm compost.

#### **Soils 52 Elementary Soil Physics and Conservation**

**2+1**

**Sem. II**

Soil as a three phase system - components and distribution in surface and subsoil. Soil texture - importance and textural classification. Volume-mass relationships in soils. Soil Structure - classification, significance and management. Soil-water retention, storage, measurement, plant available water, soil water constants, infiltration. Soil air -composition and renewal. Soil temperature - thermal properties, diurnal and seasonal variations and management. Soil erosion - significance. Soil erosion - forms, causes, factors affecting, soil erosion management including gully erosion control. Wind erosion - causes, factors, forms and management including shelterbelts and wind breaks.

Practical: Particle size analysis. Dry aggregate size analysis. Determination of bulk and particle density. Determination of soil moisture, soil moisture tension, and water intake in soils. Determination of total and air filled pore spaces. Measurement of soil temperature. Determination of per cent surface cover by mulches and crop canopy. Determination of run-off and soil loss. Determination of splash erosion. Visit to soil conservation works.

### Undergraduate Courses

#### **Soils 101 Fundamentals of Soil Science**

**2+1**

**Sem. I**

Soil as a natural body, pedological and edaphological concepts of soil; Soil genesis: soil forming rocks and minerals; weathering, processes and factors of soil formation; Soil Profile, components of soil; Soil physical properties: soil-texture, structure, density, porosity, soil colour and consistence; Elementary knowledge of soil taxonomy classification and soils of India; Soil water retention, movement and availability; Soil air, composition, gaseous exchange, and plant growth, Soil temperature; source, amount and flow of heat in soil; effect on plant growth, Soil reaction-pH, soil acidity and alkalinity, buffering, effect of pH on nutrient availability; soil colloids - inorganic and organic; silicate clays: constitution and properties; sources of charge; ion exchange, cation exchange capacity, base saturation; soil organic matter: composition, properties and its influence on soil properties; humic substances - nature and properties; soil organisms: macro and micro organisms, their beneficial and harmful effects.

Practical: Study of soil profile in field. Collection of representative soil sample, its processing and storage. Study of soil forming rocks and minerals. Determination of particle and bulk densities, moisture content and porosity. Determination of soil texture by feel and laboratory methods. Determination of soil pH and electrical conductivity. Determination of cation exchange capacity of soil. Study of soil map. Determination of soil colour. Estimation of organic matter content of soil.

**Env 101 Environmental Studies and Disaster Management** **2+0** **Sem. I and II**  
 (For students B.Sc. (Hons) Agri./B.Tech.(Biotechnology)/ B.Tech. (Food Technology)/Integrated M.Sc (Hons.)/B.Sc. (Hons) Community Science & B.Sc. (Hons) ND) Definition, scope and importance of environmental science. Natural Resources - renewable and non-renewable resources. Forest resources - use and over-exploitation. Water resources - use and over-utilization of surface and ground water, floods, drought. Mineral resources - use, exploitation and their environmental effects. Food resources - world food problems, challenges of modern agriculture. Energy resources - renewable and non-renewable. Land resources - land degradation and restoration. Ecosystems - concepts, types, structures and functions. Biodiversity at global, national and local levels, hot-spots of biodiversity, threats to biodiversity. Environmental Pollution - air, water, soil, marine, noise, thermal pollution and nuclear hazards. Solid waste management - causes, effects and control. Social issues and the environment - unsustainable to sustainable development. Water conservation - rain water harvesting, watershed management. Environmental ethics - issues and possible solutions, climate change, global warming, acid rain, ozone layer depletion, nuclear accidents and holocaust. Environment Protection Acts - air, water, wildlife protection, forest conservation. Human population and environment. Role of information technology in environment and human health. Natural disasters - nature, types and their effects. Climatic change - ozone depletion, global warming, sea level rise. Man-made disasters - types and their effects. Disaster management - concept of disaster management, national disaster management framework, financial arrangements, role of Government, NGOs, media and other organizations in disaster management. Visits to ecologically important places and management organizations during weekends as a part of advisory and class tours by the respective departments/class incharges.

**Soils 102 Principles of Soil Science** **1+1** **Sem. I**  
 (For students of B.Tech. Agricultural Engg.)  
 Concepts of soil; soil forming rocks and minerals, their classification and composition, soil forming processes; soil physical properties and their importance; soil inorganic colloids – their composition, properties and origin of charge; ion exchange in soil and nutrient availability; soil reaction – acidic, saline and sodic soils; soil organic matter – its composition and decomposition, effect on soil fertility; quality of irrigation water; essential plants nutrients – their functions and deficiency symptoms in plants; important inorganic fertilizers and their fates in soils.  
 Practical: Identification of rocks and minerals; Examination of soil profile in the field; Collection of Soil Sample; Determination of bulk density; particle density and porosity of soil; Determination of organic carbon of soil; Determination of Nitrogen, Determination of Phosphorus and Determination of Potassium; Identification of nutrient deficiency symptoms of crops in the field; Determination of water quality parameters.

**Soils 202 Problematic Soils and their Management** **2+0** **Sem. II**  
 Soil quality and health. Distribution of waste land and problem soils in India, their categorization based on properties. Reclamation and management of saline, sodic, acid, acid sulphate, eroded, compacted, flooded, waterlogged and polluted soils. Irrigation water – quality and standards. Utilization of saline and sodic water in agriculture. Remote sensing and GIS in diagnosis and management of problem soils. Bioremediation of problem soils through multipurpose tree species. Land capability classification. Land suitability classification. Problematic soils under different agro-ecosystems.

**Soils 301 Manures, Fertilizers and Soil Fertility Management** **2+1** **Sem. I**  
 Introduction and importance of organic manures. Properties and methods of preparation of bulky and concentrated manures. Green/leaf manuring. Fertilizer recommendation approaches. Integrated nutrient management. Chemical fertilizers - classification, composition and properties of major

nitrogenous, phosphatic, potassic fertilizers, secondary and micronutrient fertilizers, complex fertilizers and nano fertilizers. Soil amendments. Fertilizer storage. Fertilizer Control Order. History of soil fertility and plant nutrition. Criteria of essentiality, role, deficiency and toxicity symptoms of essential plant nutrients. Mechanisms of nutrient transport to plants. Critical levels of different nutrients in soil. Forms of nutrients in soil. Factors affecting nutrient availability to plants. Chemistry of soil nitrogen, phosphorus, potassium, calcium, magnesium, sulphur and micronutrients. Soil fertility evaluation - Soil testing, plant analysis, rapid plant tissue tests, indicator plants. Factor influencing nutrient use efficiency (NUE), Time and methods of application of fertilizers under rainfed and irrigated conditions. Practical: Introduction of analytical instruments and their principles, calibration and applications. Colorimetry, flame photometry and atomic absorption spectrophotometry. Determination of soil organic carbon, alkaline hydrolysable N and extractable P in soils. Determination of exchangeable Na, K, Ca and Mg in soils. Determination of extractable S and DTPA extractable Zn, Mn, Fe and Cu in soils. Determination of N, P, K, S and micronutrients in plants.

### **Soils 302 Precision Farming, Geoinformatics and Nano-technology 1+1 Sem. II**

Precision agriculture - concepts and techniques, their issues and concerns for Indian agriculture. Definition (Nanoscience and Nanotechnology, Nanobiotechnology), History and timeline (Contribution of important scientific discoveries for the development of nanotechnology), Nanoscale effects. Types of nanomaterial, Basic information on top down and bottom up approaches for the synthesis of nanomaterials. Physical, chemical and biological approaches for synthesis of nanomaterials, Characterization techniques. Use of nanomaterials for enhancing crop productivity, Nanofertilizers and nanopesticides: basic concepts and application. Nanodiagnosics: Easy detection of phytopathogens using nano-based sensors. Global positioning system (GPS), components and its functions. Geographic information system (GIS), components and its functions. Spatial data and their management in GIS. Use of geospatial technologies in studying Crop stress (biotic/abiotic). Geo-informatics - definition, concepts, tool and techniques. Use of Geo-informatics in precision agriculture. Remote sensing concepts. Application of Remote sensing in agriculture. Image processing and interpretation. Crop discrimination and yield monitoring. soil mapping and fertilizer recommendation using geospatial technologies. Crop simulation models. Uses of crop models for optimization of agricultural inputs. STCR approach for precision agriculture.

Practical: Preparation protocols of soil and plant samples for characterization using spectroscopy and electron microscopy tools. Role of stabilizers or surfactants for development of stable formulations and applications of nanoparticles for enhanced seed germination and growth, anti-microbial properties of nanomaterials. Use of GPS for agricultural survey, Introduction to GIS software, spatial data creation and editing. Crop stress (biotic/abiotic) monitoring using geospatial technology. Introduction to image processing software. Visual and digital interpretation of remote sensing images. Generation of spectral profiles of different objects. Supervised and unsupervised classification and acreage estimation. Multispectral remote sensing for soil mapping. Creation of thematic layers of soil fertility based on GIS. Creation of productivity and management zones. Fertilizers recommendations based on VRT and STCR techniques.

### **Soils 303 Biofertilizers and Biopesticides 2+1 Sem. II**

Biofertilizers - introduction, status and scope. Structure and characteristic features of bacterial biofertilizers - *Azospirillum*, *Azotobacter*, *Bacillus*, *Pseudomonas*, *Rhizobium* and *Frankia*, cyanobacterial biofertilizers - *Anabaena*, *Nostoc*, *Hapalosiphon* and fungal biofertilizers - AM endomycorrhiza and ectomycorrhiza. Nitrogen fixation - free living and symbiotic nitrogen fixation. Mechanism of phosphate solubilization and mobilization, K solubilization. Production technology - strain selection, sterilization, growth and fermentation. Mass production of carrier based and liquid biofertilizers. Factors influencing the efficacy of biofertilizers. Application technology for seeds,

seedlings, tubers and sets. Storage, shelf life, quality control and marketing of biofertilizers. FCO specifications for quality control of biofertilizers. Biopesticides-History, concept, importance, scope and potential of biopesticides. Definitions and classification of biopesticides - pathogen, botanical pesticides and biorationales and their uses. Mass production technology of biopesticides. Virulence, pathogenicity and symptoms of entomopathogenic organisms. Methods of application of biopesticides. Quality control of biopesticides. Impediments and limitations in production and use of biopesticides. Registration of biopesticides.

Practical: Isolation, biochemical characterization and purification of *Azospirillum*, *Azotobacter*, *Rhizobium*, P-solubilizers, K-solubilizers and cyanobacteria. Mass multiplication and production of inocula of biofertilizers. Isolation of AM fungi - wet sieving method and sucrose gradient method. Mass production of AM inoculants. Isolation and purification of important biopesticides - *Trichoderma*, *Pseudomonas*, *Bacillus*, *Metarhizium* and *Beauveria* and their production. Techniques of mass production of biopesticides. Equipment in biopesticide production. Field visit to naturally infected cadavers. Identification of entomopathogenic entities in field condition.

**Soils 491 Agro-Industrial Attachment**

**0+4**

**Sem.I**

- (i) Fertilizer Industries
- (ii) Vermicompost Units
- (iii) Biofertilizer Units

**Soils 492 Experiential Learning in Soil, Plant, Water and Seed Testing**

**0+20**

**Sem.II**

**Postgraduate Courses**

**Soils 501 Soil Physics**

**2+1 Sem. I**

Soil physical behavior. Soil consistence. Dispersion and workability of soils. Soil compaction and consolidation. Soil strength-bulk density relations. Swelling and shrinkage- basic concepts. Soil structure- genesis, characterization and management. Soil tilth. Soil crusting - mechanism, factors affecting and evaluation. Soil conditioners. Puddling, its effect on soil physical properties. Soil water - retention, constants. Energy state of soil water, soil-moisture characteristics. Hysteresis. Water flow in saturated and unsaturated soils, Darcy's law, hydraulic conductivity, permeability. Infiltration, internal drainage and redistribution. Evaporation. Hydrologic cycle, field water balance. Soil-plant-atmosphere continuum. Composition, renewal and measurement of soil air. Aeration requirement for plant growth. Modes of energy transfer in soils, energy balance, thermal properties of soil. Soil temperature in relation to plant growth.

**Practical:** Mechanical analysis of soil. Measurement of Atterberg limits. Aggregate analysis. Measurement of soil-water content. Measurement of soil-water potential. Determination of soil- moisture characteristics curve and computation of pore-size distribution. Determination of hydraulic conductivity under saturated and unsaturated conditions. Determination of infiltration rate of soil. Determination of aeration porosity and oxygen diffusion rate. Soil temperature measurements.

**Soils 502 Soil Fertility and Fertilizer Use**

**2+1 Sem. I**

Soil fertility and soil productivity. Nutrient sources - fertilizers and manures. Soil N - sources and N transformations. Biological nitrogen fixation. Nitrogenous fertilizers - their fate in soils and enhancing N use efficiency. Soil P - forms, reactions in soils and factors affecting availability. Management of P fertilizers. Potassium- forms, mechanism of fixation, Q/I relationships. Management of K fertilizers. Sulphur, Ca and Mg - source, forms, fertilizers and their behavior in soils and management. Micronutrients- critical limits in soils and plants, factors affecting their availability, sources and management. Common soil test methods for fertilizer recommendations. Site-specific and plant need based nutrient management. Integrated

nutrient management. Blanket fertilizer recommendations- usefulness and limitations. Soil fertility evaluation. Soil quality in relation to sustainable agriculture.

**Practical:** Laboratory and greenhouse experiments for evaluation of indices of nutrient availability and their critical values in soils and plants. Chemical analysis of soil for total and available nutrients. Analysis of plants for essential elements.

### **Soils 503 Soil Chemistry**

**2+1 Sem. I**

Chemical composition of earth's crust and soils. Elements of equilibrium thermodynamics, chemical equilibria, electrochemistry and chemical kinetics. Inorganic and organic colloids-surface charge characteristics, diffuse double layer theories, zeta potential stability, coagulation/ flocculation, peptization, electrometric and sorption properties of soil colloid. Soil organic matter-fractionation, clay-organic interactions. Cation exchange-theories, adsorption isotherms, Donnan-membrane equilibrium concept, clay-membrane electrodes and ionic activity measurement, thermodynamics, anion and ligand exchange-inner sphere and outer-sphere surface complex formation, fixation of oxyanions, hysteresis in sorption-desorption of oxy-anions and anions. Experimental methods to study ion exchange phenomena and practical implications in plant nutrition. Potassium, phosphate and ammonium fixation in soils and management aspects. Chemistry of acid, salt-affected and submerged soils and management aspects

**Practical:** Analysis of equilibrium soil solution for electrochemical properties. Determination of point of zero-charge and associated surface charge characteristics. Potentiometric and conductometric titration of soil humic and fulvic acids. E4/E6 ratio of soil humic and fulvic acids. Adsorption-desorption of phosphate/ sulphate. Construction of adsorption envelop of soils by using phosphate/fluoride/sulphate and ascertaining the mechanism of the ligand exchange process involved. Determination of titratable acidity of an acid soil.

### **Soils 504 Soil Mineralogy, Genesis, Classification and Survey**

**2+1 Sem. II**

Fundamentals of crystallography, space lattice, coordination theory, isomorphism and polymorphism. Classification, structure, chemical composition and properties of clay minerals. Genesis and transformation of crystalline clay minerals. Amorphous soil constituents and other non-crystalline silicate minerals. Clay minerals in Indian soils. Soil formation - factors, models, processes. Weathering of rocks and mineral transformations. Soil profile. Soil classification systems - historical developments and modern systems of soil classification. Soil survey- types, techniques. Soil series- characterization and procedure for establishing soil series, benchmark soils and soil correlations. Soil survey interpretations. Techniques for generation of soil maps. Landform- soil relationship, major soil groups of India with special reference to respective states. Land capability and land irrigability classification. Land evaluation and land use type. Approaches for managing soils and landscapes in the framework of agro-ecosystem.

**Practical:** Identification and quantification of minerals in soils. Morphological properties of soil profile in different landforms. Classification of weathering indices and its application in soil formation. Grouping soils using available data base in terms of soil quality. Cartographic techniques for preparation of maps, processing of field sheets, compilation and obstruction of maps in different scales. Land use planning exercises using conventional and RS tools

### **Soils 505 Soil Biology and Biochemistry**

**2+1 Sem. II**

Soil biota, soil microbial ecology, types of organisms. Soil microbial biomass, microbial interactions, unculturable 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 N, P, S, Fe and Mn in soil. Biochemical composition and biodegradation of soil organic matter and crop residues. 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 organic manures, rural and urban



composts and vermicompost. Biofertilizers - definition, classification, specifications, method of production and role in crop production.

Practical: Determination of soil microbial population. Soil microbial biomass. Elemental composition, fractionation of organic matter and functional groups. Decomposition of organic matter in soil. Soil enzymes. Measurement of important soil microbial processes such as ammonification, nitrification,  $N_2$  fixation, S oxidation, P solubilization and mineralization of other micro nutrients. Study of rhizosphere effect.

### **Soils 506 Soil Erosion and Conservation**

**2+1 Sem. II**

History, distribution, identification and description of soil erosion problems in India. Soil erosion by water-factors and mechanism. Raindrops and soil erosion. Rainfall erosivity - estimation of erosivity indices. Soil erosion in relation to soil properties. Wind erosion- factors affecting, extent of problem. Principles and practices of erosion control. Soil conservation planning in hilly, arid and semi-arid regions, waterlogged and wet lands. Type, factors and processes of soil/land degradation and its impact on soil productivity. Watershed management. Water harvesting, recycling and flood control. Socio-economic aspects of watershed management. Case studies in respect to monitoring and evaluation of watersheds. Use of remote sensing in assessment and planning of watersheds.

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 indices ( $EI_{30}$ ) using rain gauge data. Measurement and estimation of runoff and soil loss. Visits to soil and water conservation works.

### **Soils 507 Geomorphology and Geochemistry**

**2+0 Sem. I**

General introduction to geology and geochemistry. Major and minor morphogenic and genetic landforms, study of schematic landforms and their elements with special reference to India. Methodology of geomorphology, its agencies, erosion and weathering. Soil and physiography relationships. Erosion surface of soil landscape. Geochemical classification of elements. Geo-chemical aspects of weathering and migration of elements. Geochemistry of major and micronutrients and trace elements.

### **Soils 508 Soil, Water and Air Pollution**

**2+1 Sem. II**

Soil, water and air pollution problems associated with agriculture. Nature and sources of pollutants-their CPC standards and effect on plants, animals and human beings. Sewage and industrial effluents - their composition and effect on soil, plant growth and human beings. Soil as sink for waste disposal. Pesticides - their classification, behavior in soil and effect on soil micro-organisms. Toxic elements - their sources, behavior in soils, effect on nutrients availability and on plant and human health. Pollution of water resources. Emission of greenhouse gases. Remediation/amelioration of contaminated soil and water, remote sensing applications in monitoring and management of soil and water pollution to safeguard food safety.

Practical: Sampling of sewage waters and sludge, industrial wastes, polluted soils and plants. Estimation of dissolved and suspended solids, COD, BOD, nitrate and ammonical N and P, heavy metal content in effluents. Heavy metals in contaminated soils and plants. Air sampling and determination of particulate matter and oxides of S. Visit to various industrial sites to study the impact of pollutants on soil and plants.

### **Soils 509 Analytical Techniques and Instrumental Methods in Soil and Plant Analysis**

**1+2 Sem. II**

Atomic structure. Radioisotopes-properties and decay principles. Principles and use of radiation monitoring instruments. Isotopic dilution techniques. Doses of radiation exposure, radiation safety aspects. Storage and handling of radioactive materials. Principles of visible, ultraviolet and infrared spectrophotometry,

inductively coupled plasma spectrometry, chromatographic techniques, mass spectrometry and X-ray diffractometry.

Practical: 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 P and K. Identification of minerals by different methods. Electrochemical titration of clay. Estimation of root CEC. Analysis of soil and plant samples for N, P, K, Ca, Mg, S, Zn, Cu, Fe, Mn, B and Mo. Analysis of plant materials by digesting plant material by wet and dry ashing and soil by wet digestion methods. Drawing normalized exchange isotherms. Measurement of redox potential. Preparation of soil and plant samples for radioactive measurements. Determination of half life and decay constant.

### **Soils 510 System Approaches in Soil and Crop Studies**

**2+0 Sem. I**

Systems concepts- definitions, general characteristics, general systems theory. Systems - thinking, dynamics, behavior and study. Model - definition and types. Mathematical models and their types. Modeling- concepts, objectives, processes, abstraction techniques. Simulation models, their verification and validation, calibration. Representation of continuous systems simulation models- procedural and declarative. Simulation- meaning and threats, experiment, design and analysis. Application of simulation models in understanding system behavior, optimizing system performance, evolution of policy options under different soil, water, and nutrient, climatic and cultural conditions. Decision support system, use of simulation models in decision support system.

### **Soils 511 Management of Problem Soils and Water**

**2+1 Sem. I**

Area, distribution, origin and basic concepts of problematic soils. Morphological features and characterization of salt-affected soils. 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 and dry land soils. Acid soils - nature, sources and management. Effect on plant growth. Lime requirement of acid soils. Biological sickness of soils and its management. Quality of irrigation water, management of brackish water. Salt balance under irrigation. Characterization of brackish waters, area and extent. Agronomic practices in relation to problematic soils. Cropping pattern for utilizing poor quality ground waters.

Practical: Characterization of acid, acid sulfate, salt- affected and calcareous soils. Determination of cations ( $\text{Na}^+$ ,  $\text{K}^+$ ,  $\text{Ca}^{2+}$ , and  $\text{Mg}^{2+}$ ) in ground water and soil samples. Determination of anions ( $\text{Cl}^-$ ,  $\text{SO}_4^{2-}$ ,  $\text{CO}_3^{2-}$  and  $\text{HCO}_3^-$ ) in ground waters and soil samples. Lime and gypsum requirement of acid and sodic soil.

### **Soils 601 Advances in Soil Physics**

**3+0 Sem. II**

Soil water potential, free energy and thermodynamic basis of potential concept, chemical potential of soil water and entropy of the system. Development of differential equations in saturated and unsaturated water flow, capillary conductivity and diffusivity. Limitations of Darcy's law. Numerical solution for one dimensional water flow. Theories of horizontal and vertical infiltration under different boundary conditions. Movement of salts in soils, models for miscible-immiscible displacement, diffusion, mass flow and dispersion of solutes and their solutions through differential equations. Break-through curves. Thermal properties of soil, heat transfer in soils, differential equation of heat flow, and measurement of thermal conductivity of soil. Structural management of puddled rice soils. Soil conditioners - significance in agriculture. Solar and terrestrial radiation measurement, dissipation and distribution in soil-crop systems. Prediction of evapotranspiration using aerodynamic and canopy temperature-based models. Leaf diffusion resistance in relation to plant water deficit.

### **Soils 602 Advances in Soil Fertility**

**3+0 Sem. II**

Modern concepts of nutrient availability. Soil solution and plant growth. Nutrient response functions and availability indices. Nutrient movement in soils, absorption by plants. Mechanistic approach models to nutrient supply and uptake by plants. Models for transformation and movement of major micronutrients in soils. Chemical equilibrium involving nutrient ions in soils, particularly in submerged soils. Modern concepts of fertilizer application, evaluation, nutrients use efficiency and nutrient budgeting. Soil fertility evaluation techniques. Role of soil tests in fertilizer use recommendations. Site - specific nutrient management for precision agriculture. Monitoring physical, chemical and biological changes in soils. Permanent manurial trials. Soil productivity under long term intensive cropping- direct, residual and cumulative effects of fertilizer use.

### **Soils 603 Physical Chemistry of Soils**

**2+0 Sem. I**

Colloidal chemistry of inorganic and organic components of soils - their formation, clay organic interaction. Predictive approaches for cation exchange equilibria - thermodynamics, empirical and diffuse double layer theory, relationships among different selectivity coefficients. Structure and properties of diffuse double layer. Thermodynamics of nutrients transformation in soils. Cationic and anionic exchange and their models, molecular interaction. Adsorption / desorption isotherms - Langmuir adsorption isotherm, Freundlich adsorption isotherm, normalized exchange isotherm, BET equation. Selective and non - selective adsorption of ions on inorganic surfaces and organic surfaces of soil materials. Common solubility equilibria - carbonates, iron oxide and hydroxides, aluminum silicate, aluminum phosphate. Electrochemical properties of clays.

### **Soils 604 Soil Genesis and Micropedology**

**2+0 Sem. I**

Pedogenic evolution of soil. Soil composition and characterization. Weathering and soil formation-factors and pedogenic processes. Thermodynamics of mineral stability and weathering sequences of minerals. Assessment of soil profile development by mineralogical and chemical analysis. Micro - pedological features of soils - their structure, fabric analysis, role in genesis and classification.

### **Soils 605 Biochemistry of Soil Organic Matter**

**2+0 Sem. I**

Organic matter- pools, composition and distribution in soils and its functions. Environmental significance of humic substances. Decomposition of organic residues in soil in relation to organic matter pools. Biochemistry of the humus formation and different pathways for humus synthesis in soil. Soil carbohydrates and lipids. Nutrient transformations - N, P, and S. Trace metal interaction with humic substances, Significance of chelation reactions in soils. Reactive functional groups of humic substances, adsorption of organic compounds by clay and role of organic substance in pedogenic soil aggregation processes. Clay-organic matter complexes. Humus - pesticide interaction in soil, mechanisms.

### **Soils 606 Land Use Evaluation and Planning**

**2+0 Sem. II**

Concept and techniques of land use planning. Factors governing present land use. Land evaluation methods and soil-site suitability evaluation for different crops, land capability classification and constraints in application. Agro - ecological regions / sub - regions of India and their characteristics in relation to crop production. Water harvesting - concept, significance, types, methodology and use of harvested water in agriculture to increase water productivity. Watershed development / management - concept, objectives, characterization. Planning, execution, community participation and evaluation. Rehabilitation of watershed. Developing economically and ecologically sustainable agro - forestry systems for watershed through Participatory Rural Appraisal (PRA) and case studies

### **Soils 591 Seminar**

### **Soils 600 Master's Research**

### **Soils 700 Ph.D. Research**



## VEGETABLE SCIENCE

### PROGRAMMES

1. M.Sc.
2. Ph.D.

### COURSE REQUIREMENTS

#### M.Sc.

Field of Specialization	Vegetable Breeding, Vegetable Production, Post-harvest Handling
Required Courses	Veg. 501, Veg. 502, Veg. 503, Veg. 504, Veg. 505
Supporting Courses	Stat. 421, PGS 501 and other courses from subject matter fields (other than minor) relating to the area of special interest and research problem.
Minor Fields	Plant Breeding and Genetics, Biotechnology, Botany, Agronomy, Horticulture, Soil Science or any other as approved by Dean, postgraduate Studies.
Deficiency courses for students with elective other than Horticulture	As recommended by the Student's Advisory Committee and approved by the Dean, Postgraduate Studies

#### Ph.D.

Field of Specialization	Vegetable Breeding, Vegetable Production, Post-harvest Handling
Required Courses	Veg. 601, Veg. 602, Veg. 603
Supporting Courses	Courses from subject matter fields (other than minor) relating to area of special interest and research problem.
Minor Fields	Plant Breeding and Genetics, Biotechnology, Botany, Agronomy, Horticulture, Soil Science or any other as approved by Dean, postgraduate Studies.
Deficiency courses for students with M.Sc.(Agri.) in a discipline other than Vegetable Science	Veg. 501, Veg. 502, Veg. 503, Veg. 504, Veg. 505 and other courses as recommended by Student's Advisory Committee



## DESCRIPTION OF COURSE CONTENTS

### Diploma Courses

#### **Veg. 51 Elementary Vegetable Cultivation**

**2+1**

**Sem. I**

Role of vegetables in human nutrition and agricultural economy. Types of vegetable gardens including home garden, market garden, truck garden, seed garden and processing garden. Roof top cultivation. Production practices of winter season vegetable crops i.e. potato, cole crops (cabbage, cauliflower, knol khol, broccoli), root crops (radish, carrot, turnip, beetroot), bulb crops (onion, garlic), garden peas, lettuce, palak, methi, and summer season vegetable crops i.e. tomato, brinjal, chilli, sweet pepper, okra, beans (cowpeas, French bean, cluster bean), sweet potato and amaranthus.

Practical: Identification of vegetable seeds and crops. Nursery raising. Layout of kitchen garden. Sowing methods of potato, cucurbitaceous and leafy vegetables. Fertilization, irrigation, plant protection measures and weed management. Off-season vegetable production.

#### **Veg. 52 Protected Cultivation of Vegetable Crops**

**0+1**

**Sem. II**

Importance, scope, future prospectus of protected cultivation. Types of protected structures and their fabrication. Media for protected cultivation. Low tunnel technology. Green house production of tomato, capsicum and cucumber. Training and pruning. Bulb set technique in onion. Hybrid seed production of vegetables. Drip irrigation, fertigation and mulching in vegetables.

### Undergraduate Courses

#### **Veg. 202 Production Technology for Vegetable and Spices**

**1+1**

**Sem I**

Importance of vegetables & spices in human nutrition and national economy, kitchen gardening, origin, area, climate, soil, improved varieties of regional importance and cultivation practices such as time of sowing, transplanting techniques, planting distance, fertilizer requirements, irrigation, weed management, harvesting, yield and important physiological disorders of vegetable and spices (Tomato, Brinjal, Chilli, Capsicum, Cucumber, Melons, Gourds, Pumpkin, French bean, Peas, Okra; Cole crops - Cabbage, Cauliflower, Knol-khol; Bulb crops - Onion, Garlic; Root crops - Carrot, Radish, Beetroot; Tuber crops - Potato; Leafy vegetables - Amaranth, Palak; Perennial vegetables.

Practical: Identification of vegetable and spice crops. Identification of vegetable and spice crop seeds. Bed preparation and method of nursery sowing. Raising of cucurbit seedlings for early cultivation. Direct sowing of cucurbits. Planning and layout of kitchen garden. Method of fertilizer application and calculation of different fertilizer doses. Intercultural operations in vegetable crops. Harvesting, grading and packaging of vegetable crops. Seed extraction of cucurbit vegetables. Economics of vegetable and spice cultivation.

#### **Veg. 301 Vegetable Breeding**

**2+1**

**Sem II**

(Optional course)

Definition and history of vegetable breeding. Origin, distribution, wild relatives and breeding objective of different vegetable crops viz. tomato, brinjal, chilli, muskmelon, watermelon, cucumber, bitter gourd, pumpkin, squashes, onion, garlic, carrot, radish, cauliflower, cabbage, pea, okra and potato. Plant genetic resources, their utilization and conservation. Breeding procedures of self-pollinated, often cross pollinated, cross-pollinated and vegetatively propagated vegetable crops. Conventional and modern techniques for improvement of vegetable crops. Breeding for stress tolerance and quality in vegetable crops. Genetic mechanisms for exploitation of heterosis in vegetable crops.

Practical: Study of inflorescence and flower structures. Practice for emasculation and artificial pollination. Distinguished morphological characteristics of released varieties/hybrids. Layout of field experiments. Estimation of genetic advance and heritability. Handling of germplasm and segregating populations by different methods like pedigree, bulk and single seed decent methods. Visit to vegetable seed production field.

**Veg. 302 Protected Cultivation****2+1****Sem. II**

In collaboration with Department of Floriculture)  
(Optional course)

Protected cultivation- importance, scope and constraints. Status of protected cultivation in India and world. Soil/substrate preparation and management. Types of benches and containers. Irrigation and fertigation management. Propagation and production of quality planting material of horticultural crops. Greenhouse cultivation of important horticultural crops viz., rose, carnation, chrysanthemum, gerbera, lillium, tomato, bell pepper, cucumber, brinjal, pot plants, etc. Off-season production of flowers and vegetables. Insect pest and disease management.

Practical: Raising of seedlings and saplings under protected conditions. Use of protrays in quality planting material production. Bed preparation, planting and inter cultural operations for crop production. Soil EC and pH measurement. Regulation of irrigation and fertilizers through drip, fogging and misting.

**Veg.491 Agro-industrial Attachment****(0+4)****Sem I**

The students opting for this module under 491 series of Agro-industrial Attachment will be attached for hands on training at either of the following locations:

- i. Commercial Vegetable Nurseries
- ii. Farms of Progressive Vegetable Growers

**Veg.492 Experiential Learning in Commercial Vegetable Production (0+20) Sem II**

The students opting for this module under Experiential Learning programme shall raise the vegetable(s) following the recommended PAU package of practices for vegetable crops.

**Postgraduate Courses****Veg. 501 Production Technology of Winter Season Vegetable Crops****2+1 Sem. I**

Introduction, nutritional value, origin, botany and taxonomy, important countries and states growing vegetables along with area, climate and soil requirements, commercial varieties/hybrids evolved by private and public sector, sowing/ transplanting time, seed rate and seed treatment, nutritional and irrigation requirements, chemical weed control, mulching, physiological disorders, harvesting techniques, post-harvest management, plant protection measures and seed production of potato, cole crops; cabbage, cauliflower, knol khol, broccoli, brussels' sprout, chinese cabbage, root crops; carrot, radish, turnip, beet root, bulb crops; onion and garlic, peas and beans, green leafy cool season vegetables.

Practical: Study of nutrient deficiency symptoms. Experiments on improved water use efficiency through mulching and different irrigation methods. Different methods of weed control and herbicide sprays. Preparation of cropping scheme for commercial farms. Quality evaluation for carotene, protein and ascorbic acid. Visit to an established vegetable farm in the region.

**Veg. 502 Production Technology of Summer Season Vegetable Crops****2+1 Sem. II**

Introduction, nutritional value, origin, botany and taxonomy, important countries and states growing vegetables along with area, climate and soil requirements, commercial varieties/hybrids evolved by private and public sector, sowing/ transplanting time, seed rate, seed treatment, nutritional and irrigation requirements, chemical weed control, mulching, physiological disorders, harvesting techniques, post-harvest management, plant protection measures and seed production of warm season vegetable crops i.e. solanaceous crops, okra, cucurbitaceous crops, cowpea, sweet potato, cluster beans, amaranth,



basella, kang-kong, tapioca. Poly-house, net- house and low tunnel technology for off-season production of summer vegetables

Practical: Experiments to demonstrate the role of mineral elements. Fertigation. Chemical weed control. Hybrid seed production of summer vegetables. Use of growth regulators. Seed extraction techniques. Identification of pests and diseases and their control. Forcing techniques for raising summer vegetables. Pruning, grafting and staking. Quality determination for sugar, capsaicin and minerals using atomic absorption.

**Veg. 503 Breeding of Self Pollinated and Vegetatively Propagated Vegetable Crops 2+1 Sem. II**

History of vegetable breeding. Origin, botany, taxonomy, cytogenetic, genetics, breeding objectives, breeding methods (introduction, selection, hybridization, mutation), resistance breeding for biotic and abiotic stress, quality improvement in self-pollinated crops viz. tomato, brinjal, cowpea, pea, beans, okra, salad crops and asexually propagated crops like potato, sweet potato, colocasia and tapioca. Molecular marker, marker assisted breeding and QTLs, biotechnology and their use in breeding in self pollinated and vegetatively propagated vegetable crops. Issue of patenting, PPV& FRA. Concept of ideotypes. Present status of varietal/hybrid development in India. New approaches in breeding of self pollinated vegetables.

Practical: Selection of desirable plants from breeding population. Observations and analysis of various qualitative and quantitative traits in germplasm, hybrids and segregating generations. Induction of flowering. Selfing and crossing techniques in vegetable crops. Hybrid seed production of vegetable crops in bulk. Screening techniques for insect-pests, disease and environmental stress resistance in above mentioned crops. Demonstration of sib-mating and mixed population. Molecular marker techniques to identify useful traits in the vegetable crops and special breeding techniques.

**Veg. 504 Breeding of Cross Pollinated Vegetable Crops**

**2+1 Sem. I**

History of vegetable breeding. Origin, botany, taxonomy, cytogenetic, genetics, breeding objectives, breeding methods (introduction, selection, hybridization, mutation), quality improvement, in cross- pollinated crops viz. capsicum, chilli, cucurbits (muskmelon, watermelon, cucumber, bottle gourd, long melon, bitter gourd, sponge gourd, summer squash), cole crops (cabbage, cauliflower, broccoli, brussels' sprouts), root crops (carrot radish, turnip), bulb crops (onion, garlic), asparagus, leafy vegetables and spices (black pepper, turmeric, cardamom, coriander). Molecular marker, marker assisted breeding and QTLs, biotechnology and their use in breeding cross pollinated vegetable crops. Present status of varietal/hybrid development in India. New approaches in breeding of cross pollinated vegetables.

Practical: Selection indices in cole crops, cucurbitaceous crops, bulb crops, root crops, leafy vegetables and spices. Selfing and crossing techniques in cross pollinated vegetable crops. Biometrical analysis - Line x tester analysis, North Carolina Designs, Stability analysis, Triple test cross analysis, generation mean analysis, diallel analysis. Estimation of heritability, heterosis and combining ability.

**Veg. 505 Systematics of Vegetable Crops**

**2+1 Sem. I**

Principles of classification, different methods of classification, salient features of international code of nomenclature of vegetable crops. Origin, history, evolution and distribution of vegetable crops, botanical description of families, genera and species covering self and cross pollinated vegetable crops viz. brinjal chilli, tomato, muskmelon, water melon, bottle gourd, cucumber, bitter gourd, onion, cabbage, cauliflower, carrot, radish, turnip, amaranth, palak, peas, beans, okra and vegetatively propagated vegetables like potato, garlic, sweet potato and spices ( turmeric, coriander); cytological level of various vegetable crops, descriptive blanks for describing various varieties of important vegetable crops.

Practical: Identification, description, classification and maintenance of vegetable species and varieties. Survey, collection of allied species and genera locally available. Preparation of keys to the species and varieties. Methods of preparation of herbarium and specimens.

**Veg. 506 Seed Production Technology of Vegetable Crops****2+1 Sem. I**

Definition of seed and its quality; DUS test, scope of vegetable seed industry in India. Agronomical principles and methods of seed production in important vegetable crops; use of growth regulators and chemicals in vegetable seed production; floral biology, pollination, breeding behaviour, seed development and maturation; methods of hybrid seed production. Categories of seed; maintenance of nucleus, foundation and certified seed; seed certification, seed standards; seed act and law enforcement, plant quarantine and quality control. Physiological maturity, seed harvesting, extraction, curing, drying, grading, seed processing, seed coating and pelleting, packaging (containers/packets), storage and cryopreservation of seeds, synthetic seed technology.

Practical: Seed sampling, seed testing (genetic purity, seed viability, seedling vigour, germination, physical purity) and seed health testing. Notification procedures of varieties. Floral biology. Rouging off-types. Methods of hybrid seed production in important vegetable crops. Seed extraction techniques. Handling of seed processing and seed testing equipments. Visit to seed processing units. Seed testing laboratory and seed production farms.

**Veg. 507 Production Technology of Under Exploited Vegetable Crops****2+0 Sem. I**

Introduction, botany and taxonomy, climatic and soil requirements, commercial varieties/hybrids, sowing/planting times and methods, seed rate and treatment, nutritional and irrigation requirements, intercultural operations, weed control, mulching, physiological disorders, harvesting, post harvest management, plant protection measures and seed production of asparagus, artichoke, leek, Brussels sprout, chinese cabbage, broccoli, kale, amaranth, celery, parsley, parsnip, lettuce, rhubarb, spinach, basella, bathu (chenopods), elephant foot, yam, lima bean, winged bean, vegetable pigeon pea, jack bean, sword bean, spine gourd, pointed gourd, oriental pickling melon and little gourd (kundru).

**Veg. 508 Organic Vegetable Production Technology****2+1 Sem. II**

Importance, principles, perspective, concept and component of organic production of vegetable crops. Managing soil fertility, pests and diseases and weed problems in organic farming system; crop rotation in organic vegetable production; processing and quality control for organic foods. Methods for enhancing soil fertility, mulching, raising green manure crops. Indigenous methods of compost, Panchgavya, Biodynamics preparation etc. Pest and disease management in organic farming; ITK's inorganic farming, Role of botanicals and bio-control agents. GAP and GMP -Certification or organic products; organic production and export opportunity and challenges. Organic production of vegetables crops, viz. solanaceous crops, cucurbits, cole crops, root and tuber crops.

Practical: Method of preparation of compost, vermi-composting, biofertilizers, soil solarization. Bio pesticides in horticulture. Green manuring. Mycorrhizae and organic crop production. Water management. Organic soil amendment for root diseases. Weed management in organic horticulture. Visit to organic fields and marketing centers.

**Veg. 509 Post-harvest Handling of Vegetable Crops****2+1 Sem. II**

Determination of maturity in different vegetable crops, assessment of post-harvest losses, pre-harvest methods and practices effecting post-harvest shelf life of vegetables, mechanized harvesting of vegetables, pre-cooling of vegetables using different techniques, post-harvest chemical and non-chemical treatments to enhance shelf life, sorting and grading for packaging, ripening of vegetables, packaging of vegetables including latest techniques like MAP, storage of vegetables including latest techniques like CA storage, food safety and quality, non-destructive methods of quality analysis, quality of raw material for processing, transportation and destination handling, marketing, treatments before shipment and storage, fresh-cut vegetables.

Practical: Practices in judging the maturity of vegetables, harvesting methods and tools. Methods used for pre-cooling and their efficiency measurements. Post-harvest chemical treatments to extend shelf life. Sorting and grading methods. Ripening techniques used in climacteric vegetables. Traditional and latest safe storage techniques. Respiration measurements in harvested produce. Field visit to post-harvest and processing industry.

**Veg. 601 Advances in Vegetable Production**

**3+0 Sem. II**

Present status and prospects of vegetable cultivation. Nutritional and medicinal values of vegetables. Sustainable vegetable production, Effect of climate on vegetables, Different farming systems used to improve land use efficiency, Choice of varieties/hybrids for maximizing vegetable production. Modern concepts in water nutrient and weed managements like INM, IWM, Drip irrigation etc. Role of growth regulators in vegetables. Cropping systems, Mulching, Hydroponics, Nutrient Film Technique, organic gardening, low cost poly house, net house cultivation for export market. Harvesting, grading, packaging, transportation of vegetables. Post harvest treatment of vegetables.

**Veg. 602 Advances in Vegetable Breeding**

**3+0 Sem. II**

Evolution, distribution, cytogenetic, genetic resources, genetic divergence, types of pollination and fertilization mechanisms, sterility and incompatibility, anthesis and pollination, hybridization, inter-varietal, inter-specific and inter-genetic hybridization, heterosis breeding, inheritance pattern of traits, qualitative and quantitative, plant type concept and selection indices, genetics of spontaneous and induced mutations, problems and achievements of mutation breeding, ploidy breeding and its achievements, in vitro breeding; breeding techniques for improving quality and processing characters; breeding for stresses, mechanism and genetics of resistance, breeding for salt, drought; low and high temperature; toxicity and water logging resistance, breeding for insect pests, disease, nematode and multiple resistance of Tomato, brinjal, chilli, sweet pepper and potato; cucurbits, cabbage, cauliflower and knol-khol, bhindi, onion, peas, beans, amaranthus, drumstick, carrot, beet root, radish, sweet potato tapioca, elephant foot yam and taro.

**Veg. 603 Laboratory Techniques in Vegetable Crops**

**1+2 Sem. I**

Use of laboratory equipments for determining the various bio-chemical constituents. Principles and procedures for determination of various biochemical constituents including protein, ascorbic acid, dry matter, colouring matter, beta carotene, lycopene, oleoresin content, capsaicin, sugars (total and reducing), chlorophyll, chromatography, electrophoresis and determination of enzymes relevant to post-harvest handling and processing.

Practical: Determination of sugars (reducing and non-reducing), protein, capsaicin, ascorbic acid, titrable acidity, phenols, O-dihydroxy phenols, carotene and pigments, dry matter, colour, lycopene, colouring matter, texture, oleoresin content, TSS, flavonols, chromatography including TLC, GLC, column chromatography. Electrophoresis, PCR and isolation of plant DNA. Respiration and ethylene measurements.

**Veg. 604 Abiotic Stress Management in Vegetable Crops**

**2+1 Sem. I**

Environmental stress and its types, soil parameters including pH, classification of vegetable crops based on susceptibility and tolerance to various types of stresses, root stock, use of wild species, use of anti-transpirant. Mechanism and measurements of tolerance to drought, water logging, soil salinity, frost and heat stress in vegetable crops; Soil-plant-water relations under different stress conditions in vegetable crops production and their management practices. Techniques of vegetable growing under water deficit, water logging, salinity and sodicity. Techniques of vegetable growing under high and low temperature conditions, use of chemicals in alleviation of different stresses.

Practical: Identification of susceptibility and tolerance symptoms to various types of stress in vegetable crops. Measurement of tolerance to various stresses in vegetable crops. Short term experiments on growing vegetable under water deficit, water-logging, salinity and sodicity, high and low temperature conditions and use of chemicals for alleviation of different stresses.

**Veg. 605 Seed Certification, Processing and Storage of Vegetable Crops 2+1 Sem. I**

Seed certification, objectives, organization of seed certification, minimum seed certification standards, field inspection, specification for certification; Seed processing, study of seed processing equipments seed cleaning and upgrading, seed packing and handling, equipment used for packaging of seeds, procedures for allocating lot number; Pre-conditioning, seed treatment, benefits, types and products, general principles of seed storage, advances in methods of storage, quality control in storage, storage containers, seed longevity and deterioration, sanitation, temperature and relative humidity control, Seed testing; ISTA rules for testing, moisture, purity, germination, vigor test, seed sampling, seed viability, seed health testing; seed dormancy, factors responsible for dormancy. Seed marketing, demand forecast, economics of seed production; farmers' rights, seed law enforcement, seed act and seed policy, project formulation on vegetable seed production.

Practical: Seed sampling, purity, moisture testing, seed viability, seed vigour tests, seed health testing, seed cleaning, grading and packaging. Handling of seed testing equipment and processing machines. Seed treatment methods, seed priming and pelleting. Field inspection. Practices in rouging. Seed storage. Isolation distances. Mixing and dividing instruments. Biochemical tests. Visit to seed testing laboratories and processing plants. Visit to warehouse to know about sanitation standards.

**Veg. 591 Seminar**

**Veg. 600 Master's Research**

**Veg. 700 Ph.D. Research**

**COURSE CURRICULUM FOR B.Sc. (Hons) Agriculture  
4 -YEAR PROGRAMME (CORE COURSES)**

**DEFICIENCY COURSES**

**BASIC SCIENCES AND HUMANITIES**

Th + Pr

For PCM base

1.	Bio. 102	Introductory Biology	1+1
			1+1=2

For PCB base

1.	Math. 103	Elementary Mathematics	2+0
			2+0=2

**Regional Language**

For students with domicile of Punjab who have not taken Punjabi at Matric/10+2 level

1.	Pbi. 101	Basic Punjabi	0+2(NC)
For ICAR nominees and foreign students			
1.	Pbi. Cul 101	Punjabi Culture	2+0 (NC)

**REQUIRED COURSES**

**BASIC SCIENCES AND HUMANITIES**

Th+Pr

1.	Biochem. 101	Introduction to Biochemistry	2+1
2.	Bot. 104	Fundamentals of Crop Physiology	1+1
3.	Econ. 102	Fundamentals of Agricultural Economics	2+0
4.	Econ. 204	Agricultural Marketing, Trade and Prices	2+1
5.	Econ. 205	Agricultural finance and Cooperation	2+1
6.	Econ. 304	Farm Management, Production and Resource Economics	1+1
7.	Eng. 101	General English	1+1
8.	Eng. 201	Communication Skills and Personality Development	1+1
9.	Micro. 102	Elementary Microbiology	2+1
10.	Mgt. 201	Entrepreneurship Development and Business Management	2+1
11.	Soc. 101	Rural Sociology and Educational Psychology	2+0
12.	Stat. 206	Basic Statistics	1+1

19+10=29

**AGRICULTURAL ENGINEERING AND INFORMATION TECHNOLOGY**

Th+Pr

1. EST 202	Renewal Energy and Green Technology	1+1
2. CSE 101	Information and Communication Technology in Agriculture	1+2
3. FMP 102	Farm Power and Machinery	1+1
4. PFE 303	Protected Cultivation and Secondary Agriculture	1+1
5. SWE 102	Soil and Water Conservation Engineering	1+1

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**5+6=11****HORTICULTURE**

Th+Pr

1. Forst. 102	Introduction to Forestry	1+1
2. Flori. 202	Production Technology for Ornamental Crops and Landscaping	1+1
3. Hort. 103	Fundamentals of Horticulture	1+1
4. Hort. 202	Production Technology for Fruit and Plantation Crops	1+1
5. Hort. 301	Post-harvest Management and Value Addition of Fruits and Vegetables	1+1
6. Veg. 202	Production Technology for Vegetables and Spices	1+1

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**6+6=12****AGRICULTURE**

Th+Pr

1. AS 201	Livestock and Poultry Management	2+1
2. Agromet. 102	Introductory Agrometeorology and Climate Change	1+1
3. Agron. 101	Fundamentals of Agronomy	3+1
4. Agron. 201	Production Technology for <i>Kharif</i> Crops	1+1
5. Agron. 202	Crop Production Technology for <i>Rabi</i> Crops	1+1
6. Agron. 203	Farming Systems and Sustainable Agriculture	1+0
7. Agron. 301	Practical crop Production-I ( <i>Kharif</i> Crops)	0+2
8. Agron. 302	Practical crop Production-II ( <i>Rabi</i> Crops)	0+2
9. Agron. 303	Rainfed Agriculture and Watershed Management	1+1
10. Agron. 304	Principles of Organic Farming	1+1
11. Biotech. 206	Fundamentals of Plant Biotechnology	2+1
12. Ent. 201	Fundamentals of Entomology	3+1
13. Ent.-Pl. Path. 202	Principles of Integrated Pest and Disease Management	2+1
14. Ent. 301	Pest of Crops and Stored Grains and their Management	2+1
15. Ent. 302	Management of Beneficial Insects	2+1
16. Ext. 101	Agricultural Heritage	1+0

17. Ext. 201	Fundamentals of Agricultural Extension Education	2+1
18. FT 313	Principles of Food Science and Nutrition	2+0
19. PBG 102	Fundamentals of Genetics	2+1
20. PBG 201	Fundamentals of Plant Breeding	2+1
21. PBG 301	Crop Improvement-I ( <i>Kharif</i> Crops)	1+1
22. PBG 302	Crop Improvement-II ( <i>Rabi</i> Crops)	1+1
23. PBG 303	Intellectual Property Rights	1+0
24. PBG 304	Principles of Seed Technology	1+1
25. Pl. Path. 102	Fundamentals of Plant Pathology	3+1
26. Pl. Path. 301	Diseases of Field and Horticultural Crops and Their Management –I	2+1
27. Pl. Path. 302	Diseases of Field and Horticultural Crops and Their Management –II	2+1
28. Soils 101	Fundamentals of Soil Science	2+1
29. Soils 202	Problematic Soils and their Management	2+0
30. Soils 301	Manures, Fertilizers and Soil Fertility Management	2+1
31. Soils 302	Precision farming, Geoinformatics and Nano-technology	1+1
32. Env. 101	Environmental Studies and Disaster Management	2+0
33. Optional Course-1		2+1/1+2
34. Optional Course-2		2+1/1+2
35. RAWE 401	General Orientation and On-campus Training	0+1
36. RAWE 402	Village Attachment	0+8
37. RAWE 403	KVK and Research Station Attachment	0+5
38. RAWE 404	Plant Clinic	0+2
39. AIA 491	Agro-Industrial Attachment	0+4
40. ELP 492	Experiential Learning Modules	0+20
41. Educational Tour	Compulsory Educational Tour	0+2(NC)

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55 +70=125

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### COMMUNITY SCIENCE

1	HDFS 106	Human Values	Th+Pr 1+0
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1+0=1

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### NCC/NSO/NSS

1.	NCC/NSO/NSS	(SEM-I)	0 + 1 (NC)
2.	NCC/NSO/NSS	(SEM-II)	0 + 1 (NC)
3.	NCC/NSO/NSS	(SEM-III)	0 + 1 (NC)
4.	NCC/NSO/NSS	(SEM-IV)	0 + 1 (NC)

Total credit hours requirement for B.Sc.(Hons.)Agri.Programme:180+2NC\*+2NC\*\*+4NC\*\*\* =188

\*Educational Tour

\*\*Pbi 101/Pbi Cul 101/

\*\*\*NCC/NSS/NSO



**SEMESTER- WISE STUDY PROGRAMME OF  
B.Sc. (Hons) Agri. 4 YEAR PROGRAMME**

**FIRST YEAR**

<b>SEM I</b>			<b>SEM II</b>		
1.	Bio. 102* /Math. 103*	1+1/2+0	1.	Agromet. 102	1+1
2.	Agron. 101	3+1	2.	Env. 101	2+0
3.	Ext. 101	1+0	3.	Forst. 102	1+1
4.	Hort. 103	1+1	4.	PBG 102	2+1
5.	Soils 101	2+1	5.	Pl. Path. 102	3+1
6.	Biochem. 101		6.	FMP 102	1+1
7.	Eng. 101	1+1	7.	SWE 102	1+1
8.	Soc. 101	2+0	8.	Bot. 104	1+1
9.	HDFS 106	1+0	9.	Econ. 102	2+0
10.	Pbi 101**/Pbi Cult 101***	0+2/2+0(NC)	10.	Micro. 102	2+1
11.	NCC/NSO/NSS	0+1(NC)	11.	NCC/NSS/NSO	0+1 (NC)
20+2(NC)+1(NC)=23			16+8+1(NC)=25		

\*Remedial Course Bio 102 for Non Medical stream and Math 103 for Medical stream students

\*\* For students with Punjab domicile who have not taken Punjabi at Matric/10+2 level

\*\*\* For students admitted through ICAR and foreign students

**SECOND YEAR**

<b>SEM III</b>			<b>SEM IV</b>		
1.	Agron. 201	1+1	1.	Agron. 202	1+1
2.	AS 201	2+1	2.	Agron. 203	1+0
3.	Ent. 201	3+1	3.	Biotech. 206	2+1
4.	Ext. 201	2+1	4.	Ent. -Pl. Path. 202	2+1
5.	PBG 201	2+1	5.	Flori. 202	1+1
6.	CSE 101	1+2	6.	Hort. 202	1+1
7.	Econ. 205	2+1	7.	Soils 202	2+0
8.	Mgt. 201	2+1	8.	Veg. 202	1+1
9.	NCC/NSO/NSS	0+1 NC	9.	EST 202	1+1
			10.	Econ. 204	2+1
			11.	Stat. 206	1+1
			12.	NCC/NSO/NSS	0+1 (NC)
15+9+1(NC)=25			15+9+ (NC)=25		



THIRD YEAR

SEM V			SEM VI		
1.	Agron. 301	0+2	1.	Agron. 302	0+2
2.	Agron. 303	1+1	2.	Agron. 304	1+1
3.	Ent. 301	2+1	3.	Ent. 302	2+1
4.	FT 313	2+0	4.	PBG 302	1+1
5.	Hort. 301	1+1	5.	PBG 304	1+1
6.	PBG 301	1+1	6.	Pl. Path. 302	2+1
7.	PBG 303	1+0	7.	Soils 302	1+1
8.	Pl. Path. 301	2+1	8.	Econ. 304	1+1
9.	Soils 301	2+1	9.	PFE 303	1+1
10.	Eng. 201	1+1	10.	Optional Course-1	2+1/1+2
11.	Edu. Tour	0+2 (NC)	11.	Optional Course-2	2+1/1+2
13+9+2(NC)= 24			14+12=26		

FOURTH YEAR

SEM VII			SEM VIII		
1.	RAWE 401	0+1	1.	ELP 492	0+20
2.	RAWE 402	0+8			
3.	RAWE 403	0+5			
4.	RAWE 404	0+2			
5.	Agro-Industrial Attachment	0+4			
0+20=20			0+20=20		

**Optional Courses**

(A student will have to opt for any two of the following courses during VI semester)

S.No.	Course No.	Course Title	Credit Hours
1.	Agromet. 301	System Simulation and Agro-advisory	2+1
2.	Agron. 305	Weed Management	2+1
3.	Biotech. 308	Micropropagation Technologies	1+2
4.	Flori. 301	Landscaping Grading	2+1
5.	FT 314	Food Safety and Standards	2+1
6.	Hort. 302	Hi-tech Horticulture	2+1
7.	PBG 305	Molecular Breeding Technologies	2+1
8.	Soils 303	Biofertilizers and Biopesticides	2+1
9.	Veg. 301	Vegetable Breeding	2+1
10.	Veg. 302	Protected Cultivation	2+1
11.	Chem. 308	Chemistry of Agrochemicals	2+1
12.	Jour. 302	Agricultural Journalism	2+1

13.	Mgt. 304	Agribusiness Management	2+1
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### Agro-Industrial Attachment

(A student will opt for only one module out of the following 491 series courses under Agro-Industrial Attachment during VII semester)

S. No.	Course No.	Course Title	Credit Hours	Modules
	Agron. 491	Agro-industrial Attachment	0+4	(i) Seed Industries (ii) Herbicide Formulators
	Ent. 491	Agro-industrial Attachment	0+4	(i) Commercial Honey Production, Hive and Apicultural Equipment and Honey Processing Manufacturing Units; Honey Trading, Processing, Packaging, Exporting and Marketing Units.
	Ent.-Pl. Path. 491	Agro-industrial Attachment	0+4	(i) Pesticide and Biopesticide Industries (ii) Biocontrol Agents Production Units (iii) Plant Quarantine Station (iv) Virus free Potato Tuber Production Units
	FT 491	Agro-industrial Attachment	0+4	(i) Fruit and Vegetables Industry (ii) Beverages Industry (iii) Cereal Industry (iv) Milk Industry
	Flori. 491	Agro-industrial Attachment	0+4	(i) Commercial Flower Nurseries (ii) Flower Marketing Firms (iii) Flower Seed Production and Landscaping Units
	Forst. 491	Agro-industrial Attachment	0+4	High-tech Nursery (Tree Planting Stock Production)
	Hort. 491	Agro-industrial Attachment	0+4	(i) Commercial Fruit Nurseries
	PBG 491	Agro-industrial Attachment	0+4	Commercial Hybrid Seed Production Units
	Soils 491	Agro-industrial Attachment	0+4	(i) Fertilizer Industries (ii) Vermicompost Units (iii) Biofertilizer Units
	Veg. 491	Agro-industrial Attachment	0+4	(i) Commercial Vegetable Nurseries (ii) Farms of Progressive Vegetable Growers
	Micro. 491	Agro-industrial Attachment	0+4	Mushroom Production Units

## Experiential Learning Modules

(A student will opt for only one of the following Experiential Learning Modules during VIII semester)

S. No.	Course No.	Course Title	Credit Hours
1.	Agron. 492	Experiential Learning in Organic Production Technology	0+20
2.	Ent. 492	Experiential Learning in Commercial Apiculture	0+20
3.	Ent. -Pl. Path. 492	Experiential Learning in Production Technology for Bioagents	0+20
4.	Flori. 492	Experiential Learning in Commercial Floriculture and Landscaping	0+20
5.	Forst. 492	Experiential Learning in Nursery Production of Agro-forestry Trees	0+20
6.	Hort. 492	Experiential Learning in Commercial Horticulture	0+20
7.	PBG 492	Experiential Learning in Seed Production and Technology	0+20
8.	Soils 492	Experiential Learning in Soil, Plant Water , and Seed Analyses	0+20
9.	Veg. 492	Experiential Learning in Commercial Vegetable Production	0+20
10.	FT 492	Experiential Learning in Food Technologies	0+20
11.	EST 492	Experiential Learning in Agricultural Waste Management	0+20
12.	Micro. 492	Experiential Learning in Mushroom Production	0+20
13.	Micro. 493	Experiential Learning in Production Technology for Biofertilizers	0+20

## Semester Wise Total Credit Hours

Semester	Credit Hours
I	$20(14+6/15+5)+2(\text{NC}^{**})+1(\text{NC}^{***})=23$
II	$24(16+8)+1(\text{NC}^{***})=25$
III	$24(15+9)+1(\text{NC}^{***})=25$
IV	$24(15+9)+1(\text{NC}^{***})=25$
V	$22(13+9)+2(\text{NC}^*)=24$
VI	$26(14+12)$
VII	$20(0+20)$

VIII	20(0+20)
<b>TOTAL</b>	<b>180+2NC*+2NC**+4NC***=188</b>

\*Educational Tour

\*\*Pbi 101/Pbi Cul 101/

\*\*\*NCC/NSS/NSO

**COURSE CURRICULUM FOR B.Sc. (Hons) Agri. 2+4 PROGRAMME  
CORE COURSES FOR FIRST TWO YEARS**

**COLLEGE OF AGRICULTURE**

Th+Pr

1. Ort. 91 Orientation 0+1NC

**BASIC SCIENCES AND HUMANITIES**

Th+Pr

- |     |          |   |     |
|-----|----------|---|-----|
| 1.  | Bot. 91  | Introduction to Morphology and Reproductive Botany            | 3+1 |
| 2.  | Bot. 92  | Basics of Systematic Botany and Ecology                       | 3+1 |
| 3.  | Bot. 93  | Introduction to Plant Histology and Genetics                  | 3+1 |
| 4.  | Bot. 94  | Basics of Plant Physiology                                    | 3+1 |
| 5.  | Chem. 91 | Fundamentals of Inorganic Chemistry                           | 3+1 |
| 6.  | Chem. 92 | Introductory Organic Chemistry                                | 3+1 |
| 7.  | Chem. 93 | Fundamentals of Physical Chemistry                            | 3+1 |
| 8.  | Chem. 94 | Fundamentals of Organic Chemistry                             | 3+1 |
| 9.  | Eng. 91  | General Reading, Vocabulary Building and Translation          | 2+1 |
| 10. | Eng. 92  | Reading, Comprehension, Paragraph Writing and Applied Grammar | 2+1 |
| 11. | Eng. 93  | Conversational Structure and Communicative Function           | 2+1 |
| 12. | Eng. 94  | Discourse Patterns in Spoken English                          | 1+2 |
| 13. | Phys. 91 | Mechanics   | 3+1 |
| 14. | Phys. 92 | Matter Properties and Thermodynamics                          | 3+1 |
| 15. | Phys. 93 | Electricity and Magnetism                                     | 3+1 |
| 16. | Phys. 94 | Modern Physics  | 3+1 |
| 17. | Zoo. 91  | Elementary Cell Biology                                       | 3+1 |
| 18. | Zoo. 92  | Elementary Animal Diversity                                   | 3+1 |
| 19. | Zoo. 93  | Elementary Animal Physiology                                  | 3+1 |
| 20. | Zoo. 94  | Human Welfare and Environment                                 | 3+1 |

**SEMESTER- WISE STUDY PROGRAMME OF  
B.Sc. (Hons) Agri. 2+4 year programme for first two years**

**FIRST YEAR**

<b>SEM I</b>			<b>SEM II</b>		
1	Phys. 91	3+1	1	Phys. 92	3+1
2	Chem. 91	3+1	2	Chem. 92	3+1
3	Bot. 91	3+1	3	Bot. 92	3+1
4	Zoo. 91	3+1	4	Zoo. 92	3+1
5	Eng. 91	2+1	5	Eng. 92	2+1
6	Ort. 91	0+1NC			

14+5=19 + 1NC			14+5=19		
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SECOND YEAR

SEM I				SEM II	
1	Phys. 93		3+1	Phys. 94	3+1
2	Chem. 93		3+1	Chem. 94	3+1
3	Bot. 93		3+1	Bot. 94	3+1
4	Zoo. 93		3+1	Zoo. 94	3+1
5	Eng. 93		2+1	Eng. 94	1+2
14+5=19				13+6=19	

**Note :**

1. All courses given in RIB 2016 for B.Sc. (Hons) Agri. 4-year programme will also be applicable to B.Sc. (Hons) Agri. 2+4 programme from 3rd year onwards
2. The students of B.Sc. (Hons) Agri. 2+4 programme will be exempted from clearing Bio. 102 (1+1) courses equivalent to 10+2 medical stream as they will clear 16 credit hours each in Botany (Bot. 91, Bot. 92, Bot. 93 and Bot. 94) and Zoology (Zoo 91, Zoo. 92, Zoo. 93 and Zoo. 94) during initial two years.
3. The students who join 3<sup>rd</sup> year of B.Sc. (Hons) Agri. 2+4 programme at PAU, Ludhiana after completion of two years at IOA, Bathinda and IOA, Gurdaspur will register compulsory three fold programme of NCC /NSO /NSS (0+1 NC) during their first four semesters at PAU, Ludhiana.



**COURSE CURRICULUM FOR B.Tech. (Food Technology)  
4 YEAR PROGRAMME ( CORE COURSES)**

**DEFICIENCY COURSES**

**BASIC SCIENCES AND HUMANITIES**

**Regional Language**

For student with domicile of Punjab who have not taken Punjabi at Matric/10+2 level

Th + Pr

1	Pbi. 101	Basic Punjabi	0+2(NC)
	For ICAR nominees and foreign students		
1	Pbi. Cul 101	Punjabi Culture	2+0 (NC)

**REQUIRED COURSES**

**BASIC SCIENCES AND HUMANITIES**

Th + Pr

1	Math. 101	Basic Mathematics - I	3+0
2	Env. 101	Environmental Studies & Disaster Management	2+0
3	Eng. 101	General English	1+1
4	Micro.103	General Microbiology	2+1
5	HDFS 106	Human Values	1+0
6	Math. 102	Basic Mathematics - II	3+0 NC
7	Micro. 104	Food Microbiology	2+1
8	Eng.201	Communication Skills and Personality Development	1+1
9	Mgt. 202	Marketing Management and International Trade	2+0
10	Math. 205	Higher Mathematics - I	2+0
11	Stat. 205	Statistical Methods and Numerical Analysis	2+1
12	Biochem. 208	Food Biochemistry and Nutrition	2+1
13	Math. 206	Higher Mathematics - II	2+0
14	Mgt. 204	Business Management and Economics	2+0
15	Micro. 308	Fundamentals of Industrial Microbiology	2+1
			<b>26+7+3NC=36</b>

**AGRICULTURE**

1	Agron. 105	Crop Production Practices	2+1
2	FT 102	Food Chemistry of Macroconstituents	2+1
3	FT 201	Fundamentals of Food Processing	1+1
4	FT 202	Processing Technology of Liquid Milk	1+1
5	FT 203	Food Additives and Preservatives	1+1
6	FT 204	Food Chemistry of Microconstituents	2+1
7	FT 205	Processing Technology of Meat and Poultry Products	2+1
8	FT 206	Technology of Bakery, Confectionery and Snack Foods	2+1
9	FT 207	Processing Technology of Legumes and Oilseeds	2+1

10	FT 208	Processing Technology of Spices and Plantation Crops	1+1
11	FT 301	Processing Technology of Fruits and Vegetables	2+1
12	FT 302	Processing Technology of Cereals	2+1
13	FT 303	Processing Technology of Dairy Products	2+1
14	FT 304	Sensory Evaluation of Food Products	2+1
15	FT305	Techniques and Instruments for Food Analysis	1+2
16	FT 306	Food Plant Sanitation	1+1
17	FT 307	Processing Technology of Fish and Marine Products	1+1
18	FT 308	Processing Technology of Beverages	2+1
19	FT 309	Food Quality, Safety Standards and Certification	2+0
20	FT 310	Food Packaging Technology and Equipment	2+1
21	Biotech. 308	Food Biotechnology	2+1
22	FT/Mgt 493	Entrepreneurship Development	2+1
23	FT 494	Student READY - Experiential Learning Programme - I	0+7
24	FT 495	Student READY - Experiential Learning Programme – II	0+7
25	FT 496	Student READY - Research Project	0+3
26	FT 497	Student READY - Seminar	0+1
27	FT 498	Student READY - Industrial cum Educational Tour	0+2
28	FT 499	Student READY - In-Plant Training	0+20
			37+62=99

### AGRICULTURAL ENGINEERING AND TECHNOLOGY

1	EE 101	Electrical Engineering	2+1
2	ME 101	Workshop Technology	1+2
3	CSE 204	Computer Programming and Data Structures	1+2
4	EE 206	Applied Electronics and Instrumentation	2+1
5	ME 102	Engineering Drawing and Graphics	0+3
6	ME 106	Food Thermodynamics	2+1
7	PFE 102	Post Harvest Engineering	2+1
8	ME 201	Heat and Mass Transfer in Food Processing	2+1
9	PFE 201	Unit Operations in Food Processing - I	2+1
10	PFE 202	Unit Operations in Food Processing - II	2+1
11	PFE 203	Food Refrigeration and Cold Chain	2+1
12	CSE 101	Information and Communication Technology in Agriculture	1+2
13	PFE 301	Food Process Equipment Design	2+1
14	PFE 302	Food Storage Engineering	2+1
15	EE 304	Instrumentation and Process Control in Food Industry	2+1
16	ME 305	Fluid Mechanics	2+1
			27+21=48

### COMMUNITY SCIENCE

1	HDFS 106	Human Values	11+0
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### NCC/NSO/NSS

1	NCC/NSO/NSS	SEM I	10+1 NC
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2	NCC/NSO/NSS	SEM II	10+1 NC
3	NCC/NSO/NSS	SEM III	10+1 NC
4	NCC/NSO/NSS	SEM IV	10+1 NC

Total credit hours requirement for B.Tech. (Food Technology)4 year Programme :  
 $185+4(\text{NC}^{**})+2(\text{NC})^*=191$

\*Pbi 101/Pbi Cul 101/\*\*NCC/NSS/NSO

**SEMESTER- WISE STUDY PROGRAMME OF  
B.Tech. (Food Technology) PROGRAMME**

**FIRST YEAR**

<b>SEM I</b>			<b>SEM II</b>		
1.	Math 101	3+0	1.	Math 102	3+0 NC
2.	Agron 105	2+1	2.	FT 102	2+1
3.	Env 101	2+0	3.	CSE 204	1+2
4.	EE 101	2+1	4.	EE 206	2+1
5.	ME 101	1+2	5.	ME 102	0+3
6.	Eng 101	1+1	6.	ME 106	2+1
7.	Micro 103	2+1	7.	PFE 102	2+1
8.	HDFS 106	1+0	8.	Micro 104	2+1
9.	*Pbi/Pbi.Cul. 101	0+2/2+0 NC	9.	NCC/NSO/N SS	0+1NC
10.	NCC/NSO/NSS	0+1 NC			
		14+6+2NC+1NC=23			11+10+4NC=25=25

**SECOND YEAR**

<b>SEM III</b>			<b>SEM IV</b>		
	FT 201	1+1	1.	FT 205	2+1
2.	FT 202	1+1	2.	FT 206	2+1
3.	FT 203	1+1	3.	FT 207	2+1
4.	FT 204	2+1	4.	FT 208	1+1
5.	ME 201	2+1	5.	PFE 202	2+1
6.	PFE 201	2+1	6.	PFE 203	2+1
7.	Eng. 201	1+1	7.	Biochem. 208	2+1
8.	Mgt. 202	2+0	8.	Math. 206	2+0
9.	Math. 205	2+0	9.	Mgt. 204	2+0
10.	Stat.205	2+1	10.	NCC/NSO/N SS	0+1NC
11.	NCC/NSO/NSS	0+1 NC			
		16+8+1NC=25			17+7+1NC=25

THIRD YEAR

SEM V			SEM VI		
	FT 301	2+1	1.	FT 306	1+1
2.	FT 302	2+1	2.	FT 307	1+1
3.	FT 303	2+1	3.	FT 308	2+1
4.	FT 304	2+1	4.	FT 309	2+0
5.	FT305	1+2	5.	FT 310	2+1
6.	CSE 101	1+2	6.	Biotech. 308	2+1
7.	PFE 301	2+1	7.	EE 304	2+1
8.	PFE 302	2+1	8.	ME 305	2+1
			9.	Micro. 308	2+1
		14+10=24			16+8=24

FOURTH YEAR

SEM VII			SEM VIII		
	FT/Mgt 493	2+1	1.	FT 499	20 (0+20)
2.	FT 494	0+7			
3.	FT 495	0+7			
4.	FT 496	0+3			
5.	FT 497	0+1			
6.	FT 498	0+2			
		2+21=23			0+20=20

\*For students with the domicile of Punjab who did not study Punjabi at matric or 10+2 level.

**Semester Wise Total Credit Hours**

Sr. No.	Semester	Credit hours
	Semester – I	20 (14+6)+2NC+ 1NC=23
	Semester – II	21 (11+10)+4NC=25
	Semester – III	24 (16+8)+1NC=25
	Semester – IV	24 (17+7) +1NC=25
	Semester – V	24 (14+10) =24
	Semester – VI	24 (16+8) =24
	Semester – VII	23 (2+21) =23
	Semester – VIII	20 (0+20) = 20
Total		180 (90+90)+7NC**+2NC*=186

\*Pbi 101/Pbi Cul 101/

\*\*NCC/NSS/NSO

**COURSE CURRICULUM FOR B.Tech. (Biotechnology)  
4-YEAR PROGRAMME (CORE COURSES)**

**DEFICIENCY COURSES**

**BASIC SCIENCES AND HUMANITIES**

**For PCM base**

			<b>Cr. Hrs.</b>
	1. Bot. 101	Basic Botany	Th + Pr 2 + 1
	2. Zoo. 101	Basic Zoology	2 + 1
			4 + 2 = 6

**For PCB base**

	1. Math. 101	Basic Mathematics-I	Th + Pr 3 + 0
	2. Math. 102	Basic Mathematics-II	3 + 0
			6 + 0 = 6

**Regional Language**

For students with domicile of Punjab who have not taken Punjabi at Matric/10+ 2 level

	1 Pbi. 101	Basic Punjabi	0 + 2 (NC)
For ICAR nominees and foreign student			
	1 Pbi. Cul. 101	Punjabi Culture	2 + 0 (NC)

**REQUIRED COURSES**

**AGRICULTURE**

			Th+Pr
	1. Agron. 103	Crop Production Technology	2 + 1
	2. AS 201	Livestock Production Management	2 + 1
	3. Biotech. 101	Cell Biology	2 + 0
	4. Biotech. 102	Molecular Biology	2 + 1
	5. Biotech. 103	Introduction to Biotechnology	2 + 1
	6. Biotech. 104	Plant Tissue Culture	2 + 1
	7. Biotech. 106	Electronics and Instrumentation in Biotechnology	1 + 1
	8. Biotech. 201	Recombinant DNA Technology	2 + 1
	9. Biotech. 202	Introductory Bioinformatics	2 + 1
	10. Biotech. 203	Plant Genetic Transformation	2 + 1
	11. Biotech. 204	Classical and Molecular Cytogenetics	2 + 1
	12. Biotech. 301	Molecular Genetics	2 + 0
	13. Biotech. 302	Nanobiotechnology	2 + 0

14.	Biotech. 303	Molecular Marker Technology	2 + 0
15.	Biotech. 304	Genomics and Proteomics	3 + 0
16.	Biotech. 305	Biosafety, Bioethics and IPR	2 + 0
17.	Biotech. 306	Computational Biology	2 + 1
18.	Biotech. 310	Applications of Genomics and Proteomics	2 + 1
19.	Biotech. 311	Molecular Breeding	2 + 1
20.	Biotech. 312	Epigenetics and Gene Regulation	3 + 0
21.	Biotech. 313	Programming for Bioinformatics	2 + 2
22.	Biotech. 314	Next Generation Sequencing and Data Analysis	2 + 1
23.	Biotech. 491/ Biotech. 492	In-house Skill Development in Plant Biotechnology/ In-house Skill Development in Bioinformatics	0 + 20/ 0 + 20
24.	Biotech. 493	Project Formulation, Execution and Presentation	0 + 10
25.	Biotech. 494	Entrepreneurial Development in Biotechnology	0 + 10
26.	Ent.-Pl. Path. 203	Fundamentals of Crop Protection	2 + 1
27.	Env. 101	Environmental Studies and Disaster Management	2 + 0
28.	FT 101	Food Science and Processing	1 + 1
29.	Hort. 201	Production Technologies for Horticultural Crops	2 + 1
30.	PBG 102	Fundamentals of Genetics	2 + 1
31.	PBG 201	Fundamentals of Plant Breeding	2 + 1
32.	PBG 301	Crop Improvement-I ( <i>Kharif</i> Crops)	1 + 1
33.	PBG 302	Crop Improvement-II ( <i>Rabi</i> Crops)	1 + 1
34.	Edu. Tour	Educational Tour	0 + 2 (NC)
			58+63=121+2 (NC)

### AGRICULTURAL ENGINEERING AND TECHNOLOGY

1.	CSE 101	Information and Communication Technology in Agriculture	1 + 2
			1 + 2 = 3

### BASIC SCIENCES AND HUMANITIES

Biochem. 207	Basic Biochemistry	3 + 1
Biochem. 304	Enzymology and Enzyme Technologies	2 + 1
Bio. 103	Biodiversity and its Conservation	2 + 0
Bot. 201	Plant Physiology	2 + 1
Econ. 201	Economics and Marketing	2 + 1
Eng. 101	General English	1 + 1
Eng. 201	Communication Skills and Personality Development	1 + 1
Math. 207	Biomathematics	2 + 1
Mgt. 201	Entrepreneurship Development and Business Management	2 + 1
Micro. 102	Elementary Microbiology	2 + 1

.	Micro. 201	Microbial Genetics	2 + 1
.	Phy. 202	Fundamentals of Biophysics	2 + 1
.	Stat. 206	Basic Statistics	1 + 1
.	Stat. 302	Fundamentals of Biostatistics	2 + 1
.	Zoo. 312	Immunology	2 + 1
.	Zoo. 313	Animal Biotechnology	3 + 1
			<hr/>
			31 + 15 = 46
			<hr/>

### COMMUNITY SCIENCE

1.	HDFS 106	Human Values	1 + 0
			<hr/>
			1 + 0 = 1
			<hr/>

### NCC/NSO/NSS

1.	NCC/NSO/NSS	(SEM-I)	0 + 1 (NC)
2.	NCC/NSO/NSS	(SEM-II)	0 + 1 (NC)
3.	NCC/NSO/NSS	(SEM-III)	0 + 1 (NC)
4.	NCC/NSO/NSS	(SEM-IV)	0 + 1 (NC)
			<hr/>

Total credit hour requirements for B.Tech. (Biotechnology) 4 year Programme  
 $177 + 2NC^* + 2NC^{**} + 4NC^{***} = 185$

\*Educational Tour

\*\*Pbi 101/Pbi Cul 101/

\*\*\*NCC/NSS/NSO



**SEMESTER-WISE STUDY PROGRAMME OF  
B.Tech. (Biotechnology) PROGRAMME**

**FIRST YEAR**

<b>SEM- I</b>		<b>SEM- II</b>	
*Bot. 101/	2+1/	1. *Zoo. 101/	2+1/
*Math. 101	3+0	*Math. 102	3+0
Biotech.101	2+0	2. Biotech. 102	2+1
Biotech. 103	2+1	3. Biotech. 104	2+1
Agron. 103	2+1	4. **Biotech. 106	1+1
Eng. 101	1+1	5. PBG 201	2+1
Env. 101	2+0	6. CSE 101	1+2
PBG 102	2+1	7. Bio. 103	2+0
FT 101	1+1	8. Eng. 201	1+1
HDFS 106	1+0	9. Micro. 102	2+1
**Pbi 101/	0+2 (NC)/	10. NCC/NSO/NSS	0+1(NC)
***Pbi. Cul. 101	+0 (NC)		
NCC/NSO/NSS	0+1(NC)		
15+6/16+5=21+2NC+1NC=24		15+9/16+8=24+1NC=25	

**SECOND YEAR**

<b>SEM- I</b>		<b>SEM- II</b>	
Ent.-Pl.Path. 203	2+1	1. **Biotech. 201	2+1
Hort. 201	2+1	2. Biotech. 203	2+1
Bot. 201	2+1	3. Biotech. 204	2+1
Econ. 201	2+1	4. AS 201	2+1
Math. 207	2+1	5. Biochem. 207	3+1
Micro. 201	2+1	6. Mgt.201	2+1
*Biotech. 202	2+1	7. Phy. 202	2+1
NCC/NSO/NSS	0+1(NC)	8. Stat. 206	1+1
		9. NCC/NSO/NSS	0+1(NC)
14+7=21+1NC=22		16+8=24+1NC=25	

THIRD YEAR

SEM-I		SEM-II	
Biotech. 301	2+0	1. Biotech. 306	2+1
Biotech. 302	2+0	2. Biotech. 310	2+1
Biotech. 303	2+0	3. Biotech. 311	2+1
Biotech. 304	3+0	4. Biotech. 312	3+0
Biotech. 305	2+0	5. Biotech. 313	2+2
PBG 301	1+1	6. Biotech. 314	2+1
Biochem. 304	2+1	7. PBG 302	1+1
Zoo. 312	2+1	8. Stat. 302	2+1
Zoo. 313	3+1		
<b>19+4=23</b>		<b>16+8=24</b>	

FOURTH YEAR

SEM-I		SEM-II	
Biotech. 491	0+20	1. Biotech. 493	10(0+10)
Biotech. 492	0+20	2. Biotech. 494	10(0+10)
Edu Tour	0+2(NC)		
<b>0+20+2NC=22</b>		<b>0+20=20</b>	

A student will opt for only one module among the following:

- Micropropagation
- DNA Fingerprinting
- Testing for Genetic Purity
- Marker Assisted Selection
- Haploid Production
- DatabaseManagement

\*Remedial courses

\*\*For students with domicile of Punjab who have not studied Punjabi at Matric/10+2 level

\*\*\*For students admitted through ICAR and foreign students

### Summary Semester Wise Total Credit Hours

Sr. No.	Semester	Credit hours
	Semester-I	$15+6/16+5=21+2NC+1NC=24$
	Semester-II	$15+9/16+8=24+1NC=25$
	Semester-III	$14+7=21+1NC=22$
	Semester-IV	$16+8=24+1NC=25$
	Semester-V	$19+4=23$
	Semester-VI	$16+8=24$
	Semester-VII	$0+20+2(NC) =22$
	Semester-VIII	$0+20 =20$
	Total	$177+2NC^*+ 2NC^{**}+4NC^{***} =185$

\*Educational Tour

\*\*Pbi 101/Pbi Cul 101/

\*\*\*NCC/NSS/NSO

## Course curriculum for 2 year Diploma in Agriculture

### CORE COURSES

#### BASIC SCIENCES AND HUMANITITES

1.	Bot. 51	Agricultural Botany	1+1
2.	Econ 51	Elementary Farm Management and Finace	2+1
3.	Econ 52	Marketing of Farm Products	2+0
4.	Mgt 51	Agricususiness and Entrepreneure Development	2+1
5.	Micro 51	Mushroom Cultivation	1+1
6.	Zoo 51	Fish Production	1+1

9+5= 14

### COLLEGE OF AGRICULTURE

1.	Agron. 52	Elementary Agronomy	2+1
2.	Agron. 53	Crop Production-I	2+1
3.	Agron. 54	Crop Production-II	2+1
4.	Agromet. 51	Elementary Agronomy	1+1
5.	Biotech. 51	Elementary Plant Tissue Culture	1+1
6.	Ext. 51	Elementary Extension Eudcation	2+2
7.	Ent. 51	Elementary Agricultural Entomolgoy	2+1
8.	Ent. 52	Useful Insects	2+1
9.	Forst. 51	Elementary Agroforestry	1+1
10.	Flori. 51	Lanscaping and Floriculture	1+1
11.	FT 51	Elementary Food Technology	1+1
12.	Hort. 51	Elementary Fruit Cultivation	2+1
13.	Hort. 52	Nursery Production of Fruit Crops	0+1
14.	Pl. Path. 51	Diseases of field Crops	1+1
15.	Pl. Path. 52	Diseases of Fruit and Vegeable Crops	1+1
16.	PBG 59	Elementary Plant Breeding and Seed Production	2+1
17.	LPM 51	Elementary Livestock and Poultry Production	3+1
18.	Soils 51	Elementary Soil Fertility	2+1
19.	Soils 52	Elementary Soil Physics and Conservation	2+1
20.	Veg. 51	Elementary Vegetable Cultivation	2+1
21.	Veg. 52	Protected Cultivation of Vegetable Crops	0+1

32+22=54

### COLLEGE OF AGRICULTURAL ENGINEERING AND TECHNOLOGY

1.	FPM 51	Farm Mechanization	2+1
2.	PFE 51	Elementary Agro-processing	1+1

3.	SWE 51	Farm Irrigation and Drainage	2+1
			5+3=8

### SEMESTER WISE STUDY PROGRAMME OF

#### 2-year Diploma in Agriculture

#### FIRST YEAR

SEM I			SEM II		
1	Bot. 51	1+1	1	Agron. 54	2+1
2	Agron. 52	2+1	2	Hort. 52	0+1
3	Agron. 53	2+1	3	Soils 52	2+1
4	Hort. 51	2+1	4	FT 51	1+1
5	Forst. 51	1+1	5	Flori. 51	1+1
6	Soils 51	2+1	6	Agromet. 51	1+1
7	Veg. 51	2+1	7	Econ. 51	2+1
			8	FPM 51	2+1
Total		12+7=19	Total		12+7=19

#### SECOND YEAR

SEM III			SEM IV		
1	Mgt. 51	2+1	1	Pl. Path. 52	1+1
2	Ent. 51	2+1	2	Micro. 51	1+1
3	Pl. Path. 51	1+1	3	Biotech. 51	1+1
4	Econ. 52	2+0	4	Ent. 52	2+1
5	SWE 51	2+1	5	LPM 51	3+1
6	PFE 51	1+1	6	Ext. 51	2+2
7	PBG 59	2+1	7	Veg. 52	0+1
				Zoo. 51	2+1
Total		12+6=18	Total		11+9=20

**Course curriculum for Diploma Course in Hybrid Seed Production Technology (Two Semesters)**

**CORE COURSES**

**COLLEGE OF AGRICULTURE**

1.	Agron. 51	Elementary Agriculture	1+1
2.	PBG 51	Hybrid Seed Production-I	2+2
3.	PBG 52	Seed testing and Quality Control	2+2
4.	PBG 53	Visits to Seed Production and Processing Units-I	0+2
5.	PBG 54	Project on Seed Production	0+4
6.	PBG 55	Hybrid Seed Production-II	2+2
7.	PBG 56	Seed health	2+2
8.	PBG 57	Seed processing and Storage	2+2
9.	PBG 58	Visits to Seed Production and Processing Units-II	0+2
			11+19=30

**SEMESTER WISE STUDY PROGRAMME OF**

**Diploma in Hybrid Seed Production Technology (Two Semesters)**

SEM I			SEM II		
1	Agron 51	1+1	1	PBG 55	2+2
2	PBG 51	2+2	2	PBG 56	2+2
3	PBG 52	2+2	3	PBG 57	2+2
4	PBG 53	0+2	4	PBG 58	0+2
5	PBG 54	0+4			
Total		5+11=16	Total		6+8=14