## Courses and Curricula for Ph. D. Degree in Agricultural Botany

| Course Code | Course Title | Credit Hour |
|---|---|---|
| **1. Major Courses** | | |
| **1a. Core** | | **18** |
| ABOT 601 | Developmental Plant Physiology | 3 |
| ABOT 602 | Advanced Stress Physiology | 3 |
| ABOT 603 | Crop Physiology | 3 |
| ABOT 604 | Molecular Biology | 3 |
| ABOT 605 | Crop Climatology | 3 |
| ABOT 606 | Crop Ecology | 3 |
| **1b. Elective** | | **6** |
| ABOT 607 | Agroecology and Ecosystem Management | 3 |
| ABOT 608 | Protected and Soilless Crop Culture | 3 |
| ABOT 609 | Cell Signaling | 3 |
| ABOT 610 | Pollution and Agriculture | 3 |
| ABOT 611 | Ecotoxicology | 3 |
| ABOT 612 | Research Methodology and Analytical Techniques | 3 |
| ABOT 613 | Lab Techniques in Plant Physiology | 3 |
| ABOT 614 | Lab Techniques in Plant Ecology | 3 |
| BOT 507 | Cell Physiology | 3 |
| BOT 509 | Plant Growth Regulators | 3 |
| BOT 511 | Floral Biology | 3 |
| BOT 512 | Seed Physiology | 3 |
| BOT 513 | Biodiversity and Conservation | 3 |
| BOT 517 | Statistical Approach in Agricultural Research | 3 |
| **2. Minor Courses** | | **6** |
| Courses offered from other Departments will be selected by the Advisory Committee as per student's requirement. | | |
| **3. Seminar Courses** | | **2** |
| ABOT 698A | Seminar-1 | 1 |
| ABOT 698B | Seminar-2 | 1 |
| **4. Research** | | |
| ABOT 699 | Research work for Thesis | **30** |
| | **Total Cr. Hr.** | **62** |

**ABOT 609. Cell Signaling (Elective)**
**Credit hour: 3**

Signal transduction, receptor and their types, signaling molecules-hormones, second messengers production-reactive oxygen species, reactive nitrogen species, calcium, pH. Signaling to stresses during plant growth and development. Molecular mechanism of signaling. Roles of second messengers on ion channel activation in the plasma membrane as well as intracellular organelles membranes. Guard cell signaling pathway in response to light, dark, wound, drought, salt, bacteria, fungi and other stresses.

**ABOT 610. Pollution and Agriculture (Elective)**
**Credit hour: 3**

Sources, fate and transformation of pollutants. Management of polluted agricultural land and water use. Mitigation of air, water and soil pollution by agricultural plants. Management of air, water and soil pollution. Bioindicators of pollution. Environmental risk assessment due to agricultural pollution.

**ABOT 611. Ecotoxicology (Elective)**
**Credit hour: 3**

Toxicology, toxicants and toxicity; factors influencing toxicity. Concemtration-response relationship; biochemical mechanisms of toxicity. Toxicity testing: acute early life-stage and chronic toxicity tests; statistical analysis. Factors modifying toxicity; toxicity of chemical mixtures; pre-release toxicity testing for protection of ecosystems. Chemical distribution; bioaccumulation, biomagnification, biotransformation. Specific toxicant effects; metals, lipids, herbicides, pesticides, fertilizers, oil spills, PCBs, others. Biological monitoring; biomarkers and bioindicators. Ecological risk assessment; national and international legislation of toxic substances.

**ABOT 612. Research Methodology and Analytical Techniques (Elective)**
**Credit hour: 3**

Research planning, execution, monitoring and evaluation: Needs and types of research, hypothesis, proper planning, methods of execution and monitoring; evaluation procedure and interpretation. Important statistical approaches: Tests of hypothesis, topics of central tendency and dispersion, probability distribution, correlation, regression; sampling theory and test of significance. Design of experiments: Important experimental designs and analysis of experimental data. Application of statistical methods through appropriate computer packages.

Interpretation of results: Writing of seminar paper, assignment, scientific papers and thesis. Presentation of experimental findings through different approaches.

## ABOT 613. Lab Techniques in Plant Physiology (Elective)
**Credit hour: 3**

Different techniques and methods of plant physiological experiments: Electron microscopy, enzyme cytochemistry, auto radiography, separation of cell or organelles, chromatography, gel filtration, electrophoresis. Optical methods of analysis, colorimetric determination of different compounds and elements. Estimation, measurement and extraction of different enzymes, compounds, elements inhibitors and other important chemicals; estimation of radioisotopes. Estimation, measurement of the different foresees and effects; PAR, photosynthesis, respiration, transpiration, evaporation, photorespiration, vernalization, photoperiodism, absorption of water and minerals, translocation, ascent of sap, separation of plant pigments and other important physiological phenomena.

## ABOT 614. Lab Techniques in Plant Ecology (Elective)
**Credit hour: 3**

Different aspects of soil characteristics measurement. Different aspects of atmospheric and aerial environment analysis. Study of vegetation, community structure. Study of different ecosystems. Study of different types of adaptation. Study of production and nutrient budget. Measurements of water relations and stresses. Estimation of mineral nutrition. Study of site and soil. Study of plant population biology. Chemical analysis of different types. Data analysis in ecological experiments.

## ABOT 507. Cell Physiology (Elective)
**Credit hour: 3**

**Functional organization of cell:** Cell organization; biochemistry of cell; structures and functions of cell organelles.

**The cell environment:** Temporal organization of the cell; water, gases and pressure in the cell environment; radiation in the cell environment; temperature as a factor in the cell environment.

**Exchange of materials across cell membrane:** The chemical nature and structure of cell membranes; movement of water and solutes across cell membrane.

**Correlation of energy and matter in the cell:** Cellular enzymes and their dymamics of action; release of energy in cells; oxidation-reduction potentials in cellular oxidation.

**Cell division and growth:** Phases of cell division and growth; process of cellular growth; formation of plasma membrane and cell wall.

## ABOT 509. Plant Growth Regulators (Elective)
**Credit hour: 3**

**Introduction:** Concept, classification and quantification of plant hormones and other growth substances; hormone sensitivity and correlation of growth with hormone concentration.

**Auxins, gibberellins, cytokinins, ethylene and abscissic acid:** Bioassay, metabolism and transport; biosynthesis; mechanism of action and physiological functions during growth and development of plant.

**Other growth substances:** Occurrence and role of uncommon natural growth substances - morphactins, brassinosteroids, polyphenols, polyamines, fusicoccin and batasins, jasmonic acid and effects of synthetic growth substances.

**Use of growth substances:** Application of plant growth regulators in agriculture, horticulture and forestry.

## ABOT 511. Floral Biology (Elective)
## Credit hour: 3

**Floral morphology:** Floral parts, appendages and their variation; evolution of micro - and macro-sporophylls.

**Phenology:** Phenological phases; quantifying phenological phases.

**Pollens:** Development of pollen and male gametophyte; pollen structure.

Ovules: Formation of ovule and embryo sac; types of ovule, embryo sac, ovary wall and placentation.

Anthesis and pollination: Process of anthesis and factors affectors affecting it; anther dehiscence, pollination and artificial pollination.

Pollen germination; pollen germination; entry of pollen tubes into ovule, fertilization process and types of fertilization.

Endosperm and embryo: Formation of the different types of endosperm and embryo.

Apomixis and polyembryony: Types of apomixis; development of embryo in aposporic embryo sac; causes, types, types and practical implication of polyembryony.

## ABOT 512. Seed Physiology (Elective)
## Credit hour: 3

**Seed development:** Development of seeds and fruits; seed structures.

**Seed growth and maturation:** Source of assimilates; physiological maturity; metabolism during drying and rehydration in orthodox and recalcitrants seeds.

**Dormancy and germination:** Biological role, types, causes and breaking of seed dormancy; control of dormancy and germination; water uptake, soaking injury and solute leakage; causes and metabolic consequences of viablity loss.

**Physiology of seed production, utilization and storage:** Viability and longevity of seeds; malting and pre-harvest sprouting in cereals; physiological principles of seed storage; causes and metabolic consequences of viability loss.

## ABOT 513. Biodiversity and Conservation (Elective)
## Credit hour: 3

**Sources of diversity:** Natural and artificial selection; random events; variability in population; racicle differentiation; isolation; spaciation; hybridization, mutation and other breeding methods.

**Centres of diversity:** Centres of origin of crop plants; their past and present geographic distribution; trends of future spread and extinction.

**Plant genetic resources:** Genetic diversity in agriculture; crop diversity and stability; change in genetic structures; cultivar development; genetic advance and maintenance of diversity.

**Biodiversity crisis:** Effect of population pressure; causes and rate of extinction; natural and artificial selection pressure; monoculture and modern agriculture.

**Biodiversity conservation:** Principles of conservation and preservation; *in situ* conservation; *ex situ* conservation.

## ABOT 517. Statistical Approach in Agricultural Research (Elective)
## Credit hour: 3

Research planning, execution, monitoring and evaluation. Data collection and tabulation. Sampling, field plot techniques. Standard deviation, coefficient of variation, standard error, test of hypothesis, analysis of variance. Design of experiments, principles of design, types of design. Correlation and regression analysis. Multiple comparison procedures. Use of computer in data analysis software packages. Interpretation of results. Writing of seminar papers, assignment, scientific paper and thesis; presentation of experimental findings.

## Course and Curricula for Ph. D. Degree in Agricultural Chemistry

| Course Code | Course Title | Credit Hour |
|---|---|---|
| **1. Major Courses** | | |
| **1a. Core:** | | **18** |
| AGCH 601 | Fertilizer Chemistry | 3 |
| AGCH 602 | Agrochemicals Regulation and Quality Control | 3 |
| AGCH 603 | Pesticide Transformation, Metabolism and Residue Chemistry | 3 |
| AGCH 604 | Waste Utilization and Clean Technology | 3 |
| AGCH 605 | Chemistry of Food Adulteration | 3 |
| AGCH 606 | Industrial Pollution in Agroecosystems | 3 |
| **1b. Elective** | | **6** |
| AGCH 607 | Bioenergy: Principle and Practices | 3 |
| AGCH 608 | Advanced Environmental Chemistry | 3 |
| AGCH 502 | Instrumental Methods of Analysis | 3 |
| AGCH 503 | Colloid Chemistry in Relation to Plant Nutrition | 3 |
| AGCH 504 | Analysis of Fertilizer, Pesticide, Plant, Soil and Water | 3 |
| AGCH 505 | Chemistry of Pesticides | 3 |
| AGCH 507 | Formulation and Safety of Agro-chemicals | 3 |
| AGCH 509 | Chemistry of Plant Products | 3 |
| AGCH 511 | Water and Solution Chemistry | 3 |
| AGCH 512 | Chemistry and Technology of Industrial Crops | 3 |
| AGCH 515 | Nuclear Chemistry and Tracer Techniques | 3 |
| **2. Minor Courses** | | **6** |
| Courses offered from other Departments will be selected by the Advisory Committed as per student's requirement | | |
| **3. Seminar Courses** | | **2** |
| AGCH 698 A | Seminar-1 | 1 |
| AGCH 698 B | Seminar-2 | 1 |
| **4. Research** | | |
| AGCH 699 | Research work for Thesis | **30** |
| | **Total Cr. Hr.** | **62** |

## AGCH 601. Fertilizer Chemistry (Core)
**Credit hour: 3**

Concepts, raw materials and reserves. Chemistry, production technology, uses, and factors influencing choice of advanced nitrogenous and phosphatic fertilizers. Chemistry and production technology of secondary, micro-nutrient, mixed, liquid and slow released fertilizers. Comparative study and chemical changes of fertilizers during storage and after application. Aerobic and anaerobic decomposition of organic wastes and factors involved therein. Biodynamics of nutrient elements during composting; losses of plant nutrients during preparation and conservation of composts. Importance, scope and production technology of biofertilizer. Reaction, kinetics involved in microbial, thermal and vermicomposting of agricultural, municipal and industrial wastes. Role of organic waste as compost and vermicompost in Bangladesh agriculture. Use of supplemental plant nutrients (though fertilizer or other means) for plant protection measure. Use, overuse and misuse of fertilizers. Preparation of nutrient balance sheet for the evaluation of manures and fertilizers. Compatibility among fertilizers and with other agrochemicals.

## AGCH 602. Agrochemicals Regulation and Quality Control (Core)
**Credit hour: 3**

Definition, classification, chronological developments in evolution, structure, general properties and uses of major conventional agro-chemicals including plant protection and plant production chemicals, safety standards. Overview of agrochemical industry in Bangladesh, various laws, acts and rules governing regulation and registration of agrochemical industry. WHO and FAO guidelines. Quality-definition, specifications and needs. Rules and regulations governing quality. Production, consumption and trade statistics of pesticides. Regulatory measures as per agrochemicals Act and specifications of major chemicals. Implications in the environment, poisoning, antidotes etc. Sanitary and phytosanitary (SPS) measures: Definition of an SPS measure, core disciplines, basic SPS rights, harmonization, equivalency, risk assessment, pest or disease free status, transparency, sanitary and phytosanitary committee.

## AGCH 603. Pesticide Transformation, Metabolism and Residue Chemistry (Core)
**Credit hour: 3**

Concepts of pesticide metabolism; Defence system, nervous system; enzymes responsible for metabolism of pesticides and their role; acetylcholinesterase -its action and inhibition. Classification and mode of action. Effect of pesticides on major microbial population. Compatibility of pesticides with other agrochemicals. Limitations of use of pesticides. Scope and principles of photo and microbial degradations and other transformations. Biotic and aboitic transformations of conventional pesticides in air, soil, plant, water etc. Pesticide transformation in microbes, insects, nematodes and other living systems and transportation in environment. Concepts of pesticide residues, toxicological significance, principles of residue analysis-sampling, extraction, clean-up and analysis of pesticide residues from different substrates. Interpretation of data. Decontamination of pesticide residues in on treated commodities.

## AGCH 604. Waste Utilization and Clean Technology (Core)
## Credit hour: 3

Concepts of environment and ecology. Waste management technologies-biological oxidation of aqueous organic waste, storage, thermal oxidation (incineration), chemical treatment for detoxification. Possible utilization of by-products from different mills and factories. Recycling of wastes for the production of biogas and use of effluents; waste reduction; management and recycling of municipal and domestic wastes; resource recovery. Regulation, legal provisions and institutional frame work for the protection of environmental degradation in Bangladesh; comprehensive regulations regarding the total allowable mass emission of sulphur dioxide, nitrogen peroxide and other obnoxious gases and fumes. Pollution prevention in industry, energy, transportation and agricultural products; integrated pollution prevention and control-goals, alternative focuses and techniques and institutional measures.

## AGCH 605. Chemistry of Food Adulteration (Core)
## Credit hour 3

Food adulteration process, adsorption and disposition, factors governing adulteration, toxic effects of adulteration. Quantitative toxicology; dose-response relationships, factors affecting quantitative response, toxic kinetics, toxicity measurement and endpoints. Intoxication mechanisms: The biochemical lesion, receptors and targets, mechanisms of general toxicity, plant specific mechanisms, microbe-specific mechanisms. Exposure and risk: hazard and risk, exposure, risk assessments, ecological risk, risk management. Inorganic toxicants: toxic inorganic chemicals, some basic chemistry, non-metallic elements, the metalloids, heavy elements, transition elements, radioactive elements, other toxic elements. Biotoxins: what is biotoxins, the alkaloids, toxic glycosides, plant phenolics, amino acids, peptides and proteins, lactone, mycotoxins. Refractory pollutants: what is refractory chemicals, DDT and DDE, chlorinated alicyclics, chlorinated dioxins, polychlorinated biphenyls and phthalate esters. Bangladesh Standardization of Testing Institution (BSTI) rules and regulations.

## AG[illegible]. Industrial Pollution in Agroecosystems (Core)
## Credit hour: 3

Agro[illegible]ystems, ecological and social attributes, interactions among chemical, physical, biological and socio-economic components of agro-ecosystems; biodiversity, characteristics and functions of agro-environmental resources viz; soil, water, climatic factors, living organisms, farm chemicals, rural infrastructure and options for sustainable development. Definition and source of pollution; different types of pollution i.e. air, water and soil pollutions and their sources and effects on biosphere and atmospheric pollutants; sources and diffusion of $SO_2$, CO, $CO_2$, CFC, $CH_4$, NO in atmosphere, particulates and heavy metals in environment. Different industrial sludges such as nitrates, heavy metals detergents, explosives, dyes, insecticides, fungicides, fertilizers, plastics, resins etc and their treatment processes.

## AGCH 607. Bioenergy: Principle and Practices (Elective)
**Credit hour: 3**

Bio-energy principle and practices: concept, scope and importance of bio-energy. Energy from biomass: past and present perspectives of bio-energy. Biomass resources: a) biomass wastes b) energy crops c) aquatic sources. Energy profiles: a) producer gas b) biogas c) hydrogen d) ethanol e) methanol f) vegetable oil and g) solid fuels. Bioconversion processes: a) microbial conversion b) thermal conversion c) fuels and d) co-products. Biogas: historical developments of biogas technology in Bangladesh. The anaerobic digestion process, digester design, primary products and by-products of biogas effluents, use of biogas. The role of energy production in Bangladesh: a) prospect and resources b) description of the process c) requirements for agricultural application. Energy economics and environments: a) Energy analysis and economics of biomass b) environmental and sociological issues. Renewable resources of energy: concept, scope and importance, comparative feasibility of renewable energy against bio-energy in Bangladesh.

## AGCH 608. Advanced Environmental Chemistry (Elective)
**Credit hour: 3**

Introduction, concept and scope of environmental chemistry, natural cycles of the environment such as hydrological, oxygen, nitrogen, phosphate and sulphur, chemical and photochemical reactions in the atmosphere, photolytic and radiolytic scavenge. Industrial chemicals: what are industrial chemicals, petrochemicals, toxic byproducts and conversion products. Reactive pollutants: what is reactivity, alkayl halides, chlorophenols, divalent sulfur compounds, dithiocarbamates, nitroarenes, amines and their derivatives, ester, carbon monoxide and cyanides. Predicting environmental fate and effects: quantitative prediction, predicting environmental transport, predicting environmental transformations, modeling environmental fate, Quantitative Structure-Activity Relations (QSAR) and microc.

## AGCH 502. Instrumental Methods of Analysis (Elective)
**Credit hour: 3**

**Colorimetry and Spectrophotometry:** Principle and theory of spectrophotometry, methods of colour measurement; components of spectrophotometric instruments.

**Atomic spectroscopy:** Theory of flame emission and atomic absorption spectrophotometry-Bohr's equation and Boltzman equation; components of flame emission spectrophotometer (FES) and atomic absorption spectrophotometer (ASS), interferences in atomic absorption spectrophotometric analysis; Principles and instrumentations of atomic fluorescence spectroscopy (AFS), inductively coupled plasma spectroscopy (ICP), mass spectroscopy (MS), X-ray absorption, fluorescence and diffraction spectroscopy, ion selective electrodes.

**pH and conductivity measurement:** Principle, calibration and maintenance of pH and conductivity meters.

**Chromatography:** Column and planar chromatography; Phase and basic techniques of thin layer chromatography (TLC), gas liquid chromatography (GLC), high performance

liquid chromatography (HPLC) and ion chromatography; partition ratios in chromatography.

**Laboratory instrumentation:** Maintenance and trouble shooting of laboratory instruments.

## AGCH 503. Colloid Chemistry in Relation to Plant Nutrition (Elective) Credit hour: 3

**Colloids:** Nature and types of colloids; properties and mineralogical organization of silicate clay and humic colloids; development of charges of soil colloids.

**Nutrient flux in soils and plants:** Nutrient adsorption process in soil-plant system; movement of nutrients from soils to roots. Nutrient uptake mechanism from soil to plant roots, active and passive ion transport; Root cell membrane integrity

**Cation and anion retention:** Cation selectivity and exchangeable cation with its cation exchange equations; diffuse double layer; specific and nonspecific anion reactions; anion and cation exchange. Antagonistic and synergestic interactions of nutrient ions in soil-plant system.

**Essential and beneficial nutrients:** History of the essential nutrients and their available forms, classification; dissociation of minerals and ionization of nutrients; deficiency and toxicity levels of nutrients.

**Essential and beneficial nutrients:** History of the essential nutrients and their available forms, classification; dissociation of minerals and ionization of nutrients; deficiency and toxicity levels of nutrients.

**Nutrient accumulation and metabolism in plants:** Activation, transport and reduction of nutrients- Carbon, nitrogen, phosphorus, sulphur, zinc and other nutrients; biosynthesis of starch, ATP, amino acid and their metabolism.

**Laws governing ionic reactions:** Law of mass action; ratio law and second law of thermodynamics; kinetic and molecular theory of gases and its application to absorption.

## AGCH 504. Analyses of Fertilizer, Pesticide, Plant, Soil and Water (Elective) Credit hour: 3

**Sampling:** Principles, time and frequency of sampling; procedures for obtaining soil, plant, water, fertilizer and pesticide samples, errors in sampling.

**Analytical techniques:** Analytical techniques of titrimetry, colorimetry, flame emission, atomic absorption spectrophotometry and chromatography.

**Fertilizer analysis:** Moisture and nutrient contents in urea, SSP, TSP, DAP, MOP, zinc sulphate and borax.

**Pesticide analysis:** Residue analysis and identification of different group of pesticides.

**Plant analysis:** Plant tissue for different nutrients.

**Soil analysis:** Available, exchangeable and total nutrient contents and toxic elements; fractionation of soil macro and micronutrients.

**Water analysis:** Surface, ground and rain waters for dissolved constituents including As, Cr, Cd, Pb, Co and Hg.

## AGCH 505. Chemistry of Pesticides (Elective)
### Credit hour: 3

**Pesticide:** Concepts, definition, classification.
Preparation, properties, mode of action, field performance, storage, and uses of inorganic pesticides- copper, sulphur and mercury compounds.

**Organochlorinated hydrocarbons-** DDT, dieldrin, aldrin, heptachlor, chlordane, methoxychlor.

**Organophosphorus compounds-** Dichlorvos, phosphamidon, bidrin, parathion, methyl parathion, sumithion, chlorothion, diazinon, malathion.

**Organocarbamate compounds-** Carbaryl, baygon, dimetan, furadan, pyrolan.

**Concepts of pesticide metabolism:** Defence system, nervous system; enzymes responsible for metabolism of pesticides and their role; acetylcholinesterase -its action and inhibition.

**Fungicides:** Nabam, zineb, maneb, vapam, ceresan-M, captan, folpet, cupravit, granosan, vitavax, bordeaux mixture, mancozeb and propiconazole.

**Herbicides:** 2,4-D, dalapon, maleic, hydrazide, paraquat, endothal, ronstar, diquat, machet.

**Acaricides:** Kelthane, ethion, thiovit.

**Methods of pesticide application:** Chemical and integrated control.

Effects of pesticides on major microbial populations and environment.

Compatibility of pesticides with other agrochemicals; limitations of uses of pesticides.

## AGCH 507. Formulation and Safety of Agro-chemicals (Elective)
### Credit hour: 3

Introduction, classification, chronological developments in evolution structure, general properties and uses of major conventional agro-chemicals including plant protection and production.

History of pesticide use and pesticide Ordinance in Bangladesh.

Formulation of pesticidal dust, wettable powder, granules, aerosol, fumigants, emulsifiable concentrates and capsules.

Different types of plants for the formulations of pesticides.

Mechanism of penetration and translocation of pesticides in insect and plants.

Pesticide chemical drift due to gravitational and electrostatic forces, application equipments, meteriological conditions and drift residue characteristics.

Adsorption, movement, leaching, diffusion and decomposition of pesticides in soil.

Toxic hazards of pesticides and antidotes for pesticide poisoning.

Agro-Chemicals Regulations, Quality control and Management.

## AGCH 509. Chemistry of Plant Products (Elective)
## Credit hour: 3

Biosynthesis, chemical nature, extraction and properties, formulations and mode of actions of nicotine, pyrethrin, neem (Azadirectin) and other biopesticides. Biosynthesis, functions, properties and regulations of chlorophylls, carotinoids, flavonoids and tannins. Characteristics, chemical nature, biosynthesis, translocation, mode of action and role of auxins, gibberellins, cytokinins and abscissic acid. Biosynthesis, translocation, role and mode of actions of ethylene and phytochrome. Biosynthesis, chemical nature, properties and mode of actions of vitamins. Characteristics of alkaloids in medicinal plants; extraction and isolation of alkaloids.

## AGCH 511. Water and Solution Chemistry (Elective)
## Credit hour: 3

**Water:** Occurrence and sources of water; the hydrologic cycle and processes, physical, chemical, biological and radiological qualities; quality assessment and criteria for drinking, domestic, livestock, poultry, fisheries, irrigation and industrial usage; ionic toxicity and plant tolerance; Management and reclamation of sodic and saline waters

**Water pollution:** Sources and causes of water pollution and its control measure; transport and hydrochemical processes of pollutants- As, Cd, Cr, Pb and Zn; health contamination and safety.

**Treatment:** Filtration, sorption, dilution, desalination, biological and chemical processes of wastewater treatment; Lab. waste and disposal.

**Precision and detection of analytical result:** Anion-cation balance; measured and calculated TDS to EC ratio.

**Soil Solution:** Composition of solution, ionic strength, ion activity co- efficient, Debye-Huchel theory, Davies equation, ion speciation in soil solution, Chemical potential, soil solution PH, Carbonate equlibria, lime potential equation

## AGCH 512. Chemistry and Technology of Industrial Crops (Elective)
## Credit hour: 3

**Exploitation of Hevea:** Evolution of tapping methods; stimulants their methods and practices; microtapping-puncture method; natural and synthetic rubbers; production, properties and uses of synthetic rubbers; rubber derivatives and processing.

**Manufacturing technology of raw sugar and plantation white sugar:** Sucrose recovery and refining of sugar; physical and chemical characteristics of sugarcane and cane juice; chemistry and utilization of sugar mill by-products; fermentation of molasses products; molasses as a feed for livestock; colour of cane juice; deterioration of sugar during storage.

**Chemistry and technology of black tea manufacturing processes:** withering, rolling, roll breaking and fermentation; biochemical changes; preparation process of green tea; composition of tea leaves and shoots; liquoring qualities, infusion, aroma and food value of tea.

**Curing processes of tobacco leaves-their characteristic features and differences:** chemical changes; chemical composition of leaf and its relation to type and quality, fermentation and aging processes.

## AGCH 515. Nuclear Chemistry and Tracer Technique (Elective)

**Credit hour: 3**

**Nuclear radiations:** Nuclear stability and reactions; Properties and absorption of radiations; radioactive decay and equilibria; average and half life; specific activity and radiocarbon dating; techniques of autoradiography, Geiger Muller counter, basic and liquid scintillation counters; radiation safety; biological effect of radiation.

**Tracer methodology:** Selection of radioisotopes; isotopic dilution and plant injection techniques; difficulties in tracer methodology.

**Laws governing of radiation reactions in soil:** Law of mass action; ratio law and second law of thermodynamics; kinetic and molecular theory and its application to absorption.

Application of radioisotopes in soil, crop, plant protection, irrigated agriculture and irradiation studies

## Courses and Curricula for Ph. D. Degree in Agricultural Extension

| Course Code | Course Title | Credit Hour |
|---|---|---|
| **1. Major Courses** | | **18** |
| **1a. Core** | | |
| AEIS 601 | Comparative Agricultural Extension Education | 3 |
| AEIS 602 | Advanced Social Research Methodology | 3 |
| AEIS 603 | Communication for Development | 3 |
| AEIS 604 | Agricultural Knowledge Management | 3 |
| AEIS 605 | Extension Administration and Training Management | 3 |
| AEIS 606 | Project Planning, Development and Management (PPDM) | 3 |
| | | |
| **1b. Elective** | | **6** |
| AEIS 607 | Human Resource Development and Organizational Behaviour | 3 |
| AEIS 608 | Statistics for Advanced Socio-economic Research | 3 |
| AEIS 609 | Education for Adult Learners | 3 |
| AEIS 501 | Agricultural Extension and Communication | 3 |
| AEIS 502 | Extension Administration, Supervision and Management | 3 |
| AEIS 503 | Technology Diffusion | 3 |
| AEIS 505 | Group Dynamics and Leadership | 3 |
| AEIS 508 | Fundamental of Journalism | 3 |
| AEIS 509 | Psychology of Human Behaviour | 3 |
| AEIS 510 | Non – Government Organization in Rural Development | 3 |
| AEIS 511 | Gender and Development | 3 |
| AEIS 512 | Anthropological Studies in Agriculture | 3 |
| AEIS 514 | Rural Home Management | 3 |
| AEIS 518 | Planning, Monitoring and Evaluation of Extension Programme | 3 |
| AEIS 519 | Environmental and Farming Systems in Extension | 3 |
| AEIS 521 | Extension Teaching Methods and Techniques | 3 |
| AEIS 522 | Sociology and Psychology of Extension Education | 3 |
| | | |
| **2. Minor Courses** | | **6** |
| Courses offered from other Departments will be selected by the Advisory Committee as per student's requirement. | | |
| | | |
| **3. Seminar Courses** | | **2** |
| AEIS 697A | Seminar-1 | 1 |
| AEIS 698B | Seminar-2 | 1 |
| | | |
| **4. Research** | | |
| AEIS 699 | Research work for Thesis | **30** |
| | **Total Cr. Hr.** | **62** |

## AEIS 601. Comparative Agricultural Extension Education (Core)
## Credit hour: 3

**Origin of Agricultural Extension Education:** Ancient concepts and evolution of agricultural extension education. Agricultural Extension as a Social Science; Components of Agricultural Extension Education: Training, Extension Program, Information, Policy and Law, Field Experience.

**Agricultural Extension in Bangladesh:** a. Gradual development of Agricultural Extension in Bangladesh: Crop Sector, Livestock Sector and Fisheries Sector b. Extension Approaches/Models/ Systems followed by DAE, c. Extension Services of NGOs and private companies' d. Extension- Research linkage, e. Problems of Agricultural Extension services in Bangladesh.

**Agricultural Extension in Japan:** a. Historical development of Agricultural Extension Service in Japan (1868 to onward), b. Extension organization, extension approaches and methodology of extension activities, c. Present System of Agricultural Extension Work in Japan, d. Agricultural Cooperatives in Japan.

**Agricultural Extension in India:** a. Historical development of Agricultural Extension in India: Community Development Program, National Extension Service, Intensive Agricultural Program, b. Extension organization, extension approaches and methodology of extension activities, c. T & V System, Transfer of Technology Program and University Extension System, d. Extension-Research and Research-Extension-Farmer linkages e. Extension Services under corporation/Board f. Indian Council of Agricultural Research & Extension Service, g. Agricultural Extension in livestock sector.

**Agricultural Extension in Thailand:** a. Agricultural Extension Services in Thailand: Gradual development (1967-1993), b. Extension Organization, Extension approaches and central and provincial administration, c. Agricultural Extension in livestock Sector.

**Agricultural Extension in USA:** a. Evolution of Extension Service in the USA, b. Cooperative Extension Service of USA: Profile of the Cooperative Extension Service; Developing Sound Extension Program, c. Extension Organization, Approaches and methodology of extension activities, d. Home Economics Extension Program, e. Extension Service's 4-H and Youth Program, f. Some Acts: Moril Act (1st & 2nd), Smith-Lever Act.

**A Look of Extension Service Around the World:** Comparison of Agricultural Extension Across the countries.

## AEIS 602. Advanced Social Research Methodology (Core)
## Credit hour: 3

**Basics of Social Research:** Characteristics of science and scientific methods, types and methods of social research, Philosophy and ethics of social research prioritization and selection of researchable problems, fundamental basis of research planning, formulation of theoretical framework, preparation of research proposal.

**Research Designs:** Meaning and purpose of research design, type of research design in social science and their uses

**Population and Sample:** Locale, population, sample and sampling techniques for social research

**Data and variables:** Types of data-qualitative and quantitative, discrete and continuous; Variables- nature and types of variables.

**Measurement of variables:** Concept of measurement, levels of measurement, scaling techniques, measurement of validity and reliability, attitude scales - equal appearing intervals scale, summated rating scale, cumulative, Guttman scale, Bogardus, semantic scale, summated rating scale, cumulative, Guttman scale, Bogardus, non-referenced and criterion-referenced techniques of measurement.

**Research Instruments:** Types and quality of research instruments, Preliminary preparation and pre-testing of research instruments, objectivity in testing research instruments, final preparation of research instruments.

**Methods of Data Collection:** Group and individual interview, Survey, case study, PLA, RRA, observation, etc.

**Hypotheses:** Importance, nature and types of hypothesis, formulation of hypothesis and testing.

**Analysis of Data:** Coding of data, data entry techniques and use of SPSS PC+, categorization and tabulation of data, application of descriptive and inferential statistics for social research, selection and use of appropriate statistical tests, content analysis.

**Presentation of Data:** Forms of data presentation, interpretation of data - meaning, tools, techniques and precautions, use of graphics (charts, histogram, pie-graph, pictures, plates etc.) in interpretation of data.

**Review of literature:** Use of hard copies and digital web based archives for review of literatures, getting the best out of the internet.

**Preparation of research report:** Types of research report, format for different types of research report, quoting references, style of writing, using footnotes, citation of bibliography.

**Research Systems Management:** Research systems and theories and practices of management, current issues and problems in management of research organizations.

**Assignment**

## AEIS 603. Communication for Development (Core)
### Credit hour: 3

**Communication Process:** Nature of communication; Propose of Communication; Levels of communication; Communication Behavior; Communication Skills; Fidelity of Communication; Theories and Models of Communication; Barriers in Communication.

**Presentation style in communication:** Types of message preparation; Physical attributes of presentation style; Vocal attributes of presentation style.

**Communication Apprehension:** Understanding Communication apprehension; Speech anxiety; Consequences of high communication apprehension; reducing high communication apprehension; source credibility

**Development Communication:** Concept of Development Communication; Development Communication - national and international perspective

**Organizational Communication:** Understanding organization communication; Types of organizational communication; Downward and upward communication

**Communicator-Communicate Relationship:** Orientation empathy; Feedback; Physical Interdependence; credibility; Interaction; Homophily; Heterophily.

**Communication Planning:** Meaning and concept of communication planning; Elements in the planning process; Role of Communication Planner; Qualities of communication planner; Levels of Planning.

## AEIS 604. Agricultural Knowledge Management (Core)
## Credit hour: 3

**Introduction to Agricultural Knowledge Management:** a) Concept of Knowledge Management (KM) and KM framework, b) Acquisition, Transformation and Sharing of Knowledge in Agriculture, c) Importance of Knowledge Management (KM) in Agricultural Extension and Business, d) Opportunities and constraints of knowledge sharing in Agriculture.

**Information and Communication Technologies (ICTs) in Agriculture:** a) ICTs role in Agricultural Knowledge Management (AKM), b) Opportunities of Ubiquitous Information Systems (including Mobile and Web 2.0) in Agricultural Knowledge Acquisition and Sharing.

**Theories and Research in Agricultural Knowledge and information System:** a) Adaptive Structuration Theory, b) Social Exchange Theory, c) Social Capital Theory, d) Social Cognitive Theory, e) Social Network Theory, f) Actor Network Theory.

## AEIS 605. Extension Administration and Training Management (Core)
## Credit hour: 3

Concept of Administration, Management and Supervision; General Administration VS Extension Administration; Public Administration VS Private Administration; Difference, Interrelation and Similarities among administration, management and Supervision; Principles of administration. Administrative Functions: Planning, Organizing, Directing, Staffing, Coordination, Reporting, Budgeting, Controlling Office Management: Administration, management and supervision systems in DAE; Role of different administrator, manager and supervisor of DAE. Training: Types of Training; Pre-service VS In-service; Formal VS Non-formal; Components of Training; Training Schedule, Module, Brochure and Module. Training for Extension Services- Policy Level, Mid Level and Front Level and Farmers Level Training Conducted by DAE, RDA, BARD, Private Extension Providers and NGOs. Training Need Assessment, Curriculum Development and Execution of Training Program. Evaluation of Training: Pre-Test, Post Test, Evaluation by Paired T-test. Farmers Field School: Organizing, Managing and Evaluating.

## AEIS 606. Project Planning, Development and Management (PPDM) (Core)
## Credit hour: 3

**Planning and Recent Development Issues in Bangladesh:** Planning and Development: Concept and Relations; Millennium Development Goal (MDGs); Five Year Plan; Concept and content of local level development planning; Planning process in Bangladesh; National budget and Medium Term Budgetary Framework (MTBF); Globalization and development of Bangladesh.

**Project Planning:** a) Concept of project, programme, plan and policy; Classification of projects; Definition of project planning; Difference between project planning and proposal writing; Project planning approaches; Logical Framework Approach; Steps of project planning - Need assessment, Stakeholder, Problem, Objective, Strategy analysis, Logframe developing, Activity scheduling and Resource scheduling. b) Definition and steps of project cycle; Details of project identification, feasibility study and appraisal; Definition, objectives, scopes and types of project appraisal; Technical, Environmental, Financial and Economic

appraisal; Discounting technique; Calculation of NPV, BCR and IRR; Cashflow analysis of Introduction to Project Performa (DPP, TPP), Project Approval and Revision Procedures

**Project Management:** a) Project Monitoring and Evaluation: Definition, areas, levels and purposes of monitoring and evaluation; basic difference between monitoring and evaluation; rationale for monitoring and evaluation; benefits of monitoring and evaluation, types of evaluation; Post evaluations and its necessity; Different Types of indicators for evaluation; Principles of extension project evaluation; Phases and steps in an evaluation process; Extension project evaluation process; Role of IMED in project monitoring and evaluation; Explanation and exercise of IMED formats; Sustainability of Development Projects. b) Indicators and Targets for Project Monitoring and Evaluation: Concept of indicators and targets; Explanation of SMART indicators; Dimension of indicators; Characteristics of good indicators; Sources of indicators; Target setting for indicators; Factors considered in setting targets; Ways of targets expression; Types of rates of change of indicators; Baseline and Endline Surveys. c. Result Chain and Logic Model: Concepts and component of result chain; Input-Activity-Output-Outcome-Impact; Horizontal and vertical result chain; Definition of logic model, characteristics of good logic model and wording of results. d. Project Implementation Management: Functions, purposes and scopes of project implementation management; Efficiency in successful project implementation; The twelve critical success factors model, A dozen rules for the project manager and Total Quality Management (TQM); Strategic Planning - Concepts and Steps; Use of CPM/PERT in project implementation.

**Project Financing:** Project Financing and Source of Financing

## AEIS 607. Human Resource Development and Organizational Behavior (Elective)
## Credit hour: 3

**Human Resource Development:** HR challenges; Introduction to Human Resource Development; Scope and cost of HRD; A System model of training cycles; different phase of HRD

**Introduction to Organizational Behavior:**

**Attitudes and job satisfaction:** Components of attitudes, major job attitudes, measurement of employee's attitude, importance of attitude to workplace diversity. Measuring job satisfaction, cause of job satisfaction, impact of satisfied and dissatisfied employees on workplace

**Motivation:** From concept to application.

**Personality and values:** Meaning Personality, personality traits, major personality attributes influencing OB. Importance of values, loyalty and ethical behavior, values across cultures.

**Emotion and Moods:** Emotional labor, affective events theory, emotional intelligence.

**Group behavior and team work:** Defining, classifying groups, group development, group properties, group decision making. Types of team, creating effective teams, turning individual into effective team player.

**Communication:** Functions of communication, communication process, interpersonal communication, organizational communication, choice of communication, barrier to effective communication.

**Contemporary issues in leadership:** Inspirational approaches to leadership, Authentic leadership, Contemporary leadership role, finding and crating effective leaders.

**Power and politics:** Contrasting leadership and power, bases of power, power tactics, Sexual harassment: unequal power in the workplace.

**Conflict and negotiation:** Definition of conflict, the conflict process, negotiation

**Organizational culture:** Definition, Process of learning culture from employees, creating an ethical organizational culture, creating a customer-responsive culture.

**Organizational change and stress management:** Forces for change, resistance to change, approaches to managing organizational change, work stress and its management

## AEIS 608. Statistics for Advanced Socio-Economic Research (Elective)
## Credit hour: 3

**Measuring relationship between variables:** Pearson product-moment correlation, Intercorelation, Spearman Rank-difference correlation.
**Measuring mean differences:** Simple t-test, paired t-test.
**Measuring association between variables:** Chi-square test.
**Determining contribution of independent variables on dependent variables:** Full model regression, Step-wise multiple regression.
**Determining direct and indirect effect of contributing factors:** Path analysis
**Common misuses of correlation and regression analysis in socio-economic research**
**Preparing indices and rank order,Content analysis, Other statistical tests:** Binominal test, McNemar test, Sign test.
**Presentation of research results, Assignment**

## AEIS 609. Education for Adult Learners (Elective)
## Credit hour: 3

(a) Concept, meaning and definition of Adult Education (b) Objectives of Adult Education: Specific knowledge, skills and career, Contributory member of the society, Develop individual, unique potential, (c) Scope of Adult Education, (d) Principles and philosophies of Adult Education (e) Characteristics of adult learners and Youth learners (f) Psychology of Adult Education: Adult behavior, Learning process for adult learners, Experiential Learning, Motivation for adult learners, Leadership development of adult learners. (g) Approaches to Adult Education: Teaching strategy for adult learners, Effective criteria for adult education, Creation of teaching-learning situation for the adults, (h) Professional Adult Education: Crops, livestock, fisheries and Agroforestry. Various contemporary issues in Adult education: History of Adult Education in Bangladesh, Distance education for the adults, Adult Education and community development, Adult Education organized by NGOs, Extension Activities for Landless, Youth & Women.

## AEIS 501. Agricultural Extension and Communication (Elective)
## Credit hour: 3

Concept, nature and importance of agricultural communication. Models of communication and its elements-factors affecting fidelity. Feedback-importance and effects. Communication and learning-the similarity of the process. Media of communication-mass, group, inter-personal and traditional their types, roles and functions. Social psychological approach to mass and inter-personal communication. Farm information method-publicity, propaganda and education. Communication and social change. Barriers of communication-social, cultural and psychological. Communication strategy for agricultural development.

Significant researches in communication and their implications. Organizational communication in agricultural development. Basic features of development communication. Principles of rural journalism. Assignment.

**AEIS 502. Extension Administration, Supervision and Management (Elective)**
**Credit hour: 3**

Concepts, scope and characteristics of Extension administration. Extension administration vs. general administration, historical perspective of agricultural administration with special reference to extension services. Changes and implications; administrative vs. management; administrative role, function and responsibilities; administrative processes. Techniques and principles applied to agricultural organizations; coordination and supervision-techniques and principles; administrative theories and their implications, theory X and theory Y. Decision making and human relationships, management by objective (MBO). Administrative communication and analysis of research studies in agricultural Administration and their implications to agricultural development and future researches. Identification of forces affecting administration of agricultural programs, conflict management. Principal, theories and management concepts of program management. Concept and principles of supervision. Performance appraisal stress in managing, grievance handling. Analysis of change agents and client systems problems, management of sustainable agriculture. Assignment.

**AEIS 503. Technology Diffusion (Elective)**
**Credit hour: 3**

**Concept of technology diffusion and technology generation:** Diffusion process and Innovation-decision process. Models of technology diffusion process. Innovativeness and Adopter categories and generalizations about adopter categories. Measurement of adoption and Management development for farmers. Ecological factors in adoption: Client system constraints in technology transfer program.

The rise of diffusion research traditions. Converting research into practice. Significant researches in the field of diffusion and adoption conducted in Bangladesh. Research-extension-linkage mechanism for technology diffusion; Role of PRA, RRA and FFS in technology identification and dissemination.

**Opinion Leadership and Diffusion networks;** Models of Mass Communication flows. Heterophily-Homophily and the flow of communications. Measuring opinion leadership and Networks links. Characteristics of opinion leaders. Diffusion networks.

**The change agent:** Change agent as linkers; change agents' roles, Factors in change agent success, Homophily and change agent contact

**Consequence of Innovation:** Gap analysis in technology transfer, Group approach in transfer of technology, Communication in innovation-decision process. Assignment.

**AEIS 505. Group Dynamics and Leadership Development (Elective)**
**Credit hour: 3**

**Concept of groups:** Occasions for group association; Nature and types of groups, Groups in the rural community and methods of approach to them

**Group Dynamics:** Introduction to group dynamics; Internal and external dynamics of

Groups; Reasons for group's failure; Principal of working with groups and their Mobilization; Group participation; Problem solving steps in tackling group problems

**Leadership:** Concept of leadership; Theories of leadership; The leader and the group; Functions, skills and style of leadership; leadership in organization; Principals of democratic leadership; Functions of Leader, Determinants of Effectiveness of a Leadership functions, factors determining effectiveness of a leader, The basis of power of leadership,

**Farm Leadership:** Pattern of Farm Leadership; Characteristics of farm leaders, Homophily- Heterophily between leaders, Role of farm leader

**Groups in organization:** Formal and informal group, Committee to stove organizational problems, measures for making committees effective.

**Leadership Styles:** Characteristics of autocratic, democratic and laissez-affair styles of leadership. Assignment.

## AEIS 508. Fundamental of Journalism (Elective)
### Credit hour: 3

Concept of Journalism. Journalism in Agricultural Extension Work. Reporting. Art of writing a newspaper story-the journalistic style, characteristics of good journalism. Editing, proof reading. Broadcasting journalism, present status of broadcasting journalism in agriculture in Bangladesh. Public relations in journalistic communication: how to prepare a handout, press release, how to organize a press campaign, how to handle radio / TV interviews. Mass communication and development, participatory communication for social change. Acquaintance with various journalistic terms. Practical project: i) Audience research for improving agricultural communications vide print and Electronic media ii) Visit to a newspaper, radio or television station to practically watch their operation preparation of a campus newsletter, radio or TV program in group, analysis of group discussion.

## AEIS 509. Psychology of Human Behavior (Elective)
### Credit hour: 3

**Introduction of Psychology:** Concept of psychology, Human Behavior, Methods of study psychology, Correlation methods and Experimental methods.

**Attitude:** Concept of attitude, Formation of attitude, Change of attitude.

**Perception:** Concept of perception, Principles of perception.

**Personality and self Development:** Self and self development, Cooley's view of self development, Freud's view of self development, Concept of personality, Factors of personality development, Development of organization personality.

**Group and Group Dynamics:** Concept, External; group dynamics and Internal group dynamics.

Social change and planned social change. Social Influence and Social power; Concept of social influence and social power, Types of social powers. Psychology of learning and teaching; Variables influencing learning, Characteristics of adult learning. Assignment.

## AEIS 510. Non-Government Organization in Rural Development (Elective)
### Credit hour: 3

**Origin and Historical Development of Non-government Organizations (NGOs):** Concept of non-government organizations, historical development in parts of the world, initiation and gradual growth of non-government organizations in Bangladesh.

**NGOs in Agricultural Development:** Philosophies, modus operandi, project activities, income generating activities, seed production and marketing,

**Rural Development Activities in Selected NGOs:** Different rural development activities operated by the NGOs: i. BRAC- Rural Development Program (RDP), Rural Education Program (REP), Sericulture Program, Micro-finance, and Training; (ii) RDRS-Farmer Led Extension (FLE), Women Led Extension (WLE),Livelihoods Improvement Approach (LIA); Micro-finance, Health and Sanitation Program, Union Federation of Group Members (Men and Women); (iii) PROSHIKA- Ecological Agriculture, Organic Farming, Sustainable Agriculture and Rural Development; (iv) CARE-INTERFISH, and NOPEST programmes.

**Project Management:** Preparation of Project Concept Paper (PCP), Management and Operation of Projects by the NGOs; Partnership programs of NGOs with the GOs.

**Farm Management by the NGOs:** Farm management - crops, poultry, dairy, fishes, Sericulture, rabbit production, and fish hatchery.

**Coordination of NGO activities:** Bangladesh Beauro of NGO affairs, ADAB, Functions, controlling and coordination system of NGOs, rules of NGO formation, Collaboration between GO and NGO activities.

Assignment.

## AEIS 511. Gender and Development (Elective)
### Credit hour: 3

Concepts about gender, gender roles and needs, analysis of gender needs; Emerging role of women in agriculture in changed situation in respect of environment-friendly sustainable agriculture; developing technologies for farm men and women; Transfer of appropriate technologies to farmwomen: ways and means; Employment opportunities for rural women; Extension needs for farm women; Women's employment and role in participatory community development; Participation of rural women in decision-making in respect of agricultural and family welfare Innovations; Rural women's concern on farming and life; Case studies about the success stories of Women in generating farm technologies; Nature, characteristics and scope of Indigenous technologies for sustainable agricultural development; Use of indigenous, Technologies by the rural women in Bangladesh, India and Japan; Role of women in Generating environment-friendly sustainable agricultural technologies; Generation of Women-friendly communication technologies. Household resources management, health and population education, nutrition Management; Women empowerment different approaches and models of women empowerment, improving capabilities of women farmers. Status of women in SAARC region; recent studies in gender issues in Bangladesh.

## AEIS 512. Anthropological Study in Agriculture (Elective)
**Credit hour: 3**

Anthropology: The concept and scope; general and sub disciplines of Anthropology. Study of Anthropology in relation to Agriculture. Methods of Anthropological Research: a) Survey Research b) Ethnography: Anthropology's distinctive strategy c) Difference between Survey and Research d) Ethnographic techniques. Cultural Evolution: a) Anthropological concept of culture: Culture and the individual b) History of Mankind c) Strategies of Adaptation: Foraging-Cultivation: Horticulture, Agriculture, Intensive Agriculture, Evolution of rice. Cultivation and Pastoralism. Gender: a) Gender issues among Foragers b) Gender issues among Horticulturists, Agriculturists and Pastoralists c) Gender issues among Industrialism. Social change and development: a) Acculturation b) Development c) Peasants and peasants communities. Study of Tribal Communities: a) Garo b) Chakma c) Marma. Structure and functions of society, social stratification. Assignment.

## AEIS 514. Rural Home Management (Elective)
**Credit hour: 3**

Concepts of management of a rural home in Bangladesh. Philosophy, values, goal, principles and procedures in home management. Women's role in task performance and decision-making, family relationship and home management. Resources in home management-time and energy management, work study, work simplification techniques as applied in the home. Housing pattern-structure, layout, drainage, sanitation, lighting, interior arrangement and their influence on home management. Household equipments and efficiency. Management of family finance. Recreation and outing program for home management. Assignment.

## AEIS 518. Planning, Monitoring and Evaluation of Extension Program (Elective)
**Credit hour: 3**

**Extension Program Planning:** Concept; Principles of extension program planning; Program planning model; Peoples participation in program planning; Research in extension program planning; Role of extension agents and specialist in extension program planning; Alternative approaches to program planning

**Extension Program Monitoring:** Meaning, purpose and scope of monitoring; Quantitative and qualitative monitoring; procedure for monitoring of demonstrations and field days, farmers groups, farmers training, and motivational tours/visits

**Extension Program Evaluation:** Basic concepts in evaluation; steps in evaluating extension programs; aspects of evaluation of a training program and a/v aids: total effect of Training, methods and techniques used; instructors, trainee's performance and content; Review of evaluation study of an extension program Why problems fail? Use of management information system (MIS) for effective program, future extension programs for community development Peoples' participation in extension programs, levels of participation, advantages and limitations of peoples' participation, Participatory evaluation. Assignment.

**AEIS 519. Environmental Studies and Farming Systems in Extension (Elective)**
**Credit hour: 3**

Introduction, norms and facilitation procedure of course. Concept of environment-Biological, physical and social; some concepts/issues related to environmental studies. Lessons from ecology: Factors involved in agriculture, relationship between agril systems and ecosystems.

Environmental indicators for agriculture: Environment and sustainability context, DSR framework to address agri-environment linkage. Selection criteria for agri-environmental indicators. Issues of environmental impacts from agril. dev: National and International perspectives of landscape change.

Agricultural impact on soil degradation. Types of water pollution, effects of water pollution; cultural eutrophication and its control. Water quality deterioration due to agricultural development: Overall national and international perspectives. Desertification and its reclamation.

Need for EIA of agricultural development. IPM and its prospects as EFA in Bangladesh. IPNM/INM as a way to sustainable soil nutrient management. Organic farming (OF) as an EFA practice: Bangladesh and international perspectives.

Biotechnology: a technological innovation for EFA. Concept and nature of poverty, link between poverty and environment. Ecological marginalization of poverty; Strategies of poverty alleviation; Barriers to poverty alleviation for less favored groups

FSRE: Concept, characteristics determination of FS and components. Scope of FSRE, methodological issues of FSRE. Extension strategies for environment friendly agricultural development. Sustainable farming systems and the factors affecting sustainability. Assignment.

**AEIS 521. Extension Teaching Methods and Techniques (Elective)**
**Credit hour: 3**

Principles and techniques used in planning, organizing and conducting educational programs for extension worker and collage teachers in agriculture, development workers, professional trainers of both public and private agencies (NGOs). Selection and organization of subject matter content for specific courses. Analysis of widely used teaching methods by extension agencies in Bangladesh.

**AEIS 522. Sociology and Psychology of Extension Education (Elective)**
**Credit hour: 3**

Basic concepts of sociology and psychology. Social structure, stratification and social institution in rural Bangladesh and their rules extension education. Review of some socio-logical theories.

# DEPARTMENT OF AGROFORESTRY AND ENVIRONMENTAL SCIENCE

## Courses and Curricula for Ph.D. Degree in Agroforestry and Environmental Science

| Course Code | Course Title | Credit Hour |
|---|---|---|
| **1. Major Courses** | | |
| **1a. Core:** | | **18** |
| AFES 601 | Agroforestry Systems and Management | 3 |
| AFES 602 | Physiology of Agroforestry Plants | 3 |
| AFES 603 | Forest Ecology and Management | 3 |
| AFES 604 | Ecosystem Conservation and Climate Resilience | 3 |
| AFES 605 | Global Environmental Issues and Policies | 3 |
| AFES 606 | Natural Resource Management | 3 |
| **1b. Elective:** | | **6** |
| AFES 607 | Carbon Sequestration and Carbon Trading | 3 |
| AFES 608 | Urban Forestry and Landscaping | 3 |
| AFES 609 | Hill Ecosystem and Management | 3 |
| AFES 610 | Mangrove Ecosystem and Management | 3 |
| AFES 611 | Environmental Hazards and Disaster Management | 3 |
| AFES 612 | Remote Sensing and GIS in Natural Resource Management | 3 |
| AFES 613 | Waste Management | |
| AFES 614 | Forest Mansuration and Modeling | |
| AFES 504 | Agroforestry Research Methodology | 3 |
| AFES 505 | Environment and Conservation | 3 |
| AFES 506 | Climate Change Mitigation and Adaptation | 3 |
| AFES 508 | Economics of Agroforestry | 3 |
| AFES 511 | Medicinal Plants and Non-wood Products | 3 |
| AFES 512 | Wood Fuel Production and Marketing | 3 |
| AFES 514 | Biodiversity Conservation and Management | 3 |
| AFES 516 | Pest Management in Agroforestry | 3 |
| **2. Minor Courses** | | **6** |
| Minor courses offered from other departments will be selected by the advisory committee as per student's requirement | | |
| **3. Seminar Courses** | | **2** |
| AFES 698A | Seminar-1 | 1 |
| AFES 698B | Seminar-2 | 1 |
| **4. Research** | | |
| AFES 699 | Research Work for Thesis | **30** |
| | **Totat Cr.Hr.** | **62** |

# Courses and Curricula for Ph. D. Degree in Agronomy

| Course code | Course Title | Credit Hour |
|---|---|---|
| **1. Major Courses** | | |
| **1a. Core:** | | **18** |
| AGRO 601 | Organic Agriculture | 3 |
| AGRO 602 | Integrated Crop Management | 3 |
| AGRO 603 | Laboratory and Field Techniques in Agronomy | 3 |
| AGRO 604 | Sustainable Agriculture Resource Management | 3 |
| AGRO 605 | Advanced Crop Physiology | 3 |
| AGRO 606 | Climate Change and Crop Production | 3 |
| **1b. Elective:** | | **6** |
| AGRO 607 | Agro-meteorology and Crop Ecology | 3 |
| AGRO 608 | Environment and Seed Quality | 3 |
| AGRO 609 | Dryland Farming and Watershed Management | 3 |
| AGRO 610 | Precision Agriculture | 3 |
| AGRO 611 | Biotechnological Improvement of Agronomic Crops | 3 |
| AGRO 612 | Crop Management on Problem Soils | 3 |
| AGRO 613 | Soil Plant Water Relations | 3 |
| AGRO 614 | Risk Management in Agriculture | 3 |
| AGRO 501 | Advanced Crop Production Technology | 3 |
| AGRO 502 | Sustainable Agriculture and Organic Management | 3 |
| AGRO 503 | Principles of Seed Technology | 3 |
| AGRO 504 | Applied Weed Science | 3 |
| AGRO 505 | Farming System | 3 |
| AGRO 506 | Crop Physiology and Stress Agronomy | 3 |
| AGRO 509 | Irrigation Water Management | 3 |
| AGRO 513 | Fertilizer Management | 3 |
| AGRO 514 | Post Harvest Technology | 3 |
| AGRO 516 | Agronomic Research | 3 |
| **2. Minor Courses** | | **6** |
| Minor courses offered from other departments will be selected by the advisory committee as per student's requirement | | |
| **3. Seminar** | | **2** |
| AGRO 698A | Seminar-1 | 1 |
| AGRO 698B | Seminar-2 | 1 |
| **4. Research** | | |
| AGRO 699 | Research work for Thesis | **30** |
| | **Total Cr. Hr.** | **62** |

## AGRO 601. Organic Agriculture (Core)
**Credit hour: 3**

Evaluation and overview of organic agriculture, Origin of organic agriculture, History, importance, scope and benefits of organic agriculture, Environmental impacts. Crop rotation, Nutrient management, Green manures, Cultural strategies used in organic agriculture. Importance and limitation of tillage in organic agriculture, Environmental impact of tillage, Conceptualizing tillage management in organic agriculture. Components of soil fertility, Soil fertility management in organic farming, Sustaining soil fertility through organic matter management. Variety characteristics, Variety testing, Seed production, Research for organic breeding concepts and strategies. Insect, Disease and weed management studies in organic versus conventional agriculture. Production systems and food qualities, Safety from pathogens, Safety from toxic substances, Beneficial nutritional properties or other positive impacts on health. Housing, Organic livestock production, Animal nutrition and feeding, Grazing and grassland management, Health promotion and human role in organic animal herds. Opportunity and challenges, Trends in organic agriculture, Benefits of biotechnology in organic agriculture, Research prioritization of organic agriculture, Research and development need under organic agriculture in Bangladesh. Economic management, SWOT analysis, Demand, consume and marketing of organic foods.

## AGRO 602. Integrated Crop Management (Core)
**Credit hour: 3**

Concept, history, components, requirements and objective of integrated crop management (ICM); Approaches of ICM, Agricultural and environmental practices in ICM, Importance and future of ICM. Effects of site features, Crop rotation and varietal choice on achieving ICM, Factors influencing the choice of crop rotation, Environmental impact of contrasting rotations, Crop rotation basics. Soil properties relating agricultural management and prevention of soil erosion, Technology used in planned cultivation systems, Preplant N fertilizer application, In-season N fertilizer application, Integrated plant nutrient management system (IPNMS). Economics of IPM- microeconomics, economic thresholds, optimization, Tactics in IPM- Regulatory control, Cultural control, Biological control, Genetic manipulation of pests, Genetic manipulation of crops, Chemical control, Weed management and weed allelopathy, Organic crop production. Interaction between, Crop-livestock, Crop- weed, Alley cropping, Cultivar- soil, Nutrient- water- carbondioxide, Deleterious- beneficial rhizosphere. Importance of food quality and safety for developing countries, Need for action, Key elements and standard to ensure food safety, Physiology and principles relating to key systems and standards. Natural agricultural waste production, Non-natural agricultural waste production, Agricultural plastics, Management of farm waste, Potential pollution risk, Hazardous waste, Implications of farm wastes for farmers, Fly-tipping, Town waste collection and disposal authorities. Steps in good records management plan, Benefits of good record of management practices, Long-term and short-term farm business and their objectives, Farm policies and objectives, Evaluation and improvement of current farm practices, Safety and legal farm [illegible]

## AGRO 603. Laboratory and Field Techniques in Agronomy (Core)
## Credit hour: 3

Seed purity, Moisture content, Germination of non-dormant seed, Seed dormancy, Seed germination test, Tests for viability and vigor, Light and temperature effect on germination, Salinity and water stress effects on germination and seed vigor. Measurement of leaf area and dry matter production, Growth analysis, Leaf development, Canopy structure, Light interception and radiation use efficiency. Measurement of photosynthesis, Dark respiration, Stomatal conductance, Mesophyll conductance and internal $CO_2$ concentration, Transpiration. Measurement of soil moisture, Soil water potential, Leaf water content, Relative water content, Water saturation deficit, Leaf water potential and osmotic potential, Root growth, Measurement of root length density, Root porosity and root activity. Crop tolerance to deficient water, Sub-and supra-optimal temperature and salinity stress, Measurement of leaf membrane thermostability. Analyses of organic matter, Nitrogen, Phosphorus, Potassium, Sodium, Calcium, Magnesium, Carbonate and bicarbonate, Sulfate, Boron, Micronutrients, Irrigation water quality. Temperature measurement of soil, Leaf, Canopy, Room.

## AGRO 604. Sustainable Agricultural Resource Management (Core)
## Credit hour: 3

Definition and concept of Agricultural resources, Historical perspectives of agricultural resource management, Types of Agricultural Resources, Integrated natural resource management (INRM) and its implication in crop production, Global goals and resource capacity. Introduction, Basics and background of sustainability, Sustainability concerns of agricultural resource, Future of sustainability concept. Principles and strategies of agroecology for designing, Agricultural Resource Management, Agro-ecological mechanisms for improving Agricultural Resource Management, Outcomes of agroecological approaches; Effects on yields, Effects on pesticides uses and yield, Effects on carbon balances, Effects on farm water use efficiency, Labor markets and migration patterns, Dietary and reproductive health to large farms, Small farms, Landless families. Concept of community based agricultural resource management, Qualifications, Strategies and reasons for paying attention to community based agricultural resource management. Options for agricultural resource management, Strengths and weakness. Community, Groups, Locality. Background or introduction of Agricultural resources of Bangladesh, Threats that degraded agricultural resource of Bangladesh, Conservation and sustainable ecological management of agricultural resources of Bangladesh. Coastal zones, Active flood plains and char land, Haor area, Piedmont plains (Foot Hill) area, Hilly area, Peat basin.

## AGRO 605. Advanced Crop Physiology (Core)
## Credit hour: 3

Photosynthesis, Solar radiation and irradiance, The photosynthetic apparatus, Carbon dioxide fixation, The leaf as a photosynthetic organ, Net photosyntheis, Management factors affecting photosynthesis, Photosynthate utilization by crops, Interception of solar radiation, Radiation attenuation through crop canopies. Growth respiration, Maintenance respiration and photorespiration. Dry matter accumulation at different growth stages,

Assimilate translocation, Phloem loading and unloading, Assimilate partitioning, Source - Sink relationship, Remobilization of assimilate, Agronomic factors affecting assimilate translocation and partitioning. Properties of water, Soil water availability, Water uptake and movement, Osmotic adjustment, Soil-plant-atmosphere continuum, Leaf energy balance, Agronomic regulations, Nutrient availability, Quantitative requirement and uptake, Charge balance, Enzyme activation and nutrient status, Agronomic management. Allometry, Growth dynamics, Growth analyses, Vegetative growth, Stem and root growth, Root differentiation, Contributions of seminal and crown root, Root efficiency, Root distribution, Flowering and fruiting and maturation, Agronomic factors affecting crop growth, Crop growth regulators, Development factors, Yield functions, Population dynamics, Harvest index, Agronomic managements. Physiology of seed development, Physiology of seed germination; Metabolism of stored foods, Respiratory quotient, Germination requirements, Seedling emergence, Seedling growth, Seedling vigor, Factors of crop establishment. Definition and Types of stress, Moisture stress, Physiological adaptation of crop plants to moisture stress, Physiology of saline plants, Adaptive mechanisms of salt tolerance, Growth and physiological adaptations of different crops to salinity, Physiological mechanisms of nitrogen adsorption and assimilation in plants under stressful conditions, Stress signal transduction, Stress physiology research, Temperature, Physiological responses to climate change, Agronomic managements.

## AGRO 606. Climate Change and Crop Production (Core)
## Credit hour: 3

Concept of climatic change, General causes of climatic change; green house gasses, high and low temperature, and high $CO_2$ concentration, Climatic change hazards, Climatic change risk - global and Bangladesh perspective. Scenario of climatic change of the world over last 100 years, Climatic change scenario in Bangladesh, Projected climatic change in future. Maximum and minimum rainfall, Acid rain, Increasing temperature, Carbon sequestration, Salinity and drought over the world and Bangladesh. Increased temperature, $CO_2$ concentration, Rainfall, Drought, Salinity and Green house gases on crop, Weed, pest and diseases, Impact on food security, Agricultural lands and cropping season. Crop and climate models and their possibilities and limitations for HYV rice (Aus, Aman and Boro), Wheat, Maize, Pulses, Oil seeds, Fodder, Green manuring crops etc., GCM (general circulation models) for climatic change. Current challenge, Monitoring climatic change, Predicting of climatic change and possible losses of climatic change. Climatic change adaptation. Education and extension of climatic change hazards, Optimizing agronomic practices against climatic change, Priorities of production risk coverage in agronomic research, National adaptation program, Government strategy, Policy, Future plan and IPCC (Intergovernmental panel on climate change), International convention and global initiatives.

## AGRO 607. Agro-meteorology and Crop Ecology (Elective)
## Credit Hour: 3

**Introduction to agricultural meteorology:** Weather, climate, components of weather and climate. Importance of climate in relation to crop production. Scope of agricultural meteorology.

**Climate and weather of different zones of world:** Different climatic zones of the world and their characteristics. Causes of variations in climates.

**Climate and weather of different zones of Bangladesh:** Variability of climates in Bangladesh. Patterns of temperature, rainfall, relative humidity, solar radiation and wind in different regions of Bangladesh.

**Crop adaption and distribution in relation to climate:** Adaptive mechanism of plants in response to different climatic condition. Crop adaptation to adverse climatic conditions. Climate and Cropping Systems.

**Diurnal and seasonal variation in photoperiod and light integral:** Concept, causes and responses to seasonal variations.

**Quantitative analysis of crop-weather relationship and crop yield.**

**Atmospheric pollution and plant productivity:** Plant responses to atmospheric pollutions. Crop productivity under polluted atmosphere. Ways to mitigated atmospheric pollution.

**Remote sensing:** Concept of remote sensing, Application of remote sensing in determining climatic variability.

**Geographical Information System (GIS):** Concept, Application of GIS in agriculture.

**Crop monitoring and forecasting:** Concept of crop modeling, major crop modeling systems and their comparative studies. Practicing major crop modeling packages.

**Crop Ecology:** Concept, Ecology and Ecosystem. Interactions between individuals, species, communities and their environments. Circulation of energy and matter in ecosystems.

**Environmental Plant Ecophysiology:** Physiological and ecological principles of plants and the relation of those principles to plant responses to the environment.

## AGRO 608. Environment and Seed Quality (Elective)
## Credit Hour: 3

Relationship between weather and agriculture macro and micro climate and their impacts on agriculture.

**Environmental effect on seed quality in field:** Temperature effect on nutrient availability and grain growth and development; drought and cold effect on seed quality; water stress on seed quality; impact of proper water management on seed quality; effect of precipitation on seed quality; relative humidity and temperature effect on seed quality; sunshine hour, light intensity, red and infra red light, prolonged dark period and seed quality.

**Environmental effect on seed quality in store house:** Temperature, relative humidity, dark and light period, direct sunshine, mustiness effect on seed quality.

## AGRO 609. Dryland Farming and Watershed Management (Elective)
## Credit Hour: 3

**Dryland farming:** introduction and definition. Management of land and water, the basic resources. Dry climates and their classification. Activities of research centres of dryland agriculture. Problems of crop production in dryland agriculture. Existing pattern of land

use in low rainfall areas. Rainfall patterns in dry regions. Drought-occurrence, types and management strategies for drought. Soil erosion: types, factors affecting erosion, agronomic soil conservation measures. Fertilizer use in dryland agriculture, inorganic, organic and biofertilizers. Efficient crops and varieties, cropping systems, normal and contingency crop planning under aberrant weather conditions. Evapotranspiration: measures to reduce evaporation and transpiration. Watershed management: objectives and approaches, steps in watershed planning. Land use capability and classification. Soil and water conservation measures in watershed areas. Water harvesting and life saving irrigation. Problems and prospects under watersheds. Alternate land use systems.

## AGRO 610. Precision Agriculture (Elective)
## Credit Hour: 3

Introduction: Definition, Basics of Precision Agriculture, Impacts and Areas of Precision Agriculture, Benefits of adopting Precision Agriculture. Tools for implementation of precision agriculture, Current status, uncertainties, future trends of Precision Agriculture. Precision Agronomy: Precision Agronomist vs traditional agronomists, Aspects of precision Agronomy, Equipment, methods, and technology. Basis of precision agriculture: Information technology, spatial location, basics of GPS, Information acquisition, crop condition, weed detection, grain yield, grain quality and spraying. The benefits of precision agriculture: Benefits from Precised nutrient applications, Precised pesticide applications, Variable rate irrigation and other uses for precision agriculture, Costs to implement precision agriculture and economic perspectives on precision agriculture. Environmental concerns: Introduction, Steps for the environmental focus of precision Agriculture, Precision agriculture for the environment. Fertilizer and Soil fertility management: Site specific nutrient management, Fertilizer application, Soil fertility and productivity aspects. Precision water management: Introduction, Precision irrigation, Irrigation application and system control, auxiliary system components.

Precision Weed management: Weed distribution, Stability of weed population, Weed monitoring, site specific herbicide application, site specific weed control. Measurement and management of grain quality: Quality factors and their measurement, on-line quality measurement, nutrition and grain quality, grain quality and crop management. Precision Agronomy in different crops: Rice, wheat, maize, oilseed crops, pulse crops, fiber crops.

## AGRO 611. Biotechnological Improvement of Agronomic Crops (Elective)
## Credit Hour: 3

Concepts of plant biotechnology, history of plant tissue culture and plant genetic engineering; scope and importance in crop improvement.Techniques of *in vitro* cultures: *In vitro* selection pressure technique, somatic embryogenesis; artificial/synthetic seed production technology; double haploid production; triploid production by endosperm culture; production of virus free plants by meristem, shoot-tip culture; Cell Suspension cultures; protoplast isolation and regeneration, somatic hybridization and cybridization; protoclonal, somaclonal and gametoclonal variation for crop improvement; Cryopreservation. Development of abiotic stress-tolerant plants through *in vitro* selection: Development of salt tolerant plants - mechanisms for salt tolerance, antioxidative defense.

ion-homeostasis, accumulation of compatible solutes, characterization of salt-tolerant plants during in vitro selection, development of drought tolerant plants. Development of biotic stress-tolerant plants through *in vitro* selection: *In vitro* selection through enhanced expression of pathogenesis-related (PR) proteins, antifungal peptides and phytotoxins, characterization of disease resistant plants during in vitro selection. Molecular mapping and tagging of agronomically important traits, Marker-assisted selection for qualitative and quantitative traits; QTLs analysis in crop plants, marker assisted selection and molecular breeding for crop improvement, Transgenic plants and their applications. GMOs and related issues (risk and regulations); nanotechnology and its applications in crop improvement programmes. Innovations in agricultural biotechnology in response to climate change.

## AGRO 612. Crop Management on Problem (Elective)
## Credit Hour: 3

Perspective and problems of crop production in eroded, salt affected, water deficient and water-logged soils. Salinization: A global land degradation issue, soil salinization processes. Environmental consequences of soil salinity- impact on pedosphere, impact on hydrosphere, impact on biosphere- particularly in plants. Salt stress in crop production: Background, nutrient uptake under salt stress - Impact on food production. Options for mitigating salt stress in crop production- sustainable agricultural management in salinized conditions, genetic mechanisms of increasing of salt tolerance in plants. Site specific cultural practices, fertilizer and irrigation adjustment, specific cropping patterns and crop management practices for economic production in problem soils. Soil improvement/ reclamation. Demonstration of problem soils.

## AGRO 613. Soil Plant Water Relations (Elective)
## Credit Hour: 3

Water potential, water potential gradient, water potential and its components, capillary rise in xylem, hydrostatic pressure, water activity and osmotic potential, Van't Hoff relations, matric potential, water potential and plant cells, plasmolysis, plant air interface, water flux and kinetics of volume change, absorption and water flow through plants, the ascent of sap, the cohesion mechanism, anatomy of pathway. Practical aspects of measuring plant water status: Pressure chamber, Porometry, Portable water potential meter. Water dynamics in soil-plant-atmosphere system: Soil water, water absorption by the roots, ascension of water through the plant-vascular system, leaf water and transpiration. Physiological and biochemical aspects of water in plants: Water deficit and its effects on plant growth, elements that define water demand, mechanisms of water status regulation- morphological and anatomical characteristics associated with water control, stomata metabolism, hormonal and molecular responses in different water conditions, osmotic regulation.

## AGRO 614. Risk Management in Agriculture (Elective)
## Credit Hour: 3

**Concept of risk:** Concepts, objectives and impacts. Sources of Risk in Agriculture: Production Risk, Price Risk, Casualty Risk, Technological Risk, Uncertainty Caused by the

Actions of Other People, Businesses, and Institutions, Legal Uncertainty, Personal Uncertainty-Sickness and Injury and Death, risk of climate variability and climate extremes, climate change threatens agriculture biodiversity.

**Strategies for Managing Operational Risks:** Financial Strategies, Marketing Strategies, Production Strategies, Insurance. Avoiding dangers, Preventing/reducing the frequency of impacts, Controlling/reducing consequences (adaptation measures), transferring the risk (e.g. insurance), responding appropriately to incidents/accidents (e.g. disaster management) and recovering (e.g. media response). Management of Strategic Risks: Positioning for Flexibility, Positioning to Avoid, Positioning to Absorb Contingency Planning, Implementing Flexibility, the Decision and Risk Analysis Model (D&RA), Implementing Change Incrementally, Intervention, Control Strategies, Risk Assessment, and Exit Strategies. Management of production risk: Choosing Low Risk Activities, Diversifying Enterprises, Dispersing Production Geographically, Selecting and Diversifying Production Practices, Maintaining Flexibility, Spreading Sales, Forward Contracting, Hedging, Insuring Against Losses, Maintaining Reserves, Pacing of Investments, Acquiring Assets, Working Off Farm. Integrated Risk Management Strategies. Managing Climate Risks to Advance Adaptation to Climate Change: Climate risk management (CRM) in the context of climate variability, Adaptation to climate variability and extreme events, optimization of farm management practices conditioned by climate, preparation of farmer advice and communication. Risk Management and Sustainable production: Weather forecasts and early warning systems, Seasonal climate forecasts, Addressing gaps in climate information services, better informed institutional decision support services for climate risk management- Early warning systems and humanitarian response, Crop monitoring and yield forecasting, Medium-term warning systems (5-10 years), Agricultural insurance, Data, tools and methods, strengthening technical and institutional capacities, Increased diversity of management options and selecting best management options.

## AGRO 501. Advanced Crop Production Technology (Elective)
## Credit hour: 3

**Crop Production Statistics:** World crop production statistics of major crops and their comparison with Bangladesh. Interpretation of lower crop yields under Bangladesh condition.

**Yield and Quality of Crops:** Yield determinants, concept of yield improvement, agronomic means of improving yield and quality of crops.

**Advanced Production Technology of Crops:** Economic importance, varieties, soil and climatic requirements, production technology, resource response and post-harvest processing of the following crops:

| | |
|---|---|
| Cereal crops | : Rice, Wheat, Maize, Kaon, Cheena, Sorghum, Bajra, Jowar |
| Fibre crops | : Jute, Cotton |
| Sugar crops | : Sugarcane |
| Pulse crops | : Lentil, Chickpea, Grasspea, Mungbean, Blackgram, Cowpea |
| Oilseed crops | : Mustard, Groundnut, Soybean, Sesame, Sunflower, Safflower |
| Narcotic crops | : Tobacco |
| Beverage crops | : Tea, Coffee |
| Minor crops | : Kaon, Cheena, Sorghum, Bajra, Jowar |

## AGRO 502. Sustainable Agriculture and Organic Farming (Elective)
## Credit hour: 3

**Sustainable agriculture:** Concept, importance, evolution of sustainable agricultural systems of Bangladesh.

**Factors affecting sustainability in agriculture:** Nutrient mining, soil erosion, deterioration of water resources; changes in soil pH, climate change, pest incidence; problems of marketing and trading; changes in cropping systems

**Social and economic infra-structure:** Socio-economic condition of the farming communities, communication, market and storage facilities, inputs and credits, linkage mechanism between research, extension and education, information and support services, land tenure, national policy.

**Biodiversity and sustainability of farming systems:** Diversity and biodiversity, the role of biodiversity in farming systems, maintenance of biodiversity through creation of micro-environments, properties of micro-environments, contribution of micro-environments towards sustainability of farming systems.

**Organic farming in sustainable agriculture:** Concept, principles and practices of organic farming. Components-

**Soil management:** Increasing rooting depth, replenishing soil organic matter, special soil management practices.

**Crop management:** Choice of cultivars, crop diversification, planting time plant population, application time, rate and placement of fertilizers, herbicides and pesticides.

**Farm waste management:** Animal waste and crop waste, time of application rate of application, effect of farm waste on soil and crop.

**Domestic and industrial wastes management:** Types and characteristics, waste decomposition in soil and associated problems, management of wastes.

**Future trend in organic farming.**

## AGRO 503. Principles of Seed Technology (Elective)
## Credit hour: 3

**Introduction to Seed Technology:**

Seed and Civilization; Seed and Agriculture.
Definition of Seed, Seed morphology classification of seeds.
Concept of Seed Technology; Subjects related to Seed Technology.

**Components of Seed Technology:**

**Varietal Development:**

Definition of a variety, importance of varietal development and variety.
Plant breeding systems (incl. OP + Hybrid + recombinent)
Variety evaluation - DUS, VCU test.
Variety release, registration, Novelty. IPR, IPBR

**Seed Multiplication:**

Factors influencing seed multiplication, multiplication ratio.
Techniques of seed multiplication.

Seed multiplication of open pollinated and self pollinated crops.
Hybrid, Synthetic and composite seed production.

**Seed Processing and Preservation:**

Drying
Cleaning and grading
Seed treatment
Seed packaging
Preservation

**Quality Assurance:**

Seed Quality:

- Concept of seed quality, quality class, seed standard and field standard, seed lot and seed sampling.
- Purity- cultivar (grow out test, pre-post control) purity and analytical purity.
- Moisture content of seed.
- Germination capacity.
- Seed and seedling vigour.
- Dormancy.
- Seed health.
- Seed size.

Pre-harvest to pre-cleaning seed quality control
Seed Legislation:
Seed Certification:
Pre and post marketing quality control.

**Seed Marketing:**

Marketing Functions.
Seed Sale; quality of Salesmen.
Seed extension and promotion.

**AGRO 504. Applied Weed Science (Elective)**
**Credit hour: 3**

**Weed Biology and Ecology:** Propagation by means of vegetative propagules and seed. Factors related to weed seed production and germination. Bio-diversity of weeds. Dormancy of weed-seed and factors affecting it. Soil as a weed seed bank.Weed adaptation in relation to climatic, edaphic and biotic factors. Crop-weed interference, capability, critical period of weed control and factors affecting it.

**Weed control through crop Husbandry:** Role of seedbed preparation, planting geometry, establishing proper crop stand, crop rotation, hydrology, soil moisture regime and soil fertility in managing weeds.

**Biological Methods in Weed Management:** History of biological weed control. Biological-based controlling of weeds viz. insects, nematodes, fungi, bacteria and as well as plant-based chemicals. Interaction of Bioherbicides and Herbicides. Allelopathy.

**Herbicidal Methods in Weed Management:** Herbicide formulation and Adjuvant/ Additives. Mode of action of herbicides. Fate of herbicides in soil and plant. Interaction of herbicide, Plant, and Environment. Selectivity of Herbicides.

**Integrated Weed Management (IWM):** Definition, importance and basic concepts of IWM. Role of weeds in IWM. Interaction between Weed and Management Practices. Ecological, Eco-physiological approaches of Weed Management.

**Herbicide Resistance:** Major concept, development of herbicide resistance in weeds. Factor affecting weed resistance to herbicides. Mechanism to develop herbicide resistance. Crop resistance to herbicides, Biotechnology in developing herbicide-resistant crops. Concerns regarding use of herbicide-resistant crops.

**Weed Management of Major Crops in Bangladesh:** Present status and future strategy of Weed Management in rice, major field crops jute, wheat, sugarcane, cotton.

## AGRO 505. Farming System (Elective)
## Credit hour: 3

**Systems:** Concept, properties agroecosystems, systems hierarchy.

**Farming Systems:** Concept, characteristics, resources, components and enterprises.

**Interaction of components of farming systems:** Interaction of crop - livestock, crop - fish, crop - livestock - fish.

**Determinants of farming systems:** Physical, biological, economic and socio-cultural.

**Type of farming systems:** Farming system in Bangladesh and other countries

**Farming Systems Research and Development (FSRD):** Introduction, concept, importance, categories, processes, characteristics and strategies.

**Category of FSRD Trials:** On-farm, On-station, Component, Technology system, Farmer's Managed and Researcher's Managed Trials.

**Farming Systems Research Methodology:** National Methodology, Site selection, Site description, Design and testing, Validation trial, Technology transfer.

**Participatory Research:** Concept, objectives, and modes of farmer's participation.

**Methods and Techniques of PRA (Participatory Rural Appraisal):** Concept and importance of PRA. Methods of PRA-visualized analysis, intervening, group and team dynamics, direct observation and review of secondary sources,. Techniques, of PRA-transects, physical mapping, social mapping, Venn diagram, seasonal calendar, time line, production flow chart, matrix ranking, preference ranking and SOWT (Strength, Opportunity, Weakness and Threat)

**Cropping systems:** Evolution of cropping systems in Bangladesh, its impact on environment; designing, testing and evaluation on cropping systems.

## AGRO 506. Crop Physiology and Stress Agronomy (Elective)
## Credit hour: 3

**Crop physiology:**

**Crop growth and development:** Growth curve, growth limiting factors, growth stages of some major crops, relations of dry matter accumulation with interception and conversion of solar radiation, photosynthesis in $C_3$ and $C_4$ plants, soil-water-plant relationships, thermal time in relation to crop, growth. Agronomic management for optimum growth of plants.

**Growth analysis:** plant height, leaf area, leaf area index, leaf net assimilation rate, crop growth rate, relative growth rate, specific leaf weight, light transmission ratio. Leaf, stem and root growth.

Rate of development, relationships of development of temperature, photo period, photothermal time, solar radiation, assimilate supply, stress, determinacy and growth.

**Reproductive development**: Flowering initiation, switching mechanism.

**Inflorescence formation:** Histogenesis, grain formation

Yield components, factors influencing grain formation and grain filling, relations of yield with climatic parameters, determinacy, harvest index, source-sink relations, partitioning of dry matter, plasticity of vegetative growth, growth and development, green area duration, senescence, duration of reproductive period, crop nutrition and water management, population density, cropping systems and agronomic management.

**Stress Agronomy:**

**Deep water stress:** Concept, crop response to deep water stress, characteristics of flood water, factors affecting survival and morphological change of submerged plants, management of deep water stress in crops.

**Drought stress:** Concept, nature, causes and kinds of drought, effect of drought on crops, basis of drought tolerance, available technologies to reduce crop losses from drought.

**Light stress:** Nature and causes of light stress, crop growth, development and yield mechanisms due to light intensity and photoperiod.

**High temperature stress:** Concept, high temperature injuries in plants, adaptation features in plants due to high temperature, agronomic manipulations to mitigate crop losses due to high temperature.

**Cold stress:** Concept, types of clod shocks, symptoms of cold temperature injuries in plants, management of cold stress in crops.

**Salinity stress:** Concept, kinds of salinity, occurrence, nature and extent of crop damage, salinity management.

**Heavy metal stress:** Concept, plant responses to heavy metals, plants tolerance to heavy metals.

## AGRO 509. Irrigation Water Management (Elective)
## Credit hour: 3

**Introduction:** History, importance of irrigation, harmful effect of excess irrigation, hydrological cycle, source of water for crop plants, irrigation area in Bangladesh, rainfall and evaporation patten in Bangladesh.

**Soil Water Relationship:** Physical properties influencing soil water relationship, classification of soil water constants, soil water retention, infiltration, permeability, water movement in soils, soil water measurement.

**Soil Water-Plant Relationship:** Role of water in plants, rranspiration, soil water availability to plants, water deficit and plant responses, water requirement of plants, estimation of evapotranspiration, duty of water, irrigation requirement.

**Methods of Irrigation:** Classification of irrigation, surface, subsurface, overhead and drip irrigation methods.

**Irrigation Efficiency and Scheduling:** Efficiency of irrigation practices, water use and operation of Irrigation system. Time of irrigation, critical stages of water need of crops, crtieria for scheduling irrigation, frequency and interval of irrigation, depth of irrigation.

**Irrigation Water Saving Technologies:** Alternate wetting and drying, system of rice intensification, Aerobic rice water management.

**Irrigation and Fertilizer Use:** Synergism of irrigation fertilizer, water and nutrient availability in soils affecting crop yield, irrigation and fertilizer interaction on crop growth and yield, quality of crops as influenced by irrigation and nutrient use, water and fertilizer use efficiency of crops.

**Irrigation Water Quality:** Excess nutrients, salinity, Toxic elements.

**Irrigation Practices in Crops:** Cereal crops, pulses, oilseeds, fiber crops, sugar crops, narcotic crops, beverage crops, tuber crops, green manuring crops and fodder crops.

## AGRO 513. Fertilizer Management (Elective)
## Credit hour: 3

Fertilizer elements, types of fertilizers, fertilizer use statistics in Bangladesh, fate of applied fertilizer in crops and soil.
Soil fertility management under intensive and extensive cropping.
Determination of optimum fertilizer dose, factors influencing fertilizer dose, fertilizer doses in different crops under varying agro-ecological conditions and cropping systems.
Balanced fertilization, laws of fertilizer application, methods of fertilizer applications.
Principles of fertilizer applications, fertilizer use efficiency, fertilizer management in different crops.

## AGRO 514. Post Harvest Technology (Elective)
## Credit hour 3

**Post harvest technology:** Concept, objective and importance. Classification and steps of post harvest operations.

**Post harvest technology of the following crops:**

**Grain crops.**

- Cereal crops: Rice, wheat, maize, barley sorghum and millets.
- Oil seed crops: Rapeseed/ mustard, groundnut, sesame, sunflower, soybean, Saflower, nizer, cottonseed, flax, coconut, castor etc.
- Pulse crops: Lentil, gram, mungbean, black gram, grass pea, pigeon pea, soybean, field pea, cow pea, bush bean etc.

Physico-chemical properties of grains, safe moisture content of grains and seeds, theory and methods of grain drying, cleaning, grading, marketing, storing, transportation, parboiling, milling.

**Fiber crops:** Jute, cotton, keanf, sunnhemp, mesta, flax (retting, ginning and drying).

**Sugar crops:** Sugarcane and sugarbeet-crushing sugar, gurr and syrup manufacture.

**Narcotic crops:** Tobacco- curing, handling and marketing.

**Beverage crops:** Tea, coffee and cocoa- processing, handling and marketing.
**Tuber/Root crops:** Potato, sweet potato, cassava and yams- storage and use.
**Forage crops:** Alfalfa, Lucerne, para, napier, grass and cowpea- hay and silage preparation.
**Green manuring crops:** Preparation of green manure.
**Other crops:** Rubber manufacture.
**Spices and condiments:** Onion, garlic, turmeric and ginger-their curing processing storing and marketing.

**Visit to different post harvest technological plants:**

## AGRO 516. Agronomic Research (Elective)
### Credit hour: 3

**Agricultural Research System in Bangladesh:** National Agricultural Research System (NARS), National and International organizations involved in agronomic research.

**Research Planning Methodology:** Purpose of conduction research, Research planning, Scientific research planning and methodology, Identification of researchable problems, Prioritization of agronomic problems and their possible solution through agronomic research, Data collection for different crops.

**Experimental design:** Types of experiments. Experimental desigs, Experimental designs appropriate for agronomic experimentation, their merits and demerits.

**Statistical Analysis of Experimental data:** Statistical packages for data analysis. Analysis of variance, Comparison of treatment means. Regression and correlation analysis.

**Thesis/ Scientific paper writing:** Structure and procedure of data interpretation. How to write up a scientific paper and thesis.

**Presentation of Research Findings:** Slide preparation. Points to be considered for effective presentation.

08

# DEPARTMENT OF ENTOMOLOGY

## Courses and Curricula for M.S. in Entomology

| Course Code | Course Title | Credit Hours |
|---|---|---|
| **Compulsory Courses** | | **18** |
| ENTO 501 | Insect Taxonomy | 3 |
| ENTO 502 | Insect Ecology | 3 |
| ENTO 503 | Insect Physiology | 3 |
| ENTO 504 | Biological Control | 3 |
| ENTO 505 | Insecticide Toxicology | 3 |
| ENTO 506 | Integrated Pest Management | 3 |
| **Elective Courses** | | **12** |
| ENTO 507 | Insect Morphology | 3 |
| ENTO 508 | Economic Entomology-I | 3 |
| ENTO 509 | Host Plant Resistance | 3 |
| ENTO 510 | Medical Entomology | 3 |
| ENTO 511 | Pesticide Management | 3 |
| ENTO 512 | Industrial Entomology | 3 |
| ENTO 513 | Vegetables Pests | 3 |
| ENTO 514 | Economic Entomology-II | 3 |
| ENTO 520 | Research Methodology and Data Analysis | 3 |
| PLPA 511 | Plant Virology | 3 |
| AGCH 505 | Chemistry of Pesticides | 3 |
| | OR Related Courses from other Departments | |
| **Research Semester** | | |
| ENTO 598 | Seminar | **1** |
| ENTO 599 | Research work for Thesis | **16** |
| | **Total Cr. Hr.** | **47** |

## January-June Semester

**(Elective courses may be changed in different semesters)**

| Course Code | Course Title | Credit Hour |
|---|---|---|
| ENTO 501 | Insect Taxonomy | 3 |
| ENTO 502 | Insect Ecology | 3 |
| ENTO 503 | Insect Physiology | 3 |
| ENTO 505 | Insecticide Toxicology | 3 |
| ENTO 512 | Industrial Entomology | 3 |

## July-December Semester

| Course Code | Course Title | Credit Hour |
|---|---|---|
| ENTO 504 | Biological Control | 3 |
| ENTO 506 | Integrated Pest Management | 3 |
| ENTO 507 | Insect Morphology | 3 |
| ENTO 508 | Economic Entomology-I | 3 |
| ENTO 520 | Research Methodology and Data Analysis | 3 |

### ENTO 501. Insect Taxonomy (Compulsory)
**Credit hour: 3**

History, zoogeography and evolution of insect terms; of taxonomy and systematics, principles and methods of zoological classification; rules of zoological nomenclature, major features of taxonomic publications; Classification and phylogeny of insects, Important genera and / or species of major orders; Collection and preservation of insects, Identification of immature stages of insects.

### ENTO 502. Insect Ecology (Compulsory)
**Credit hour: 3**

Ecology-History, development and classification: population ecology: ecological systems community diversity and distribution; Insects and its environment, ecological genetics, population estimation: pest surveillance, and momtonne and torecastine: interaction and stability; analysis of ecological data and; ecological management of the crop pest environment to reduce the insect pest population.

### ENTO 503. Insect Physiology (Compulsory)
**Credit hour: 3**

Embryonic development in insects; integument and moulting; Physiology of digestive, respiratory, circulatory, excretory and nervous system; reproduction; growth and metamorphosis; sex determination in insects: locomotion in insects: insect nutrition; insect behavior: endocrine organs and hormone; exocrine glands, pheromones and defensive secretion in insects.

### ENTO 504. Biological Control (Compulsory)
**Credit hour: 3**

History and present status of biological control; fostering pest through misuse of chemicals; insects pests and their natural enemies; advantages and constraints of biological control and desirable characters of biological control agents; Foreign exploration, importation and of natural enemies: maximizing biological control through augmentation and conservation of natural enemies. Microbial control of insect, evaluation of performance of natural enemies.

## Courses and Curricula for Ph. D. in Entomology

| Course Code | Course Title | Credit Hour |
|---|---|---|
| **1. Major Courses** | | |
| **1a. Core** | | **18** |
| ENTO 601 | Advanced Insect Ecology | 3 |
| ENTO 602 | Environmental Contamination of Pesticides | 3 |
| ENTO 603 | Insect Biosystematics | 3 |
| ENTO 604 | Advances in Insecticide Toxicology | 3 |
| ENTO 605 | Plant Resistance in Pest Management | 3 |
| ENTO 606 | Urban Entomology | 3 |
| **1b. Elective** | | **6** |
| ENTO 607 | Insect Plant Interactions | 3 |
| ENTO 608 | Beekeeping Technology | 3 |
| ENTO 609 | Immature Insect Taxonomy | 3 |
| ENTO 610 | Insect Behavior | 3 |
| ENTO 611 | Insect Chemical Ecology | 3 |
| ENTO 612 | Insect Nutrition | 3 |
| ENTO 613 | Insect Pathology | 3 |
| ENTO 614 | Insects in Relation to Plant Diseases | 3 |
| ENTO 615 | Medical and Veterinary Entomology | 3 |
| ENTO 616 | Principles and Methods of Insecticides Residue Analysis | 3 |
| ENTO 617 | Stored Products Pests and Their Management | 3 |
| ENTO 618 | Special Studies in Entomology | 3 |
| ENTO 620 | Advanced Research Methodology | 3 |
| ENTO 504 | Biological Control | 3 |
| ENTO 506 | Integrated Pest Management | 3 |
| **2. Minor Courses** | | **6** |
| Minor Courses offered form other Departments will be selected by the advisory committee as per student's requirement. | | |
| **3. Seminar Courses** | | **2** |
| ENTO 698A | Seminar-1 | 1 |
| ENTO 698B | Seminar-2 | 1 |
| **4. Research** | | |
| ENTO 699 | Research work for Thesis | 30 |
| | **Total Cr. Hr.** | **62** |

## ENTO 601. Advanced Insect Ecology (Core)
**Credit hour 3**

Ecology of individual insect; response of abiotic conditions, resource acquisition, resource allocation. Population ecology; population system; population dynamics; life tables, survivorship curves; population regulation; population growth, factors affecting population regulation. Behavioural ecology- displacement, sexual behaviour, defense, communication, sexual communication with pheromones and use of insect pheromones in plant protection. Environment, habitats and niche, trophic level, energy transfer, nutrient cycling. Community ecology; species interactions, community structure, community dynamics. Ecosystem level; ecosystem structure & function, succession, herbivory, pollination, decomposition, insects as regulators of ecosystem processes. Biogeography, co-evolution, conservation- principles and practices.

## ENTO 602. Environmental Contamination of Pesticides (Core)
**Credit hour: 3**

Extent and use of pesticides; world and Bangladesh situation. Dynamics of pesticides in the environment; atmosphere, hydrosphere, lithosphere, biosphere. Pesticide residues in food, air, soil and water. Movement of pesticides; models for predicting the behaviour of pesticides in the environment. Environmental alterations of insecticide residues; characteristics. Degradation of pesticides by various agents, microorganisms, sunlight, plants and animals. Pesticide hazards, misconceptions. Hazards of pesticides to human; accidental poisoning and occupational exposure; domestic animals; acute and chronic toxicities of important insecticides. Effects of pesticides on wild life - bio transfer, bioaccumulation in terrestrial and aquatic environment through food chain, factors affecting bioaccumulation. Histophathological and biochemical effects of pesticides; carcinogenicity, teratogenicity, mutagenicity, effects on reproduction.

## ENTO 603. Insect Biosystematics (Core)
**Credit hour: 3**

Concept and history of systematic entomology; principles and application of zoological nomenclature; phylogeny, geological time table represented by fossil records, Theories on the origin of insects. Species concept and speciation. Taxonomic collections and curation and importance in biosystematics. Taxonomic characters, procedures of classification, mutations, concept and causes of diversity. Taxonomy and statistics; numerical taxonomy. Molecular systematic and current trends in insect classification. Taxonomic publications and preparation of publications. Studies on important orders and super family. Identification keys, use of keys in classification and preparation of diagnostic keys procedures in description of a species. Taxonomic drawings-drawing of insects and their parts-preparation of illustrations.

## ENTO 604. Advances in Insecticide Toxicology (Core)
**Credit hour: 3**

Introduction, development and types of resistance. Mechanism of resistance- biochemical and genetic. Metabolism of insecticides. Detoxification mechanism in insects; phase I reactions such as oxidation, hydrolysis, reduction and dehydrochlorination etc.; phase II

reaction such as conjugation, multiple pathways, induction of detoxification enzymes. Management of resistance, Genotoxicity. FAO/WHO on Pesticide Residues; Codex Alimentarious Commission; acceptable daily intake (ADI); maximum residue limit (MRL). Pesticide residues and relevant directions for management in developing countries. Application techniques in respect of safe use and handling of pesticides.

### ENTO 605. Plant Resistance in Pest Management (Core)
**Credit hour: 3**

Desirable features of plant resistance. Physical and chemical environment of crop plants. Morphological basis of resistance- colour, shape, contact factors, stem solidness, pubescense, deposition in epidermal wall, surface waxes, cell wall thickening, tissue proliferation. Anatomical adaptations chemical basis of resistance. Role of secondary plant substances in Host Plant Resistance (HPR). Ecological resistance, environmental impact of resistance in agroecosystem. Factors influencing expression of resistance, genetics of resistance. Achievements and utilization of resistant crop varieties in rice, cotton, sugarcane and other crops. Integration of plant resistance with other methods of pest control. National and international network programs. Genetic engineering and development of transgenic plants -wide hybridization. Transgenic plants with pest resistance trypsin inhibitor gene and other protease inhibitor genes. Genetic manipulation of secondary plant substances.

### ENTO 606. Urban Entomology (Core)
**Credit hour: 3**

Introduction, urban ecosystem, understanding of the theory and practice of major urban insect pests and other arthropods, the factors that contribute to their pest status. The biology, behavior, ecology, identification and management of urban pests; cockroaches, ants, bees, wasps, mosquitoes, termites, bedbugs, flies, lice, fleas, booklice, silver fish, beetles, moths and others.

### ENTO 607. Insect Plant Interactions (Elective)
**Credit hour: 3**

Co-evolution between host plants and insects. Plant herbivore interactions. Receptor systems, sensory perception in phytophagous insects. Dynamics of insect plant interactions in selected crop plants viz., rice, cotton, sugarcane, pulses. Insects and chemical environment of plants. Secondary and tertiary compounds, their effects on orientation, feeding, reproduction, growth and development of herbivorous insects. Role of enzymes in plant systems, detoxification of plant chemicals. Inter- and intraspecific competition of herbivores on selected crops. Tritrophic interactions among plants herbivores and their natural enemies, their implications in pest management.

### ENTO 608. Beekeeping Technology (Elective)
**Credit hour: 3**

Management and production in honeybee keeping. Techniques of queen rearing and instrumental insemination. Selection and improvement of honeybee races. Diagnosis and

control techniques of honeybee diseases and pests. Technology and manufacture, medical importance, chemical analysis of honeybee products. Potential effects of beekeeping on agriculture.

### ENTO 609. Immature Insect Taxonomy (Elective)
**Credit hour: 3**

Principles and theories of taxonomy. Terminology and morphology of immature insects. Using taxonomic keys for identification of agriculture insects to the order and family levels. Collection, preserving and rearing of immature insects.

### ENTO 610. Insect Behavior (Elective)
**Credit hour: 3**

Introduction, types of behaviour. Sensory receptors (mechanoreception, hygroreception, thermo-reception, photoreception). Nervous system and behaviour; hormones and behaviour. Displacement; causes of migration, classes of migration, adaptive nature of migration, orientation, navigation and homing. Communication; bio-luminescence chemical, acoustic, communication, visual, tactile communications. Sexual behaviour and reproduction, host selection and feeding behaviour. Defense; behavioral, structural, coloration defenses; Population behaviour and social behaviour. Collection of diurnal and nocturnal insects; Laboratory studies of various organs; sensillae. Rearing of social and solitary insects. Insect responses to audio-visual stimuli.

### ENTO 611. Insect Chemical Ecology (Elective)
**Credit hour: 3**

Glandular Secretions in insect communications; Pheromones, Allomones, Kiromones, etc.. Source of secretion, function, and chemical nature. Neuro-physiological basis of glandular secretions. Mechanisms of releasing, receiving, and dispersal. Other methods of communications in insects. Utilization of insect glandular secretions in IPM programs. Methods of chemical analysis for insect glandular secretions.

### ENTO 612. Insect Nutrition (Elective)
**Credit hour: 3**

Introduction; dietary requirements of insect. Micro and macro nutrients with their role in insects diet. Artificial diets for insects and their quality control. Micro-organisms and insect nutrition. Co-efficient of digestion, metabolism and growth; nutrition and host specificity; phago-stimulation. Preparation of synthetic diets for different groups of insects. Rearing of insects on synthetic, semi-synthetic and natural diets. Determination of co-efficient of utilization.

### ENTO 613. Insect Pathology (Elective)
**Credit hour: 3**

Introduction; history, definitions, scope and techniques in insect pathology; classification and types of insect pathogens; diagnostics and symptoms caused by insect pathogens-

protozoa, bacteria, rickettsiae, fungi, viruses and nematodes; transmission, host range, persistence and virulence of insect pathogens; resistance and immunity in insects against pathogens; types of injuries and methods of infection by pathogens in insects; pathogenic diseases and their diagnosis; extra-cellular and intracellular microbiota of healthy insects; factors affecting epizootology / enzootology of insect diseases and field efficacy; mass production of insect pathogens; bioassay and field evaluation; mammalian toxicity and safety of insect pathogens; commercial production and formulations; application and precautions; control of microbial diseases of useful insects; potential and effectiveness of entomopathogens in the management of key insect pests; role of pathogens in IPM; diseases of beneficial insects; molecular biology of insect pathogens.

**ENTO 614. Insects in Relation to Plant Diseases (Elective)**
**Credit hour: 3**

Introduction, identification, biology and control of insect and mite vectors. Mode of transmission of plant pathogens by insects and mites vectors. Study of causal organisms, etiology, symptoms of important fungal, bacterial and viral diseases of crop plants transmitted by insects and mites. Management of fungal, bacterial and viral diseases of crop plants transmitted by insects and mites vectors.

**ENTO 615. Medical and Veterinary Entomology (Elective)**
**Credit hour: 3**

Introduction; epidemiology; identification, biology and control of insects and other arthropods of medical and veterinary importance; insect and some other arthropod transmitted diseases, their symptoms and diagnosis; venoms, defense secretions and allergens. Collection, identification and control of different arthropod pests; cockroaches, lice, mosquitoes, flies, fleas, mites and others in relation to diseases of man and domestic animals.

**ENTO 616. Principles and Methods of Insecticides Residue Analysis (Elective)**
**Credit hour: 3**

Importance of residue analysis, Historical development, Residues in agro-ecosystem. Methods of residue analysis, basic principles, sampling techniques. Extraction procedures, clean up by liquid-liquid, breaking emulsions, solid, liquid, sweep co., distillation, sulphuric acid digestion. Final determination-bioassay, spectrophotometric, TLC, enzyme inhibition, GLC, HPLC. Multi residue methodology. Legal aspects of residues in consumable articles. Good laboratory practices. Estimation of active ingredient content in pesticides, plant products/pheromones. Laying supervised trial; sampling of different products; storage grains, vegetables, fruits, milk, egg, fish, meat, processed food, water, air; Extraction of insecticides of different groups from different matrices. Clean up of extracts; liquid- liquid partitioning, solid- liquid cleanup; sulphuric acid digestion; Final determination; bioassay, TLC, spectrophotometry; GLC, HPLC, GCMS; statistical interpretation of data; dissipation curve with confidence intervals. Different transformations of residue data, modified transformation. Visit to toxicology laboratory.

## ENTO 617. Stored Products Pests and Their Management (Elective)
**Credit hour: 3**

Introduction; Identification, biology and control of different stored products pests. Storage principles, types of storages; Factors affecting grain and other products in storages; stored product losses and their prevention. Visits to the godowns and demonstration of sampling methods and estimation of losses; collection, identification and control of different stored products pests.

## ENTO 618. Special Studies in Entomology (Elective)
**Credit hour: 3**

Selected entomological study for an individual student related to his area of specialization under the direction of the advisor.

## ENTO 620. Advanced Research Methodology (Elective)
**Credit hour: 3**

Statistical concepts and components of Entomological research. Purposes of conduction of research, planning of research and identification of researchable problems. Qualities and classification of research. Steps in experimental research. Sampling techniques-Simple Random Sampling, Stratified Random Sampling, Systemic Sampling, and Cluster Sampling. Basic principles of experimental design, layout and randomization of experiments, types of experimental design-Completely randomized design (CRD), Randomized completely block design (RCBD) and Latin square design (LSD). Missing plot techniques. Factorial experiments, Split plot design and Strip-plot design. Data transformation. Correlation and regression analysis, analysis of covariance. Survey methodology. Methods of data collection, calculation and processing. Statistical computer packages for analysis of experimental data and interpretation of research results. Graphical representation of experimental data. Instructions in Thesis/Dissertation/ scientific paper writing.

## ENTO 504. Biological Control (Elective)
**Credit hour: 3**

Concept, history, principles and present status of biological control. Fostering pest through misuse of chemicals. Important groups of predators, parasitoids and pathogens; desirable characters of biological control agents; advantages and constraints of biological control. Biological control ecology, host seeking behavior of predatory and parasitic group of insects. Principles of classical biological control-foreign exploration and importation of natural enemies; maximizing biological control through augmentation and conservation of natural enemies. Mass culture and periodic release of biological control agents-mass production techniques of quality bio-control agents and economics. Microbial control of insects- role of insect pathogenic bacteria, viruses, nematodes, fungi, protozoa etc. Biological control of weeds using insects. Methods of natural enemy colonization, recovery and evaluation of performance of natural enemies. Biological control of important crop pests and weeds.

## ENTO 506. Integrated Pest Management (Elective)

**Credit hour: 3**

Pest and pest management. History of pest control. Philosophy, basis principles and guidelines of integrated Pest management (IPM). Ecological basis of pest management; the economics of pest management, the quantitative basis of Pest management sampling and measures, analysis and modeling in pest management. Pest control tactics: cultural, mechanical, biological, genetic and legal control. Host plant resistance, use of semio-chemicals and insecticides biotechnology and integrated pest management. Training needs for IPM, role of extension entomology in IPM. Present status and prospects of integrated pest management in Bangladesh.

## Courses and Curricula for Ph. D. Degree in Genetics and Plant Breeding

| Course Code | Course Title | Credit Hour |
|---|---|---|
| **1. Major Courses** | | **18** |
| **1a. Core:** | | |
| GEPB 601 | Crop Plant Evolution | 3 |
| GEPB 602 | Crop Genetic Resources | 3 |
| GEPB 603 | Advanced Crop Breeding | 3 |
| GEPB 604 | Stress Breeding | 3 |
| GEPB 605 | Plant Biotechnology | 3 |
| GEPB 606 | Gene Regulation | 3 |
| **1b. Elective:** | | **6** |
| GEPB 501 | Genetics and Embryology | 3 |
| GEPB 503 | Biometrical and Population Genetics | 3 |
| GEPB 504 | Advanced Cytogenetics | 3 |
| GEPB 505 | Molecular Genetics | 3 |
| GEPB 506 | Breeding for Field Crops | 3 |
| GEPB 507 | Advanced Heterosis Breeding | 3 |
| GEPB 508 | Experimental Design and Data Analysis | 3 |
| GEPB 512 | Breeding for Horticultural Crops | 3 |
| GEPB 515 | Plant Tissue Culture | 3 |
| GEPB 518 | Genomics and Bioinformatics | 3 |
| **2. Minor Courses** | | **6** |
| Minor courses offered form other Departments will be selected by the advisory committee as per student's requirement. | | |
| **3. Seminar Courses** | | **2** |
| GEPB 698A | Seminar-1 | 1 |
| GEPB 698B | Seminar-2 | 1 |
| **4. Research** | | |
| GEPB 699 | Research work for Thesis | 30 |
| | **Total Cr. Hr.** | **62** |

## GEPB 601. Crop Plant Evolution (Core)
**Credit hour: 3**

Crop evolution - concept, scope, importance and history of crop evolution. Hunting and gathering of food. Origin of agriculture - Why, when and where. Crop domestication and genetic changes, weed and its relation to crops. Centers of origin and diversity. Evolution of major crops - rice, wheat, maize, potato, Brassica. Major dissemination pathways of crops, evolving plants under domestication. Contemporary methods in the study of crop evolution, plant science and archaeology. Relevance of crop evolution to plant breeding.

## GEPB 602. Crop Genetic Resources (Core)
**Credit hour: 3**

Germplasm-definition, importance, scope. Classification of genetic resources. Land races and its importance, wild and weedy form of genetic resources and their importance. Exploration and collection, conservation. Characterization of genetic resources-morphological, biochemical, cytological and molecular finger printing of germplasm and its importance. Evaluation and utilization of genetic resources. Documentation of germplasm. Participatory approaches in genetic resource management, on farm management of genetic diversity, national and international genetic resources centre and institute. Plant genetic resources policies-convention of biological diversity (CBD), international treaty on plant genetic resources for food and agriculture. Introduction to IPR, plant breeders rights, farmers rights and patents. Plant material exchange and quarantine.

## GEPB 603. Advanced Crop Breeding (Core)
**Credit hour: 3**

Concept of variety and cultivars of crops- genetic makeup and their features. Application of biometrical techniques in crop breeding. Breeding for physiological traits, Plant ideotype breeding, Distant hybridization and chromosome manipulation, Breeding for Biotic and Abiotic stress, Breeding for quality, Breeding for adaptation, Breeding for multiple cropping, Apomixis and its use in plant breeding, Maximizing genetic improvement. Marker aided breeding. Tissue culture and crop improvement, Application of genetic engineering in Plant Breeding, Intellectual Property Rights, Participatory breeding.

## GEPB 604. Stress Breeding (Core)
**Credit hour: 3**

Plant responses to abiotic and biotic stresses. Reduction of crop yield. Resistance mechanism to tolerate stress. Change in gene expression patterns in response to stress. Stress factors. Physiological, Biochemical and Genetic mechanisms for stress tolerance. Breeding for abiotic stress tolerance - High temperature stress, drought stress, salt stress, cold stress, flooding stress and oxidative stress. Breeding for biotic stress tolerance - Disease resistance and Pest resistance.

## GEPB 605. Plant Biotechnology (Core)
**Credit hour: 3**

Biotechnology- concept & scope, role of tissue culture in crop improvement, somaclonal and gametoclonal variation, somatic hybridization, embryo rescue, protoplast culture, haploid production. Concept of genetic engineering, plant transformation, transfer of cloned genes- delivery system and expression of cloned genes in foreign cells. Progress in molecular biology and genetic engineering of specific characters in specific plants. Potential application of genetic engineering in Agriculture. Processing of genetically engineered variability for evolving superior genotypes. Transgenic plants and transgenic crop, present status of transgenic crop. Marker assisted selection. Problems and prospective of genetic engineering. Regulations related to handling and releasing transgenic crop.

## GEPB 606. Gene Regulation (Core)
**Credit hour: 3**

Control of gene expression in prokaryotes. Operon. Negative control-lac operon, polar mutations, constitutive mutations. Positive control-Catabolite repression of lac operon. Control of gene expression in eukaryotes. Transcription factors. Cis and trans-controlling elements. Plant genome & Agrobacterium. Mendel to McClintock / Mutant isolation. Genetics vs. Epigenetics. Epigentic gene regulation-DNA and histone methylation, Chromatin remodeling & transcription. Post-transcriptional gene silencing, Transcriptional gene silencing & activation. Plant hormone-mediated gene regulation. Gene regulation in the shoot apical meristem. Translational regulation, post translational modification. Protein sorting and tagging. Gene imprinting and seed development. Cell Signaling and transduction. Cell-to-cell communication. DNA microarray analysis.

## GEPB 501. Genetics and Embryology (Elective)
**Credit hour: 3**

Critical review of Mendelism. Gene expression, penetrance and expressivity, phenocopies and pleiotropism, xenia and metaxenia. Multiple alleles; inheritance of multiple alleles, self incompatibility. Extranuclear inheritance; mitocondrial and chloroplast genomes, male sterility and its use in plant breeding. Molecular basis of mutation, mutagens and its action mechanism at molecular level. Apomixis and its genetic basis. Fine structure of DNA and RNA and their replication in prokaryotes and eukaryotes. Protein synthesis; transcription and translation of genetic information. Genetic code; basis of cryptoanalysis, codon assignment, characteristics of genetic code, anticodon and wobble hypothesis. Gene regulation at transcriptional and translation level, gene silencing.

Gametophytic generation of angiosperm; development of male and female gametes, fertilization and formation of fruits, seed and embryo; factors affecting embryo abnormalities and degeneration; problem associated with interspecfic hybridization in relation to development and ways to circumvent them; apomixis and polyembryony - basis of cytology and implication.

## GEPB 503. Biometrical and Population Genetics (Elective)
**Credit hour: 3**

Gene in populations- frequency of gene and genotypes, genetic similarity and genetic distance. Polymorphism.

Quantitative genetic analysis and biometrical approach. Additive and dominance effect of gene- components of means, components of variation, testing the additive-dominance model, scaling test. Non-allelic interaction and genetic analysis- biometrical basis of heterosis. Multivariate analysis of genetic divergence. Heritability, co-heritability and expected genetic advance- maximizing genetic advance for a polygenic character. Analysis of G E interaction and stability parameters. Analysis of gene interaction and variance components; Top cross, polycross design and Line Tester analysis, Diallel analysis and combining ability-Hayman and Griffing's approaches. North Carolina designs of Biparental mating. Correlated response and selection index.

## GEPB 504. Advanced Cytogenetics (Elective)
**Credit hour: 3**

Concept, scope, and application of Cytogenetics in crop improvement. Structural variation in chromosomes - and their genetic consequences. Numerical variation in chromosome and their genetic consequences. Permanent inversion in chromosome and translocation heterozygosity, their role in speciation. Haploid - its production, behaviour and use in plant breeding. Polyploids- autoplyploids and allopllyploids, cytogenetic behaviour and their role in crop improvement. Evolution of major crops like rice, wheat, brassica, maize, cotton sugarcane. Cytogenetic behaviour and use of aneuploids in crop improvement. Alien gene transfer through chromosome manipulation. Cytogenetical basis of self-incompatibility and male sterility with their application in plant breeding.

## GEPB 505. Molecular Genetics (Elective)
**Credit hour: 3**

Introduction. Fine structure of gene. Gene function- transcription and post transcriptional modification, translation and post translational modification. Restriction endonuclease, restriction mapping, molecular markers and their use. cDNA and genomic library. Method of genetic analysis. Gene cloning- conventional and modern method of gene identification and isolation, gene insertion into vectors, selection of transformants, use of markers, DNA sequencing and gene synthesis. DNA probe, southern, northern and western blot. Genetic interactions between nucleus, chloroplast and mitochondria; transport of unclearly encoded products into organelles. Transposable elements their characteristics and use.

## GEPB 506. Breeding for Fields Crops (Elective)
**Credit hour: 3**

Introduction, Importance, history and evolutionary aspects of field crop breeding. Methods in plant breeding. Breeding of rice, wheat, maize, jute, sugarcane, potato, oil crops and pulses, Present status of varietal improvement of field crops in Bangladesh.

# Courses and Curricula for Ph.D. Degree in Horticulture

| Course Code | Course Title | Credit Hour |
|---|---|---|
| **1. Major Courses** | | |
| **1a. Core** | | **18** |
| HORT 601 | Advanced Floriculture and Landscaping | 3 |
| HORT 602 | Biodiversity and Conservation of Fruit Crops | 3 |
| HORT 603 | Modern Technology in Vegetable Crops | 3 |
| HORT 604 | Advanced Physiology of Horticultural Crops | 3 |
| HORT 605 | Advanced Plant Molecular Biology | 3 |
| HORT 606 | Stress Management in Horticultural Crops | 3 |
| **1b. Elective** | | **6** |
| HORT 607 | Environmental Horticulture | 3 |
| HORT 608 | Advances in Spices and Plantation Crop | 3 |
| HORT 505 | Seed Technology of Horticultural Crops | 3 |
| HORT 506 | Research Methodology | 3 |
| HORT 508 | Biotechnology in Horticulture | 3 |
| HORT 509 | Medicinal Plants | 3 |
| HORT 512 | Postharvest Technology of Horticultural Crops | 3 |
| HORT 513 | Growth Regulators in Horticulture | 3 |
| HORT 514 | Hydroponics and Organic Farming | 3 |
| **2. Minor Courses** | | **6** |
| Minors courses will be selected as per requirement of the student and suggestions given by the advisory committee | | |
| **3. Seminar** | | **2** |
| HORT 698 A | Seminar-1 | 1 |
| HORT 698B | Seminar-2 | 1 |
| **4. Research** | | |
| HORT 699 | Research work for Thesis | **30** |
| | **Total Cr. hr.** | **62** |

## HORT 601. Advanced Floriculture and Landscaping (Core)
**Credit hour: 3**

**Commercial flower production:** Global scenario in cut flower production and trade, Varietal wealth and diversity; Special characteristics and requirements, Cut flower, Loose flowers, Dry flowers. Flower color, scent, structure, production of target color.

**Environmental manipulation:** Influence of environmental parameter, light, temperature, moisture, humidity and $CO_2$ on growth and flowering.

**Flower forcing:** Flower forcing and year-round flowering through physiological interventions. Regulation for quality flowers.

**Pre and postharvest management:** Harvest indices; harvesting techniques; Postharvest handling; Chemical regulation; Packaging, Marketing; Export potential; Agricultural Export Zones.

**Crop specific practices:** Anthurium, Bird of paradise, Crossandra, Carnation, Gladiolus, Gerbera, Jasminum, Liliums, Marigold, Orchids, Rose, Tuberose.

**Floral oil industry:** Extraction methods, production of scent, perfume, recent advances.

**Landscape architecture and designing:** History of landscaping, Elements of landscape architecture, Principles of garden design, design process.

**Landscape management:** Landscape management in relation to recreation, reclamation, social forestry, arboriculture and nature conservation.

**Climate change and landscaping:** Ecological principles applied for design and management of landscape. Landscaping for sustainable environment.

## HORT 602. Biodiversity and Conservation of Fruit Crops (Core)
**Credit hour: 3**

**Biodiversity:** Issues and goals of biodiversity, centers of origin of cultivated fruits; primary and secondary centers of genetic diversity. Maintenance of diversity,

Germplasm conservation Present status of gene centers; exploration and collection of germplasm; conservation of genetic resources conservation in situ and ex situ. Important aspects of home gardens from a plant genetic resource perspective. Problem of recalcitrancy - cold storage of scions, tissue culture, cryopreservation, pollen and seed storage; inventory of germplasm, introduction of germplasm, plant quarantine. Approaches to conservation, Biodiversity conservation and development in home gardens. Conservation value of home gardens.

**IPR:** Intellectual property rights, regulatory horticulture. Detection of genetic constitution of germplasm and maintenance of core group.

**GIS:** Global Information System and documentation of local biodiversity, Geographical indication.

## HORT 603. Modern Technology in Vegetable Crops (Core)
**Credit hour: 3**

**Introduction:** Present scenario of vegetable crop production in Bangladesh, scopes and importance, problems of vegetable production in Bangladesh and remedies.

**Organic cultivation:** Principles, perspective, concept and components of organic production of vegetable crops. Organic production of vegetables crops, viz. solanaceous crops, cucurbits, cole crops, root and tuber crops. Managing soil fertility, pests and diseases and weed problems in organic farming system; crop rotation in organic horticulture.

**Protected cultivation:** Importance and scope of protected cultivation of vegetable crops; types of greenhouse/ polyhouse/ nethouse; effect of environment factors, viz. temperature, light, $CO_2$, and humidity in protected cultivation. Problems of growing vegetables in protected structure and their remedies, insects and diseases management in protected structures and soil-less culture.

**Under exploited vegetables:** Production of non-traditional vegetable crops of Bangladesh and their management and conservation.

**Processing:** Present status and future prospects of vegetable preservation industry in Bangladesh. Raw materials for processing, primary and minimal processing; processing equipments; layout and establishment of processing industry. Spoilage of fresh and processed horticulture produce; biochemical changes and enzymes associated with spoilage of horticultural produce; food poisoning and control measures. Role of microorganisms in food preservation.

## HORT 604. Advanced Physiology of Horticultural Crops (Core)
## Credit hour: 3

**Water and mineral nutrient in plant:** Water transport processes; water balance in plants; mineral nutrition in plants; solute transport processes; assimilation of mineral nutrients. Issues of growth and development in plants.

**Photosynthesis:** Photosynthesis in higher plants; the light reactions; carbon reactions; translocation in the phloem; physiological and ecological consideration.

**Respiration:** Glycolysis; the citric acid cycle; respiratory metabolism of carbohydrates, proteins and fats; respiratory effects during storage and transportation of assimilate.

**Photoperiodism:** Discovery; Impact of photoperiodism; Photoperiodism control of flower initiation; biochemical and molecular aspects of photoperiodism; genetic aspects of photoperiodism; photoperiodic control of development.

## HORT 605. Advanced Plant Molecular Biology (Core)
## Credit hour: 3

**Introduction:** Definition, Scope and importance. Advantages and limitations of different types of culture.

**Molecular Concept of Gene:** Structural features of nucleic acids; Watson and Crick model of DNA, Evidence for DNA and RNA as genetic material, Physical and chemical properties of DNA.

**Basic Techniques in Molecular Biology:** Regulation of gene expression in prokaryotes and Eukaryotes, Southern Blotting, Northern blotting, Western Blotting. Extraction of DNA and RNA. Visualization of DNA using Gel electrophoresis, Polymerase chain reaction, Primer designing and considerations for primers designing, Processing of PCR product and Cloning vector using restriction enzymes (Ligation and Transformation).

**Sequencing:** DNA Sequencing, Gene mapping and PCR-based DNA fingerprinting. Sequence Alignment, Database Searching, Phylogenetic Analysis: Evolutionary basis of sequence alignment, Database similarity searching (FASTA, BLAST), Phylogenetic tree building, and submit DNA Sequences to the Databases (NCBI).

**Application of Genetic Engineering in Horticulture:** Principles of Insect, diseases and stress tolerant variety development (Transgenic breeding. RFLP, RAPD and AFLP, Marker assisted Horticultural crop improvement. Recombinant DNA Technology. Breeding for drought & Salinity tolerant) and DNA Microarray and its application.

**GMOs and Biosafety Regulations:** Genetically modified crops: Benefits and risks, Bio-safety regulations to protect nature, Public acceptance and ethical issues.

**Protemics and bioinformatics:** Concept, importance, protein expression, SDS-PAGE, Biochemical analysis of protein.

## HORT 606. Stress Management in Horticultural Crops (Core)
### Credit hour: 3

**Introduction:** Definition, Different stresses: water stress, drought stress, heat stress, wind stress, salinity stress, nutrient stress and other important stresses. Mechanism and measurements of tolerance to drought, water logging, soil salinity, frost and heat stress.

**Stress physiology:** Mechanism of plant response to different types of stress, impact of stress in horticultural crop production, stress indices, physiological and biochemical factors associated with stress. Soil-plant-water relations under different stress conditions in crops production and their management practices.

**Crop modeling:** Crop modeling for stress situations, assessing the stress through remote sensing, understanding adaptive features of crops for survival under stress, interaction among different stress and their impact on crop growth and productivity.

**Techniques of stress management:** Techniques of crop growing under high and low temperature, water deficit, water logging and salinity. Greenhouse effect and methane emission and its relevance to stresses, use of chemicals in stress management.

## HORT 607. Environmental Horticulture (Elective)
### Credit hour: 3

**Introduction:** Climatic components and their impact on Horticultural crops Environmental complex, interaction of ecological factors in horticultural crop production, interaction of physiographic factors in horticultural crop production. Geo-chemical and hydrological cycles and their impact on ecosystems.

**Global warming:** Carbon trading role of green house gases, elevated $CO_2$ and its impact on productivity of horticultural systems. Habitat ecology, changes in habitats and its impact on horticultural production, Habitat analysis, conservation biology, domestication. Forest ecosystem and its evolution to a hort-ecosystem.

**Land use pattern:** Changes in land use pattern and its impact on horticultural crop production. Natural resource management in horti-systems. Subsistence farming systems of the world: threat and challenges.

**Environmental pollution:** Pollutants, Environmental pollution in horti systems, chemicals, fertilizers, etc. Waste management in processing industry, phytoremediation. Alternate farming systems, horticultural therapy, environmental policy and legislation in Bangladesh.

### HORT 608. Advances in Spices and Plantation Crop (Elective)
### Credit hour: 3

**Introduction:** Present status, scope and problems of spices and plantation crop production in Bangladesh. Export potential - varietal wealth and appraisal on the crop improvement.

**Spices Production:** Cultivation and management practices of pepper, cardamom, nutmeg, clove, cinnamon, turmeric, ginger, garlic, coriander, fenugreek, fennel, cumin and important herbal spices. Protected cultivation of high value spice crops.

**Postharvest Management:** Maturity indices, harvesting, curing, processing and value addition, grading, packing and storage, role of commodity boards in plantation crop development, Production of spices and plantation crops through GAP, GMP, HACCP.

**Plantation Crops:** Cultivation and management practices of coffee, tea, cashew, cocoa, rubber, oil palm, coconut, areca nut, wattle and betel vine.

### HORT 505. Seed Technology of Horticultural Crops (Elective)
### Credit hour: 3

**Introduction:** Background of seed technology, present status, problems and scope of vegetable and flowers seed production in Bangladesh.

**Morphology and development of seed:** Seed structure, seed quality, characteristics of good seed, seed formation, embryo development, endosperm development, seed coat development.

**Vegetable and flower seed growing Business and Industry:** Present status, scope and opportunities for development of seed industry in Bangladesh. Scope of vegetable seed agribusiness.

**Seed Classes and Seed rules:** Breeder's seed, foundation seed, registered seed, certified seed, truthfully labeled seed, farmer's seed. Seed certification, seed certification standards of vegetable seed. National seed policy and seed rule.

**Postharvest Biotechnology:** Harvesting, drying, processing and storage of seed, use of instrument for threshing, cleaning, drying, grading and packaging. Seed marketing. Demand forecast, marketing structure, factors affect seed marketing.

**Seed production of Horticultural Crops:** Seed production technology of tomato, brinjal, cauliflower, cabbage, okra, chili, onion, potato, TPS, use of TPS for potato production.

### HORT 506. Research Methodology (Elective)
### Credit hour: 3

**Identification and Prioritization of Researchable Problem:**
Guidelines, planning and development of research projects and their evaluation.

**Statistical procedure:**
Field plot techniques
Design of experiments and analysis of data
Comparison among means
Correlation and regression analyses

**Presentation and Interpretation of Experimental Results:**
Scientific report writing
Types of scientific reports
Contents of scientific reports
Techniques of presentation

**Research System in Bangladesh:**
Research and development systems in different organizations of Bangladesh, including visit of activities of the organization

**Practical:** Data entry and analysis

## HORT 508. Biotechnology in Horticulture (Elective)
## Credit hours 3

**Introduction to biotechnology:** Concept, role in horticulture, presents situation, achievement, prospects and limitations

**Laboratory requirements:** Laboratory equipments, required environmental facilities, different culture media and necessary chemicals.

**Micro propagation and plant regeneration:** Concept, technique of micro propagation and its application, differentiation of cell and tissue, cytodifferentiation, organogenesis, somatic embryogenesis, protoplast fusion, somatic hybridization. Regeneration of potato, papaya, banana, jackfruit, orchid, onion, garlic, mushroom, thuja and other horticultural crops.

***In vitro* techniques for horticultural crops:** Meristem, anther, pollen and ovary for horticulture, production of haploids in vegetable crops, cryopreservation, and embryo rescue.

**Production of vegetative propagating material through tissue culture:** Virus elimination and clean seed production of potato, sweet potato, yam, ginger, turmeric, etc.

**Genetic engineering in horticulture:** Gene cloning, cloning vehicles and strategies, restriction, digestion, ligation, genomic and cDNA isolation. cDNA library screening, isolation of genomic DNA and RNA from papaya potato. Plasmid DNA isolation, DNA sequencing. Use of DNA markers vegetables and fruits for genimic analysis, Gene transfer technique and its detection, transfer of desired genes in important horticultural crops.

## HORT 509. Medicinal Plants (Elective)
## Credit hour: 3

**Introduction:** Nomenclature & classification on medicinal plants. Morphology, cultivation of important medicinal plants in Bangladesh:

Aonla, Apang, Agar Antigonon, Aloe, Arjun, Asparagus, Ajowan, Bitter gourd, Belledona,

Bohera, Bael, Colchicin, Cinnamon, Clove, Chirata, Cardamon, Ciruander, Cissus, Cassia, Clitonia, Camphor, Datura, Fig, Garlic, Ginger, Gloriosa, Horitoki, Ixora, Kalanchoe Mimosa, Moringa, Neem, Nishinda, podophyllum, Sweet potato, Saffron, Tamarind, Vinca, Vitex, Verononia, etc.

**Plant parts use as medicine:** Fresh and dry plant parts uses for treating common diseases. Collection Technique of Extracts from medicinal plants, Different medicinal extracts-alkaloid, essential oil, glycosides, active constituents, latex, organic acid pigment , resins, tannins, vitamin and enzymes, waxes -their properties, preparation and preservation.

**Products from medicinal plants and their use:** Syrup, ointment, extract, tablet, juice, tincture, aromatic water, lotion, spirit, vinegar, plaster etc. Use of products for control of diseases.

## HORT 512. Postharvest Technology of Horticultural Crops (Elective)
## Credit hour: 3

**Introduction:** Concept, Quality, present status and improvement of postharvest situation of horticultural crops. Factors affecting postharvest of horticultural products

**Postharvest handling of horticultural crops:** Harvesting, cooling, cleaning, sorting, grading, packaging and transportation of horticultural crops. Export of horticultural commodities.

**Postharvest physiology:** Physiological and biochemical changes after harvest, factor causing physicochemical changes

**Technology of storage:** Principles, methods of storage and maintenance of conditions in store houses. Environmental requirements for storage of fruit, vegetable and flower.

**Postharvest spoilage:** Causes of spoilage and their remedies, postharvest disorders, disease, pests and their minimization techniques.

**Processing and preservation:** Importance, principles and techniques of processing and preservation of fruits and vegetable. Quality control of processed fruits and vegetables and value added products, food safety issues.

## HORT 513. Growth Regulators in Horticulture (Elective)
## Credit hour: 3

**Introduction:** Classification and overview of PGRs. Beneficial and detrimental effect of PGRs.

**PGRs and Plant physiology:** Mechanism of action of plant hormones. Naturally occurring plant hormones, their major physiological effect on plant growth and development

**PGRs on plant growth:** Structure, physiological effect, biosynthesis, metabolism and transport of Auxin, Gibberellins, Cytokinins, Ethylene, Abscisic acid

**Synthetic PGRs and their application:** Different synthetically produced plant growth regulators. Methods of applying plant growth regulators.

**Uses of PGRs:** Uses of growth regulators in fruit, vegetable, ornamental and cut flowers. Practical uses of PGRs in agriculture

## HORT 514. Hydroponics and Organic Farming (Elective)
### Credit hour: 3

**Introduction to hydroponics:** Concept, objective and importance. Advantages and disadvantages. Hydroponic basic. Research activities of soilless culture in the world. Present status and future prospect of hydroponics in Bangladesh.

**Hydroponics systems:** Hydroponic growing systems, Circulating and non-circulating systems, Liquid-NFT, specific NFT system, oxygen problem and NFT-infrastructure, solid/aggregate and aeroponics systems. Structural preparation of different system.

**Hydroponic system for the tropics:** Low-cost hydroponic system (LCS) for Bangladesh. Tips on carrying out an installation. Protected vegetable cultivation system in urban and peri-urban areas in Bangladesh.

**Substrate culture:** Properties of substrates, substrate materials, system settings and maintenance, aeration system.

**Growing unit for hydroponics:** Different units in the world and Bangladesh. Consideration of selecting equipments and units, equipments and their installation supplementary needs. Hydroponic Seeding methods, containers, and growing media.

**Nutrient solution:** Nutrient formulae-Hoagland and Arnon (1938), Rahman and Inden (2012), etc. preparation of mixtures, rate of application. Solution-pH/CF, temperature and EC. Nutrient solution application equipments, automatic dosing equipments.

**Environmental control:** Temperature, RH, cold and heat, lighting management system. CEA, Greenhouse design and materials. Greenhouse for the tropics and automated system.

**Introduction to organic farming:** Concept, scope and importance in Bangladesh.

**Sustainable agriculture and cycle for survival:** Adverse effects of agricultural practices on farm Towards organic farming: Management of autonomous ecosystem, general principles of organic agriculture.

**Bio-intensive nutrient management:** Soil populations and process, use of bio-fertilizes, enrichment of compost with microbial inoculates.

**Biological pest management:** Ecological pest management, Neem etc.

**Food safety:** Concept, present status in Bangladesh. Toxins in conventional system of crop production, Probable remedies.

**IFOAM:** Global scenario of organic movement.

## Courses and Curricula for Ph. D. Degree in Plant Pathology

| Course Code | Course Title | Credit Hour |
|---|---|---|
| **1. Major Courses** | | |
| **1a. Core:** | | **18** |
| PLPA 601 | Advanced Mycology | 3 |
| PLPA 603 | Advanced Epidemiology and Plant Disease Dynamics | 3 |
| PLPA 605 | Advanced Clinical Plant Pathology | 3 |
| PLPA 606 | Advanced Molecular Biology of Host-Pathogen Interaction | 3 |
| PLPA 616 | Advanced Seed Pathology | 3 |
| PLPA 502 | Phytopathological Research Methodology | 3 |
| **1b. Elective:** | | **6** |
| PLPA 608 | Advanced Plant Nematology | 3 |
| PLPA 609 | Advanced Plant Bacteriology | 3 |
| PLPA 611 | Advanced Plant Virology | 3 |
| PLPA 612 | Genetic Engineering for Disease Resistance | 3 |
| PLPA 614 | Biological Control of Plant Diseases | 3 |
| PLPA 504 | Plant Disease Management | 3 |
| PLPA 513 | Post Harvest Pathology | 3 |
| **2. Minor Courses** | | **6** |
| Minor courses offered from other Departments will be selected by the advisory committee as per student's requirement | | |
| **3. Seminar** | | **2** |
| PLPA 698A | Seminar-1 | 1 |
| PLPA 698B | Seminar-2 | 1 |
| **4. Research** | | |
| PLPA 699 | Research work for Thesis | 30 |
| | **Total Cr. Hr.** | **62** |

### PLPA 601. Advanced Mycology (Core)
### Credit hour: 3

Modern fungal classification; history of fungal systematics. Ecological principles and fungal symbiosis. Evolutionary genetics and genomics. Comparative fungal genomics. Hyphal growth and branching. Regulation of dimorphism and development. Fungal speciation and population dynamics. Fungal life cycles, fungal growth, development, reproduction, survival and dispersal. Major groups of fungi and use keys to identify a particular organism, the basic biology of fungal organisms, plant diseases and other interactions involving fungi from the major taxonomic groups, molecular mechanisms of pathogenicity. Molecular characterization tools: isozyme analysis, AFLP, RFLP, RAPD, SSR. Fungal population genetics and fungal growth patterns. Problems associated with fungal mycotoxins in cereal.

## PLPA 603. Advanced Epidemiology and Plant Disease Dynamics (Core)
**Credit hour: 3**

Essential principles and concept of plant disease epidemics. Forms and patters of epidemics. Famine for epidemics and their impact on global food security. Understanding of risk factors and their interactions that lead to plant disease epidemics. Production, liberation and dissemination of inoculums and population dynamics. Monocyclic and polycyclic epidemics. The dynamics of pathogens associated with seeds, seedlings as well as those causing soil-borne, foliar and fruit diseases before harvest, and decay and damage after harvest. Quantifying and modeling disease development over time and space. Critical and multiple point model for crop loss assessment: characterization of relationship between disease development and crop losses. Analysis of environmental, ecological and host-pathogen genetic factors that influence the course of plant disease epidemics. Rational management strategies for controlling epidemics. Monitoring and predict epidemics and plant disease forecasting models.

## PLPA 605. Advanced Clinical Plant Pathology (Core)
**Credit hour: 3**

Introduction to Plant Disease Diagnosis: Concepts in diagnosing plant diseases, reasons for diagnosing plant diseases, steps in diagnosing a plant disease. Equipments and supplies of plant disease clinic. Examining field problems, recording field information, collection, and preparation and shipping disease specimens. Symptoms and signs to look for when diagnosing a plant disorder, integration of information, hypothesis formulation and hypothesis testing. Plant examination and pathogens isolation and identification techniques of different plant Pathogens. Conventional and Molecular methods used in Plant disease diagnosis. Diagnosing diseases of tomato, cucurbits, pepper, eggplants, beans, lettuce, cauliflower, cabbage, potato, onion and garlic, etc. Diagnosing diseases of rice, wheat, maize, chickpea, lentil etc. Diagnosing diseases of mango, jackfruit, banana, papaya, guava, grapes. Diagnosing diseases of Citrus. Field trips and use of compendium in diagnosing of diseases.

## PLPA 606. Advanced Molecular Biology of Host-Pathogen Interaction (Core)
**Credit hour: 3**

Analysis of current concepts in the physiology, biochemistry, genetics and molecular biology of host-parasite interactions supported by recent research papers. Recent developments in research on host specificity, recognition, penetration, toxin production, altered plant metabolism during disease, resistance mechanisms and regulatory aspects of gene expression during host-parasite interactions. Molecular methods for detection of plant pathogen. Antigens and antigenic determinants, Antibodies: Properties, preparation and purification. Nuclear and fractionation, DNA sequence and gene mappings. Molecular hybridization and polymerase chain reaction, gene cloning.

## PLPA 608. Advanced Plant Nematology (Elective)
**Credit hour: 3**

Plant Nematology, nematode morphology and biology, systematics and evolution. Identification of nematodes. Nematode diversity as revealed by morphological and molecular evidence. Structural features used in taxonomy. Phylogenetic relationships based on morphological and molecular data used to consider patterns of character change among taxa. Theory and practice of inferring phylogenetic trees using molecular sequence data. Molecular biology and physiology of nematodes using *Caenorhabditis elegans* as a model, but with emphasis on plant-parasitic species. Reproduction and reproductive system. Feeding, symptomatology, life cycle, host parasite relationship. Extraction of nematodes. Major concepts in population and community ecology of plant-parasitic nematodes. Current advances in techniques, theory, and basic information about nematode-host dynamics, and application to management of nematode diseases. Techniques and equipment used to manage nematodes and methods used to analyze their effectiveness. Diagnosis and prediction of nematode field problems, strategies for control, and field plot design and establishment.

## PL PA 609. Advanced Plant Bacteriology (Elective)
**Credit hour: 3**

History and introduction to phytopathogenic procarya, viz., bacteria, MLOs, spiroplasmas and other fastidious procarya. Importance of phytopathogenic bacteria. Evolution, classification and nomenclature of phytopathogenic procarya and important diseases caused by them. Growth, nutrition requirements, reproduction, preservation of bacterial cultures. Variability among phytopathogenic procarya. General biology of bacteriophages, L form bacteria, plasmids. Procaryotic inhibitors and their mode of action against phytopathogenic bacteria. Survival and dissemination of phytopathogenic bacteria. Isolation, purification, identification and host inoculation of phytopathogenic bacteria. Staining methods, biochemical and serological characterization, isolation of plasmid and use of antibacterial chemicals/antibiotics.

## PLPA 611. Advanced Plant Virology (Elective)
**Credit hour: 3**

Recent advances in plant virology. Advanced techniques, equipments and principles involved in plant virus studies. Modern classification, biochemistry, molecular characterization, detection and transmission of viruses. Ultracentrifugation, spectrophotometry, electrophoreses, electron - microscopy and serology. Infection process and ultra structure of diseased plant cell. Ecology and epidemiology of plant virus. Plant virus management.

## PLPA 612. Genetic Engineering for Disease Resistance (Elective)
**Credit hour: 3**

Introduction and problems in breeding for disease resistance. Genetics of host plants, plant pathogen and their interactions. Flor's gene-for-gene hypothesis and its implications in breeding for disease resistance. Kinds of resistance: horizontal and vertical resistance,

oligogenic and polygenic resistance, major and minor gene resistance, race specific and race non specific resistance, seedling resistance, intermediate resistance, partial resistance, adult plant resistance, generalized resistance and cytoplasmic resistance. Components of host resistance: latent period, receptivity, infection rate, infection frequency, infection efficiency, sporulation capacity, fructification period etc. Role of environment on host and pathogen in disease resistance. Genetical engineering for developing resistant variety. Breeding for disease resistance. Systemic Activated Resistance (SAR). Visit to breeding stations.

## PLPA 614. Biological Control of Plant Diseases (Elective)
## Credit hour: 3

Concept, strategies of plant disease protection. Principles and mechanism of biological control. Interaction of host, pathogen, antagonist and physical environment. Approaches of biological control. Bio-control tools. Antagonistic properties of bio-control agents. Ecology of rhizosphere bio-control agents. Arbuscular mycorrhizal fungi as bio-control agent. Recent bio-control researches. Bio-control of areal pathogen - future understanding. Bio-pesticides, the commercial bio-control products.

## PLPA 616. Advanced Seed Pathology (Core)
## Credit hour: 3

History and concept of seed pathology, importance of seed health and its impact on food security, significance of seed borne disease and effect of seed diseases on crop production. Recent advances in the establishment and subsequent cause of disease development in seed and seedling. Inoculum density of seed borne pathogen and its relationship with disease. Ecological relationship of seed borne micro organism, mechanism of transmission of seed borne pathogens in plant seed sampling and related issues. Laboratory seed health testing methods, common seed health testing methods and report writing, detection and identification of seed borne pathogen(s): Fungi, bacteria, virus, mycoplasma, nematode etc. Evolutionary adaptations of crop plants to defend seed invasion by seed-borne pathogens. Epidemiological factors influencing the transmission of seed-borne diseases, forecasting of epidemics through seed-borne infection. Production of toxic metabolites by storage fungi affecting seed quality and its impact on human, animal and plant health. Control of seed borne pathogens, seed treatment - procedure and equipment, integrated management of seed borne pathogens. National laws related to seeds and seed certification, international rules related to seed business, plant quarantine and SPS under WTO. Pest risk analysis-seed perspective. Seed supply chain management in Bangladesh. Analysis of current research trend in seed pathology, future seeds and seed protection. Assignment presentation.

## PLPA 502. Phytopathological Research Methodology (Core)
## Credit hour: 3

Concept and components of Phytopathological research, collection of facts, analysis of the situation, identification and priotization of problems, developing the hypothesis. Methodology for achieving the objectives in Phytopathological experiments. Determining treatments, variables, parameters of data collection, experimental unit, size of experimental

unit and fixing replication for simple and factorial experiments in different types of Phytopathological research. Correlation and regression in Phytopathology. Model experimental design on: disease incidence and severity, disease management, integrated disease management, vector borne, seed borne and soil borne diseases, fungicide evaluation, fungicide residues, disease resistance, detection of pathogens, yield loss estimation. Analysis of Phytopathological data.

## PLPA 504. Plant Disease Management (Elective)
**Credit hour: 3**

Concept and principles of plant disease management. Control of plant diseases through integration of cultural, physical, chemical, biological, host resistance and legislative methods. Principles and components of biological control. Modern approachs of biological control: Black box and Silver Bullet approach. Formulation of bio control agents. Principles and practices of plant quarantine. The groups and mode of action of fungicides. Management of fungicide resistance. Plant defence strategies and mechanisms. Development of host resistance through conventional breeding. Development of transgenic crops through bacteria mediated gene transfer. Integrated approaches for plant disease management and cost benefit analysis.

## PLPA 513. Post-Harvest Pathology (Elective)
**Credit hour: 3**

Scope and importance of Post harvest pathology. Nature and causes of postharvest diseases. Physiogenic diseases. Infections diseases caused by fungi and bacteria. Factors influencing post harvest diseases. Field conditions including control of post harvest infection. Harvesting, handling and packaging conditions during transit and storage. Control of post harvest diseases: pre harvest protestant treatment, general precaution during harvest, transit, marketing and storage. Post harvest treatments. Disease loss assessment of fruits and vegetables. Demonstration of post harvest disease management, estimation of chemical residue in treated perishable agricultural produce.

## Courses and Curricula for Ph. D. Degree in Soil Science

| Course Code | Course Title | Credit Hour |
|---|---|---|
| **1. Major Courses** | | |
| **1a. Core** | | **18** |
| SOIL 601 | Soil Chemical Environment and Plant Growth | 3 |
| SOIL 602 | Biochemical Processes in soil | 3 |
| SOIL 603 | Soil Physical Environment and Plant Growth | 3 |
| SOIL 604 | Integrated Nutrient Management and Sustainable Agriculture | 3 |
| SOIL 605 | Land Degradation and Management | 3 |
| SOIL 606 | Analysis of Soil, Plant and Water | 3 |
| **1b. Elective** | | **6** |
| SOIL 607 | Soil and Clay Mineralogy | 3 |
| SOIL 608 | Green House Gases, Pesticide and Environment | 3 |
| SOIL 609 | Fundamentals of Geographic Information Systems (GIS) | 3 |
| SOIL 610 | Soil Survey and Classification | 3 |
| SOIL 611 | Soil-water and Nutrient Transport | 3 |
| SOIL 612 | Modelling in Soil Plant System | 3 |
| SOIL 613 | Radio Tracer Techniques in Soils and Fertilizers | 3 |
| **2. Minor Courses** | | **6** |
| Courses offered from other Departments will be selected by the Advisory Committee as per student's requirement. | | |
| **3. Seminar Courses** | | **2** |
| SOIL 698A | Seminar-1 | 1 |
| SOIL 698B | Seminar-2 | 1 |
| **4. Research** | | |
| SOIL 699 | Research work for Thesis | **30** |
| | **Total Cr. Hr.** | **62** |

### SOIL 601. Soil Chemical Environment and Plant Growth (Core)
### Credit hour: 3

Soil chemical environment: Concept and characteristics; solid phase-solution equilibria in soils; soil solution: characterization and extraction; GEOCHEM in chemical speciation; influence of metal toxicity, industrial effluents, sewage, pesticides and fertilizers; radioactive contamination of soil environment; soil solution and plant growth; nutrient ion movement- mechanisms and their relative importance, factors affecting nutrient movement; theory of diffusion and mass flow in root zone; root ion uptake properties-root morphology; root absorbing power, root demand coefficient; ion uptake theories, mechanisms and kinetics, active and passive absorption; quantitative models onion uptake-theoretical developments, boundary conditions.

## SOIL 602. Biochemical Processes in Soil (Core)
**Credit hour: 3**

Soil as biological habitat, soil organisms-their role in organic matter decomposition and nutrient transformations, soil organic matter-its nature and constitution; biology of root soil interface-microbial population in rhizosphere, its role in nutrient transport; enzymes in soils-their role in organic matter breakdown and plant nutrient transformations. Energy flow In plant- microorganism system. Biology of transformation of Nitrogen, sulphur, zinc, iron and manganese in soil. Soil organisms and pedogenesis, mycorrhizae and plant nutrition Biological equilibrium in soil, biology of water-logged and salt affected soils. Soil degradation due to biological agents; toxins and antibiotic production in soil. Biofertilizer in INM.

## SOIL 603. Soil Physical Environment and Plant Growth (Core)
**Credit hour: 3**

Composition of soil physical environment in relation to plant growth and development, soil aggregates, soil structure and fabric, soil strength, surface and subsurface mechanical impedance to seedling emergence and root development, soil conditioners; soil-water-plant relationship-seed water uptake, root growth and development, water flow in soil-plant-atmosphere continuum, plant water status and stress development. Soil-air-plant relations, critical oxygen concentration and factors affecting; soil temperature in relation to germination of seeds and growth and development of plants. Soil and plant criteria for irrigation under adequate and inadequate water supply conditions. Irrigation and nutrient interaction. Soil physical properties in relation to erosion, water logging, salt build-up and their management for crop production. Soil based indices for sustainability evaluation. Crop growth simulation models and their applications.

## SOIL 604. Integrated Nutrient Management and Sustainable Agriculture (Core)
**Credit hour: 3**

Integrated nutrient management- concept, components and objectives of INM. INM effects in soil. Benefits, constraints, opportunities and threats of INM practices in Bangladesh. Balanced fertilization (BF) and INM practices for sustainable crop production. INM practices for major crops and cropping pattern. INM and soil properties. INM sustainability conceptual ideas in general, relevance of soil management to sustainable agriculture. Modeling approaches in INM. Uses of soil and land. Competition between different uses of land. Sustainable land management (SLM)- concept and frame-work of SLM, evaluation of SLM.

## SOIL 605. Land Degradation and Management (Core)
**Credit hour: 3**

Extent and distribution of degraded soils in Bangladesh; genesis, development and management of acid, acid sulphate, saline, sodic, and eroded soils, sandy soils (deserts) and other degraded soils. Dynamics of salts in the soils. Land improvement by regulating soil and water management- Effect of long term operations of irrigation and drainage on water and salt dynamics. Sandy soils and their management; land use and management practices

arid zone, and rainfed areas, land water management in semi-arid rainfed areas. Management of desert, coastal, hilly and haor soils and charlands. Soil and water conservation- extent and types of erosion and conservation. Watershed management for sustainable crop production; soil-plant adjustment principles. Land drainage in relation to soils and crops. Rain water management for leaching. Drainage of tidal marsh, coastal plains and swamp land. Coastal soils of Bangladesh and their reclamation and management-Saline mangrove tidal floodplain ecosystem. Bunds, embankments, leaching-drainage operation. Biological and cultural management practices.

**SOIL 606. Analysis of Soil, Plant and Water (Core)**
**Credit hour: 3**

Principles and procedures of soil, plant and water sampling; principles of volumetric and spectrophotometric analysis; basic principles of total elemental analysis of soils and plants; irrigation water quality and its rating. Preparation of soil and water samples for analysis. Atomic absorption and flame emission spectrometry. ICP-Mass spectrometry. Total elemental analysis. Carbon and organic matter determination. Fractionation of different organic compounds in soil. Determination of total N, P, K, S, Fe, Mn, Zn, B, Cu and Cd in soil and plant. Neutron activation analysis. Redox, acidity and electrical conductivity measurements in soil. Determination of Cation and anion exchange capacity of soil. Lime requirement of soil.

**SOIL 607. Soil and Clay Mineralogy (Elective)**
**Credit hour: 3**

Definition and structural units of clay minerals, Classification of silicate clay structures. Nomenclature and classification of clay minerals, Crystal chemistry of silicates-bonds, ionic radii, radius ratios, coordination number, isomorphism substitution. Uses of clays-CEC, plasticity, shrinkage, cohesion and swelling. Charge development-permanent and pH-dependent charges. Properties of individual clay minerals-mica, kaolinite, vermiculite smectite, chlorites and their stratified minerals. Accessory minerals. Technique for identification of clay minerals, X-ray diffraction, microscopy, infrared analysis, thermal analysis, electrometric and selective dissolution analysis. Clay-organic complexes and their role in soil productivity, Minerals-classification and composition. Description of rock forming minerals. Weathering of-rocks and minerals, weathering stability, sequences and indices of minerals, weathering and release of nutrients, major geological formation of Bangladesh. Distribution of clay minerals in Bangladesh soils and their impact on soil properties.

**SOIL 608. Green House Gases, Pesticides and Environment (Elective)**
**Credit hour: 3**

Concept and sources of pollution; different types of pollution-Air, water and soil pollution and their effects on biosphere; fuel and atmospheric pollutants; sources and diffusion of $SO_2$ $CO_2$, CO, CFC, $CH_4$, NO in atmosphere. Potential consequences of global warming, controlling of GHG emissions. Pollution and Chemical degradation of soil; toxic metals and their impact on crop growth. Types and sources of water pollution; waste water and its treatment; nitrate, heavy metals and pesticide residues in surface and sub-surface waters.

Pesticide residue in soil and soil organisms. Fate of pesticide in soil. Insecticide pollution and soil fertility. Pollution impact of modern trends in agriculture, transport of pesticides, metals and nutrients from land to water. Characteristics of domestic, municipal and industrial effluents, merits and demerits of their utilization in agriculture.

## SOIL 609. Fundamentals of GIS and GPS (Elective)
### Credit hour: 3

Introduction to GIS, Overview, History and Concepts of GIS, Scope and Application areas, Purpose and Benefits of GIS, Functional elements of GIS, Required functions of GIS software, Installation of GIS, Mapping Concept- Map Elements, Map scales and representations, Map Projection, Geometric rectification, Data Structure- raster and Vector Data Structures, Input of geospatial data, Sources of data and input devices, Spatial database -concept of spatial database, Data Acquisition and Management Techniques, Data Manipulation and Analysis, Map Output Generation. State of the Art of GIS Technologies, Developments in GIS Technology, Various applications of GIS. GIS modeling and land use planning. Networks, Spatial Regression Analysis and Modeling, Customization and Automation in GIS, Customization to End User Needs, Introduction to Programming in GIS, Automation in GIS Functionality, Introduction to Web GIS.

**GPS and its Applications:** Concepts of GPS; space segment-planned constellation of satellites; characteristics of GPS satellites; control segment- GPS monitoring and uploading stations; user's segment-working principles of GPS; triangulation from satellite; GPS signals almanac; measuring distance from satellite, position measurement types of GPS receivers;; applications of GPS in survey and mapping, positioning and navigation services and environmental studies, nature resource management, emergency search and rescue.

## SOIL 610. Soil Survey and Classification (Elective)
### Credit hour: 3

Concept and importance of soil survey, techniques of exploratory, reconnaissance, semi-detailed and detailed soil surveys. Prefield and postfield activities of soil survey, actual field investigations, interpretation of soil survey data for research, extension and planning purposes with particular emphasis to agricultural development. Historical development of soil classification, modem systems of soil classification with special emphasis on USDA Soil Taxonomy, importance of epipedon, end oped on, soil moisture and soil temperature regimes. Characteristics of Tropical soils. Importance of soil classification in agricultural research and development. Classification of Bangladesh soils according to USDA Soil Taxonomy.

## SOIL 611. Soil-Water and Nutrient Transport (Elective)
### Credit hour: 3

Soil water properties-water structure, energy concept of soil water, redox potential, soil water movement under saturated and unsaturated conditions, solute content and its movement in soil. Plant-water relations-role of water in plant, concept of water potential, components of water potential and their measurement, water relationships of cell and

whole plant, water and ion uptake and movement mechanism in plant systems, water loss through plants (transpiration and factors affecting). Soil-water plant-atmosphere continuum, energy balance at crop surface and measurement of crop evapotranspiration, weather parameters and measurements, climatic factor influencing crop water loss, aridity indices, water stress in relation to plant physiological processes, influence of water stress on crop yield. Flow of water in soil, application of Darcy's law and Laplace equation; steady state and transport state flow; theory of saturated and unsaturated flow; measurement of saturated and unsaturated hydraulic conductivity and diffusivity; permeability, infiltration, redistribution and evaporation of soil water; internal drainage, evapotranspiration and uptake of soil water by plant.

## SOIL 612. Modeling in Soil Plant System (Elective)
**Credit hour: 3**

Computer hardware software for modellers, techniques of modelling, dynamic deterministic models. Mathematical programming, regression and correlation, high level computer languages for modellers, testing and evaluation of models: simulation of transport and transformation processes in soil-salt, water, pesticides, nitrogen, phosphorus and potassium, modelling plants and coop-solute movement near roots, nutrient uptake, water uptake, evapotranspiration; growth models; fertilizer response models.

## SOIL 613. Radio Tracer Techniques in Soils and Fertilizers (Elective)
**Credit hour: 3**

Introduction and scope of nuclear techniques in soil, plant and water studies; background for the use of radioisotopes and radiations in agriculture; radioactivity-discovery, nature and properties of radiations; atom and structure of atoms; fundamental decay law, units for radioactivity, radioactive decay series and their transformation; concept of specific activity and isotope dilution principle; tracer kinetics, principles and methods for detection and measurement of radiation, procedures for radioassay, nuclear emulsion technique; radio autography; statistics of counting; nuclear instrumental techniques; scintillation counting, mass spectrometry; radiation hazards and safety procedures; labeling, synthesis of labeled compounds; radiation dosimetry and waste disposal; activation and radiometric analysis.