14. Crop Physiology Syllabus for conducting written Examination for direct Recruitment of Teaching posts in the Cadre of Assistant professors at UASM.

PRINCIPLES OF PLANT PHYSIOLOGY-1 CELL ORGANELLES, WATER RELATIONS AND MINERAL NUTRITION

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

PRINCIPLES OF PLANT PHYSIOLOGY – II METABOLIC PROCESSES AND GROWTH REGULATION

Photosynthesis, Translocation and the respiration as key processes regulating carbon metabolism and plant growth. Photosynthesis, its importance in bio productivity. Photochemical process – chloroplast, its structure, photochemical reactions, CO2 reduction in Calvin cycle, supplementary pathway of C fixation in C4 and CAM plants and its significance. Photorespiration and its relevance. Photosynthesis as a diffusive process, effect of environmental factors on photosynthetic rates. Synthesis of sucrose, starch, oligo and polysaccharides (composition of cell wall). Translocation of photosynthates and its importance in sink growth. Mitochondrial respiration, growth and maintenance respiration, cyanide resistant respiration and its significance. Nitrogen metabolism: inorganic nitrogen species (N2, NO3 and NH3) and their reduction to amino acids, protein synthesis and nucleic acids. Lipid metabolism-Storage, protective and structural lipids. Biosynthesis of fatty acids, diacyl and triacyl glycerol, fatty acids of storage lipids. Secondary metabolites and their significance in plant defense mechanism. Growth and differentiation. Hormonal concept of growth and differentiation, plant growth hormones (Auxins, gibberellins, cytokinins, ABA, ethylene etc). biosynthesis of growth hormones, their metabolism and their physiological role synthetic growth regulators, growth retardants. Apical dominance, senescence, fruit growth abscission. Photo morphogenesis: Photoreceptors, phytochrome. Cryptochrome, physiology of flowering photoperiodism and vernalization.

PLANT DEVELOPMENTAL BIOLOGY, PHYSIOLOGICAL AND MOLECULAR BASIS

Basic Physiological and molecular processes concerning various faces of growth and development of plants. Plant Biodiversity, Concept of evolution in plants. General Aspects – Novel features of plant growth and development; Concept of plasticity in plant development; Analysing plant growth, seed germination and seedling growth – Mobilization of food reserves during seed germination; tropisms; hormonal control of seed germination and seedling growth. Shoot, Leaf and Root Development – Organization of shoot apical meristem (SAM); Control of cell division and cell to cell communication; Molecular analysis of SAM; Leaf development and differentiation; Organization of root apical meristem (RAM); Root hair and trichome development; Cell fate and lineages. Floral Induction and Development – Photoperiodism and its significance; Vernalization and hormonal control; Inflorescence and floral determination; Molecular genetics of floral development and floral organ differentiation; Sex determination. Seed Development and Dormancy – Embryo and endosperm development; Cell lineages during late embryo development; Molecular and genetic determinants; Seed maturation and dormancy. Senescence and Programmed Cell Death (PCD) – Senescence and its regulation; Hormonal and environmental control of senescence; PCD in the life cycle of plants. Light Control of Plant Development – Discovery of phytochromes and cryptochromes, their structure, iochemical properties and cellular distribution; Molecular mechanisms of light perception, signal transduction and gene regulation; Biological clocks and their genetic and molecular determinants. Embryonic Pattern Formation – Maternal gene effects; Zygotic gene effects; Homeoticgene effects in Drosophila; Embryogenesis and early pattern formation in plants. Regeneration and totipotency; Organ differentiation and development; Cell lineages and developmental control genes in maize. Special Aspects of Plant Development and Differentiation – Pollen germination and pollen tube guidance; Phloem differentiation; Sex d etermination in plants; Selfincompatibility and its genetic control; Heterosis and apomixis.

PHYSIOLOGICAL AND MOLECULAR RESPONSES OF PLANTS TO ABIOTIC STRESSES

Response of plants to abiotic stresses: Abiotic stresses affecting plant productivity. Basic principles of a crop improvement programme under stress, Interactions between biotic and abiotic stresses. rought-characteristic features, Water potential in the soil-Plant air continuum. Development of water deficits, energy balance concept. Transpiration and its regulation – stomatal functions. Physiological processes affected by drought. Drought resistance mechanisms: Escape Dehydration postponement(Drought avoidance), Dehydration tolerance and characteristics of resurrection plants. Osmotic adjustment, Osmoprotectants, Stress proteins. Water use efficiency as a drought resistant trait. Molecular responses to water deficit: Stress perception, Expression of regulatory and functional genes and significance of gene products. Stress and hormones- ABA as a signaling molecule- Cytokinin as a

negative signal. Oxidative stress: Reactive Oxygen Species (ROS). Role of scavenging systems (SOD, catalase etc.). High temperature stress: Tolerance mechanisms- role of membrane lipids in hightemperature tolerance. Functions of HSP's. Chilling stress: Effects on physiological processes. Crucial role of membrane lipids. Salinity: Species variation in salt tolerance. Salinity effects at – Cellular and whole plant level, tolerance mechanisms. Salt tolerance in –Glycophytes and halophytes, Breeding for salt resistance. Heavy metal stress: Aluminium and cadmium toxicity in acid soils. Role of Phytochelatins (heavy metal binding proteins).

HORMONAL REGULATION OF PLANT GROWTH AND DEVELOPMENT

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

PHYSIOLOGY OF GROWTH, YIELD AND MODELLING

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

GENOME ORGANIZATION IN HIGHER

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

MORPHOGENESIS, TISSUE CULTURE AND TRANSFORMATION

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

PHYSIOLOGY OF CROP PLANTS – SPECIFIC CASE STUDIES

Physiological aspects of different crop plants. Crop physiological aspects of rice, wheat, maize, sorghum, millets, sugarcane, pulses, oil seeds, cotton and potato Crops. Six to Eight Species could be chosen based on local importance. Crop specific topics. Seed dormancy, photoperiodic and thermoperiodic responses. Source-sink relationship, Yield structure and factors influencing yield, Nutrients and other resource requirements and crop specific features.

PHYSIOLOGICAL AND MOLECULAR ASPECTS OF PHOTOSYNTHESIS-CARBON AND NITROGEN ASSIMILATION

Physiological and molecular aspects of carbon reduction cycle and nitrogen assimilation. Photosynthesis- its significance in plant growth, development and bio productivity. Gaseous fluxes in atmosphere. Physiological and biochemical aspects: chloroplast structure development and replication, ultra structure of thylakoids, photo systems, mechanism of light absorption, chloroplast electron transport chain, Coupling factors and mechanisms of ATP synthesis, and concept of quantum yield. Photosynthetic carbon reduction cycle and its regulation. CO2 Concentration Mechanism (CCM) as a complementary strategy for carbon fixation. CCM in photosynthetic bacteria, micro algae, Submerged Aquatic Macrophages (SAM), C4, CAM and single celled C4 organisms, C3-C4 intermediates. Ecological significance of CCM. Rubisco structure, assembly and kinetics, photorespiration and its significance. Carbon fluxes between chloroplast and cytoplasm and Carbonfixation as a diffusive process, the concept of ra, rs and rm. Pi recycling, starch and sucrose synthesis and export. Concept of canopy photosynthesis, influence of environmental factors such as water stress, high light stress VPD etc. Molecular aspects: chloroplast genome organization, expression and regulation of plastid genes Genes regulating potential traits of photosynthesis, biotechnological approaches for improving photosynthetic rate and productivity – transgenics. Conceptual approaches of expressing C4 photosynthesis genes in C3 species. Photosynthesis and crop productivity, energy utilization efficiency by crops. Photo inhibition, photo oxidation, excitation energy dissipation mechanisms, photochemical and non-photochemical quenching of chlorophyll fluorescence. Photosynthesis and transpiration interaction, significance of WUE, carbon isotope discrimination concept. Prospects of improving photo synthetic rate and productivity – potential traits of photosynthesis-biotechnological approaches. Nitrogen assimilation in photosynthesizing cells – NO3 -, NO2 -reduction, GS-GOGAT pathway. Photorespiration loss of Ammonia and its reassimilation and NUE.

PHYSIOLOGY OF PLANT NUTRITION *P*CPH

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

PHYSIOLOGY OF WOODY PLANTS

Growth and development of horticultural and plantation crop species. Juvenility, shoot growth, types of shoots. Patterns of shoot growth, cambial growth and its regulation. Physiological aspects of pruning and dwarfing. Growth measurements. Water relations of tree species. Water uptake and transport. Concepts of transpiration ratio and water use efficiency. Sexual and asexual propagation. Root stock and scion interactions. Physiology of flowering in perennial species, photoperiodism and thermoperiodism. Physiological aspects of fruit crops, mango, banana, grapes, citrus, papaya and pineapple, etc. physiological aspect of plantation crops coffee, tea, cardamom, coconut, pepper. NB species could be chosen based on the local importance.

PHYSIOLOGY OF SEED GROWTH AND DEVELOPMENT

Structure of seeds and their storage resources. Seed developmental patterns and source of assimilates for seed development. Pathway of movement of assimilates in developing grains of monocots and dicots. Chemical composition of seeds. Storage of carbohydrates, proteins and fats in seeds. Storage chemistry including biosynthesis. Hydration of seeds, physiological processes. Seed respiration, mitochondrial activity. Mobilization of stored resource in seeds. Chemistry of oxidation of starch, proteins and fats. Utilization of breakdown products by embryonic axis. Control processes in mobilization of stored resources. Role of embryonic axis. Gibberllin and á-amylase and other hydrolytic activity. Seed maturation phase and desiccation damage. Role of LEA proteins. Seed viability. Physiology of seeds and means to prolong seed viability. Seed dormancy, types and regulation. Means to overcome seed dormancy.

HERBICIDE PHYSIOLOGY

Introduction-Classification of herbicides. Absorption and translocation of soil and foliar applied herbicides. Physiological and biochemical effect of herbicides – effect on membrane structure and functions, on cell division and cell development. Nature of herbicide receptor proteins and their role in herbicide tolerance. Effect on chloroplast, photosynthesis, respiration, protein synthesis, synthesis of lipids. Molecular mechanisms of herbicide resistance in relation to chloroplast gene expression. Methods to increase the efficiency of soil and foliar applied herbicide – pH adjuvants, synergists. Antidotes. Case studies of different types of herbicides – growth regulating types, triazines, substituted ureas,chloroacetamides, substituted uracils. Thiocarbamates, nitriles, bipyridylium, unclassified groups, herbicide mixtures. Herbicide resistance – induction – taxonomic and biological consideration of herbicide resistance- nature of resistance to triazine – Breeding herbicide tolerant crop cultivars. Herbicide resistance in plant cell cultures – practical significance.

POST HARVEST PHYSIOLOGY OF FRUITS AND VEGETABLES

Senescence and ageing in plants. Ethylene-the senescence hormone, leaf senescence, chloroplast degradtions. Monocarpic plant senescence. Biochemistry and molecular biology of flower senescence. Gene expression during senescence. Concepts of physiological maturity of seeds – post harvest changes in biochemical constituents in field crops – loss of viability, loss of nutritive value (changes in fat deterioration etc). environmental factors influencing post-harvest deterioration of seeds. Post harvest physiological and biochemical changes during fruit ripening and storage. Senescence and post harvest of life and cut flowers. Hormonal and chemical control of post-harvest deterioration of fruits, vegetables and cut flowers and its significance during storage and transport. Regulation of fruit ripening at molecular level-Transgenic technology for improvement of shelf life.