Plant Breeding and Biotechnology Training Program at the University of Nairobi

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KENYA VISION 2030

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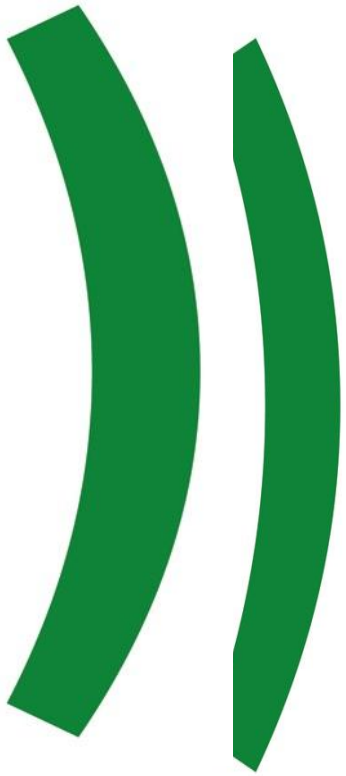

Introduction

- One of the oldest programs in East and Central Africa established in 1974
- One of the 22 graduate programs in College of Agriculture and Veterinary Sciences (CAVS)
- Offered by course work and Thesis, Part-time and ODEL
- Course duration: 2 years for MSc
- 3 years for PhD
- Curriculum reviewed every five years
- Last review -2009/2010
- Class size : 5-15 per year

Objectives

The objectives of this programme are therefore: -

(i) To produce graduates with ability to :

- identify research imperatives in plant breeding and biotechnology,
- design and execute plant breeding research projects aimed at solving the problems within a changing agricultural environment.
- At the same time, the program aims to update the plant breeders with the latest developments in the field of crop improvement, plant biotechnology, plant molecular genetics, genomic studies, proteomics and epigenomics.

(ii) To train highly skilled plant breeders and plant biotechnologists who will help optimise the country's ability to:

- attain food security and
- better nutrition while
- improving agriculture-based incomes from
- improved products while
- maintaining the natural resource base.

Admission Requirements

The common regulations for the Masters' degrees of the University of Nairobi and Faculty of Agriculture shall apply.

The following shall be eligible for admission into the Master of Science degree in Horticulture:-

- A holder of a degree with at least Upper Second Class Honours in Bachelor of Science in Horticulture, Agriculture, Botany and Zoology, Environmental Sciences, Forestry, or related plant science degree or Bachelor of Education in Science with botany and Zoology option and any other relevant subject from the University of Nairobi or any other institution recognized by Senate
- Holders of a degree with at least Lower Second Class Honours in any of the degrees specified in 2.2.1 with at least two years' relevant experience as evidenced by research publications, or relevant postgraduate diploma or an equivalent qualification from the University of Nairobi or any other institution recognised by the Senate may be considered for admission
- Holders of a pass Bachelor's degree in disciplines specified in 2.2.1 and a postgraduate diploma in the relevant areas.

Course Structure and Duration

- The programme is be offered as:
  - full time,
  - or part time, and through
  - Open, Distance, and e- Learning (ODEL) for students who cannot attend regular University programmes

4.1 Full time students

- The degree program shall consist of coursework, examinations and thesis.
- The course shall cover a minimum of 4 semesters and a maximum of 6 semesters and each semester will be 15 weeks.
- Each candidate will be required to take and pass all courses.
- Each candidate will be required to undertake a research project leading to an examinable thesis. The choice of the thesis research topic shall be made in consultation with the department and the academic supervisor.
- Each course unit shall have 45 hours covered in one semester.

4.2. Part time

- As in 4.1 above in addition to the following:
  - The course shall cover a minimum of 4 semesters and a maximum of 8 semesters and each semester will be 15 weeks.
  - A student shall be required to take a minimum of two and a maximum of four courses in one semester.

4.3. Open and Distance Learning

- Under open and distance learning modes will involve largely home and/ or office-based media:
- 4.3.1 Written self **instructional study modules** issued at registration time
  - » Study course materials like booklets
  - » Relevant literature
  - » Interactive devices and self tests
- 4.3.2 Mediated technical learning materials for example:-
- Audio visual
- e-learning materials

Open and Distance Learning -Contd

- 4.3.3 Limited face-to-face sessions to provide overview of the course at commencement of semester, mid semester and revision period before examinations.
- 4.3.4 Support study centres at the University of Nairobi
- Access to information through computers at the University of Nairobi.
- Use of libraries at the University of Nairobi.
- 4.3.6 Orientation (immediately after registration):
  - Orientation in ODL delivery.
  - Study, reading and computer skills.
  - Time management and techniques of handling assignments.
  - Mentorship, guidance and counselling.
  - Emphasis is on satellite centres that serve as a link between the University and the student in the following manner: registration, collecting reading materials, collecting results and programmes, examination information, posting timetable and holding meetings.

4.3.7 Duration and the course load of the programmes

- The Open and Distance Learning programme will run for a minimum of semesters of 15 weeks each and a maximum of 8 semesters of 15 weeks each.
- There will be two semesters per academic year. Therefore, the minimum calendar years for completion of the programme shall be 2 years and a maximum of 4 years.
- The minimum course load per semester will be 2 course units studied through the 15 weeks.
- Each course unit in the programme has a loading of a minimum of 45 hours.
- The thesis shall be equivalent to 8 course units.

COURSES

- ACS 600 Biometrics for Agricultural Sciences 45 hrs
- ACS 601 Advanced Plant Physiology and Metabolism 45 hrs
- ACS 603 Pest management 45 hrs
- ACS 604 Seed Science and Technology 45 hrs
- ACP 612 Research Methods and Scientific communication 45 hrs
- ACS 610 Entrepreneurship in Agriculture 45 hrs
- ACB 601 Molecular Genetics and Bioinformatics 45 hrs
- ACB 602 Biotechnology, Cytogenetics and Mutation Breeding 45 hrs
- ACB 603 Biometrical Genetics 45 hrs
- ACB 604 Advanced Plant Breeding 45 hrs
- ACB 605 Breeding East African crops 45 hrs
- ACB 606 Breeding for biotic and abiotic stresses 45 hrs
- ACB 607 Thesis research project 360 hrs

Total 900 hrs

ACS 600: BIOMETRICS FOR AGRICULTURAL SCIENCES

- Review of descriptive statistics and basic inference. Overview of sampling concepts: simple random sampling and proportional sampling. The concept of power and sample size determination. Principles of experimental design: randomization, replication, error control. Modeling: translating study designs into statistical models considering both treatment and blocking structure; assumptions underlying a model; approaches to model fitting; correct handling of continuous and factor explanatory variables; data analysis, presentation and interpretation of coefficients and model output; Techniques for generalized linear models. Principles of survey and questionnaire design.

ACS 601 ADVANCED PLANT PHYSIOLOGY AND METABOLISM

- Structure and function of plant cell. Photosynthesis. Respiration: function, conversion efficiency, alternative pathways, important factors. Lipid and protein metabolism. Plant water relations. Transpiration and implications in crop production. Translocation. Stress physiology (drought, heat, flooding, salinity, acidity). Plant development and regulation. Plant nutrients. Nitrogen metabolism. Secondary metabolites their nature, structure and function in key East African crops. Research methods in plant physiology for crop productivity. Use of transgenic plants and metabolic engineering to analyse plant metabolism. Techniques in modern crop physiology

ACS 603 PEST MANAGEMENT

- Overview of weed science and management; Weed management and crop quality and environmental implications; Invasive weed species, origin, spread and their management; Climatic change and weed species dynamics; Biotechnology issues in weed science (GMOs, resistance, genetic pollution), Weed-crop interference (competition and allelopathy), Research methods. Economic importance and losses caused by plant diseases and insect pests. Disease causal pathogens and other agents; isolation and identification techniques; symptoms and effects on plants and produce; disease epidemiology. Principles of disease management. Insect classification and identification; crop pests and their management. Environmental considerations in crop protection.

ACS 604 SEED SCIENCE AND TECHNOLOGY

- Crop seed as a basis of crop production; Types of seed, asexual and sexual. Seed biology, morphology, anatomy, physiology, seed dormancy, Crop seed environment: Micro- and macro aspects of water, air/wind temperature, radiation, and relative humidity on crop seed yield in relation to seed quality. Above and below ground management of controllable and natural factors in seed production. Husbandry and harvesting of seed crops. Processing practices, harvesting, cleaning, drying, conditioning, storage and seed testing protocols. Variety development and release. Formal and informal seed production and delivery systems. Seed health and quality standards. Seed packaging, labelling and marketing. Legislative control of seed industry including registration, inspection and certification. Role of private and public agencies in seed industry. Plant breeders rights and intellectual property rights and benefit sharing. Synthetic seed, transgenic seed and biosafety protocols

ACP 612: RESEARCH METHODS AND SCIENTIFIC COMMUNICATION

- Research process: problem analysis, literature review, developing the research question, hypotheses and objectives; understanding outputs/outcomes/impact; log frames and budget planning; research quality control including protocol development and critical review of research instruments such as questionnaires, field manuals, debriefing documents. Data management: disciplined use of spreadsheets for data entry, data validation, audit trails and archiving. Scientific communication: thesis, scientific papers, power point slides, technical reports, posters, brochures, videos, policy briefs and press releases

ACP 610: ENTREPRENEURSHIP IN AGRICULTURE

- The entrepreneurial perspective: nature and importance of entrepreneurs; entrepreneurial opportunities; creating and starting a venture: creativity and business idea, legal issues for entrepreneurs, the business plan; financing the new venture: sources of capital, informal risk capital and venture capital; managing, growing and ending the new venture: new venture expansion strategies and issues, going public, ending the venture; records in business management

ACB 601: MOLECULAR GENETICS AND BIOINFORMATICS

- Genetics systems of eukaryotes, prokayotes and viruses. Development and physiological genetics. Recombinant DNA technology; methods of creating recombinant molecules, isolation of cloned genes, tumour viruses, movable genes, viral vectors; genetic engineering of plants. Application of biotechnology techniques in crop improvement. Genome, proteome, epigenome. Linkage mapping, cross-overs, repulsion and coupling phases, interference and coincidence, recombination frequencies, genetic mapping; mapping functions; mapping populations, lod score; linkage disequilibrium, two point and three point crosses. Molecular markers; RAPDs, RFLPs, SSR, AFLP, ESTs, SNPs. QTL analysis and mapping. Marker assisted selection (foreground and background selection). DNA sequencing theory. Analysis of gene expression transcript profiling; microarrays. Bioinformatics; Gene families; genome analysis; identification of introns/exons; genome analysis tools and automation, measuring biodiversity. Analysis of protein expression, prediction of protein structure, comparative genomics, sequence alignment and comparisons.

ACB 602: BIOTECHNOLOGY, CYTOGENETICS AND MUTATION BREEDING

- Principles of plant biotechnology; DNA and RNA structure and function; DNA replication; central dogma of molecular biology, genetic code, transcription and translation. Protein synthesis, molecular biology tools, principles of gene transfer in plants-*Agrobacterium tumefaciens*. Restriction enzyme digestion, cloning, molecular tools (agarose electrophoresis and PCR). Genetically mordified foods; social and ethical issues in biotechnology. Recombinant DNA technology, plant molecular biology, plant cell and tissue culture, techniques of genetic analysis at molecular and organism level including segregation, cytogenesis, linkage, transformation, gene expression and analysis of transgenic plants. Current issues in biotechnology; applications of biotechnology in crop production. Variants in chromosome structure; pairing, recombination, inversions, translocations, duplications. Specialised chromosomes; isochromosomes, telocentric, ring and B chromosomes. Variation in chromosome number: types of polyploidy, aneuploidy, euploidy and their use in plant breeding. Special cytogenic systems. Variation in chromosome types: polyteny vs endopolyploidy, puffing, super chromosomes, somatic synapsis and lambrush chromosomes. Variation in chromosome function and movement including somatic segregation, variation in mitosis; variations in meiosis including preferential segregation of chromosomes. Extrachromosomal inheritance: plastids, mitochondria, intracellular symbionts, plasmids, episomes and transposable elements. Cytogenetics of coffee, cotton, citrus, cassava, brassicas, potato, pyrethrum, wheat, barley and maize.

ACB 603: BIOMETRICAL GENETICS

- Principles of population genetics: Hardy-Weinberg equilibrium. Factors influencing genetic equilibrium including multiple allelic systems, sex linkage, polyploidy, mating systems, mutation, migration and selection. Genetic fitness in relation to natural and zygotic selection. Nature and types of natural selection. Inbreeding depression and inbreeding coefficient. Measuring genetic variation in populations. Application of molecular techniques in population genetics. Polymorphism and heterozygosity. Heterozygous advantage and unstable genetic equilibrium; random genetic drift. Evolutionary genetics. Basic concepts of statistical genetics. Inheritance of quantitative traits. Nature and properties of polygenic inheritance. Expression of quantitative traits. Factors influencing response to selection. Heritability and its estimation. Partitioning phenotypic variance. Relationship among continuous variation, genetic variation and heritability. Estimation of components of genetic variance and covariance: parent-offspring, half-sibs and full-sibs, mating design I, II and III and their analysis. Diallel crossing systems and their analyses. Use molecular markers in analysis of quantitative traits; mapping and characterizing quantitative trait loci (QTL); detection of major genes. Genotype x environment interactions. Heterosis and inbreeding depression. Genetic basis of heterosis.

ACB 604: ADVANCED PLANT BREEDING

- The art and science of plant breeding. Objectives of modern plant breeding. Strategy of plant breeding. Genetic basis for breeding self-pollinated crops. Pure line and mass selection. Selection procedures following hybridisation: pedigree, bulk population and backcross breeding methods. Choice of parents and breeding method. Single seed descent method and its modifications. Doubled haploid procedure. Gamete selection for multiple constraints. Genetic basis for breeding cross-pollinated crops. Gene frequencies, response to selection, inbreeding depression and heterosis. Production and evaluation of hybrid varieties. Recurrent selection methods. Principles of breeding clonally propagated crops. Special techniques in breeding horticultural crops including clonal propagation, embryo culture, anther culture, somaclonal variation, somatic cell hybridisation and genetic engineering. Principles of cell and plant tissue culture. Principles and application of marker assisted breeding. Participatory plant breeding including formal and farmer led approaches, institutionalisation and value in a breeding program. Polyploidy: effects value and use in breeding

ACB 605: BREEDING EAST AFRICAN CROPS

- Breeding procedures for major crops in East Africa including their origin, genetics, breeding objectives and methods and their improvement in Kenya and eastern Africa . Breeding cereal crops (maize, wheat, rice and sorghum). Breeding legume crops with special emphasis on common bean, pigeonpea and cowpea). Breeding fiber crops with emphasis on cotton; Breeding perennial tree crops including beverage and fruit crops with emphasis on coffee, tea, mango and avocado. Breeding horticultural crops including vegetables (snaps, tomato and onions). Forage and grass breeding. Breeding oil crops in eastern Africa. Breeding major root crops in eastern Africa. Breeding pyrethrum. Production, maintenance and distribution of certified seeds.

ACB 606: BREEDING FOR BIOTIC AND ABIOTIC STRESSES

- General principles and methods of breeding for resistance; choice of parental material, sources of resistance, inheritance of resistance, methods of testing for resistance; requirements for successful inoculation; assessment of resistance; selecting for resistance; production of resistant varieties. Major insect and nematode pests of East African crops: cereals, legumes, root crops, tree crops, horticultural crops and pyrethrum. Economic importance of pests. Genetic variability of crop pests. Types of resistance to pests: non-preference, antibiosis, tolerance, pest avoidance. Morphological and chemical basis of resistance. Environmental and genetic factors influencing expression and stability of plant resistance. Resistance to insects at egg-laying stage and to feeding. Effect of host on insect development. Mechanisms of plant resistance to nematodes. Resistant varieties in pest management systems. Mechanisms and breeding for adaptation to drought, low soil fertility including low soil phosphorus, nitrogen; soil acidity (including aluminium and manganese toxicities).

ACB 607: THESIS

- Each candidate will submit, with the approval of the supervisors, a duly completed thesis for examination by the main supervisor and two independent examiners. The thesis will be equivalent to eight courses. The thesis will be developed from the first semester of study through identification and formulation of a research proposal to meet current Plant breeding and biotechnology problems in the region, performance of adequately designed experiments and data analysis and preparation of a complete thesis/ project paper for examination, and presentation of thesis in a defence committee in accordance to current regulations for submission and examination of master of science degree .

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