

Research Application Summary

**Progress with establishment of the Makerere University Regional Centre for Crop Improvement (MaRCCI) - an East and Southern Africa African Centre of Excellence**

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**Abstract**

Low agricultural productivity in Eastern and Southern Africa has led to recurrent chronic food insecurity, poor nutrition, and widespread poverty that continue to affect a significant proportion of the population. This low productivity is due to a number of factors key among which include use of unimproved crop varieties; biotic and abiotic stresses; a lack of access to quality seeds, fertilizer, and other inputs; and poor agronomic practices. Conversely, the use of improved crop varieties by Africa's smallholder farmers can substantially boost their production in response to local and international demand for food and nutritional security. However, there is a critical shortage of well-trained crop scientists and plant breeders at graduate level to develop and deploy improved crop varieties. This is exacerbated by the fact that plant breeding techniques are crop specific and thus, the need for diverse expertise and professionals to address crop improvement challenges for multiple crops and agro-climatic zones in the region. The recently instituted Makerere University Regional Centre for Crop Improvement (MaRCCI) will strengthen and expand the regional MSc and PhD programs in Plant Breeding, Biotechnology and Seed Systems. This initiative is to be implemented under the auspices of the African Higher Education Centres of Excellence (ACE 11) supported by respective National Governments through a Development Facility from the World Bank. The expected outputs of the MaRCCI effort include stronger regional Masters and PhD programs in Plant Breeding, Biotechnology and Seed Systems, improved curriculum and delivery, at least 70 highly trained PhD and MSc plant scientists, targeted research that is relevant to the region's agriculture, and a strengthened training and research capacity that serves the wider Africa continent.

Key words: Africa, Centers of Excellence, crop improvement, Makerere University, plant breeders

**Résumé**

La faible productivité agricole en Afrique de l'est et du sud a entraîné une insécurité alimentaire chronique récurrente, une mauvaise alimentation et une pauvreté généralisée qui continuent d'affecter une proportion importante de la population. Cette faible productivité est due à un certain nombre de facteurs clés parmi lesquels l'utilisation de variétés de cultures non améliorées ; stress biotiques et abiotiques; un manque d'accès à des semences, des engrais et d'autres intrants de qualité ; et de mauvaises pratiques agronomiques. Inversement, l'utilisation de variétés améliorées de cultures par les petits exploitants agricoles africains peut considérablement augmenter leur production en réponse à la demande locale et internationale de sécurité alimentaire et nutritionnelle. Cependant, il y a une pénurie critique de phytotechniciens et améliorateurs des plantes bien formés au niveau universitaire pour développer et déployer des variétés améliorées de cultures. Cette situation est exacerbée par le fait que les techniques d'amélioration des plantes sont spécifiques aux cultures et, par conséquent, le besoin de la diversité de compétences et des professionnels pour relever les défis de l'amélioration

de multiples cultures et zones agro-climatiques de la région. Le Centre régional d'amélioration des cultures de l'Université de Makerere (MaRCCI), récemment créé, renforcera et élargira les programmes régionaux de maîtrise et de doctorat en amélioration des plantes, biotechnologie et systèmes semenciers. Cette initiative doit être mise en œuvre sous les auspices des Centres d'excellence africains pour l'enseignement supérieur (ACE 11) soutenus par les gouvernements nationaux respectifs par le biais d'un établissement de développement de la Banque mondiale. Les résultats attendus des efforts de MaRCCI comprendront des programmes régionaux de maîtrise et de doctorat plus solides en amélioration des plantes, biotechnologie et systèmes de semences, un programme d'études et une prestation améliorés, au moins 70 scientifiques améliorateur des plants hautement qualifiés titulaires d'un doctorat et d'une maîtrise en sciences, une recherche ciblée pertinente pour l'agriculture de la région et une capacité de formation et de recherche renforcée au service de l'ensemble du continent africain.

Mots clés : Afrique, Centres d'excellence, amélioration des cultures, Université de Makerere, améliorateur des plantes

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## Introduction

The agriculture sector is considered an engine for overall economic development for sub-Saharan Africa (FAO, 2006; African Development Bank, 2010; AGRA, 2016). It contributes 32 percent of gross domestic products and employs about 65 percent of the population (FAO, 2006; AGRA, 2016). The current low agricultural productivity in Eastern and Southern Africa has led to recurrent, chronic food insecurity, poor nutrition, and rampant poverty for a significant proportion of the population (World Bank, 2015, 2016). The low productivity is a result of the use of unimproved crop varieties; biotic and abiotic stresses; a lack of access to good quality seeds, fertilizer, and other inputs; poor agronomic management; and lack of access to profitable markets (African Agriculture Status Report, 2016). A key solution to these multiple constraints is use of improved crop varieties by Africa's smallholder farmers which can substantially boost their production and productivity in response to local and international demand for food and nutritional security (De Vries and Toenniessen, 2006).

Growth in agriculture is twice to four times as effective in reducing poverty as other sectors but is held back by a lack of qualified professionals (World Bank, 2015). In Africa, the low level of human capital in the agricultural sector remains a significant drawback to growth, poverty reduction, and food security. Higher agricultural education has been neglected for several decades and is poorly prepared to address the need for qualified professionals (Flaherty and Lwezaura, 2010; Flaherty et al., 2010a, b, c; World Bank, 2015, 2016). Moreover, the current agricultural educational system is out of step with the job market (World Bank 2015, 2016). Recently, however, African leaders have asked for "a radically new approach" to agriculture education. In response, the World Bank in partnership with national Governments designed and started rolling out a unique program to transform higher education. This program dubbed African Higher Education Centres of Excellence (ACE) has the goal to produce entrepreneurs, creative thinkers and business leaders who contribute to economic growth and poverty reduction (World Bank, 2016).

Only two educational Centres of excellence in plant breeding currently exist in the continent, i.e., one in Southern Africa, namely the African Centre for Crop Improvement (ACCI) at the University of KwaZulu-Natal in South Africa, and the other in West Africa, called the West Africa Centre for Crop improvement (WACCI) at the University of Ghana, Legon. The total capacity of these two programs is far short of the training capacity at the PhD level that is needed to fill the gap. The East African Region is in need of such a programme, and can benefit from scaling up a Regional Program in Plant Breeding, Biotechnology and Seed System that exists at Makerere University and is already training for the wider African region (<http://www.ruforum.org/regional-training-program>). The Makerere

University program currently attracts several students with funding from different agencies however there is need to improve and strengthen the program.

### **Description**

Through the ACE 11 project, a Centre of excellence known as the Makerere University Regional Centre for Crop Improvement (MaRCCI) has been approved (<http://www.universityworldnews.com/article.php?story=2015081214285548>). The Centre is hosted at the College of Agricultural and Environmental Sciences (CAES) and is funded through a loan to the Government of the Republic of Uganda. The overall aim of the ACE II project is to support the Government of Uganda to strengthen selected Institutions of Higher Education in Uganda to deliver high quality post-graduate education and build collaborative research capacity in the regional priority areas.

The MaRCCI builds on two existing regional graduate programs, a PhD in Plant Breeding and Biotechnology (PBB) and an MSc in Plant Breeding and Seed Systems, PBSS) ([www.makplantbreeding.org](http://www.makplantbreeding.org)), that way designed and initiated by Makerere University, and diverse partners namely, the Alliance for a Green Revolution in Africa (AGRA), Regional Universities Forum for Capacity Building in Agriculture (RUFORUM) and others in 200B. Key elements of the curriculum of these programs include core competencies in plant breeding and genetics, basic and applied skills in plant breeding, supplemented by social research methods, management and marketing, as well as a focus on ethics and values. The content of these two programs was developed through a rigorous process under the auspices of the RUFORUM, a Network of 129 universities in Africa ([www.roforum.org](http://www.roforum.org)). The process entailed input from key stakeholders from private seed industries, the National Agricultural Research Systems (NARIs), and regional and international Universities. This input has: (i) made these programs responsive to problems and future needs in agriculture and society with research and education programs that improved life and preserve environmental quality; (ii) resulted in dynamic and relevant research and academic programs founded in scientific advances and responsive to the needs of students and farming communities in sub-Saharan Africa; and (iii) contributed to successful resource mobilization allowing for effective implementation. In the last seven years, these two programs have trained 120 MSc students ([www.makplantbreeding.org](http://www.makplantbreeding.org)) and 54 PhD students from 25 African countries with thesis research on 15 food-security crops. The MSc program has become established as a premier program, but a lack of funding and other resources has prevented the PhD program from reaching its full potential.

The MaRCCI has revised the existing PhD curriculum to include advances in plant breeding, biotechnology, and seed systems; greatly increased e-based courses and experiential learning; increased staff; added and improved facilities; and added distance learning. The curriculum is designed to emphasize creative problem-solving and self-learning skills. High-quality student and faculty research target the economic development needs of each student's home country, and involves strong coordination between Makerere University supervisors, the student, and a home-institution supervisor. Continuity of research projects is ensured using a research database that categorizes projects by crop, germplasm, and traits. The Centre builds on existing multi-institute cooperation, including industry, regional educational partners, international agricultural research centres, and major United States universities. Through the further development of an effective, progressive, and comprehensive training model, MaRCCI has the potential to catalyze a continent-wide transformation of plant breeding and seed systems training.

### **Goals and Objectives**

The goal of MaRCCI is to expand, strengthen, and transform the PhD (Plant Breeding and Biotechnology) program following the pattern of the highly successful MSc Plant Breeding and Seed

System, and to increase coordination between the two programs. Thus, the Centre provides Eastern and Southern African (ESA) nations with industry-ready plant breeders who can use cutting-edge science to develop and deliver new crop varieties (including tree crops, ornamental crops). These breeders are urgently needed throughout this region in order to improve food security, nutrition, rural incomes, poverty reduction, and economic development. The MaRCCI continues to train for other regions of Africa, including students from outside the continent. The specific objectives of MaRCCI are to:

1. Strengthen the training and research capacity in plant breeding, biotechnology and seed systems within the region, and enhance regional and international collaboration.
2. Deliver content to students that provides a strong theoretical and scientific foundation that enables product delivery.
3. Elevate the capacity and sustainability of Makerere University's regional programs in plant breeding through convergence of highly qualified, experienced experts.
4. Transform the Centre to a premier post graduate training center of excellence in crop improvement in Africa.
5. Train 26 new MSc and 45 new PhD 'level' plant breeders from the ESA region by the end of 2025.

### **Implementation**

Governance framework: Makerere University became an independent University in 1970 by Act of Parliament (Act 7). Currently the University operates under the Universities and Other Tertiary Institutions Act of 2001 (As Amended in 2003 and in 2006). These acts provide for the Administration and Standards under which the University operates. In 2006, the Makerere University statute was enacted that enabled establishment of Colleges, Schools, Departments and various Centres. Under this project the Makerere University Regional Centre for Crop Improvement (MaRCCI) is constructed in a framework that enhances Makerere University's relationships with national, regional and international academic partners (Table 1).

These partnerships have resulted in training of industry-ready PhD and MSc-level scientists and practitioners in plant breeding, biotechnology, and seed systems. The students receive a high quality education that integrates seed and business skills with graduate training in plant breeding that has a focus on the practice and produces industry ready practitioners. This is the point of departure from other plant breeding training programs elsewhere. The international collaboration has also contributed to staff skill enhancements, curriculum improvements and overall strength of the ACE.

**Governance.** The MaRCCI operates under the 2006 Makerere University Act, the provisions of which allow the hosting College of Agricultural and Environmental Sciences to not only award Degrees, Diplomas and Certificates but also create unique units such as MaRCCI to improve efficiency and increase prominence of specialized activities. The MaRCCI has been created as a semi-autonomous Centre. However, the Centre is regulated by existing Human Resources, Financial and Procurement procedures of the University. The Centre's general management is administered through the College of Agricultural and Environmental Sciences at Makerere University. The designated Centre Director (CD) provides overall oversight to MaRCCI activities and reports directly to the Principal of the College Agricultural and Environmental Sciences. The CD is the designated accounting officer for MaRCCI at Makerere University. He is responsible for the progress through regular meetings with the Centre staff, and receipt of project technical and financial reports.

The Centre management follows an implementation plan that addresses both Makerere University and ACE II reporting requirements, as well as arrangements agreed upon with cooperating partners. A competent Program Officer (PO) supports the CD in human resource management. The PO is involved

but not limited to (i) ensuring the project is in compliance with ACE II procedures, (ii) supporting students/partners with guidance on routine university procedures such as student registration, linkage to faculty internet, library access, etc., (iii) supporting students/partners in their compliance with immigration issues, obtaining appropriate medical insurance, and banking access, (iv) arranging for students/partners accommodation and other conveniences, (v) organizing logistics for visiting lecturers, and (vi) planning and organizing key functions of the Centre, e.g., proposal defenses, progress reports, seminars, and other functions.

In order to further strengthen governance and promote quality and international competitiveness of the Centre, an Advisory Committee (AC) composed of representatives from Makerere University, partnering institutions (International and National), partner universities; National Agricultural Research Institutes (NARIs), seed companies, and CGIAR Centres has been established. The AC meets once a year to guide the project planning, implementation, and progress in delivering on its mandate.

**Table 1. Key strategic collaborators for the Makerere Regional Centre for Crop Improvement.**

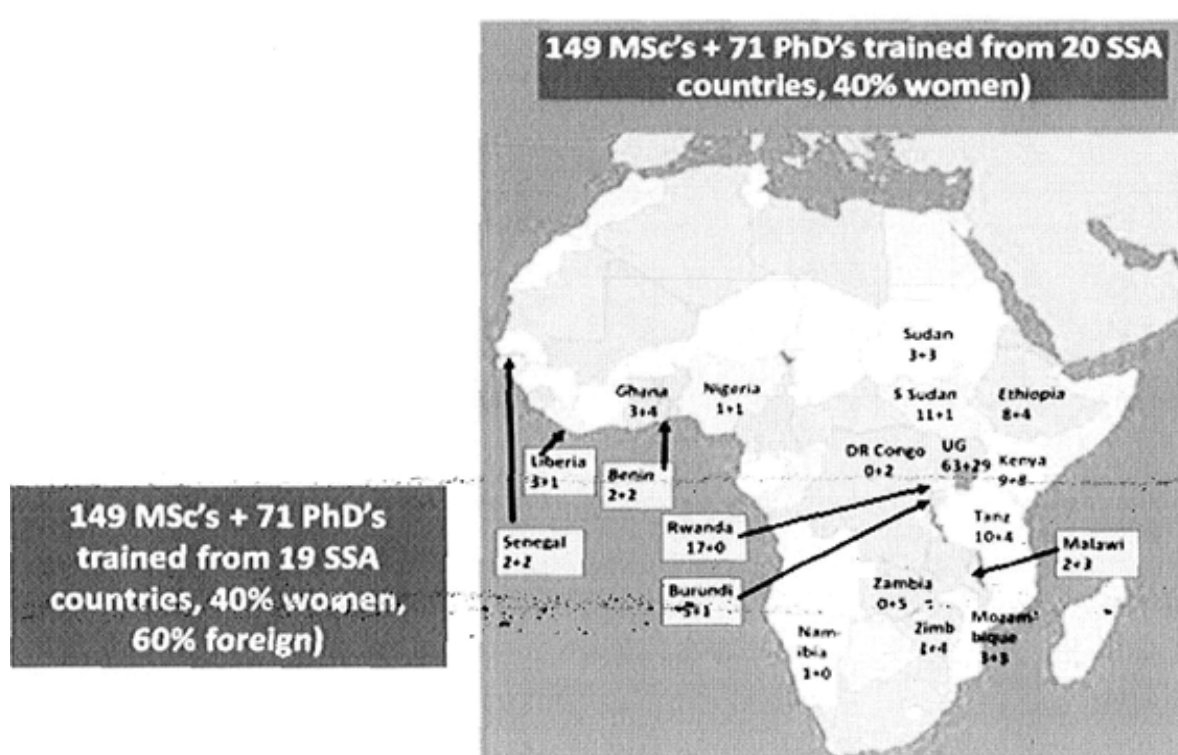
Name	Type	Country/Region
<b>Local partners</b>		
1. National Crops Resources & Research Institute, Uganda	NARIs	Uganda
2. National Semi Arid Resource & Research Institute, Uganda	NARIs	Uganda
3. Abi Zonal Agricultural Research & Development Institute	NARIs	Uganda
4. Nahuin Zonal Agricultural Research & Development Institute	NARIs	Uganda
<b>Regional partners</b>		
5. SeedCo Seed Company	Private business	Zimbabwe
6. University of Zambia	University	Zambia
7. University of Juba	University	South Sudan
8. AfricaRice	IARC	Continental
9. International Institute for Tropical Agriculture (IITA) IARC	IARC	Global
10. International Centre for Tropical Agriculture IARC (CIAT)	IARC	Global
11. The International Crops Research Institute for the Semi-Arid Tropics ICRISAT)	IARC	Global
12. World Vegetable Centre	IARC	Global
13. International Potato Centre (CIP) USA partners	IARC	Global
14. Cornell University	University	USA
15. Purdue University	University	USA
16. University of California - Riverside	University	USA
17. Ohio State University	University	USA
18. North Carolina State University	University	USA
19. Iowa State University	University	USA
20. Michigan State University	University	USA

**Expected outputs.** The Makerere University Regional Centre for Crop Improvement (MaRCCI) is set to radically transform two regional graduate programs at Makerere University to implement a menu of novel courses and training approaches. The expected outputs of the MaRCCI by the end of the five year period, supported by anticipated ACE II project funding of USD 6 million, are:

1. At least 70 graduate students in PhD (Plant Breeding and Biotechnology) and M.Sc. (Plant Breeding and Seed Systems);

2. A revised curriculum that incorporates modern techniques in plant breeding, genomics, bioinformatics and related issues associated with searching for appropriate gene from germplasm sources and utilizing them.
3. Equipment for modern delivery of instruction such as video conferencing, e-learning should be in place and in use by faculty of MaRCCI.
4. A list of short courses that have actually been delivered and a register of students that went through the program and the centres where they apply the training.
5. A register of new teaching and research infrastructure added to the centre for the improvement in delivery of teaching.
6. A record of the effective utilization of the additional teaching and research resources.
7. A list of bodies to which the curriculum is accredited and evidence thereof.
8. Evidence of local, regional and international accreditation.
9. Evidence of attracting additional resources to support plant breeding research and student support for dissertation research.
10. A list of local, regional and international private sector partners with which there is collaboration in research and other business related linkages.

**Current status of MaRCCI.** The Makerere Regional Centre for Crop Improvement (MaRCCI) started in 2008 with training programs that offer the M.Sc. in Plant Breeding and Seed Systems and the PhD in Plant Breeding and Biotechnology under the auspices of the Regional Universities Forum for Capacity Building in Agriculture. The two programmes were developed in response to the need for plant breeders that was identified following extensive consultations with various stakeholders in different countries in Africa. The uniqueness of this program lies in its regionality, its extremely close cooperation with NA RO, and the applied element of the training from the Center having two in-house variety development programs. The Centre has trained students from more than 20 different countries in Africa (Figure 1.). It was officially designated as a Centre of Excellence in Crop Improvement in 2016 under the World Bank ACE II centers of excellence.



**Figure 1. Students trained by Makerere University MSc and PhD Plant Breeding, Biotechnology and Seed System programme by country, 2008-2018**

**Program duration and completion rates.** The MSc PBSS is a 2-year training programme while the PhD PBB is a 3-year programme. Generally, the Centre achieves over 90% completion rate for MSc PBSS (Table 2) and about 75% completion rate for PhD PBB in reasonable time (Table 3). Other students are delayed for various reasons, but almost all are expected to complete. In total 26 PhD PBB and 84 MSc PBSS students coming from 19 African countries have graduated. An additional 6 PhD and 14 MSc students have submitted their theses and are waiting for examination. An additional 24 PhD and 21 MSc students have completed coursework and are at various stages of completing the writing and submission process. Also 15 PhDs and 25 MScs are currently in coursework. Through 2018, major intakes occurred every two years. From August 2019 on, intakes will occur every year. It is estimated that approximately 15 MSc's and 10 PhDs will enter each year. Most of these will be sponsored by other programs. German DAAD has committed to sponsoring 6 PhDs per year. The Intra-ACP and Intra-Africa programmes have provided sponsorships to 1-5 individuals per year for the PBSS and PBB programmes, and this is expected to continue.

**Table 2. MSc Plant Breeding and Seed System students' completion**

Entry year	Completed	Yet to complete	Total	Completion rate
2008/2009	16	0	16	100.0
2010/2011	18	0*	20	90.0
2012/2013	25	3	28	89.3
2014/2013	25	5	29	86.2

**Table 3. PhD Plant Breeding and Biotechnology students' completion rate**

Entry year	Completed	Yet to complete	Total	Percentage
2008/09	17	4	21	81.0
2012/13	3	2	5	60.0
2013/14	4	1	5	80.0
2014/15	9	2	11	81.8

**Student satisfaction.** While many potential improvements are still needed, students express overall satisfaction with the program and recommend it to others.

**Employer satisfaction.** Employers have commented favorably, hired PBB and PBSS students and recommended these students for additional study opportunities, using employee funding. Also, Donors have preferentially placed students in these two programs, and have directed grants to these students' activities after completion.

**Competitive awards.** A number of PBB and PBSS students have received competitive awards of various kinds.

**Publication rate.** Students have achieved good publication rates in peer-reviewed journals, and some have published in top-tier journals, such as Crop Science, Agronomy Journal, Euphytica, Plant Breeding, and others.

**Global reputation.** The MaRCCI program has obtained a global reputation among funding agencies and CGIAR centers.

**Attracting students with other funding.** At present, approximately 2/3 of PhD students and 1/3 of MSc students in the program have full or partial funding outside of MaRCCI's control. This is despite

the fact that the AGRA program sponsored 15 MSc students in the recent batch and MaRCCI funded several PhD students entirely with World Bank funds. It is anticipated that the next intake of 10 PhD students and 15 MSc students will be funded by other agencies.

### **Future perspectives.**

MaRCCI is poised to catalyze a continent-wide transformation in plant breeding and seed systems training. However, this will require that it develops a good strategy for sustainable financing to enable implementation and continuation of its activities. Future operational funding should be anchored on income from collaboration with a multiplicity of institutions. These are expected to include flow back from tuition, development partners that support students in achieving part of their goals, increased support from national governments as they work to address the deficit of plant breeding professionals needed to achieve food and nutrition security, delivery of short courses to clientele in the agro industry sector to achieve particular objectives, intellectual property from the release of improved varieties that the center may include in the research program, seed companies (local and international), and other agencies and indeed individuals. The MaRCCI will also need to strengthen the staffing of the various units of the centre in order to improve and maintain a high quality of instruction. The MaRCCI envisions implementation of a well-developed and coordinated e-content and blended delivery to keep the program relevant. The implementation of a blended course delivery system is expected to be operational, with the advantage of a wider reach to students, potential instructors and with students for mentoring. The revised curriculum and its delivery is envisioned to cater for the diversity of backgrounds from which the students come from in the different countries in Africa. Funding for PhD programs has generally been lower due to the longer duration and the higher costs involved. The Centre is envisioned to develop strategies to increase the funding for PhD students. This has positive ripple effects to the countries from which students trained come from.

The research output for MaRCCI's is envisioned to deliver on the release of improved varieties of cowpea, and sorghum and other crop varieties as well as on value added products. It is anticipated that the uptake of the improved varieties will generate income from intellectual property and the value added products are taken up by industry in an arrangement that brings in financial benefit to MaRCCI.

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