

Research Application Summary

**Generation of Future Science Leaders through Mentorship and Research: The case of Carnegie Post-Doctoral Fellowship**

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**Abstract**

A postdoctoral fellowship was awarded to support research focusing on grain legumes and dryland cereals. Training of young scientists towards masters and doctor of philosophy (PhD) degrees was embedded within the fellowship. Collaborative networking to exploit research potential by leveraging on available resources across institutions was adopted, whereby a multi-institutional framework to cater for regional and or international collaboration in training and research was embraced. A total of six students were brought on board under the fellowship, who are being trained to be future researchers with passion of driving Agricultural interventions for food and nutritional security forward. Additional international networking was sought, that created a strong platform for student knowledge exchange and support in their research. Through the fellowship, technologies geared at enhancing legume and sorghum production in the region were generated. The postgraduate students were exposed to modern research methods and their applications so as to be the future champions in modernization of agricultural research operations for more impact.

Key words: Crop improvement, Malawi, post-doctoral fellowship, students researchers, Uganda

**Résumé**

Une bourse postdoctorale a été accordée pour soutenir la recherche axée sur les légumineuses à grains et les céréales des zones arides. La formation de jeunes scientifiques en vue de l'obtention d'une maîtrise ou d'un doctorat a été intégrée à la bourse. Un réseau de collaboration a été adopté pour exploiter le potentiel de recherche en tirant parti des ressources disponibles dans les différentes institutions. Un cadre multi-institutionnel a été mis en place pour permettre une collaboration régionale ou internationale en matière de formation et de recherche. Au total, six étudiants ont été recrutés dans le cadre de la bourse, qui ont été formés pour devenir de futurs chercheurs passionnés par les interventions agricoles en faveur de la sécurité alimentaire et nutritionnelle. Une mise en réseau internationale supplémentaire a été recherchée, ce qui a permis de créer une plateforme solide pour l'échange de connaissances entre étudiants et les soutenir dans leurs recherches. Grâce à la bourse, des technologies visant à améliorer la production de légumineuses et de sorgho dans la région ont été générées. Les étudiants de troisième cycle ont été exposés aux méthodes de recherche modernes et à leurs applications afin d'être les futurs champions de la modernisation des opérations de recherche agricole pour un plus grand impact.

Mots clés : Amélioration des cultures, Malawi, bourse de recherche post-doctorale, étudiants chercheurs, Ouganda.

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## Introduction

Genetic improvement of legumes and dry land cereal production systems in Sub Saharan Africa (SSA) is a pathway to food and nutrition security (Glenn *et al.*, 2016). Malnutrition remains a challenge in households of most of the farming communities, thus the need to increase dietary diversity to address the high prevalence of micronutrient deficiencies. A post-doctoral fellowship was awarded to the first author to conduct research on genetic improvement of legumes and dry land cereals to enhance food and nutrition security in Malawi and Uganda. The research focused on intensifying biotic resistance with particular focus on fungal diseases and the fall army worm, and contribution to the nutrition agenda by evaluating improved nutrient dense varieties rich in nutrient components such zinc, iron, and high oleic acid for adaptability.

The rationale of the fellowship was to support and strengthen capacity for impact-oriented research via student training while promoting collaborative networking to exploit research potential. This is in response to the changing development paradigms that call for ability and technical competency in quality research to cope with emerging challenges. It was further designed as a platform for providing research and mentoring support to postgraduate students pursuing degrees in agricultural sciences to create a pool young scientists who are able to address emerging societal challenges. Partnership and collaboration act as an avenue for technology development and delivery, thus the fellowship was envisaged to strengthen regional and international between collaboration universities and international research centers. Further, inter-linkages among RUFORUM intervention, i.e., the Carnegie-RUFORUM Post-Doctoral Programme (Wajao), and the Regional Academic Mobility programme (RAM) being supported by the Intra African Academic Mobility programme going to be strengthened. The objective of the fellowship was therefore to 1) contribute to the delivery of the RUFORUM flagship programme, CREATE (Creating Research and Teaching Excellence) under its Vision 2030 Strategy, 2) to help internationalize Makerere University graduate training programme by training students from different African countries, while increasing research output through publications; 3) leverage on resources from the different institutions working together to cover research cost, provide technical expertise to supervise and mentor the students.

## Approach

Food and nutrition security can be achieved through cutting edge agricultural technologies that are well packaged and promoted for adoption by farmers. In the agricultural sector at large, there are currently glaring weaknesses in generation of context specific technologies and their consolidation towards enhancing food security. This can be addressed by having well-grounded human resource as specialists to offer refined specific solutions. The current post-doctoral fellowship focused on strengthening the research competence of the Fellow and a team of graduate students by conducting impact oriented research. This provided opportunity to train graduate students while enhancing technology development to generate products that meet market demands. Working together with the mentor and academic supervisors for the graduate students, a menu of research topics to be pursued by the graduate students were identified. The research areas were aligned to the ICRISAT dryland legumes and sorghum/millet improvement program, to enable co-funding and engage ICRISAT technical expertise to support the research.

The key research activities aimed at building a solid base for dryland legumes and cereals breeding to address challenges such biotic stresses, malnutrition and climate variability. Students were recruited in September 2018 under the Intra African Mobility Programme training plant breeders that funded tuition, so that additional resources could be leveraged from the fellowship to support their research. A total of six students were brought on board under the fellowship, including 4 MSc and 2 PhD, who are envisaged to be future researchers with passion of driving Agricultural interventions for food

and nutritional security to the next level. A multi-institutional interaction approach and a flexible, sustainable framework to cater for regional and or international collaboration in training and research was put in place. This included Makerere University, International Crops Research Institute for the Semi-Arid Tropics ICRISAT, National Semi-Arid Agricultural Resources Research Institute (NaSARRI) and the University of Georgia (UGA). Through the collaboration, the students have been exposed to international networks including interaction with the peanut innovation laboratory initiative leaders led by UGA. Through the initiative, agricultural technologies geared on enhancing legume and sorghum production in the region are being generated.

**Enhanced capacity of post-graduate students as crop of new scientists.** The postgraduate students have been capacitated to use the available resources to generate cutting edge scientific knowledge through field research. Leveraging resources from the three institutions, the students have been exposed to the use of modern Breeding Management Systems (BMS) in designing and managing nurseries, analysing data and automated operations. The students are able to set up field experiments, collect and analyse data. Through the mentorship, the students have been groomed to become independent confident scientists through exposure to scientific forums where they have made presentations on their work. The following gives a summary of the students and their areas of research:

**The list of students, their topics of research and status on progress is as indicated below:**

(i) **Name:** Solar Robert Lakidi

**Course:** Master of Science in Plant Breeding

**Title:** Farmers perception and response of sorghum lines to Fall Army Worm infestation in Uganda.

Several management options have been proposed for the management of fall armyworm (FAW). However, little is known about the most effective control practices that could control FAW under typical African smallholder conditions. Host-plant resistance is one of the most effective means of pest management in maize, sorghum and other crops. Determining the incidence of FAW in the farmers' sorghum fields and assessing the level of damage caused by the pest is key in designing appropriate control measures for the pest. Unfortunately, most research work on fall army infestation in Uganda has been done mainly on maize plant and not sorghum, yet it is a secondary host for the pest. The objectives of the study were therefore to assess the knowledge and practices in the management of fall army worm by farmers in the major sorghum growing areas of Uganda, assess the incidence and severity of fall army worm infestation in farmer's sorghum fields and to evaluate sorghum germplasm (accessions) for reaction to fall army worm infestation.

(ii) **Name:** Tabitha Lotemey

**Course:** Master of Science in Plant Breeding

**Title:** Genetics of resistance to groundnut rust in Uganda and Malawi

Groundnut rust (*Puccinia arachidis*) is a major constraint to groundnut (*Arachis hypogaea*) production in the world. In Uganda, improved varieties are mostly adapted to the lowland ecologies. However, this resistance may be inadequate when climate variability alters conditions in the lowland ecologies. The objective of this study was therefore to contribute to knowledge in the development of rust resistant varieties suited to Uganda. The specific objectives were to: 1) evaluate groundnut for morphological, agronomic and yield related traits at different altitudes, 2) determine the response

of groundnut genotypes to rust in different agro-ecologies, 3) determine mode of inheritance for resistance to rust in groundnut. The outputs from the research would be genetic information for use in breeding for resistance to rust, publication in peer refereed journal and thesis of a ward of Masters degree of Makerere University.

(iii) **Name:** Danielle Ama Essando

**Course:** Master of Science in Plant Breeding

**Title:** Performance of interspecific hybrids and synthetic allotetraploids of wild *Arachis* species in Uganda.

Narrow genetic variability has slowed down progress in groundnut breeding program in Uganda. Wild relatives of groundnuts are sources of several agriculture traits such as resistance and or tolerance to biotic and abiotic stresses. These wild types are native to South America specifically Brazil and synthetic amphidiploids and interspecific hybrids obtained from these wild types were cultivated in South America. They may however not be adopted for sub-Saharan Africa conditions particularly Uganda which has been reported to have high prevalence of several diseases. The objective of the study was therefore to test these genotypes for adaptability and identification of useful traits that can be exploited in breeding programs in Uganda.

(iv) **Name:** Rachel Mitey

**Course:** Master of Science in Plant Breeding

**Title:** Evaluation of nutrient dense groundnuts lines for adaptability and resistance to leaf spots in Uganda and Malawi.

The lack of studies on resistance to leaf spots and adaptability of nutrient dense varieties in Uganda led to the design of the study. Malnutrition due to lack of key micro-nutrients such as zinc and iron is still high in developing countries including Uganda. The shelf life of groundnut is also affected by the composition of fatty acids in the kernel. Bio-fortification has led to enhanced levels of iron and zinc in crops as a sustainable approach to address malnutrition among poor. At the same time, high levels of oleic acid influence the quality of groundnut kernels and its shelf life. The objectives of the study were to: 1) evaluate elite nutrient dense material of resistance to leaf spots and their agronomic performance and 2) analyze the mode of inheritance for resistance to leaf spot diseases.

(v) **Name:** Velma Okaron

**Course:** PhD in Plant Breeding and Biotechnology

**Title:** Genetic studies for resistance to leaf spots in groundnut in East and Southern Africa.

The resistance basis of groundnut to fungi causing leaf spots has not been well investigated in Eastern and Southern regions of Africa. This is further exacerbated by limited information on the pathogenicity and population structure of the causal agents as well as their epidemiology. This hinders the control of leafspot diseases and the creation of resistant varieties. Research and documentation of yield losses associated with leafspots in groundnut in Eastern and Southern Africa is limited. The overall objective of the study is to contribute to the generation of genetic information and materials to support management of leaf spot diseases of groundnut in Eastern and Southern Africa (ESA) region. It is envisaged that understanding the variability in the causative pathogen of leaf spot will inform

future research initiatives within breeding programs in the region. Further, molecular characterization of leaf spot pathogens will provide information on the degree of genetic variation in this pathogen in East and South Africa region. This will provide the breeders with information whether testing cultivars in one ecology will be adequate to substitute for other environments. Assessment of yield losses due to different strains and multiple infection will help breeders in streamlining the leafspot management in their breeding efforts in a bid to release varieties with multiple resistance. Exploitation of host resistance will be made possible if efforts are employed to identify resistant materials that can be used as parents in crosses targeted at increasing favorable alleles in new varieties

(vi) **Name:** Dejene Kebede

**Course:** PhD in Plant Breeding and Biotechnology

**Title:** Genetics of resistance to Ergot (*Claviceps africana*) in sorghum

Ergot (*Claviceps africana*) is a fungal disease of sorghum inflorescence which poses a significant threat worldwide (Prom *et al.*, 2008). The pathogen mainly infects unfertilized ovaries and as a result, hybrid seed production that utilizes male sterile lines are highly affected. Yield loss of 20 – 80% have been reported in hybrid seed production due to ergot (Tooley *et al.*, 2006; Prom *et al.*, 2008). Management strategies used to minimize the impact of ergot include fungicide application, pollen management and use of resistant genotypes (Prom *et al.*, 2008). Indeed Prom *et al.* (2008) reported that fungicide treatment is inconsistent and frequent application is needed to reduce the disease severity. Prom *et al.* (2008) and Parh *et al.* (2008) reported that limited resistance have been identified and the observed resistance is not stable across environments. Understanding the genetic diversity and identification of genotypes that can be used as potential source of resistant genes through extensive evaluation would assist in development of resistant varieties. The objectives of the study were to: 1) evaluate sorghum genotypes for ergot resistance and study genetic diversity of sorghum genotypes, 2) determine the mode of inheritance of resistance to ergot in sorghum, and 3). identify genomic regions associated with resistance to ergot in sorghum. The expected outputs are: genetic and information for resistance to ergot disease in sorghum, at least two publications in refereed journal, Thesis for award of Doctor of Philosophy in Plant Breeding and Biotechnology of Makerere University.

### **Enhanced Mentoring Capacity for the Fellow**

The mentorship support to the Fellow has sharpened his research and skills through short coaching sessions. The Fellow has in return supported graduate students to become leaders in research right from concept development, field experimentation, data collection and analysis and sharing of research output. The fellowship has further led to enhanced networking and collaborative ability of the Fellow in execution of agricultural research initiatives.

### **List of publications**

Under the fellowship the following manuscripts have been published and or submitted for publication:  
 Mwololo, J.K., Okori, P. and Odong, T. 2019. Progress and future prospects in groundnut improvement to feed Africa in the face of technological advancements. *African Journal of Rural Development* 3 (3): 849-858.  
 Mwololo, J.K., Odong, T. and Okori, P. 2018. Present and future strategy in groundnut improvement in the face of technological advancements. *African Journal of Rural Development 3 RUFORUM Biennial Conference extended abstract*  
 Mwololo, J.K., Odong, T. and Okori, P. 2018. Fungal foliar diseases infecting groundnut: their

management, status and the future. *RUFORUM Biennial Conference Extended Abstract*” submitted to the *African Journal of Rural Development*.

Mwololo, J.K., Odong, T. and Okori, P. 2018. The groundnut rosette disease at a glance: Basics, management and the future”; RUFORUM Biennial Conference extended abstract” submitted to the *African Journal of Rural Development*

Mwololo, J.K., Mitey, R. Odong, T. and Okori, P. 2019. Evaluation of oleic acid rich groundnut lines for adaptation and resistance to foliar diseases in Malawi. *RUFORUM Working Document Series*

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