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Research Application Summary

Diversity of sorghum in farmers' fields in Northern and Eastern Uganda

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Abstract

Crop genetic diversity is one of the key resources available to humanity for effective response to challenges associated with climate change and the ever-growing world population. Sorghum is a marginal environment crop with needs for constant breeding to respond to the changes in this fragile environment. A large pool of genetic diversity is very critical for its improvement. However, like most crops, the levels of genetic diversity (especially on-farm) in developing countries such as Uganda largely remain unknown. Loss of sorghum diversity has been reported by many authors and this limits the ability of farmers to cope up with climate change and ever growing world population. Past studies on sorghum diversity in Uganda have been carried out at regional/ecological level but information on sorghum diversity on farmers' fields in major sorghum growing areas is lacking. There is therefore urgent need to conserve genetic diversity insitu as this allows sorghum to evolve in its natural environment and provide both farmer and breeder preferred traits. This study seeks to understand the status (amount and spatial distribution) of on-farm crop genetic diversity of sorghum in the districts of Agago, Apac (northern) and Serere (eastern) in Uganda. On-farm diversity will be determined through field surveys at different growth stages in the three districts. Phenotypic field evaluation of accessions obtained from the different districts will be done in Agago and Makerere University Agricultural Research Institute Kabanyolo in the first rain of 2016. Results from the preliminary studies indicated that Agago had most diversity (in terms of the number of varieties planted per field) followed by Apac and finally Serere. The tall late maturing sorghum types were dominant in Agago district whereas the short early maturing types were dominant in the other two districts (Apac and Serere).

Key words: Genetic diversity, sorghum, Uganda

Résumé

La diversité génétique des cultures est l'une des principales ressources disponibles à l'humanité pour une réponse efficace aux défis liés au changement climatique et la population mondiale sans cesse croissante. Le sorgho est une culture d'environnement marginal nécessitant la reproduction constante pour répondre aux changements dans cet environnement fragile. Une grande base de la diversité génétique est très critique pour son amélioration. Cependant, comme la plupart des cultures, les niveaux de diversité génétique (en particulier à la ferme) dans les pays en développement comme l'Ouganda demeurent largement inconnus. La perte de la diversité du sorgho a été rapportée par de nombreux auteurs, ce qui limite la capacité des agriculteurs à faire face aux changements climatiques et à la population mondiale sans cesse croissante. Des études antérieures sur la diversité du sorgho en Ouganda ont été menées au niveau régional / écologique, mais l'information sur la diversité du sorgho dans les champs des agriculteurs dans les principales zones de culture du sorgho fait défaut. Il est donc urgent de conserver la diversité génétique in situ car cela permet le sorgho à évoluer dans son environnement naturel et fournit à la fois à l'agriculteur et au sélectionneur génétique des traits préférés. Cette étude vise à comprendre l'état (quantité et la distribution spatiale) de la récolte à la ferme de la diversité génétique du sorgho dans les districts d'Agago, Apac (Nord) et Serere (Est) en Ouganda. La diversité sur la ferme sera déterminée au moyen d'enquêtes sur terrain à différents stades de croissance dans les trois districts. L'évaluation des données phénotypiques obtenues sur terrain dans des différents districts se fera en Agago et l'Institut de Recherche Agricole de l'Université de Makerere à Kabanyolo pendant la première saison culturale de 2016. Les résultats des études préliminaires ont indiqué qu'Agago avait plus de diversité (en termes de nombre de variétés plantées par domaine), suivie par Apac, et enfin Sérère. Les types de sorgho de grande taille à maturité tardive étaient dominants dans le district d'Agago alors que les courts types à maturation précoce étaient dominants dans les deux autres districts (Apac et serere).

Mot Clés: Diversité génétique, sorgho, Ouganda

Background

Crop genetic diversity is one of the key resources available to humanity for effective response to challenges associated climate change and feeding the ever-growing world population (Esquinas-Alcazar, 2005; Govindaraj *et al.,* 2014). Since earlier farmers domesticated plant and animal species, farmers and agricultural researchers have been exploiting available genetic resources to ensure that human needs such as food, shelter and clothing have been met. Plant genetic diversity provides valuable traits needed for meeting challenges of the future such as adapting our crops to changing climatic conditions or out breaks of disease and is considered a source of continuing advances in yield, pest resistance and quality improvement (Carpenter, 2011). The genetic bases of most crops (land races, wild relatives and weedy relatives) including sorghum have been threatened by various factors of genetic erosion (Ngugi and Maswali, 2010). Past studies for example Mbeyagala *et al.* (2012) looked at regional scale of genetic diversity in sorghum and therefore there is lack of information on diversity of sorghum on farmers' fields. There is urgent need to conserve sorghum genetic diversity conserve diversity most especially on farm.

This study seeks to understand the status (amount and spatial distribution) of on-farm crop genetic diversity of sorghum in the districts of Agago, Apac and Serere in Uganda. The study has the following specific objectives: 1) to determine and compare the levels of diversity of sorghum on farmers' fields in districts of Agago, Apac and Serere; 2) to determine spatial distribution of genetic diversity within each district.; 3) to determine the phenotypic relationship between accessions from the three districts.

Literature summary

Land races or traditional varieties provide stability in low input agriculture under marginal environments, thus their cultivation contributes to farm level resilience in the face of challenges affecting food production (Grovindaraj *et al.,* 2014). Diversity also provides opportunity to develop new and improved cultivars with characteristics which include both farmer preferred traits (good taste, yield potential and large seed) and breeders preferred traits (pest and disease resistance and photosensitivity etc.). Sorghum (*Sorghum bicolor* (L.) Moench) is the fifth most important grain crop worldwide after maize (*Zea mays*), wheat (Triticum species), rice (*Oryza sativ*a L.), and barley (*Hordeum vulgare* L.) in terms of production and area planted (FAO, 2004). In Africa, it is the second most important cereal, in terms of production after maize (Gerda and Christopher, 2007).

Sorghum is a marginal environment crop with needs for constant breeding to respond to the fragile environment (Ola *et al.,* 2014). Sorghum is the crop of choice for marginal environment and food security because of its ability to tolerate drought and salt toxicity (Ebiyau *et al.,* 2005). In addition, sorghum has multiple uses including but not limited to: human consumption (bread porridge and boiled grain), beer production, sugar and biofuel production, feeding animals and as building materials (Kigozi *et al.,* 2011). The multiple use of sorghum necessitates the need for maintaining high genetic diversity from which to breed varieties suitable for different uses.

However, among the challenges hindering response to the domestic and industrial demand for sorghum for various uses is availing suitable cultivars for the desired grain and stalk uses. The success in this venture largely depends on the germplasm collection and evaluation for subsequent development to meet the desired industrial needs which calls for both genotyping and phenotyping (Kimani *et al.*, 2014).

Although sorghum originated from North Eastern Africa, it is being cultivated successfully in most parts of the world with diverse environmental conditions for different uses. The major cereals have experienced significant reduction in genetic diversity due to improvements of various agronomic traits (Petrovic and Dimitrijevic, 2012). However, in many sorghum growing areas of Africa, many sorghum accessions have been lost or are under serious risk of genetic erosion, and hence, genetic diversity within primary gene pools has been decreasing due to modern agricultural practices (Ngugi and Maswili, 2010).

The impact of such genetic reduction has occasionally been witnessed when calamities strike such as the ug99 virus is threatening wheat production globally following breakdown in resistance to stem rust (Joshi *et al*., 2008).

Therefore, comprehensive knowledge of germplasm diversity and genetic relationships among cultivated sorghum will remain an invaluable aid in the crop improvement strategies for current and future breeding programs (Mohammad and Prasanna, 2003). Many studies have indicated that sorghum diversity organization is linked to geographic and/or racial classification (Deu *et al.*, 2006). Ghebru *et al* (2002) showed exceptionally high level of genetic diversity among 28 Eritrean land races compared to a sample of 32 of the world sorghum collection. Seed exchange, pollen flow, farmers' practices and environmental pressures all affect genetic diversity in situ (Barnaud *et al.*, 2007).

Study Description

The study was carried out in the districts of Agago, Apac in Northern, and Serere in Eastern Uganda. These districts were purposely selected to represent part of Uganda where sorghum is the main food security crop (Ebiyau *et al.*, 2005).

Study 1: Determination of on-farm sorghum diversity.

Field surveys at different growth stages of the crops were carried in each of the three study districts to measure on-farm sorghum diversity. A sample of 45 farm households were selected in each district through hierarchical sampling scheme. From each district two sub-counties were purposively selected and from each sub-county three villages were selected using simple random sampling. The sub-county with high concentration of farmers growing sorghum (based on preliminary surveys) was selected. A total of 15 farm households were selected from each village using simple random sampling. From each farm household one sorghum field was selected for this diversity study.

Sorghum diversity within each field was measured based on morphological characteristics such as seed size, colour, height of plant and other characteristics as described in sorghum descriptor guide (IBPGR and ICRISAT, 1984). In addition the number of varieties/ genotypes in each field were counted. For traits measured, diversity indices were calculated to quantify the partition of the diversity in each field. The diversity indices calculated at field level were aggregated at village, sub-county and district levels.

Study 2: Phenotypic relationship between sorghum accessions.

To determine the relationships between accessions/genotypes from the different districts, field evaluation of 100 genotypes collected during the preliminary survey was undertaken in Agago district and Makerere University Agricultural Research Institute, Kabanyolo (MUARIK). The evaluation was done during the first rainy season of 2016. Agago was selected as the site of the field evaluation because of the high diversity observed during the preliminary surveys. In addition, the interest was to use the field evaluation to learn more from farmers about diversity of sorghum.

Preliminary Results

A preliminary survey was carried in January 2016 in the districts of Agago, Apac and Serere to determine the level of diversity at sorghum maturity stage and to collect germplasm for field evaluation. Findings revealed that Agago had the highest level of sorghum diversity followed by Apac and Serere districts. Results also showed that the number of varieties planted in the same field in Agago range from 3 to 7 compared to Apac and Serere where most fields have 1 to 2 varieties. Majority of farmers in Serere planted a single type or variety in their fields. Based on grain colour, head types, glum colour and seed size we collected 100 different accessions from the three districts.

The most common type of sorghum grown in Serere are red seeded types, whereas in Agago had red, brown and white types in different proportions although the brown seeded types are more dominant. In Apac, the red seeded type was dominant in Ibunye sub-county whereas the cream seeded types were more prominent in Kyegere sub-county. In Agago, field to field and village to village variability was much higher compared to the other two districts. We noted marked differences between the two sub-counties sampled from Apac district with Ibunye Sub County having predominantly the short red type sorghum with moderately high field to field variation. On the other hand Kyegere Sub County had also small variation between households but overall the cream coloured sorghum was dominant in most of the households since it was grown for sale. Elevated field diversities Kyegere Sub County were mainly associated with seed contamination. In Serere, there was little variation in the varieties grown in different fields in the two Sub Counties. Red type of sorghum was dominant across all the villages in the two Sub counties.

Research Application

Information generated will help plant breeders to exploit existing diversity to address local challenges (Food security). The rationale of this study was to help guide the development of optimal conservation strategies.

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