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REVIEW ARTICLE

Sorghum Genetic Diversity in Africa: A Mini-Review

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ABSTRACT

Genetic diversity in crops is an essential element necessary for any crop improvement programme. The study seeks to assess the causes of genetic diversity loss in Africa and possible solutions to diversity loss problems in Africa. High genetic diversity at local, regional and continental levels within Africa was reported by most of the studies reviewed. The trend of sorghum diversity in Africa remains unclear as some studies suggest an increase in sorghum's genetic diversity, while others suggest a loss in genetic diversity over the years. Replacement of farmers' variety with improved variety, population increase, climate change, a shift in the cropping system, and reduced derived benefits from certain crop varieties have reported as the major causes of diversity loss in Africa. The *in-situ* conservation practiced in the centers of diversity of sorghum has been a predominant key player in mitigating diversity loss in sorghum. This approach emphasizes the vital role of farmers' selection in generating and maintaining crop diversity in participatory plant selection and introducing new varieties where farmers grow improved varieties. Farmers' landraces were also found to improve the sorghum's genetic base, thereby mitigating diversity loss in sorghum.

Key words: *Sorghum bicolor* (L.); Genetic diversity; Variation; Africa

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INTRODUCTION

Differences in plant phenotypic expression are solely due to differences in genetic composition, in combination with environmental influences. Except for chromosomal abnormalities, nuclear gene action, and plasma gene action, variation due to plant genetic composition is essentially constant from generation to generation (Singh, 2015). According to the Hardy-Weinberg principle, without any evolutionary impacts, variation in the amount of genetic information within a population will remain constant from generation to generation (Hartl et al., 1997). However, evolutionary factors are continually playing out in the environment (Slatkin, 2010), distorting the Hard-Weinberg hypothesis and resulting in a change in the amount of genetic variety existent within and among populations. Because the goal of this study is to determine the amount of genetic variety present across African sorghum accessions, it's critical to first understand what genetic diversity is and how it occurs in general, as described above. This will assist us understand the causes responsible for the trend of genetic diversity in our target crop later on in the research.

Plant breeders benefit greatly from diversity studies since they aid in the discovery of materials that contain valuable genes for plant improvement (Bhosaleet al., 2011; Geleta and Ortiz, 2013). Many breeding strategies either employ the natural genetic diversity found in crop species or entail purposeful and planned efforts to develop the requisite variability, which is then used to improve the crops (Singh, 2015).

The scope of genetic variation in sorghum accessions on the African continent will be examined in greater depth in this review. However, the scope of this research will be limited to four primary themes: (1) the extent of genetic variety in African sorghum accessions, (2) the trajectory of genetic diversity, (3) the reasons of genetic diversity loss in Africa, and (4) viable solutions to Africa's diversity loss problems. To ensure variety conservation, this review should result in a better understanding of genetic diversity among African sorghum accession.

SORGHUM PRODUCTION IN AFRICA

Sorghum is known for its capacity to adapt to dry tropical climes, allowing it to thrive in locations with limited rainfall (Sasaki and Antonio, 2009). However, only a few regions in Africa grow sorghum under irrigation, with Sudan being one of the most well-developed irrigation and mechanised sorghum producing systems (FAO, 2001).

In 2016, the world produced 63.9 metric tonnes of sorghum, with Africa accounting for 46.7 percent of that total. Sorghum production in Africa spanned 30.54 million hectares in 2016, with a total yield of 29.83 metric tonnes. Nigeria produces the most sorghum in Africa, followed by Sudan, Ethiopia, and South Africa (FAO, 2016). Sorghum's huge production in Africa is due to the fact that it originated in Africa and its capacity to withstand drought (Westengen et al., 2014). Sorghum has become one of the most popular crops in Sub-Saharan Africa as a result of this.

SORGHUM DIVERSITY IN AFRICA

Sorghum is divided into five main races and ten secondary races (Harlan and de Wet, 1972). Bicolor, guinea, caudatum, durra, and kafir are the fundamental races, whereas intermediate races are a blend of two basic races. Due to bio-geographical considerations, some races are more suited to various climatic and environmental situations (Barro-Kondombo et al., 2010). Although some African countries, such as Uganda and Zimbabwe, grow all five principal races and intermediate races, each race appears to be better adapted and cultivated in specific countries or locations (Reddy et al., 2006). For example, in Sudan, the Caudatum race and some of its intermediate race's account for 80% of total sorghum production (Grenier et al., 2004), while in Burkina Faso, the Guinea race accounts for 94.4 percent of total sorghum production (Barro-Kondombo et al., 2010). The Khafir race is more common in South Africa, but the bicolor race has yet to be identified as the continent's dominant race (Reddy et al., 2006). In other circumstances, intermediate races, such as Kaura, an intermediate race of durra-caudatum, the primary sorghum variety in northern Nigeria, are more prevalent in the population (Bhosale et al., 2011; Reddy et al., 2006). Because of the racial diversity in African sorghum, there is a large genepool for sorghum development programmes.

Sorghum has a lot of genetic variety (Rosenow and Dahlberg, 2000), and the majority of it is represented by African landraces (Carena, 2009; Bhosale et al., 2011). Many research has utilised morphological and genetic techniques to demonstrate the level of variation among African sorghum accessions. This review intends to dig further into these studies and clearly explain the type and extent of variety, as well as the pattern and trend of diversity and the variables that contribute to it. Sorghum production in Ethiopia is dominated by landraces (Shewayrga et al., 2008).

The guinea race has higher diversity (He = 0.67) than all other basic races, according to a racial diversity study of West African sorghum. Guinea-caudatum, on the other hand, exhibits slightly more diversity than other intermediate races (Bhosale et al., 2011). Within Malian sorghum landraces, however, caudatum (He= 0.608) and durra (He=0.576) showed higher genetic diversity than guinea (He=0.355) (Sagnard et al., 2011). This could be explained by discrepancies in sample size and geographic coverage of the research population. The latter's population is a subset of the former. This means that the s guinea sorghum race is more genetically diversified on a geographical level (West Africa).

Another sorghum diversity study in Sudan found high phenotypic diversity (H'=0.81) across all regions and high within-region diversity (H'=0.64 to H'=0.78). The substantial phenotypic diversity reported in Kenyan wild and cultivated sorghum cultivars supports this conclusion (Muraya et al., 2010). Sudanese evaluations were conducted in both the wet and dry seasons in various parts of the nation. The significant phenotypic diversity seen in both seasons suggests that diversification is independent of climate changes. Barro-Kondombo et al. (2010), on the other hand, discovered that sorghum grown in low rainfall areas of Burkina Faso has a greater genetic diversity compared to sorghum planted in high rainfall areas. He also believes that sorghum grown in low-rainfall places has a high genetic diversity that could help it adjust to drought and other abiotic challenges that come with it. Sorghum diversity, on the other hand, was found to be higher in more humid areas of Niger than in drier areas, according to Bezanc et al. (2009). However, because a standard was not used to show the amount of moisture available to the crops at those different locations and how the moisture level differs from one experiment to the next, the comparison between these studies may not be valid.

Molecular markers for assessing sorghum diversity in Africa

According to Adugna (2014), both phenotypic traits and SSR markers were used for in-situ diversity assessment of eight cultivated sorghum landraces in Ethiopia; high diversity was observed for phenotypic traits measured, with principal component analysis showing that plant height, number of tillers and leaf length contributed the largest (80.53%) part of the variation observed. SSR markers used in the study, with high Polymorphic Information Content (0.62), showed high genetic diversity (0.67) in the Ethiopian in-situ sorghum germplasm. Similar results reported for sorghum accessions in Niger Kenya (Deu et al., 2008). Ngugi and Onyango, (2012) and Eritrea (Ghebru et al., 2002) using similar SSR markers. Other studies using similar SSR markers, on the other hand, showed much lower genetic diversity was observed for sorghum accessions from Morocco (Djè et al., 2000) and northern Cameroun (Barnaud et al., 2007). However, it might not be comparable due to the different sample size and sampling strategy employed by the further studies.

Regional diversity studies of west African sorghum accessions using SSR markers showed high genetic diversity estimates (He = 0.70) (Bhosale et al., 2011). East and Central African sorghum accessions too have been found to contain large amount of genetic diversity with accessions in countries like Sudan, having the highest diversity (He=0.685), followed by Ethiopia (He=0.653) then Kenya (He=0.569), Eritrea (He=0.561) and Uganda (He=0.537). While Burundi (He=0.466) and Rwanda (He=0.330) possess low genetic diversity (Salih et al., 2016).

TREND OF SORGHUM DIVERSITY IN AFRICA

The importance of genetic variety in breeding programmes is important to monitor the levels and trends of diversity in crops in order to prevent biodiversity loss and to take advantage of the new gene pool if genetic diversity increases (Bezanc et al., 2009). According to Westengen et al. (2014), the organisation of variety observed in African sorghum accessions is primarily due to the mobility and dispersion of ethnolinguistic groups across Africa. As a result of this mobility, sorghum accessions have adapted to various climatic and agronomic situations. This is consistent with the findings of Adugna (2014), who discovered that variation in Ethiopian sorghum landraces followed human migratory patterns. Grenier et al. (2004) discovered that the racial distribution and total phenotypic diversity of sorghum landraces in Sudan varies by region, implying that these landraces were selected and differentiated along a geographical pattern likely related to climatic circumstances and landrace use.

A comparison of a substantial collection of sorghum germplasm collected in 1973 and a collection of landraces collected in 2003 in eastern Ethiopia by Shewayrga et al. (2008) revealed a considerable loss of variety over 30 years. Some prominent landraces have vanished, while others have faded into obscurity. On the contrary, a 26-year study of sorghum diversity in Niger revealed no significant loss of variability (Bezanc et al., 2009). This makes it difficult to determine the precise trend in sorghum variety in Africa, as detailed research on a wide temporal and geographical scale are limited (Bezanc et al., 2009). More research is needed on the trend of sorghum diversity, particularly on the African continent, where climate change is rapidly changing crop growing conditions.

CAUSES OF DIVERSITY LOSS IN AFRICA

Genetic erosion refers to the loss of diversity caused by changes in genetic variability in a population (Brush 2000). Plant diversity loss is caused by a variety of sources, including both human and environmental factors. They realised that by understanding these characteristics, we may develop and implement measures to protect genetic variety.

The main cause of diversity loss, according to FAO (1998), is the replacement of farmers' variety with improved variety. However, investigations in Ethiopia have indicated that the introduction of superior cultivars has widened the crop's genetic base rather than narrowing it (Mekbib, 2008). Based on the remote source of genetic loss, Mekbib (2008) classified variables responsible for genetic loss into three types.

Possible solutions to diversity conservation of sorghum genetic materials

The importance of biodiversity conservation cannot be overstated, as it has been a focal point for a number of local and international organisations. The in situ and ex situ conservation methods are two well-known broad methods of biodiversity conservation (Bonderup et al., 1991).

The in-situ conservation method is concerned with the preservation of genetic resources in their native habitat. With some regions of Africa included, this has been the prevailing conservation system in centres of variety (Altieri and Merrick, 1987; Teshome et al., 1999). (Deu et al., 2010). In many parts of Africa, the survival of sorghum genetic resources is owing more to farmers' cultural and traditional agricultural techniques than to any other aspect (Westengen et al., 2014).

Plant breeding techniques have also aided in the establishment and preservation of genetic diversity in sorghum. In contrast to the notion that selecting and introducing superior types causes genetic loss. It has been discovered that breeding methods such as participatory plant selection and introduction of new varieties, especially in certain parts of Africa where farmers grow improved varieties alongside their landraces and do not discard landraces in favour of improved varieties, add to the genetic base of sorghum populations (Tsehaye et al., 2009; Teshome et al., 1999).

Furthermore, the rapid change in climate, which threatens crop growing conditions in many parts of Africa and around the world, has required the necessity for ex situ crop conservation, including sorghum. Sorghum accessions have been preserved in gene banks thanks to efforts by local and international organisations; the ICRISAT has a substantial repository of world sorghum germplasm, with 36,774 accessions from 91 countries (Reddy et al., 2006).

CONCLUSION

A large level of genetic variety exists among African sorghums, according to this study. It has been proven that the socio-cultural and traditional agricultural practises used by sorghum farmers on the African continent are the key causes behind the sustenance and preservation of this diversity. The cultural ties that different ethnic groups have with distinct sorghum landraces, particularly in Ethiopia.

Farmers' practises of cultivating improved varieties and landraces rather than discarding landraces in favour of enhanced varieties has resulted in a larger genetic resource base for sorghum in Africa, as well as increased variety in the sorghum population. However, there was no conclusive evidence that sorghum diversity is rising or decreasing, according to the review. The reason for this is due to the scarcity of information on the subject. More research is needed, with a particular focus on the trend of diversity in African sorghum accessions. This is critical for the effective use and preservation of sorghum genetic resources.

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