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A diagnostic appraisal of the sorghum farming system and breeding priorities in *Striga* infested agro-ecologies of Ethiopia

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ABSTRACT

Sorghum (*Sorghum bicolour* L. Moench) is a globally important food security crop, particularly in arid and semi-arid environments. Sorghum productivity is low in subsistence farming systems due to biotic, abiotic and socio-economic constraints. The objective of this study was to determine farmers' sorghum production opportunities, threats, indigenous knowledge and perceptions with a focus on breeding priorities *Striga* infestations and the farmers' coping mechanisms in different agro-ecologies in Ethiopia. A multi-stage cluster sampling method was employed to interview 315 households selected from nine districts of three administrative zones within two provinces. Participatory rural appraisal tools including a structured questionnaire, pair-wise ranking, focus group discussion, and observations through a transect walk were used to collect data. The results showed that the majority of the participant farmers, (86%) were involved in sorghum production. In all study areas sorghum landraces were preferred by >85% of respondents rather than improved released varieties. Farmers listed and prioritized several sorghum production constraints based on importance and severity. The constraints varied among the study areas due to the diversity of agro-ecologies and cropping systems. Results from the pair-wise ranking showed that farmers' have variable preferences for sorghum varieties. At the north Shewa and north Wello zones drought resistance was the most farmers-preferred trait, followed by *Striga* resistance. In the Metekel zone *Striga* resistance was the number one farmer-preferred trait, followed by grain quality. The prioritised traits will form the basis for farmer-oriented sorghum breeding.

1. Introduction

Globally, sorghum (*Sorghum bicolour* L. Moench, $2n = 2x = 20$) is the fifth important grain crop providing food, fodder and bio-energy feedstock (Poehlman, 1994; FAO, 2012). Sorghum is a critical food security crop for more than 100 million people in Africa. It predominantly grows in low-rainfall, arid to semi-arid environments due to its excellent tolerance to drought, high temperature stresses and low soil fertility. The crop displays relatively high water use efficiency compared to other cereals such as maize and wheat (Doggett, 1988; Blum, 2004). It is believed that cultivated sorghum (*S. bicolour*) was first domesticated in north-eastern Africa. Vavilov (1951) described Ethiopia as a centre of origin of sorghum due to the presence of wide genetic variation. The crop has been adapteds to a range of biotic and abiotic stresses, resulting in the evolution of many landraces cultivated in various sub-regions (Roa et al., 2002).

The most important staple cereal crops grown in Ethiopia include tef [*Eragrostis tef* (Zucc.) Trotter.], maize (*Zea mays* L.), sorghum and wheat (*Sorghum bicolour* L. Moench and *Triticum aestivum* L.). On average these crops account for 24.66%, 17.56%, 16.84%, and 14.04% of the total cereal crop cultivated area over the last five years, respectively (CSA, 2011). In Ethiopia, sorghum is cultivated in almost all regions by subsistence farmers for various uses such as food, animal feed and to prepare local beverages. Further the stalk is also used for animal feed and for house and fence construction (McGuire, 2008). Despite its versatility and economic value in the livelihoods of millions of subsistence farmers, sorghum productivity is low, estimated at <2 t ha^{-1}. Important yield reducing factors are abiotic (low soil fertility and drought) and biotic (infestation by *Striga*, stem borers and shoot fly) (Wortmann et al., 2006). These factors cause significant grain yield losses but their relative importance varies between regions within the country.

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Striga (*Striga hermonthica*), an obligate, root hemi-parasitic, noxious weed, is one of the major biotic constraints in most sorghum growing areas. Gressel et al. (2004) reported that *Striga* species are native constraints and reach their greatest diversity in the tropics where they have co-evolved with cereals, especially sorghum, millets and upland rice. The weed is endemic to sub-Saharan Africa and infests about 26–50 million hectares causing annual crop losses ranging from 30% to 90%, and sometimes leading to complete crop loss (Watson et al., 2007). *Striga* reduces yield and quality through parasitic competition.

Various control options (cultural, chemical, biological, and use of resistant varieties) have been developed to reduce Striga damage on sorghum. These approaches need to be integrated to improve sorghum productivity and quality. Currently in Ethiopia, development of Striga resistant varieties relies mainly on introduced genetic resources. However, adoption of exotic cultivars by farmers' has been negligible mainly because they do not possess farmers' preferred traits (Adugna, 2007). Different reports are available on the low adoption rate of improved sorghum varieties by resource poor farmers in Ethiopia (McGurie, 2008; Sinafikesh et al., 2010). For instance, McGuire (2008) indicated that despite 25 years of sorghum breeding in Ethiopia most of the released varieties had been poorly adopted by the small-scale farmers. Reasons for slow adoption rate include lack of effective seed production and delivery mechanism and the introduced germplasm do not fulfil farmers' preferred traits. In Ethiopia, farmers' variety preferences is not only grain yield but also straw yield for livestock feed and other related social values. Wale and Yallew (2007) indicated improved variety development lacks fitness attributes to the farmers' preference traits. Also harsh growing conditions hinder the adoption rate of the breeders developed varieties due to less adaptation when compared to landrace varieties. Thus, a balance between farmers-preferred traits and solutions to production constraints should be the breeders' goal in order to enhance cultivar uptake by farmers. Sorghum landraces are invaluable sources of genetic variations for different socio-economic traits which include pest and disease resistance, early maturity, yield potential and other desired traits. These genetic resources have long agricultural histories and have co-evolved with different pests and disease. *Striga* resistance could possibly be selected from landraces, cultivated and wild sorghum species for further exploitation in sorghum breeding programs.

Participatory rural appraisal (PRA) tools are utilized to document farmers' traditional knowledge and experiences to mitigate food insecurity and improve their livelihood (Chambers, 1992). Adoption of improved sorghum technologies by smallholder subsistence farmers has been very low because the new technologies did not meet the requirements of farmers (Singh and Morris, 1997). Conventional breeding programs should be reformed to incorporate farmers-prefered traits in varietal development programs (Ceccarelli et al., 2001). Therefore, in order to develop and enhance the acceptability and adoption of new varieties and improved production technologies the farmers' actual production constraints and varietal preferences should be well-known (Soleri et al., 2000; Ceccarelli et al., 2001).

The objective of this study was to determine farmers' sorghum production opportunities, threats, indigenous knowledge and perceptions, emphasising breeding priorities and *Striga* infestation, and the coping mechanisms of farmers in the north eastern and north western Ethiopia.

2. Material and methods

2.1. Description of study sites

The survey was undertaken in three administrative zones of Ethiopia, namely the north Shewa and north Wello zones of the Amhara Regional State and the Metekel zone of Benshangul-Gumez Regional State. North Shewa and north Wello are located in north eastern Ethiopia representing semi-arid to arid lowland agro-ecologies. Metekel has a humid lowland agro-ecology and is situated in north western Ethiopia, bordering the Sudan. The geographical locations of the study zones are shown in Fig. 1 and their main agro-ecological features are summarized in Table 1.

In all study zones mixed crop and livestock farming is the predominant mode of agricultural production. Sorghum, *tef* and maize are the major cereal crops, together with pulses, oil seeds and some cotton. The study zones are believed to be the sub-diversity centres for sorghum in Ethiopia. Metekel zone is near to the Sudan-Ethio-

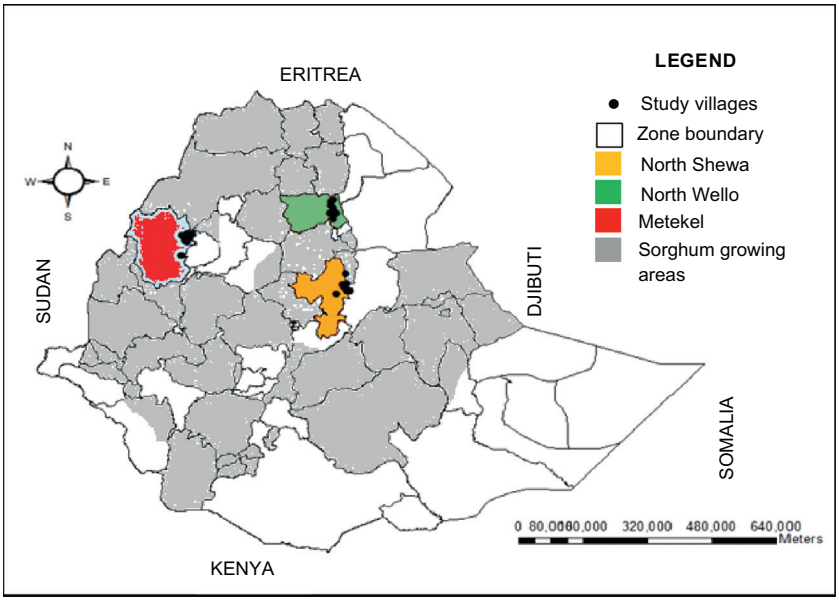

Fig. 1. Sorghum production map of Ethiopia and location of study zones.