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Yielding and stability appraisal of released varieties of sorghum (Sorghum bicolor (L.) Moench.)

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ABSTRACT

Aim: The study was planned to identify high yielding and stable sorghum varieties and to recommend for southwestern Ethiopia.

Materials and Methods: The experiment was conducted in two locations southwestern Ethiopia in different cropping seasons. Four released varieties, viz, Dagim, Baji, Geremew and Aba Melko were used for the experiment. Each plot has the size of 10 m x 10 m with row and plant spacing of 75 and 15 cm respectively.

Results: The varieties showed different performance across locations and years. Among the varieties, the highest average grain yield (39.35 qt/ha) was obtained from Aba Melko and 37.4 qt/ha was obtained from Dagim variety.

Conclusion: It was concluded that Aba Melko and Dagim could be used as checks to evaluate the performance of other genotypes and also can be recommended for wider cultivation in the locations of Southwestern Ethiopia.

Keywords: Aba Melko, Genotype by environment interaction, Performace, Sorghum bicolor.

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Introduction

Sorghum is a monocotyledon crop belongs to the *Poaceae* (grass) family, genus Sorghum, and it is scientifically called *Sorghum bicolor* subspecies *bicolor* (Smith and Frederickson, 2000). It is a perennial crop by nature and very suitable multi cut forage crop but where the end product is grain, it is as an annual rain fed crop (Poehlman and Sleper, 1995). It is a vigorous grass that reaches up to 6 m in height (Dicko *et al*. 2006). It has deep and spread roots with a solid stem, long leaves (0.3-1.4 m) and wide (1- 13 cm), with flat or wavy margins. It is naturally self-pollinating, but depending on panicle types it will reach up to 30% out-cross (Poehlman and Sleper, 1995) and the flowers open during the night or early morning. Those at the top of the panicle open first and it takes approximately 6 to 9 days for the entire panicle to flower (Laidlaw and Godwin, 2009). The many subspecies of sorghum are divided into four groups; grain sorghums, grass sorghums (for pasture and hay), sweet sorghums (used to produce sorghum syrups), and broom corn (for brooms and brushes) (Liang, 1988).

Ethiopia is among the top ten sorghum producing countries and the third largest producer of sorghum in Africa. Sorghum is largely considered as the most important staple food and feed crop following tef and maize. Cereals contributed more than 87% of total grain production and cover 80% of total area allocated for grains, and of cereals, sorghum contributes 16% of total cereal production and 15% of total area allocated for cereals (CSA, 2017). In 2015, 5.9 million small holder farmers produced 4.7 million tons of sorghum grain from an area of 1.8 million hectares (CSA, 2017). Sorghum is cultivated over a wide range of elevation and rainfall conditions in Ethiopia. It is a particularly important food and feed crop in the dry lowland areas, where moisture is limiting and it is often the only crop grown (Gebrekidan and Kebede, 1978; Damon, 1962). The grain is used for making injera (a fermented flat bread for which tef is preferred over sorghum), and porridge, or may be popped, or boiled whole. The sweet stems of some varieties are used as a confection (Alemu, 2018). Ethiopia is known to be one of the Vavilovian centres of origin, or diversity for many cultivated and wild species of crops, including sorghum (Vavilov, 1951). Sorghum is one of the cereal crops for which Ethiopia has been credited as being a centre of origin and/or diversity (Vavilov, 1951).

The genotype by environment interaction (GEI) is an important aspect in both, plant breeding programmes and the introduction of sorghum varieties. Deitos *et al*., (2006), indicated that GEI is important for plant breeding because it affects the genetic gain and recommendation and selection of cultivars with wide adaptability. On the other hand, different genotypes may have different performance in each region that can be capitalized to maximize productivity (Souza *et al*., 2008). Kang and Gorman (1989) indicated that, a significant GEI for a quantitative trait such as seed yield can seriously limit the efforts on selecting superior genotypes for improved cultivar development.

Even though Ethiopia is an important center of genetic diversity for sorghum (Vavilov, 1951) and provides germplasm having genetic diversity for yield and protein quality, host-plant resistance to insect pest (Yilma, 1991) and drought tolerance, still the research done regarding the crop improvement was limited compared to breeding program worldwide. However, in the last four decades research was conducting by dividing the sorghum growing areas in to four major traditional agro ecologies; dry lowland, intermediate altitude and high elevation areas. Landrace improvement through selection, hybridization and resistance variety development to biotic and abiotic for thematic areas was long lasting objectives of sorghum improvement program in Ethiopia (Chemeda, 2017). Accordingly, in the last four decades breeding program, a lot of improved sorghum varieties were released from different Research Center (Both Federal and Regional) (EIAR,2014). Lack of high yielding and stable varieties were major problem for variety recommendation. Therefore the objective of the experiment was to identify high yielding and stable released sorghum varieties and recommend for southwestern Ethiopia.

Materials and Methods

Description of experimental sites

The field experiment was carried out under rain-fed conditions at different locations of southwestern Ethiopia different testing site, during 2015 to 2018 cropping season.

The experiment was conducted in two locations southwestern Ethiopia in different cropping seasons. The description of experimental sites was recorded (Table 1).

Table 1: Experimental sites description

Locations	Altitude (m.a.s.l.)	Coordinates Latitude (N)	Longitude (E)	Temp (^{0}c)	Rainfall (mm)	Soil type
L1	1975	7^0 41′	37^0 12′	20	1600	Nitosol
L2	2636	7° 49'	37° 29'	NA	NA	Nitosol

NA = not available, L1 = Omonada, L2 = Yem special wereda

Experimental materials: Experimental materials are used (Table 2).

Table 2: Experimental materials description

No.	Variety name	Pedigree	Year of release	Releasing center	Adaptation area (m.a.s.l.)
1.	Dagim	(97 MW 6130(IS 10892 X RS/R20-8614-2 X IS 9379)	2011	MARC	1600-1900
2.	Baji	85MW5334	1996	MARC	1600-1900
3.	Germew	87BK-4122	2007	MARC	1600-1900
4.	Aba Melko	NA	2001	JARC	Southwestern Ethiopia

NA=not available,JARC=Jimma Agricultural Research Center,MARC=Melkassa Agricultural Research Center

Data Collection and Measurements

Phenotypic data on quantitative traits were collected on plant and plot basis. Days to 50% heading (DH), and days to 90% maturity (DM) were measured on plots basis. Plant height (PH, in cm), head length (HL, in cm), and head weight (HW, in cm) were measured on five randomly selected plants per plot. Grain yield (GY; grams of grain produced per plot, which is later converted in kg/ha) and thousand seed weight (TSW) were measured on the plots basis as per IBPGR and ICRISAT (1993).

Experimental design and field management:

The experiment was laid out at Omonada and Yem special wereda in 2015 to 2018 cropping season. Four released sorghum varieties (Dagim, Baji, Geremew and Aba Melko) were used for the experiment. Each plot has the size of 10m x 10m with row and plant spacing of 75 and 15cm respectively. The plots were fertilized with a basal application of Diammonium Phosphate (DAP) at 100kg ha^{-1} and top dressing was carried out with urea (100kg ha^{-1}) before earting up at 30 days after emergency as recommended.

Results and Discussion

Mean performance of four varieties across locations was presented (Table 3). Varieites were flowered and matured differently across locations. Days to flowering ranged from 102 (Baji) to 138.5 (Dagim) with the mean of 120.25. Physiological maturity ranged from 198 (Geremew) to 207.5 (Dagim). Comparing four varieties together, variety Baji was earlier in both days to flowering and maturity and Dagim was late in both flowering and maturity. Tsegau and Tegegn (2020) reported presence of variation in the sorghum traits of days to heading, maturity, plant height and grain yield.

Sorghum is a short-day plant (SDP) and adaptation to a wide range of environments is mainly determined by developmental responses to photoperiod and temperature (Craufurd *et al.*, 1999). Several studies indicated that both temperature and photoperiod affects phenology and thus influence adaptation of plants in particular environmental conditions (Craufurd *et al.*, 1999). Studies conducted showed development rates in sorghum to be affected by both temperature and photoperiod (Alemu, 2018).

When varieties are grown at several locations for testing their performance, their relative rankings usually do not remain the same. This causes difficulty in demonstrating significant superiority of any variety. GEI is present whether varieties are pure lines, single crosses, double crosses, top-crosses, S1 lines or any other material with which the breeder is working (Dabholkar, 1999).

Mean grain yield of varieties across different years and locations was recorded (Table 4). Mean yields of varieties across environments ranged from 30.05 qt/ha to 39.3 qt/ha with grand mean of 35.12 qt/ha qt/ha. Varieties grain yield ranged from 28.4 (Baji) to 44.5 (Aba Melko) in 2015 cropping season at Omonada wereda with the mean grain yield of 35.5 qt/ha. Variety Dagim (33.3 qt/ha) was high yielder at Omonada and Baji (20 qt/ha) low yielder at Omonada with average mean of 27.8 qt/ha during 2016 cropping season. Aba Melko (36.9 qt/ha) was high yielder and Geremew (24.8 qt/ha) was low yielder at Yem special wereda in 2016. In overall varieties compared, Variety Aba Melko (39.35 qt/ha) was high yielder and Geremew (30.05 qt/ha) low yielder. Location Yem special wereda was good yielding environment and Omonada low yielding environment. The ranking of genotypes was different from one environment to another. This indicated that genotypes may not express the same phenotypic performance under different environmental conditions or different genotypes may respond differently to a specific environment. In such circumstances the geographic region could be subdivided into sub regions which are relatively homogeneous. Varieties should be bred which are specifically adapted to these ecotypes.

Table 3: Mean Performance of phenological and growth traits of sorghum varieties tested at different locations of Jimma zone.

Varieties	**Traits**			
	DH	**DM**	**PH (cm)**	**Heads per plot**
Dagim	138.5	207.5	133.25	91
Geremew	115.5	198	147.3	89
Baji	102	185	147.65	107
Aba Melko	111.5	193.8	299.5	127

DH=days to heading, DM=days to maturity, PH=plant height

Table 4: Mean grain yield of sorghum varieties across locations and years of Southwestern Ethiopia

	Locations								
	Omonada					**Yem Special wereda**			**Overall mean across locations**
Varieties	**2015**	**2016**	**2017**	**2018**	**Mean**	**2016**	**2017**	**Mean**	
Dagim	33.6	33.3	35.9	46.3	**37.3**	33.5	41.5	**37.5**	**37.4**
Geremew	35.4	30.6	31.6	51.8	**37.3**	24.8	20.8	**22.8**	**30.05**
Baji	28.4	20	47.4	18.7	**28.6**	32.5	45.1	**38.8**	**33.7**
Aba Melko	44.5	27.3	45.2	27.1	**36.1**	36.9	48.3	**42.6**	**39.35**
Mean	**35.5**	**27.8**	**40**	**36**	**34.8**	**31.9**	**38.9**	**35.4**	**35.1**

Conclusion

Varieites showed different performances across years and locations. Crop breeders have been striving to develop genotypes with superior grain yield, quality and other desirable characteristics over a wide range of different environmental conditions. Genotype x environment interaction (GEI) effects is some of the main complications in the selection of broad adaptation in most breeding programmes. Aba Melko and Dagim could be used as checks to evaluate the performance of other genotypes and also can be recommended for wider cultivation in the locations of Southwestern Ethiopia.

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