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Performance of sorghum varieties in moisture stress areas of South Omo Zone

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ABSTRACT: Sorghum [*Sorghum bicolour* (L.)] is one of the most important cereal crops in Ethiopia. The low productivity of sorghum has been partly attributed to the use of low-yielding varieties and/or landraces. Field experiments involving four improved (ESH-1, Teshale, Dekeba, Melkam) and one local sorghum variety were carried out at Dasenech, Gnygatom, and Hammer woredas in 2019 under irrigation to identify the best performing varieties. The experimental design was a randomized complete block design (RCBD) with three replications. Parameters such as plant height, panicle length, 1000 seed weight, and seed yield were studied. The combined analysis of variance results showed that there were significant variations among the varieties for all the studied parameters. The mean values for plant height ranged from 172.33 cm for the improved variety Melkam to 263.44 cm for the local check. The mean values for panicle length ranged from 23.89 cm for the local check to 33.78 cm for the improved variety ESH-1. The mean values for 1000-seed weight ranged from 31.67 g for the variety Dekeba to 36.00 g for Melkam. The overall mean values for grain yield ranged from 1312.4 kg ha^{-1} for the local check to 4050.7 kg ha^{-1} for the improved variety Melkam. The grain yield advantages of 67.60, 64.54, 62.95, and 56.67% were obtained from the improved varieties Melkam, Dekeba, Teshale, and ESH1, respectively over the local check. The effect of varieties on grain yield was significant and therefore; the best performing varieties of sorghum namely Melkam (4050.7 kg ha^{-1}) and Dekeba (3701.4 kg ha^{-1}) are advisable and could be appropriate for sorghum production in the study areas and similar agro-ecologies even though further testing is required to put the recommendation on a strong basis.

Keywords: Sorghum, variety, yield, yield components.

INTRODUCTION

Sorghum is the world's fifth most important cereal, after wheat, rice, maize, and barley (FAO, 2010). The United States, India, Nigeria, Mexico, Sudan, and China are the largest producer of sorghum in the world (Agrama and Tuinstra, 2003). Sorghum is used as a major food grain in semi-arid tropical Africa (Tadesse *et al*., 2008). More than 105 countries in Africa, Asia, Oceania, and the Americas grow sorghum on 40 million hectares (Ashok Kumar *et al*., 2011), and 60% of this land is in Africa, where it continues to play an important food security role (Mutegi *et al*., 2011).

Sorghum is one of the most important cereal crops in Ethiopia comprising 15 to 20% of the total cereal production in the country (Wortmann, 2006). During the 2017/18 production year, Ethiopia produced 51,692,525.40 quintals of sorghum on 1,896,389.29 ha of land (CSA, 2018). It is widely distributed throughout Ethiopia and it is the most important cereal crop in the lowland areas because of its drought tolerance (Kebede, 1991). Ethiopia is the centre of origin and diversity for sorghum (Doggett, 1988). As suggested by CSA (2017), sorghum is used as whole flour mostly for making injera and the flour is also used for the preparation of 'kita' (nonfermented un-raised bread or unleavened bread) and local alcoholic drinks. CSA (2017) reported that in addition to grain, sorghum straw is an important feed for livestock. Ethiopian national average yield was 27.26 qt ha^{-1} (CSA, 2018); whereas, the world average yield was 2.3 t ha^{-1} (Tolessa, 1992). The low productivity of sorghum in Ethiopia could be attributed to biotic and edaphic factors affecting, directly and indirectly, sorghum production.

Sorghum is adapted to a wide range of environments. It is widely produced more than any other crop, in the areas where there is moisture stress. However, due to low moisture stress and lack of appropriate improved varieties that fit the growing condition, the productivity is very low.

Sorghum is the dominant crop in the low land areas of Southern Ethiopia, especially the South Omo Zone and Segen people Zone. Even though the crop is important in the target area, factors such as the lack of improved varieties associated with edaphic and biotic factors have been appreciated as one of the primary sources of lower sorghum production in the target areas. There had no trend of using improved sorghum varieties in the existing production system so it was the bottleneck problem in the study areas. Hence, there is a need to introduce improved sorghum varieties to the target area to increase production and productivity. Therefore, this study is aimed at and initiated to select the best performing sorghum varieties for the target area.

MATERIALS AND METHODS

Description of the study area

The adaptive research and seed multiplication activities were implemented in Dasenech, Hammer, and Nyangatom woredas of the South Omo Zone, Southern Nations, Nationalities, and Peoples Regional State. Geographically, these three administrative districts were found in the southwestern part of Ethiopia (Figure 1.), located at about 981, 801, and 971 kilometres, respectively from the capital (Addis Ababa). Astronomically, Dasenech woreda (administrative district) was found lying between 4°37′ to 4°48′ N latitude and 35°56 to 36°20′ E longitude, Hammer between 4°25′ to 5°30′ N latitude and 36°5′ to 36°59′ E longitude, and Nyangatom between 5°05′ to 5°21′ North latitude and 35°55′ to 36°14′ East longitude, respectively. The altitude of the areas varies between 353 m.a.s.l and 606 m.a.s.l for Dasenech, 371 m.a.s.l. and 2084 m.a.s.l for Hammer and 380 m.a.s.l and 497 m.a.s.l for Nyangatom district, respectively.

Treatments and experimental design

The experiment was executed by using four improved viz, Teshale, Dekeba, Melkam, and ESH-1, and one local sorghum variety. The field experiment was laid out in a randomized complete block design (RCBD) with three replications in Dasenech, Hammer, and Nyangatom woredas of the South Omo Zone. Sorghum was sown in ten rows per plot with a spacing of 75 cm between rows and 15 cm between plants after thinning and with a gross plot area of (7.5 m x 10 m= 75 m^2).

Data collection

At mid flowering stages, ten plants from each of the plots were selected randomly and uprooted carefully to determine crop growth parameters such as plant height and panicle length. Also, six central rows (10 m x 4.5 m = 45 m^2) were harvested for the determination of grain yield. Grain yield was adjusted to 12.5% moisture content. Ten plants were randomly selected from the six central rows to determine yield and yield components such as 1000 seed weight.

Data analysis

Analysis of variance was performed using the GLM procedure of R Statistical Software Version 3.4.2. Effects were considered significant in all statistical calculations if the p-values were $\leq$ 0.05. Means were separated using Fisher's Least Significant Difference (LSD) test. For combined analysis of variance, homogeneity of error variance was tested by the F-max method of Hartley (1950).

RESULTS AND DISCUSSIONS

According to the combined analysis of variance results, there were significant variations observed among the sorghum varieties for the studied agronomic traits (Table 1). This finding is in agreement with the previous reports of Adugna (2008), Belay and Meresa (2017), Seyoum *et al*. (2019), Assefa *et al*. (2020), Omoregie *et al*. (2021), Bejiga *et al*. (2021) and Teressa *et al*. (2021) in sorghum.

The result revealed that there were significant differences observed among the sorghum genotypes for plant height (Table 1). This finding is in line with the reports of Adugna (2008), Belay and Meresa (2017), Seyoum *et al*. (2019), Assefa *et al*. (2020), Omoregie *et al*. (2021), Bejiga *et al*. (2021) and Teressa *et al*. (2021). The maximum plant height of 292 cm was noted for the local check at Dasenech and the minimum of 138 cm was noted for the improved variety of Melkam at Gnangatom (Table 3). Similarly, Bejiga *et al*. (2021) reported that plant height ranged from 149 cm for genotype Macia to 386.73 cm for genotype IS 38279 with a mean of 299.174 cm. Generally,

Table 1. Mean Square Values for growth parameters, yield components, and grain yield of sorghum at South Omo Zone, in 2019.

Source of variations	DF	PH	PL	TSW	GY
Rep	2	3302.6*	9.489*	0.4667**	1327484*
Variety	4	13357.7***	121.967***	26.4222*	0.00104***
Location	2	291.8ns	5.489ns	16.0667ns	460648ns
Location*Variety	8	1702.8ns	9.933ns	11.7056ns	106863ns
Error	28	1423.1	16.275	7.4429	450746

Note that: *, ** and *** indicate significance at $p<0.05$, $P<0.01$ and $P< 0.001$, respectively and 'ns' indicate non-significant, DF= degree of freedom, PH= plant height (cm), PL= panicle length (cm), TSW= 1000 seeds weigh (g) GY= Grain Yield (kg ha^{-1}).

Table 2. Combined Results of Mean values of growth parameters, yield components and grain yield of sorghum varieties at South Omo Zone, in 2019.

Varieties	PH	PL	TSW	GY
Teshale	204.89b	26.778b	33.000ab	3029.0c
Melkam	172.33b	26.556b	36.000a	4050.7a
Dekeba	178.67b	26.889b	31.667b	3701.4b
ESH-1	174.00b	33.778a	32.111b	3542.2b
Local	263.44a	23.889b	32.556ab	1312.4d
Mean	198.67	27.578	33.067	3127.2
CV (%)	18.99	14.63	8.25	21.47
LSD (0.05)	51.810	5.5406	3.7469	922.08

Note that: PH= plant height (cm), PL= panicle length (cm), TSW= 1000 seeds weigh (g) GY= Grain Yield (kg ha^{-1}).

the overall mean values for plant height ranged from 172.33 cm for the improved variety Melkam to 263.44 cm for the local check (Table 2).

The analysis of variance results for mean square revealed that there were significant differences observed among the sorghum genotypes for panicle length (Table 1). This finding is in line with the reports of Adugna (2008), Belay and Meresa (2017), Seyoum *et al*. (2019), Assefa *et al*. (2020), Omoregie *et al*. (2021), Bejiga *et al*. (2021) and Teressa *et al*. (2021). The overall mean values for panicle length ranged from 23.889 cm for the local sorghum variety to 33.778 cm for the improved variety ESH-1 (Table 2). Correspondingly, Assefa *et al*. (2020) reported that the mean values of head length ranged from 17 cm (Chare) to 28 cm (Dagim), with a mean of 22 cm. The maximum panicle length of 35 cm was noted for the improved sorghum variety ESH-1 at Gnangatom and the minimum of 19 cm was noted for the local check at Dasenech (Table 3).

The combined analysis of variance results for mean squares showed that there were significant differences observed among the sorghum varieties for thousand seed weight (Table 1). This finding is in line with the reports of Adugna (2008), Belay and Meresa (2017), Seyoum *et al*. (2019), Assefa *et al*. (2020), Omoregie *et al*. (2021), Bejiga *et al*. (2021) and Teressa *et al*. (2021). The overall mean values for thousand seed weight ranged from 31.667 g for the improved varieties Dekeba to 36.000 g for the variety Melkam (Table 2). Correspondingly, Assefa *et al*. (2020) reported that the mean value of thousand seed weight ranged from 18 g for the variety Geremew to 31 g for the variety Meko and Mesay with an average value of 26 g. The maximum thousand seed weight of 37 g was noted for the improved sorghum variety Melkam at Gnangatom while the minimum of 28 g was noted for the improved sorghum varieties Dekeba and ESH-1 at Dasenech (Table 3). Similarly, Omoregie *et al*. (2021) reported that the sorghum genotype ranged from 12 g for the genotype Samsorg 46 to 17.3 gm for the genotype Samsorg 42.

The analysis of variance results depicted that there were significant differences observed among the sorghum varieties for grain yield (Table 1). This finding is in agreement with the previous reports (Adugna, 2008; Hussain *et al*., 2011; Yoseph and Sorsa, 2014; Belay and Meresa, 2017; Seyoum *et al*., 2019; Assefa *et al*., 2020; Omoregie *et al*., 2021; Bejiga *et al*., 2021; Teressa *et al*., 2021). The grain yield ranged from 1049 kg ha^{-1} for the local check at Gnangatom to 4476 kg ha^{-1} for the improved variety Melkam at Dasenech (Table 3). Generally, the overall mean values for grain yield ranged from 1312.4 kg ha^{-1} for the local sorghum variety to 4050.7 kg ha^{-1} for the improved variety Melkam (Table 2). Correspondingly, Bejiga *et al*. (2021) reported that the grain yield of sorghum ranged from 0.18 ton/ha for the genotype ETSL 100575 to 4.88 ton/ha for the genotype Gambella 1107.

The grain yield advantages of 67.60, 64.54, 62.95, and 56.67% were obtained from the improved varieties Melkam, Dekeba, Teshale, and ESH1, respectively over the local check.

Table 3. Mean values for the studied yield and yield component traits of five sorghum varieties at South Omo Zone, in 2019.

	PH (cm) Location				PL (cm) Location				TSW (g) Location				GY (kg ha^{-1}) Location			
Variety	**Dasenech**	**Hammer**	**Gynagatom**	**Mean**	**Dasenech**	**Hammer**	**Gynagatom**	**Mean**	**Dasenech**	**Hammer**	**Gynagatom**	**Mean**	**Dasenech**	**Hammer**	**Gynagatom**	**Mean**
Teshale	250	221	183	218	24	25	27	25	34	33	32	33	2865	2400	4052	3106
Melkam	171	151	138	153	29	24	27	27	36	31	37	35	4476	4007	4200	4228
Dekeba	157	159	149	155	27	28	30	28	28	34	29	31	3124	2757	4203	3361
ESH-1	188	177	167	177	34	34	35	34	28	35	31	34	4348	4306	4203	2850
Local	292	243	260	265	19	22	20	20	36	32	35	32	1244	1957	1049	1417
CV (%)	5	23	15	15	6	19	6	10	6	4	6	5	28	25	3	19
$LSD_{(0.05)}$	13	83	51	49	2	9	3	5	2	2	4	3	1071	1437	181	896

Note: PH= plant height (cm), PL=panicle length (cm), TSW= 1000 seed weight (g), GY= grain yield (kg ha^{-1}).

Conclusion and Recommendations

The overall mean values for grain yield ranged from 1312.4 kg ha^{-1} for the local check to 4050.7 kg ha^{-1} for the improved variety Melkam. The grain yield advantages of 67.60, 64.54, 62.95, and 56.67% were obtained from the improved varieties Melkam, Dekeba, Teshale, and ESH1, respectively over the local check. Based on the overall mean values for grain yield and yield advantages, it can be concluded that the use of the improved sorghum varieties such as Melkam and Dekeba is advisable and could be appropriate for sorghum production in the test area even though further testing is required to put the recommendation on a strong basis.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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