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Full Length Research

Evaluation of improved sorghum (*Sorghum bicolor* (L.) Moench) varieties for moisture deficit areas of Konso, Southern Ethiopia

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ABSTRACT: A field experiment involving seven improved sorghum [*Sorghum bicolor* (L.) Moench] varieties and one local check was carried out at Konso Woreda at Arfayde, Fuchucha and Sorobo farmers' training center during the 2016-2017 main cropping season to identify the best performing variety to the moisture deficit areas of Segen area people zone. The seven improved sorghum varieties include (Melkam, Seredo, Meko-1, 76TI#23, Teshale, Gubiye, Dekeba) and a local check. The experimental was arranged in a Randomized Complete Block Design (RCBD) with three replications. Phenological and growth parameters such as yield and yield components were studied. The result showed that all phenological and growth parameters were significantly affected by variety, also grain yield were significantly affected by variety. Grain yield accounted for 75.28 and 50.74% at Sorobo, 5 3.46 and 51.28% at Arfayde were obtained from the improved sorghum varieties Melkam and Teshale respectively, 58 and 40% were obtained from the improved sorghum varieties 76T1#23 and melkam at Fuchucha respectively over the local check. The highest grain yields of 2.67 and 1.34 t ha^{-1} at Sorobo, 4.4667 and 4.2667 t/ha) at Arfayde were recorded for the varieties Melkam and Teshale, respectively. Whereas 4.2 and 2.93 t/ha grain yield at Fuchucha were recorded for the varieties 76T1#23 and Melkam, respectively. Therefore, it can be concluded that the use of the improved sorghum varieties such as Melkam or Teshale is advisable and could be appropriate for sorghum production in the studied areas even though further testing is required to put the recommendation on a strong basis.

Keywords: Growth parameters, phenological parameters, sorghum variety, yield components, yield.

INTRODUCTION

Sorghum is the fifth leading cereal grain worldwide after wheat, rice, maize and barley (FAO, 2008). It is a staple food for millions of the poorest and most food insecure people in the Semi-Arid Tropics (SAT) of Africa and Asia. Ethiopia is the third largest sorghum producer in Africa next to Nigeria and the Sudan (FAO, 2008). The crop ranks third in area of cultivation and in total production among cereals next to teff and maize. The current sorghum production in Ethiopia is estimated to be 3.60 million tons on an area of 1.71 million hectares of land giving the national average grain yield of 2.11 tons per hectare (CSA, 2013). It is the major crop in drought stressed lowland areas that cover 66% of the total arable land in the country. Sorghum is an important food crop in Ethiopia where it is widely grown in the highlands, lowlands and semi-arid regions of in Ethiopia (Richard and Jorgensen, 2008); especially in moisture stressed parts where other crops can least survive. It has tremendous uses for the Ethiopian farmer and no part of this plant is ignored (Adugna, 2007). Besides being a major source of staple food for humans, it serves as an important source of feed and fodder for animals.

Sorghum is one of the leading traditional food crops in Ethiopia comprising 15 to 20% of the total cereal

production in the country (CSA, 2000; Wortmann et al., 2006). It is the dominant crop in the low land areas of Southern Ethiopia, especially Segen people Zone and South Omo Zone. Sorghum production is increasing in Segen people Zone of Southern Ethiopia, but there are a number of production constraints with this crop. Even though the crop is important in the target area, a number of factors constrained productivity of sorghum in the target areas. This is associated with the lack of improved varieties associated with edaphic and biotic factors that have been appreciated as one of the primary sources of lower sorghum production in the target areas. There had no trend of using improved of sorghum varieties within the existing production system, in order that it had been the bottle neck within in the study area. Hence; there is a need to introduce and evaluate improved sorghum varieties to the target area is crucial for sorghum production and productivity. Therefore, this study is aimed at and initiated with the objective of selecting the best performing sorghum varieties to the target area.

MATERIALS AND METHODS

Description of the study area

The experiment was conducted at farmer's training center at Konso Woreda at different Kebeles. It is located at 036° 40.259' E longitude and 05° 38.332' N latitude and at an altitude of 1208 meters above sea level (masl). Geographically, Konso Woreda is situated in South Ethiopia at about 597 km from the capital Addis Ababa. The long term weather data of the area revealed that the mean annual rainfall of the area is 69.54 mm with a range of 42.55 to 125.76 mm. The experiment was conducted during the main cropping season (March to July, 2016 and 2017) under rain fed conditions.

Treatments and experimental design

The experiment was executed by using seven improved sorghum varieties and one local check (Table 1). It was laid out in a Randomized Complete Block Design (RCBD) with three replications. The plot size was 5 x 3 m (15 m^2). During planting, the seeds were manually drilled 8 kg ha^{-1} in to five meters long four row plot spaced 0.75 m apart. At third week, approximately 21 days after planting, the seedlings were thinned to 0.15 m distance between plants. Nitrogen and phosphorus fertilizer were applied in the form of urea (46% N) and diammonium phosphate (18% N and 46% P_2O_5), 50 kg ha^{-1} urea and 100 kg ha^{-1} of diammonium phosphate (DAP) were used respectively. DAP fertilizer was applied at the time of planting (as basal application), whereas urea was applied in the form of split application, half of it together with DAP and the rest as top dressing before heading at knee stage of the crop. Hand weeding was practiced as frequently as needed.

Data collection

Phenological parameters

Phenological parameters such as days to emergence, days to heading and days to maturity were recorded. Days to emergence was recorded when 50% of the plants per plot emerged while days to heading was recorded by counting the number of days after emergence when 50% of the plants per plot had the first open flower. Days to maturity were recorded when 90% of heads per plot had mature.

Growth parameters

At mid flowering stages five plants from each of the plots were selected randomly and carefully to determine crop growth parameters such as plant height.

Grain yield

Two central rows (5 m x 1.5 m = 7.5 m^2) were harvested for determination of grain yield. Grain yield was adjusted to 12.5% moisture content.

Statistical analysis

Analysis of variance was performed using the GLM procedure of SAS Statistical Software Version 9.1 (SAS, 2007). Effects were considered significant in all statistical calculations if the p-values were < 0.05. Means were separated using Fisher's Least Significant Difference (LSD) test.

RESULTS AND DISCUSSION

According to the result of analysis of variance for mean squares, days to emergence, days to heading, days to maturity, plant height and grain yield was significantly ($p<0.05$) influenced by varieties (Tables 2, 3 and 4). Similar result was reported by the previous works of Lema (2016) and Hussain et al. (2011).

On the other hand, days to emergence of sorghum varieties was not significantly affected by varieties at Fuchucha (Table 3). Though no significant variations observed for days to emergence, but there was relatively lowest days to emergence recorded for the improved varieties meko and 76T1#23 than the local check (Table 3). Days to emergence (6.33) and (6.33) were recorded for the improved varieties meko and 76T1#23 respectively, while the higher days to emergence (7.67) was noted for the local check (Table 3).

The result of analysis of variance for mean squares revealed that there was a significant variation observed

Table 1. The details of varieties, agronomic characteristics and breeding center of sorghum genotypes used for the study.

Sorghum varieties	Accession code/Pedigree	Year of Release	Releasing Center	Flowering dates	Maturity date	Productivity t ha^{-1}	
						Research	Farmer
76TI#23	954062x73pp9	1979	MARC/EIAR	60-70	90-120	2.5-4.5	-
Seredo	Seredo	1986	MARC/EIAR	60-70	90-120	3.0-5.0	-
Meko 1-1	M36121	1997	MARC/EIAR	61-92	120-130	2.2-3.3	1.7
Gobiye	P9410	2000	MARC/EIAR	83	100-120	1.9-2.7	-
Teshale	3443-2-OP	2002	MARC/EIAR	65-76	100-120	2.6-5.2	-
Melkam	WSV387	2009	MARC/EIAR	76-82	118	3.7-5.8	35-43
Dekeba	ICSR24004	2012	MARC/EIAR	75	119	3.7-4.5	26-37
Local	-	-	-	75-80	110-120	-	-

MARC = Melkassa Agricultural Research Center; EIAR = Ethiopian Institute of Agricultural Research.
Source: Data were sourced and organized from MoANR (2016) and MoA and EATA (2018).

Table 2. Crop phenology, growth parameters yield and yield components of sorghum as affected by variety at Sorrobo in 2017.

Varieties	Days to 50% emergence	Days to heading	Days to maturity	Plant height (cm)	Grain yield (t ha^{-1})
Melkam	10.667^{ba}	62.333^{ba}	159.933^{bc}	134.67^{bc}	2.67^{a}
Teshale	12.000^{ba}	59.000^{ba}	158.933^{bc}	147.00^{bac}	1.34^{b}
Seredo	10.667^{ba}	65.000^{a}	162.267^{bc}	162.67^{ba}	0.88^{c}
Gubiye	13.667^{a}	63.000^{ba}	162.933^{bc}	113.33^{c}	0.67^{c}
Dekeba	8.667^{b}	62.000^{ba}	147.600^{c}	153.33^{bac}	0.67^{c}
Meko	9.333^{b}	60.333^{ba}	166.867^{bc}	144.00^{bc}	0.88^{c}
Local	11.333^{ba}	60.667^{ba}	187.400^{a}	192.67^{a}	0.66^{c}
76T1#23	9.333^{b}	56.000^{b}	169.867^{ba}	128.67^{bc}	1.33^{b}
LSD 0.05	3.5746	8.266	19.477	47.421	0.5233
CV (%)	19.06218	7.732660	6.762055	18.41574	17.49115

Means with the same letters within the columns are not significantly different at p<0.05.

Table 3. Crop phenology, growth parameters yield and yield components of sorghum as variety at Fuchucha in 2016.

Varieties	Days to 50% emergence	Days to heading	Days to maturity	Plant height (cm)	Grain yield (t ha^{-1})
Melkam	7.667	64.000^{a}	107.333^{c}	140.73^{ba}	**2.9333^{b}**
Teshale	7.333	85.000^{a}	144.333^{a}	156.00^{a}	2.0000^{c}
Seredo	7.667	64.333^{b}	85.333^{f}	133.73^{bac}	1.0667^{d}
Gubiye	7.667	59.333^{c}	96.000^{e}	116.87^{c}	1.8000^{cd}
Dekeba	7.333	62.000^{cb}	118.667^{b}	127.60^{bc}	2.0667^{c}
Meko	6.333	61.333^{cb}	101.00^{de}	152.27^{a}	2.3667^{cb}
Local	7.667	61.667^{cb}	96.333^{e}	136.73^{bac}	**1.7667^{cd}**
76T1#23	6.333	54.333^{d}	104.00^{dc}	145.27^{ba}	**4.2000^{a}**
LSD 0.05	NS	3.1426	5.384	22.682	0.7504
CV (%)	18.46250	2.803910	2.88344	9.341726	18.83612

Means with the same letters within the columns are not significantly different at p<0.05.

among the sorghum varieties for grain yield at all location (Tables 2, 3 and 4). This finding is in line with the findings of previous works (Lema, 2016; Hussain et al., 2011). The mean value result showed that the maximum grain yields of 2.67 and 1.34 t ha^{-1} were recorded for the sorghum varieties Melkam and Teshale respectively and the minimum grain yield of 0.66 t ha^{-1} was noted for the local check. Grain yield advantages of 75.28 and 50.74% were obtained from the improved sorghum varieties Melkam and Teshale, respectively over the local check in this study

Table 4. Interaction Mean of yield and yield component of different sorghum varieties evaluated at Arfayde (2016 and 2017).

Varieties	Days to 50% emergence	Days to heading	Days to maturity	Plant height (cm)	Grain yield (t ha^{-1})
Melkam	9.6667^{bac}	63.000^{ba}	114.333^{c}	145.467^{c}	4.4667^{a}
Teshale	10.6667^{ba}	63.500^{a}	112.000^{c}	169.467^{a}	4.2667^{a}
Seredo	9.666b^{ac}	62.500^{ba}	119.167^{b}	140.867^{c}	3.1500^{cb}
Gubiye	11.5000^{a}	61.833^{ba}	113.833^{c}	147.800^{bc}	3.0000^{cb}
Dekeba	8.6667^{c}	63.667^{a}	106.500^{d}	143.833^{c}	3.6000^{b}
Meko	8.8333^{bc}	60.500^{ba}	111.000^{c}	159.567^{ba}	2.6667^{cd}
Local	9.3333^{bc}	59.500^{bc}	147.333^{a}	151.350^{bc}	2.0833^{d}
76T1#23	8.6667^{c}	56.500^{c}	111.000^{c}	159.400^{ba}	3.3167^{b}
LSD 0.05	1.8747	3.9	4.0985	11.908	0.6016
Year 1	8.5417^{b}	61.7083	118.833^{a}	139.963^{b}	2.5750^{b}
Year 2	10.7083^{a}	61.0417	114.958^{b}	164.475^{a}	4.0625^{a}
LSD (5%)	0.9373	NS	2.0492	5.9539	0.3008
CV (%)	16.51843	5.389180	2.973510	6.634556	15.37289

Means with the same letters within the columns are not significantly different at $p<0.05$.

(Table 3). The Mean value result showed that the maximum grain yields of 4.2 and 2.94 t ha^{-1} were recorded for the sorghum varieties 76T1#23 and melkam respectively and the minimum grain yield of 1.76 t ha^{-1} was noted for the local check (Table 4). Grain yield advantages of 58 and 40% were obtained from the improved sorghum varieties 76T1#23 and melkam, respectively over the local check in this study.

Varieties by year interaction also indicated that there was significant difference for all tested parameters except days to heading; which were not significantly different over the year (Table 4). Varieties melkam and Teshale gave the highest grain yield 4.47 and 4.27 t/ha respectively. Melkam variety gave the highest grain yield in both years and performed consistently over years; whereas local check gave the lowest grain yield of 2.08 t/ha, it had relatively weak performance over the years among all improved varieties. Melkam and Teshale gave yield advantage of 53.46 and 51.28% over the local check respectively. The use of improved sorghum varieties had brought a proportional yield increment than the local check.

Conclusion

Using improved varieties of sorghum could make an important contribution to increase agricultural production and productivity in areas like Konso where there is low practice of using improved technologies such as improved crop varieties. To this end, use of improved sorghum technologies such as improved varieties with its full package could be one of the alternatives to improve productivity by small scale farmers. All the yield and other parameters studied in this experiment such as grain yield, days to emergence, days to heading, days to maturity and plant height were significantly affected by varieties. The highest grain yields were recorded for the sorghum varieties Melkam and Teshale. Therefore, it can be concluded that use of the improved sorghum varieties such as Melkam or Teshale is advisable and could be appropriate for sorghum production in the test area and similar agro-ecology, even though further testing is required to put the concrete recommendation.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest.

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