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Response of midland sorghum varieties to different intra-row spacing at Kaffa zone, South western Ethiopia

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ABSTRACT

The experiment was conducted to determine optimum plant spacing and suitable variety and as well as to identify the interaction effect of varieties and Intra-row spacing on the yield of sorghum. The experiment having a factorial arrangement of three varieties (Geremew, Lalo and farmer's local variety) and three intra-row levels (10 cm, 15 cm and 20 cm) was laid out in randomized complete block design (RCBD) with three replications. According to the current results, varieties were significantly ($p<0.05$) affected by all the parameters (days to maturity, plant height, panicle length, thousand seed weight and total grain yield) except stand count. The maximum days to maturity and total grain yield (205.2 days and 5628.1 kg ha^{-1} respectively) were obtained from Lalo. The highest thousand seed weight (23.1 g) was recorded from Geremew and at it takes a short period for maturity (119.5 days). Similarly, intra-row spacing significantly ($p<0.05$) affected the panicle length and stand count. The highest panicle length (28.15 cm) was recorded in 15 cm intra-row spaced plants. The maximum stand count (78.6 % and 83.6%) was obtained from 15 cm and 20 cm spaced plants respectively. Generally, the outcome of this study revealed that even though the yield was statistically non-significant to intra-raw spacing, at 15cm and 20cm the grain yield was a maximum of 4178.5 kg ha^{-1} and 4190.9 kg ha^{-1}, respectively. Therefore, among the intra-row spacing 20 cm intra-row spacing for its minimized planting materials (seed) and easy management and among the varieties, Lalo could be promoted in study areas and similar agro-ecologies.

Keywords: Intra-row, Sorghum, Spacing, Variety

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Introduction

Sorghum is one of the leading traditional food crops in Ethiopia and comprising 15-20% of the total cereal production in the country (Wortmann *et al.,* 2009). It is the second major cereal crop next to teff (Wortmann *et al.,* 2009). Sorghum grain has a high nutritive value, with 70-80% carbohydrate, 11-13% protein, 2-5% fat, 1-3% fiber, and 1-2% ash. Protein in sorghum is gluten free and thus, it is a specialty food for people who suffer from celiac disease, including diabetic patients and is a good substitute for cereal grains such as wheat, barley, and rye (Dial, 2012). However, its average yield per unit area is not more than 1.0 t ha^{-1} (CSA, 2014), which is below the world average of 2.3 t ha^{-1} (Tolessa, 1993).The main reason for the lowering productivity of sorghum in Ethiopia is lack of improved variety, moisture stress, low fertility problem and lack of proper agronomic practices (Tewodros *et al.,* 2009). Row spacing and plant populations are variables that can have a significant impact on the net returns of sorghum producers. Even though study area have potential to produce sorghum but its production and productivity is not satisfactory might be due to lack to access to improved variety, inappropriate spacing, and poor agronomic management practice. Therefore, determining location specific agronomic management practice and adaptive variety of sorghum is important to ensure nutritional and food security of study area. Hence, the paper initiated with the following objectives:

- To determine optimum plant spacing and suitable variety for yield and yield component of sorghum.
- To identify interaction effect of varieties and Intra spacing on yield and yield components of sorghum.

Materials and Methods

Description of experimental site

The field experiment was conducted at Kutashora kebele, shishonde woreda, kaffa zone of south western Ethiopia. The site is located at latitude 7°16'60.0"N and longitude of 35°52'00.0"E. Major cereals crops grown in the study area are sorghum, maize, groundnut, and fruits like mango and vegetables etc. Sorghum is the staple crops cultivated by farmers in the vicinity of the area.

Treatments and experimental design

A field experiment was laid out in Randomized Complete Block Design (RCBD) with three replications and 9 treatment combinations consisting of two factors three intra-row spacing (10 cm, 15 cm and 20 cm and variety Geremew, Lalo and local as control within inter-row spacing of 75 cm. The plot size was 3.0 m x 3.6 m (10.8 m^2). The total row for each plot was four and the outer two rows were served as border. The middle two rows were used for data collection. Spacing of 1 m and 1.5 m were allocated between plots and blocks, respectively.

Data collection

Days to 90% maturity: It was recorded number of days from planting to a stage when 90% of the plants in a plot produced matured seeds.

Plant Height: It was measured from five randomly selected plants from middle two row at maturity from the ground level to the base of the panicle was taken and the mean of value was recorded.

Final stand count: Final stand count at harvest of the crop was recorded from the net plot area.

Panicle height (cm): At the time of maturity five plants from each plot were collected randomly from the center two rows and length of panicle height from its base to the tip were measured and recorded and the mean of five sampled plants from each plot was taken.

Thousands of seed weight (g): Thousand-grain seed were counted from sample taken from the net plot area and prior to measuring the weight of the kernel was adjusted to 12.5% moisture level. The kernels were counted using the hand count and the weights were determined using the sensitive balance.

Grain yield (kg): All plants in the net plot area were harvested to determine grain yield per plot and were converted to per hectare bases and were adjusted to 12.5 % moisture level.

Data analysis

The data were subjected to analysis of variance (ANOVA) using statistical analysis Software (SAS version 9.3) with general linier model procedure. Mean separation was done using Fisher's Least Significant Difference (LSD) test at 5% probability level.

Results and Discussion

Phenological and growth parameters

Days to maturity

The analysis of variance of this study showed significant differences to date of maturity among sorghum varieties (Table 1, 2, 3). However, the intra-row spacing and interaction between the two factors did not significantly influence date of maturity. Variety Geremew matured significantly earlier (119.5 days) followed by Lalo (205.2 days) which was statistically similar with the farmer's local. The variation in days to maturity among the sorghum varieties is likely to be related with differences in their inherent genotypic variation, as supported by the earlier findings of Abubakar and Bubuche (2013); Chavan *et al.* (2010); Hassen *et al.* (2015); Pinho *et al.* (2014); Yosef *et al.* (2009) who reported that there was significant variation among sorghum variety in days to maturity.

Plant height

In the current study the combined mean value of plant height was significantly influenced by sorghum varieties differences, though intra-row spacing and the interaction effect of the two main factors showed non-significant (Table 1, 2, 3). The highest plant height (4.5 m) was obtained from local followed by Lalo (4.3 m) while the minimum was from Geremew (1.44) (Table 3). This result agrees with the report of Aklilu *et al.* (2021) who reported significant differences observed in plant height among the sorghum varieties are likely to be related to genetic differences. Although Eldie and Fadul (2017) showed that the effect of plant population on plant height was not- significant. The report of Zakka *et al.* (2020) showed that no significant effect of plant spacing on plant height, leaf length, leaf width, number of tillers per plant, stem diameter and number of leaves per plant. This was not in agreement with the findings of Munza *et al.* (2018) who reported significant effect of plant spacing on stand count per plot, leaf width and leaf area index, respectively.

Table 1. Response of sorghum varieties and intra-row spacing to maturity, plant height and stand count in 2020.

Treatments	Days to maturity	Plant height(m)	Stand count (%)
Varieties			
Geremew	125.4c	1.34c	73.2
Lalo	214.8b	4.01b	73.4
Local	227.4a	4.24a	78.9
Lsd (0.05)	0.65	0.18	7.9
Intra-row spacing			
10	216.1a	3.16	61.8
15	216.2a	3.27	78.4
20	215.3b	3.16	85.3
Lsd (0.05)	0.65	NS	7.9
CV (%)	0.27	5.11	9.8

LSD (5%) = Least significant difference at P= 0.05, CV (%) = coefficient of variation in percent, NS= non-significant
Means with the same letter(s) with in a column are nor significantly different at 5% level of significance.

Table 2. Response of sorghum varieties and intra-row spacing to maturity, plant height and stand count in 2021.

Treatments	Days to maturity	Plant height(m)	Stand count (%)
Varieties			
Geremew	114.1c	1.54c	71.3
Lalo	195.6b	4.53b	70.2
Local	199.8c	4.75c	80.3
Lsd (0.05)	1.74	7.86	NS
Intra-row spacing			
10	169.2	3.63	65.4b
15	170.2	3.56	80.9a
20	170.0	3.62	84.03a
Lsd (0.05)	NS	NS	7.5
CV (%)	0.94	2	9.25

LSD (5%) = Least significant difference at P= 0.05, CV (%) = coefficient of variation in percent, NS= non-significant
Means with the same letter(s) with in a column are nor significantly different at 5% level of significance.

Table 3. Combined values of phonological and growth parameters of sorghum as affected by varieties intra-raw spacing.

Treatments	Days to maturity	Plant height(m)	Stand count (%)
Varieties			
Geremew	119.5b	1.44c	73.4
Lalo	205.2a	4.30b	72.7
Local	213.6a	4.50a	78.8
Lsd (0.05)	23.6	0.2	NS
Intra-row spacing			
10	192.67	3.39	62.6b
15	193.22	3.41	78.6a
20	192.67	3.39	83.6a
Lsd (0.05)	NS	NS	5.7
CV (%)	18.1	8.9	11.4

LSD (5%) = Least significant difference at P= 0.05, CV (%) = coefficient of variation in percent, NS= non-significant
Means with the same letter(s) with in a column are nor significantly different at 5% level of significance.

Stand count

Analysis of variance showed varieties and interaction of variety and intra-row spacing was not statistically significant but intra–row spacing had significant ($p<0.05$) variations on stand count (Table 1, 2, 3). The highest stand count (83.6 and 78.6) was obtained from 20 cm and 15 cm intra-row spaced plants while the minimum (62.6) was from narrow intra-row spaced plants. The most likely reason for significantly maximum stand count at wider intra-row spaced plants was relatively a fewer number of plants. Thus, the increment of stand count with increasing intra-row spacing is to be due to lesser competition among neighboring plants for nutrient, light, space and water. The reasons for the reduction of stand count at the narrowest intra row spacing might be due to closing effect and hence plants crowded out and will became die due to intense competition for growth resources especially for light energy.

Yield parameters

Panicle length

Panicle length of sorghum was significantly influenced (P>0.05) by varieties and intra- row spacing (Table 4, 5, 6). However the interaction of two (variety and intra-row spacing) main effects did not significantly affect panicle length of the sorghum.

The maximum (31.0 cm) panicle length was obtained from the local cultivar followed by Lalo (27.3 cm) which was statistically in parity with Geremew (Table 6). The significant differences observed in panicle length of sorghum varieties could be associated with inherent genetic differences. Among the intra-row spacing the highest (28.15 cm and 27.8 cm) panicle length was recorded from 15 and 20 cm intra-row spaced plants while the minimum was from 10cm (Table 6). The maximum panicle length obtained from relatively wider intra-row spacing could be most probably due to the ability of the plant to use soil nutrients, water and light efficiently and effectively.

Table 4. Response of sorghum varieties and Intra-row spacing to panicle length, thousand seed weight and grain yield in 2020.

Treatments	Panicle Length (cm)	Thousand seed weight (g)	Grain Yield (kg ha^{-1})
Varieties			
Geremew	24.4b	22.7a	2730.8c
Lalo	25.6b	18.3	5374.4a
Local	30.5a	21.9a	3664.0b
Lsd (0.05)	1.79	2.8	850.37
Intra-row spacing			
10	26.3	21.1	3720.6
15	27.5	20.7	3831.5
20	26.7	21.1	4217.2
Lsd(0.05)	NS	NS	NS
CV (%)	6.15	12.4	19.9

LSD (5%) = Least significant difference at P= 0.05, CV (%) = Coefficient of variation in percent, NS= non-significant
Means with the same letter(s) with in a column are nor significantly different at 5% level of significance.

Table 5. Response of sorghum varieties and Intra-row spacing to panicle length, thousand seed weight and grain yield in 2021.

Treatments	Panicle Length (cm)	Thousand seed weight (g)	Grain Yield (kg ha^{-1})
Varieties			
Geremew	25.4b	23.6a	2188.2c
Lalo	27.1b	19.2b	5881.8a
Local	31.4a	18.1b	4990.8b
Lsd (0.05)	3.12	4.1	717.28
Intra-row spacing			
10	26.1	21.2	4370.7
15	28.8	18.9	4525.5
20	28.9	20.8	4164.7
Lsd (0.05)	NS	NS	NS
CV (%)	10	18.5	15.15

LSD (5%) = Least significant difference at P= 0.05, CV (%) = coefficient of variation in percent, NS= non-significant
Means with the same letter(s) with in a column are nor significantly different at 5% level of significance.

Table 6. Combined values of yield and yield component of sorghum as affected by varieties intra-raw spacing.

Treatments	Panicle Length (cm)	Thousand seed weight (g)	Grain Yield (kg ha^{-1})
Varieties			
Geremew	24.8b	23.1a	2459.5c
Lalo	27.3b	19.9b	5628.1a
Local	31.0a	18.7b	4327.4b
Lsd (0.05)	1.5	2.2	593.74
Intra-row spacing			
10	26.2c	21.14	4045.6
15	28.15a	19.70	4178.5
20	27.80b	20.90	4190.9
Lsd (0.05)	1.54	NS	NS
CV (%)	8.4	15.8	21.2

LSD (5%) = Least significant difference at P= 0.05, CV (%) = coefficient of variation in percent, NS= non-significant
Means with the same letter(s) with in a column are nor significantly different at 5% level of significance

Thousand seed weight

Sorghum varieties showed a significant (p<0.01) difference in thousand seed weight, despite the main effect of intra-row spacing and the interactions of the two factors were not significant (Table 4, 5, 6). The maximum thousand seed weight (23.1 g) was recorded from variety Geremew followed by variety Lalo which was statistically similar with farmer's local variety. The significant differences observed in thousand seed weight among the sorghum varieties are likely to be related to genetic differences. This result was in line with the finding of Eldie and Fadul (2017) who have shown the differences among sorghum varieties in thousand seed weight.

Grain yield

Result of analysis of variance (ANOVA) revealed highly significant differences for grain yield among the sorghum varieties despite intra-row spacing and interaction between the two factors did not significantly influence the grain yield of sorghum (Table 4, 5, 6). The maximum grain yield (5628.1 kg) was obtained from variety Lalo followed by Local whereas the minimum grain yield (2459.5 kg ha^{-1}) was recorded from variety Geremew. On the other hand, among the three varieties, variety Geremew was the shortest in plant height and too early maturing variety and hence it was more exposed for bird attack than the others variety considered in this experiment. These differences in the grain yield of varieties may have been due to the differences in their yield potential. The present results are in agreement with the findings of Eldie and Fadul (2017), Farnham (2001) and Zakka *et al.* (2020) who confirmed the existence of significant variations in grain yield of sorghum varieties.

Conclusion and Recommendation

Plant spacing plays an important role on growth, development and yield of crops. Particularly, appropriate variety with optimum plant density is important to grow plants properly with their aerial and underground parts by utilizing more sunlight and soil nutrients. It increases the capture of solar radiation within the canopy which in turn increases yield production. The experiment was conducted to determine optimum plant spacing and suitable variety for yield and yield component of sorghum. According to the current result, varieties were significantly affected all the parameters considered in this study except stand count. The highest grain yield was obtained from Lalo as compared to Geremew and the local. Variety Geremew was early maturing as compared to others and grow short but the least in yield. The main problem associated with this early maturing variety was the bird attack. This result also indicated that intra-row spacing was not significantly influence the parameters considered in this study. Therefore, among the varieties, variety Lalo will be recommended for its maximum yield. Even though the yield was non-significant to among intra-row spacing, 20 cm intra-row spacing could be promoted because of minimized planting materials (seed) and easy management.

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