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ORIGINAL ARTICLE

Response of midland sorghum varieties to different intra-row spacing at kaffa zone south western Ethiopia

A. Abriham

Department of plant science, Bonga Agricultural Research Center, Bonga, Ethiopia

**Corresponding author E-mail: asheabrish@gmail.com*

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The experiment was conducted to determine optimum plant spacing and suitable variety and as well as to identify interaction effect of varieties and Intra-row spacing. The experiment was set up in a randomized complete block design (RCBD) with three replications, and it included 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). The current findings show that all the parameters (days to maturity, plant height, panicle length, thousand seed weight, and total grain yield) were significantly (p 0.05) affected by variety, with the exception of stand count. The maximum days to maturity and total grain yield (205.2 days and 5628.1 kg ha^{-1} respectively) was obtained from Lalo. The highest weight of a thousand seed was recorded from Geremew (23.1 g), and matured early. Panicle length and stand count were also significantly (p 0.05) affected by intra-row spacing. The longest panicle length measured was 28.15 cm in plants spaced 15cm. Additionally, plants planted at 15 cm and 20 cm apart had the highest stand counts (78.6% and 83.6%), respectively. Overall, the results of this study showed that, although though the yield was statistically insignificant to intra-raw spacing, the grain yield was at its highest at 15 cm and 20 cm, respectively (4178.5 kg ha^{-1} and 4190.9 kg ha^{-1}). Therefore, Lalo might be encouraged in research areas and similar agro-ecologies among the varieties and among the intra-row spacing 20cm intra-row spacing for its reduced planting materials (seed) and easy management.

Keywords: Intra-row, Sorghum, Spacing, Variety.

Introduction

One of Ethiopia's most important traditional food crops, sorghum accounts for 15-20% of the nation's total cereal production (Wortmann et al., 2006). Next to teff, it is the second-largest cereal crop (Wortmann et al., 2006). With 70-80% carbohydrate, 11-13% protein, 2-5% fat, 1-3% fiber, and 1% ash, sorghum grain has a high nutritional value. Sorghum is a speciality meal for anyone with celiac disease, including diabetics, and is an excellent alternative to cereal grains like wheat, barley, and rye because the protein is gluten-free (Dial, 2012).

However, according to CSA (2014), its average yield per unit area is less than 1.0 t ha^{-1}, which is less than the global average of 2.3 t ha^{-1} (Benti, 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). The number of plants per row and their density are two factors that can significantly affect the net returns of sorghum growers. Even though the study region has the capacity to produce sorghum, its production and productivity are not satisfactory. This could be because there is a lack of access to better varieties, improper spacing, inappropriate spacing, poor agronomic management practice. In order to achieve dietary and economic security, it is crucial to identify location-specific agronomic management practices and adaptive varieties of sorghum. Consequently, this experiment was conducted with the following goals:

Objectives

To evaluate the best variety for sorghum yield and yield component, as well as the ideal plant spacing.

To determine how cultivars and intra spacing interact with sorghum yield and yield components.

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

With three replications and nine treatment combinations made up of two variables, three intra-row spacings (10 cm, 15 cm, and 20 cm), and variety (Geremew, Lalo, and local as control) with in inter-row spacing of 75 cm, a field experiment was set up using a Randomized Complete Block Design (RCBD).

The plot measured 3 m by 3.6 m. (10.8 m^2). Each plot had four rows overall, with the outer two rows acting as the border. Data collection was done using the middle two rows. Plots and blocks were given a 1 m and 1.5 m separation, 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

When the plants were mature, the ground level to the base of the panicle was measured on five randomly chosen middle two row plants, and the mean 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 maturity, five plants from each plot were randomly selected from the middle two rows, and the length of the panicle from the base to the tip was measured and recorded. The mean of the five plants from each plot that were sampled was then calculated.

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 seed was adjusted to 12.5% moisture level. The weights were calculated using the sensitive balance, and the weights of the seed were counted manually.

Grain yield (kg ha^{-1})

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

Significant differences in maturation dates between sorghum types were revealed by this study's analysis of variance. The intra-row spacing and interactions of the two factors, however, had no discernible impact on the 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. According to earlier research by Abubakar and Bubuche (2013), Chavan, et al., (2010), Hassen, et al., (2015), Pinho, et al., (2014), and Yosef, et al., (2009), who reported that there was significant variation among sorghum varieties in days to maturity, the variation in days to maturity among sorghum varieties is likely to be related with differences in their inherent genotypic variation (Table 1).

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	125.4[c]	1.34[c]	73.2
Lalo	214.8[b]	4.01[b]	73.4
Local	227.4[a]	4.24[a]	78.9
Lsd (0.05)	0.65	0.18	7.9
Intra-row spacing			
10	216.1[a]	3.16	61.8
15	216.2[a]	3.27	78.4
20	215.3[b]	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.

Plant height

Sorghum variety differences had a substantial impact on the total mean value of plant height in the current study, while intra-row spacing and the interaction effect of the two main components did not (Table 2).

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	114.1[c]	1.54[c]	71.3
Lalo	195.6[b]	4.53[b]	70.2
Local	199.8[c]	4.75[c]	80.3
Lsd (0.05)	1.74	7.86	NS
Intra-row spacing			
10	169.2	3.63	65.4[b]
15	170.2	3.56	80.9[a]
20	170.0	3.62	84.03[a]
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.

The highest plant height (4.5 m) was obtained from local followed by Lalo (4.3 m) while the minimum was from Geremew (Table 2). This outcome is consistent with the findings of Aklilu M., et al., (2021). Who reported large variations in plant height among sorghum varieties are probably due to genetic variations. While Die, Yahia and Fadul, Hussien (2017) and Zakka T., et al., (2020) demonstrated that the effect of plant population on plant height was not significant, these findings did not accord with those of Munza, et al., (2018), who found that plant spacing had a significant impact on plant height, stand count per plot, leaf width, and leaf area index (Table 3).

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	119.5[b]	1.44[c]	73.4
Lalo	205.2[a]	4.3[b]	72.7
Local	213.6[a]	4.5[a]	78.8
Lsd (0.05)	23.6	0.2	NS
Intra-row spacing			
10	192.67	3.39	62.6[b]
15	193.22	3.41	78.6[a]
20	192.67	3.39	83.6[a]
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

Varieties and their interactions with intra-row spacing were not statistically significant, according to an analysis of variance, although intra-row spacing had significant (p 0.05) variations on stand count (Table 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. Or 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

Variety and intra-row spacing had a significant impact on sorghum panicle length (P>0.05). However the interaction of two (variety and intra-row spacing) main effects did not significantly affect panicle length of the sorghum. The local cultivar produced panicles with a maximum length of 31 cm, while Lalo (27.3 cm), which was statistically equal to Geremew, came in second. The notable variations in panicle length among sorghum cultivars may be due to innate genetic variations.

The plants with the 15 and 20 cm intra-row spacing had the longest panicles (28.15 cm and 27.8 cm), while those with the shortest panicles (from 10 cm) were grown (Table 4). The ability of the plant to utilize soil nutrients, water, and light efficiently and effectively may be the reason why the maximum panicle length was reached with somewhat wider intra-row spacing (Table 5).

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	24.4^{b}	22.7^{a}	2730.8^{c}
Lalo	25.6^{b}	18.3	5374.4^{a}
Local	30.5^{a}	21.9^{a}	3664.0^{b}
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.

Thousand seed weight

Despite the main effect of intra-row spacing and the interactions of the two parameters being insignificant, sorghum cultivars revealed a significant (p 0.01) difference in thousand seed weight (Table 6). The variety Geremew recorded the highest thousand seed weight (23.1 gm), followed by the variety Lalo, which shared statistical similarities with the farmer's local variety. The substantial variations in thousand seed weight among the sorghum types are probably due to genetic variations. This outcome was consistent with that of Die, Yahia, and Fadul, Hussien (2017), who demonstrated the variations in sorghum cultivars' thousand seed weight.

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	24.8^{b}	23.1^{a}	2459.5^{c}
Lalo	27.3^{b}	19.9^{b}	5628.1^{a}
Local	31^{a}	18.7^{b}	4327.4^{b}
Lsd (0.05)	1.5	2.2	593.74
Intra-row spacing			
10	26.2^{c}	21.14	4045.6
15	28.15^{a}	19.7	4178.5
20	27.8^{b}	20.9	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.

Grain yield

Analysis of variance (ANOVA) results showed highly significant differences in sorghum grain yield among varieties, despite the fact that intra-row spacing and their interaction had no discernible effect on sorghum grain production (Table 6). Lalo variety had the highest grain yield (5628.1 kg ha^{-1}), followed by Local variety, while Variety Geremew variety produced the lowest grain output (2459.5 kg ha^{-1}). The Geremew variety, on the other hand, was the smallest in plant height and matured too soon, making it more vulnerable to bird attack than the other two varieties taken into account in this experiment. These variations' different grain yields may not have had the same yield potential as one another. The findings of Die, Yahia, and Fadul, Hussien (2017), Gozubenli et al., (2001), Farnham (2001), and Zakka T., et al. (2020), who confirmed the occurrence of considerable variability in grain yield of sorghum varieties, are in agreement with the current findings.

Conclusion and Recommendation

Plant spacing has a significant impact on the growth, development, and crop output. In order to grow plants properly with both their aerial and underground sections by utilizing more sunshine and soil nutrients, it is crucial to choose the right type with the ideal plant density. Increased solar radiation absorption within the canopy leads to higher yield production. The experiment was conducted to determine optimum plant spacing and suitable variety for yield and yield component of sorghum. The current findings show that, with the exception of stand count, all the study's criteria were strongly impacted by the variations. Comparing Geremew and the area to Lalo, the maximum grain output was found. Geremew was the least productive variety because it matured earlier than the others and grew more slowly. Attacks by birds were the biggest issue with this early maturing variety. This outcome also demonstrated that intra-raw spacing had no discernible impact on the study's influencing variables. As a result, Variety Lalo will be suggested among the varieties due to its highest yield. Despite the fact that the yield was not significantly different between intra-raw spacing, 20 cm intra-row spacing could be encouraged due to the reduced planting materials (seed) and simple management.

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