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Effects of Intra-Row Spacing on Growth and Yield of Two Grain Sorghum Cultivars (Sorghum bicolor L. Moench) in Gash Delta, Eastern Sudan

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ABSTRACT

The experiment was conducted to study the effect of varying plant population of two sorghum cultivars on growth and yield at research area Gash Delta Eastern Sudan, during 2014/15 and 2016/17) seasons. The RCBD design used for split-split plot trail. The treatments include two cultivars (Tabat andAklamoi) and three planting densities (spacing within the row of 30, 45 and 60 cm between holes and the number of seeds per hole factor with 3, 4, 5, 6, 7, and 10 seeds per hole).The obtained results revealed that, the two tested sorghum cultivars particularly in the second seasons showed highly significant differences in stem girth, leave area index, panicle/m^2, seeds /panicle, 100-seed weight and grain yield/ha. Aklamoi was better than Tabat in panicle/m^2, 100-seed weight while, Tabat exceeded Aklamoi in stem girth, leaf area and grain yield particularly at plant population 208333 plant/ha which was achieved from 30cm inter-row spacing with five plants/hole in the first Season. The obtained grand mean of grain yield of Sorghum and the observations across the two experimental seasons indicate the high adaptability, the highest growth and the highest grain yield of Sorghum under the conditions of the Gash Delta. Early maturity of sorghum cultivars is more important to cultivate under shortage flooding seasons.

Introduction

Sorghum (*Sorghum bicolor* L. Moench) is an important food and feed crop in Africa, Central America, and South Asia. During the last three production seasons (2015-2017), the average world sorghum areas were about 42.502 million hectares producing 61.161 million metric tons with average yields estimated at 1.44 tons per hectare [1]. Plant geometry or architecture in sorghum could be tackled through both inter and intra-row orientation of plants. In our situation, the inter-row orientation for sorghum production under irrigation was already fixed at 0.8 m, while the intra-row spacing is still debated [2-4]. Also, in Gash Delta, [5] found that plant spacing had no significant effects on sorghum grain yield, but it increased with wider spacing. From these studies, it appeared that a plant population of 125000 plants /ha was optimum for improved cultivars.The importance of plant population in increasing sorghum production has been well documented, but still it is difficult to determine the adequate sowing rates to apply of new released cultivars under Gash Delta conditions. On the other hand, introducing new cultivars has become an important tool used to increase crop yields and grain quality in intensive agricultural systems [6]. Thus combination of these two factors can increase crop productivity through application of these agricultural practices. These factors interrelate providing an important insight to the study of their interaction on sorghum production. Therefore, the objective of this study is investigation the effect of intra row spacing for growth and yield of two grain sorghum cultivars in the Gash Delta.

Materials and Methods

The study was carried in the Gash Delta During two seasons (2014/15 and 2016/17). The design used was a split-split plot design the varieties comprised the whole plot factor arranged in a randomized block design with four blocks. The main plot factor was the three spacing between holes while seeds per hole were in the subplot level. Two cultivars used in this study were (Tabat, an improved variety and Aklamoi a local variety) the seeds were obtained from Arab Seed Company, Girba station for both seasons. Three plant spacing within the row of 30, 45 and 60 cm between holes. The number of seeds per hole factor with 3, 4, 5, 6, 7, and 10 seeds per hole. Spacing between rows was kept at 80cm throughout.

The parameters measured were stem girth(cm), leaf area index, panicles/m2, number of seeds/ panicle, 100-seed weight(g) and grain yield (ton/ha).

Data was statistically analyzed according to the combined analysis of variance (ANOVA) for split-split plot trial using MSTAT_C computer software package [7]. Mean comparisons were worked out by Duncan's Multiple Range Test (DMRT) at 5% level of probability.

Results

Generally, data in table2 showed that the greater stem girth for population 166666 plants/ha was obtained from 30cm between hole with three plants/hole for variety Tabat (6.18cm) in first season. But in the second 45cm with six seeds per hole (7.10cm) was the best.

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Table 1. The different spacing and seeds/hole combinations resulted in the flowing plant populations.

between holes	30cm(S1)	30cm(S1)	30cm(S1)	45cm(S2)	45cm(S2)	45cm(S2)	60cm(S3)	60cm(S3)	60cm(S3)
Plants/ hole	3	4	5	4	6	7	5	7	10
plant populations.	125000	166666	208333	111111	166666	194444	104166	145833	208333

Table 2. Mean stem girth (cm) and LAI for each variety at each spacing and number of seeds per hole during 2014/ 2015 and 2016/ 2017seasons.

		stem girth(cm)						LAI					
Season		2014/ 2015			2016/ 2017			2014/ 2015			2016/ 2017		
		V1	V2	mean	V1	V2	mean	V1	V2	mean	V1	V2	mean
S1	3	6.10	5.83	5.97	6.95	7.28	7.12	1.29	1.91	1.60	1.52	1.76	1.64
	4	6.20	5.85	6.03	6.95	6.75	6.85	1.43	1.85	1.64	1.69	1.82	1.76
	5	6.18	5.75	5.97	6.90	6.03	6.47	1.36	1.90	1.63	1.61	1.90	1.76
mean	6.16	5.81			6.93	6.68		1.36	1.89		1.61	1.83	
S2	4	6.18	5.85	6.02	7.97	6.28	7.13	0.90	1.29	1.10	1.04	1.31	1.18
	6	6.35	5.88	6.12	6.15	6.00	6.08	0.89	1.31	1.10	1.01	1.23	1.12
	7	6.96	5.52	6.24	6.95	6.15	6.55	0.88	1.35	1.12	1.06	1.15	1.11
mean	6.50	5.75			7.02	6.14		0.89	1.32		1.04	1.23	
S3	5	6.30	5.93	6.12	6.98	7.08	7.03	0.72	1.04	0.88	0.82	0.96	0.89
	7	6.98	5.88	6.43	6.03	7.20	6.62	0.73	0.95	0.84	0.84	0.89	0.87
	10	6.28	5.88	6.08	6.23	6.95	6.60	0.69	1.00	0.85	1.77	1.01	1.39
mean		6.52	5.90		6.42	7.07		0.71	0.99		1.14	0.95	
Grand mean		6.17	5.82		6.79	6.63		0.99	1.40		1.15	1.34	
$LSD_{0.05}$VxP/S		0.50			0.30			0.11			0.13		

Table 3. Mean number of panicles/m^2 and Seeds / panicle for each variety at each spacing and number of seeds per hole during 2014/ 2015 and 2016/ 2017seasons.

		Panicles/m^2						Seeds / panicle					
Season		2014/ 2015			2016/ 2017			2014/ 2015			2016/ 2017		
treatments		V1	V2	mean	V1	V2	mean	V1	V2	mean	V1	V2	mean
S1	3	8.65	7.89	8.27	10.43	12.53	11.48	837.84	720.32	779.08	1316	767	1042
	4	11.19	10.51	10.85	16.13	15.75	15.94	679.33	577.78	628.56	1209	616	913
	5	12.28	10.13	11.21	18.57	18.86	18.72	796.72	554.20	675.46	1211	739	975
mean		10.71	9.51		15.04	15.71		771.30	617.43		1245	707	
S2	4	10.07	8.59	9.33	10.76	11.01	10.89	665.19	644.11	654.65	1325	751	1038
	6	11.37	8.27	9.82	16.05	16.40	16.23	707.80	671.14	689.47	1102	1002	1077
	7	13.80	10.27	12.04	18.00	18.25	18.13	545.35	595.68	570.52	1432	801	1117
mean		11.75	9.04		14.94	15.22		639.45	636.98		1303	851	
S3	5	6.59	7.12	6.86	10.04	10.37	10.16	823.20	733.40	778.30	1239	666	953
	7	10.73	7.02	8.88	14.13	13.85	13.99	771.22	756.76	763.99	896	709	803
	10	11.75	8.31	10.03	17.28	18.75	18.02	658.67	662.97	660.82	1404	628	1016
mean		9.69	7.48		13.82	14.29		751.03	717.71		1180	667	
Grand mean		10.66	8.68		14.60	15.07		720.59	646.25		1237	742	
$LSD_{0.05}$VxP/S		1.64			0.69			110.08			0.18		

Table 4. Mean100-seed weight(g) and Yield (ton / ha) for each variety at each spacing and number of seeds per hole during two seasons.

		100- seed weight(g)						Yield (ton / ha)					
Season		2014/ 2015			2016/ 2017			2014/ 2015			2016/ 2017		
treatments		V1	V2	mean	V1	V2	mean	V1	V2	mean	V1	V2	mean
S1	3	2.40	3.38	2.89	2.63	3.88	3.26	2.52	2.36	2.44	5.40	4.75	5.08
	4	2.35	3.40	2.88	2.95	3.68	3.32	3.22	2.51	2.87	5.38	4.15	4.77
	5	2.43	3.33	2.88	2.78	3.83	3.31	2.61	2.32	2.47	5.80	4.60	5.20
mean	2.39	3.37			2.79	3.79		2.78	2.39		5.53	4.50	
S2	4	2.35	3.38	2.87	2.58	3.63	3.11	2.20	2.37	2.29	6.28	5.70	5.99
	6	2.38	2.43	2.41	2.38	3.78	3.08	2.56	2.37	2.47	5.48	5.68	5.58
	7	2.43	3.38	2.91	2.50	3.80	3.15	2.27	2.25	2.26	6.75	5.98	6.37
mean	2.38	3.06			2.49	3.74		2.34	2.33		6.17	5.79	
S3	5	2.38	3.30	2.84	2.43	3.83	3.13	2.42	2.11	2.27	4.65	4.65	4.65
	7	2.35	3.30	2.83	2.40	3.85	3.13	2.56	2.15	2.36	3.18	4.30	3.74
	10	2.18	3.28	2.73	2.40	3.75	3.08	2.34	2.27	2.31	5.00	4.73	4.87
mean		2.30	3.39		2.41	3.81		2.44	2.18		4.28	4.56	
Grand mean		2.36	3.35		2.56	3.78		2.52	2.30		5.32	4.95	
$LSD_{0.05}$VxP/S		0.14			0.14			0.33			0.69		

For population 208333 plants/ha, 30cm between holes with five plants/hole (5.98cm) for the variety Tabat in the first season gave best stem girth. In the second season Aklamoi gave the best stem girth 6.30 when sown at 60cm between holes with ten seeds/hole (Table2). Aklamoi V1 showed larger LAI (1.40) compare to Tabat(0.99)in the first season. Moreover, spacing 30cm between hole gave large LAI(1.62) as compare to 45cmand 60cm (Table2). The difference among plants/hole within each spacing at first season, the result showed that LAI ranged from 1.64 to 0.85 for three spaces 30,45 and 60cm between holes (Table2). Further, 45cm with six plants/hole and 60cm with ten plants/hole were gave 1.18 and 1.39 LAI, respectively (Table2). At same plant population 166666 plants/ha Aklamoi gave large LAI 1.85 and 1.82, respectively in two seasons when sown at 30cm with 4 seeds/hole. Also, in 208333plants/ha 30cm with five seed gave large LAI 1.04 and 0.96 in two seasons, respectively(Table 2).

Tabat gave more number of panicles/m^2 10.66 in the first season. At second season Aklamoi gave 15.07panicles/m^2. Space 45cm gave 10.40panicles/m^2 at first season while space 30cm gave 15.32 panicles/m^2 at second season (Table3). For the difference among plants/hole within each spacing, 45cm with seven seeds/hole gave 12.04 panicles/m^2 at first season, but at second season 30cm with five seeds gave 18.72 panicles/m2 (Table 3). For same plant population 166666plants/ha, Tabat at 45cm with six seeds gave 11.37 in first season, but at second season. Tabat 30cm with four seeds gave 16.14 panicles/m^2 (Table3). For population 208333 plants/ha Tabat at 30cm with five seeds gave 12.28 panicles/m^2 in first seasons, but in second season Aklamoi at 30cm with five seeds gave 18.86 panicles/m^2 (Table 3).

Tabat gave more number of seeds/panicle by 10.32% as compared to Aklamoi (Table20). In this regard, sowing at 30cm with three seeds gave (1042 seeds) and at 45cm with seven seeds gave (1117 seeds) per panicle at second season (Table 4).

Regarding, plant population 166666 plants/ha, Tabat 45cm with six seeds/hole gave 707.80seeds in the first season. While at 30cm with four seeds at second season were gave more number of seeds /panicle 1209seeds. Oncontrast, Aklamoi ranged 577.78 to 1002 seeds/panicle for both seasons. While for population 208333 plants/ha, Tabat gave 658.67 to 1404 seeds and Aklamoi 554.20 to 739 seeds/panicle for both seasons (Table4).

At first season, Aklamoi increased 100-seed weight by more than 29.55% as compared to Tabat (Table5). For the difference among plants/hole within each spacing, for the first season s_1 with3 seeds/hole, 45cm with seven seeds/hole gave heavy 100 seed weight 2.91g at first season. While 30cm with four seeds seeds/hole gave 3.32g at second season (Table 5). For the same plant population 166666p plants/ha Aklamoi gave highest 100-seed weight 3.40g at 30cm with four seeds in first season. For population 208333plants/ha 30cm with five seeds gave 3.33 and 3.83g respectively for both seasons (Table 5).

Generally Tabat gave high grain yield as compared to Aklamoi with 8.73% and 6.95% in the both seasons. Also, spacing 30cm was the best (2.59 ton/ha) for first season and 45cm (5.98ton/ha) for second season(Table5). Regard to the difference among plant s/hole with each spacing, 30cm with four seeds gave (2.87ton/ha) at first season and 45cm with seven seeds (6.37ton/ha) at second season (Table 5).

In respect to same plant population, 166666 plants/ha, Tabat at 30cm with four seeds in the first season and Aklamoi at 45cm with six seeds for the second season gave more grain yield. For population 208333 plants/ha, Tabat at 30cm with five seeds gave 2.61 and 5.80 respectively in both seasons (Table 5).

Discussion

The increased of stem girth of Tabat variety may be due to difference of improved cultivars with local cultivars [8]. Also, Tabat variety gave high grains yield per unit area, this may be due to large leave area of Tabat variety, that gave more dry matter from the photosynthesis to this cultivar compare to Aklamoi. On the other hand, the increased of yield may be due to the more number of seeds per panicle. Further, this result is agreed with those stated by[9] they reported that improve cultivars gave high grain yield compare to local cultivars. Aklamoi variety gave high 100- seed weight compared to Tabat, it may due to genetic cultivar variation between cultivars. Spacing is an important factor affecting growth and development of crops and ultimately yields[10]. Increasing the number of plants per unit area reduces the volume of air and soil that is individual plant can exploit, therefore increase competition between plants for nutrients, moisture, light and carbon dioxide. The narrow space 30cm gave less grain yield for the second season, this was due to available water irrigation throughout the growth stages of the plant in the second season.

The local variety Aklamoi gave the highest number of plants per unit area when sawn at 60 cm between holes with 5 seeds hole in second season might be due to available water irrigation. This results was agreed with these reported by[11], they showed that long season hybrid generally produces more tillers than short season hybrid. The increased of Tabat stem girth when sown at 30 cm with 4 plants per hole in second season may be due to improved cultivar variation as reported by [8]. Further, Tabat gave the highest grain weight when sawn at 45 cm with 7 seeds. This result agreed with those reported by [10]at Gash Delta whom showed that there was significant effects at iteration between varieties and spacing on grain sorghum yield.

Conclusion

The obtained grand mean of grain yield of Sorghum and the observations across the two experimental seasons indicate the high adaptability, the highest growth and the highest grain yield of Sorghum under the conditions of the Gash Delta. Early maturity of sorghum cultivars is more important to cultivate under shortage flooding seasons.

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