

Response of improved sorghum cultivars to plant spacing under irrigation

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Abstract

The experiment was raised at the Gezira Research Farm during 2002, 2003, and 2004. It was laid out in split plot design with four plant spacing (10, 20, 30 and 40 cm) in the main plot and three genotypes (HD-1, Tabat and FW Ahmed) in the sub-plot. The objective was to investigate and ultimately recommend a practical plant spacing, (for a farmer or machine sowing) that lead to both optimum grain and fodder yield in the present improved widely sown cultivars. The study showed that plant spacing did not affect days to 50% flowering, plant height, grain number per unit area, 100 grain mass, or grain yield, but most of these parameters tended to increase with wider spacing, while stover yield was significantly greater at wider spacing. For practical considerations, it was recommended that, the improved widely sown cultivars (HD-1, Tabat and FW Ahmed) could be sown by farmers using jackjaka at 30 or 40 cm intra-row spacing with 3 or 4 grains at respective spacing and with one grain at 10 cm intra-row spacing for machine sowing.

Introduction

Sorghum (*Sorghum bicolor* (L) Moench) is an important food and feed crop. As an energy supplier for the world's population, it ranks sixth, and it is fifth in importance among cereals. Worldwide, it is grown over 42 countries (Belum VS Reddy et al. 2004) with developing countries growing 90% of the world sorghum area and producing 70% of the total sorghum production. Semi-arid tropical Asia and semi-arid tropical Sub-Saharan Africa grow about 60% of the world area (ICRISAT and FAO, 1996), while Sudan grows about 24% of Africa area and produces 17% of its production. The average yield in the Sudan (250 kg/fed) was 18% of that obtained at the research stations (Ishag and Ageeb 1987). This was attributed to the use of low yielding mixed cultivars as well as to poor cultural practices. During the last 15 years, plant breeders have successfully developed high yielding varieties such as FW Ahmed and Ingaz (Osman and Mahmud 1992), Tabat and Ryyan (Osman et al. 1996), but the cultural practices recommended for these new releases were based on previous data. In most crops, including sorghum, grain yield is a function of the number of productive plants per unit area, the number of grains or seeds per productive plant or per unit area and the weight of grains or seeds per productive plant. Due to this, plant geometry or architecture becomes essential for grain yield optimisation or maximization under a given situation. 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 was still debated (Ali 1982; Ali 1988; Farah et al. 1987, Babiker, 1998). From these studies, the reduction in yield of improved cultivars was about 10-15% when sown at a plant spacing of 15 cm (70,000 plants /fed), 25 cm (42,000 plants/fed) or 30 cm (35,000 plants /fed) with 2 seedlings left after thinning at each spacing; in comparison with a plant spacing of 20 cm (52,500 plants/fed) and 2 seedlings left after thinning. From these studies, it appeared

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that a plant population of 52,500 plants /fed was optimum for improved cultivars. The present study was designed with an objective to investigate and ultimately recommend a practical plant spacing (for a farmer or machine sowing) that lead- to both optimum grain and fodder yield in the present improved cultivars (HD-1, Tabat and FW Ahmed).

Materials and methods

The experiment was raised at the Gezira Research Farm during three seasons (2002, 2003 and 2004). The physical and chemical characteristics of the site were shown in Table 1a. The trial examined 12 treatment combinations assigned in split plot design and replicated three times. Main plots were 4 plant spacing, (10, 20, 30 and 40 cm) while subplots were 3 genotypes (HD-1, Tabat and Wad Ahmed). The experiment was sown on ridges 80 cm apart, during the second week of July in each season. At each season, plants were thinned at 2-3 weeks from emergence to 1, 2, 3 and 4 seedlings at 10, 20, 30 and 40 cm within the row, which allowed maintaining an optimum plant population of 52,500 at each treatment. More than 90% of this population was maintained till harvest. Urea (46% N) was applied as a source of N during the three seasons for all the treatments, followed by immediate irrigation. Gross and net harvested areas were 5 rows x 5 m length x 0.8 m and 3 rows x 4 m length x 0.8 m respectively. The data collected in each season for the three seasons was: Plant height, panicle length (both were recorded from five randomly selected plants), days to 50% flowering, panicle number, panicle grain number and grain number per unit area, panicle grain weight, grain yield and 100-grain mass. Stover and biomass yields were recorded in 2003 and 2004 seasons. The data in each season as well for the three seasons was statistically analysed using Genestat, version 3.2. The model followed in the analysis was as described by Gomez and Gomez 1984 and was shown in Table 1b.

Temperature maximum and minimum, % relative humidity and rainfall were presented in Table 2. Among the three seasons, the second season (2003) was wet (316.8 mm compared to 245.9 mm for 2002 and 141.7 mm for 2004), especially during August. Temperature and relative humidity in the three seasons followed the same pattern.

Results and discussion

Days to 50% flowering

There were no significant differences among the three seasons for days to flowering. Also, plant spacing had no significant effect on the days to 50% flowering as the crop had flowered within 68-71 days irrespective of plant spacing. On the other hand, differences between the three genotypes to 50% flowering were highly significant ($P < 0.001$). HD-1 exercised significantly few days to flower (65 days) in comparison with Tabat or FW Ahmed (71-73 days). The interactions of year x genotype, plant spacing x genotype, and year x plant spacing x genotype were not significant (Table 3).

Plant height

The range of plant height during the three seasons was between 164-173 cm, differences among the three seasons were not significant. Irrespective of plant spacing, the plant height was between 166-170 cm, differences among plant spacing were not significant. The interaction of year x plant spacing was also not significant. The same was true for the three genotypes. The interaction of plant spacing x genotype and year x plant spacing x genotype were not significant (Table 4).

Grain number per unit area

The same trend was also repeated here in that there were no significant differences between years or plant spacing treatments. Generally, there was steady increase in the number of grains per unit area as the spacing increased table(7). The interaction of year x plant spacing was not significant. Differences among the three genotypes were highly significant for the grain number per unit area. FW Ahmed scored a significantly more grain number per unit area (12176) than either HD-1 (11265) or Tabat (9513) (Table 5). The interaction of plant spacing x genotype was also significant (Fig. 1). There was a clear increase in grain number per unit area in the three genotypes, especially in HD-1, as the plant spacing increased from 10 to 40 cm.

100 grain mass

Plant spacing had no significant effect on 100 grain mass, but it increased with wider spacing (40 cm). There were significant differences between the genotypes for 100 grain mass, HD-1 and Tabat scored significantly greater 100 grain mass than FW Ahmed. The interaction of plant spacing x genotype for 100 grain mass was not significant (Table 6). Also other interactions were not significant.

Grain yield

Plant spacing had no significant effect on grain yield, but it increased with wider spacing (Table 7). This means that, grain yield would not be significantly affected by wider spacing if the the optimum plant population (52,500 plant /fed) was catered for. Differences among the three genotypes were significant for grain yield; FW Ahmed and HD-1 had significantly greater grain yield than Tabat. Plant spacing x ganotype interaction was also significant for grain yield (Table 7). There was a consistant increase in the grain yield of the three genotypes, especially in HD-1, as plant spacing increased from 10 to 20, 30 and to 40 cm (Fig. 2). The interactions of year x plant spacing, year x genotype and year x plant spacing x genotype were not significantly different for grain yield.

Stover yield

Plant spacing had a significant effect ($P < 0.01$) on stover yield. The stover yield increased with wider spacing. (Table 11). Genotypes were also significantly different for stover yield, FW Ahmed and Tabat had significantly more stover yield than HD-1. There were no interactions for stover yield (Table 8).

Harvest index

Plant spacing had no significant effect on harvest index (HI). Differences were significant between the genotypes for harvest index; HD-1 has significantly higher (HI) than both Tabat and FW Ahmed (Table 9). The plant spacing x genotype interaction for harvest index was not significant.

Conclusions

Grain yield was not affected by plant spacing, while stover yield was significantly more at wider spacing, especially at 40 cm.

Recommendation

For practical reasons, HD-1, Tabat and FW Ahmed could be hand sown by farmers at 30 or 40 cm intra-row spacing with 3 or 4 seeds at respective spacing and with one seed at 10 cm intra-row spacing for machine sowing.

References

- Ali, F.M. (1982). Effect of nitrogen and plant population on sorghum cultivars. Annual Report (1981/82) of the Gezira Research Station, ARC, Wad Medani, Sudan.
- Ali, M.S. (1988). Effect of N and P fertilizers on yield and yield components of sorghum. Annual Report (1987/88) of the Kenana Research Station, ARC, Wad Medani, Sudan.
- Belum, V.S. Reddy, Ramesh, S. and Sanjana, Reddy, P. (2004). Sorghum Breeding Research at ICRISAT – Goals, Strategies, Methods and Accomplishments. International Sorghum and Millets Newsletter, No. 45, pp. 5-12.
- Babikir, E. A. (1998). Reponse of Three Sorghum (*Sorghum bicolor* (L.) Moench) Varieties to Rate of N-Fertilizer, Intra-row Spacing and their Interactions Under irrigation. U.K.J. Agric. Sci., 6(1), 1998. PP. 78-95.
- Farah, S.M., Gandoul, G.I. and Tambal, H.A. (1987). Effect of plant population and levels of N- fertilizers on Hageen Dura-1, Annual Report (1986/87) of the Gezira Research Station, ARC, Wad Medani, Sudan.
- ICRISAT (International Crops Research Institute for the Semi – Arid Tropics); and FAO. (Food and Agricultural Organization of the United Nations) (1996). Part I, sorghum, pp. 5-27. In: The world sorghum and millet economics: facts, trends and outlook.
- Ishag, H.M. and Ageeb, O.A. (1987). Agricultural research / extension linkage in Sudan. Workshop on Planning and Programming of Agricultural Research. ARC/ISNAR, Wad Medani, Sudan, 30 Nov. – 2 Dec., 1987.
- Kwanchai, A. Gomez and Arturo, A. Gomez (1984). Statistical Procedures for Agricultural Research, 2nd edition, pp. 339-350.
- Osman, E.I., Elzein, I.N., Babikir, E.A. and Suliman, I.A. (1996). Evaluation of the improved sorghum varieties and hybrids for yield potential, stability and quality, under Sudan irrigated and rainfed conditions. Proceedings of Sudan National Variety Release Committee, ARC, Wad Medani, Sudan.
- Osman, E.I. and Mahmoud, M.A. (1992). Improved sorghum genotypes suitable for irrigated and rainfed lands of Sudan. Proceedings of Sudan National Variety Release Committee, ARC, Wad Medani, Sudan.

Table 2. Mean maximum and minimum temperature, % relative humidity and rainfall during 2001, 2002 and 2003 seasons.

Element	Year	July	August	September	October	November	December
Mean Max. Temp	2002	38.3	37.9	35.5	38.9	38.1	33.4
Mean Min. Temp		24.5	22.8	22.3	22.5	20.1	14.6
RH(%)		61	76	75	54	43	39
Rainfall (mm)		53.4	84.3	92.1	16.1	Nil	Nil
Mean Max. Temp	2003	35.7	33.4	36.6	39.4	38.1	35.3
Mean Min. Temp		23.4	22.5	22.3	22.9	20.2	15.9
RH(%)		75	83	76	56	45	45
Rainfall (mm)		101.9	152.1	51.0	11.8	Nil	Nil
Mean max. Temp	2004	38.4	36.3	37.8	39.3	38.1	33.8
Mean Min. Temp		23.9	23.4	23.3	22.6	20.1	16.6
RH (%)		61	73	67	50	40	45
Rainfall (mm)		19.6	99.9	10.9	11.3	Nil	Nil

Table 3. Combined means for days to flowering, seasons 2002-2004.

Year	2002	2003	2004	
Days to flowering	70	74	71	
PLS (cm)	10	20	30	40
Days to flowering	71	71	70	68
LSD	3.2			
F	NS			
Geno	HD-1	Tabat	Wad Ahmed	
Days to flowering	65	73	71	
LSD	1.6			
F	**			
Interaction	level of significance			
Year x PLS	NS			
Year x Geno	NS			
PLS x Geno	NS			
Year x PLS x Geno	NS			
CV(%)	4.8			

Table 4. Combined means for plant height, seasons 2002-2004

Year	2002	2003	2004	
Plant height	173	165	164	
PLS (cm)	10	20	30	40
Plant height	166	166	169	170
LSD	6.4			
F	NS			
Geno	HD-1	Tabat	Wad Ahmed	
Plant height	170	166	167	
LSD	3.2			
F	NS			
Interaction	level of significance			
Year x PLS	NS			
Year x Geno	NS			
PLS x Geno	NS			
Year x PLS x Geno	NS			
CV(%)	4.0			

Table 5. Combined means for grain number per unit area, seasons 2002-2004

Year	2002	2003	2004	
GRNO/m ²	8520	8987	15448	
PLS (cm)	10	20	30	40
GRNO/m ²	10627	10584	11016	11714
LSD	1818			
F	NS			
Geno	HD-1	Tabat	Wad Ahmed	
GRNO/m ²	11265	9513	12178	
LSD	605			
F	**			
Interaction	level of significance			
Year x PLS	NS			
Year x Geno	NS			
PLS x Geno	**(see figure)			
Year x PLS x Geno	NS			
CV(%)	11.6			

Fig.1 plant spacing x genotype interaction for grain number per unit area

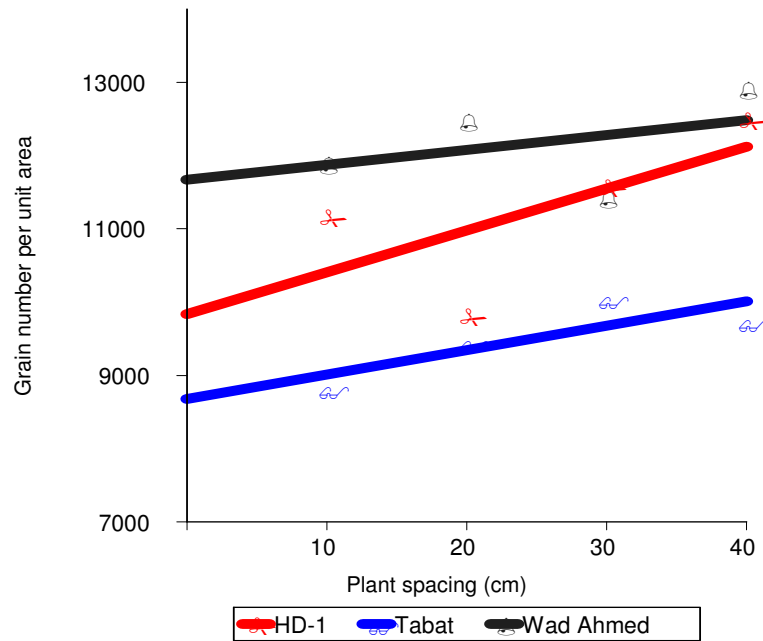


Table 6. Combined means for 100 grain mass, seasons 2002-2004

Year	2002	2003	3004	
GRM/100 (g)	2.35	2.25	2.49	
PLS (cm)	10	20	30	40
GRM/100 (g)	2.36	2.33	2.34	
2.43				
LSD	0.17			
F	NS			
Geno	HD-1	Tabat	Wad Ahmed	
GRM/100 (g)	2.46	2.37	2.27	
LSD	0.08			
F	**			
Interaction	level of significance			
Year x PLS	NS			
Year x Geno	NS			
PLS x Geno	NS			
Year x PLS x Geno	NS			
CV(%)	7.0			

Table 7. Combined means for grain yield (kg/fed), seasons 2002-2004

Year	2202	2003	2004	
Yield	838	867	1602	
PLS (cm)	10	20	30	40
Yield	1070	1046	1090	
1202				
LSD	174.9			
F	NS			
Geno	HD-1	Tabat	Wad Ahmed	
Yield	1160	975	1171	
LSD	58.9			
F	**			
Interaction	level of significance			
Year x PLS	NS			
Year x Geno	NS			
PLS x Geno	* (see figure)			
Year x PLS x Geno	NS			
CV(%)	11.3			

Fig. 2. plant spacing x genotype interaction for grain yield

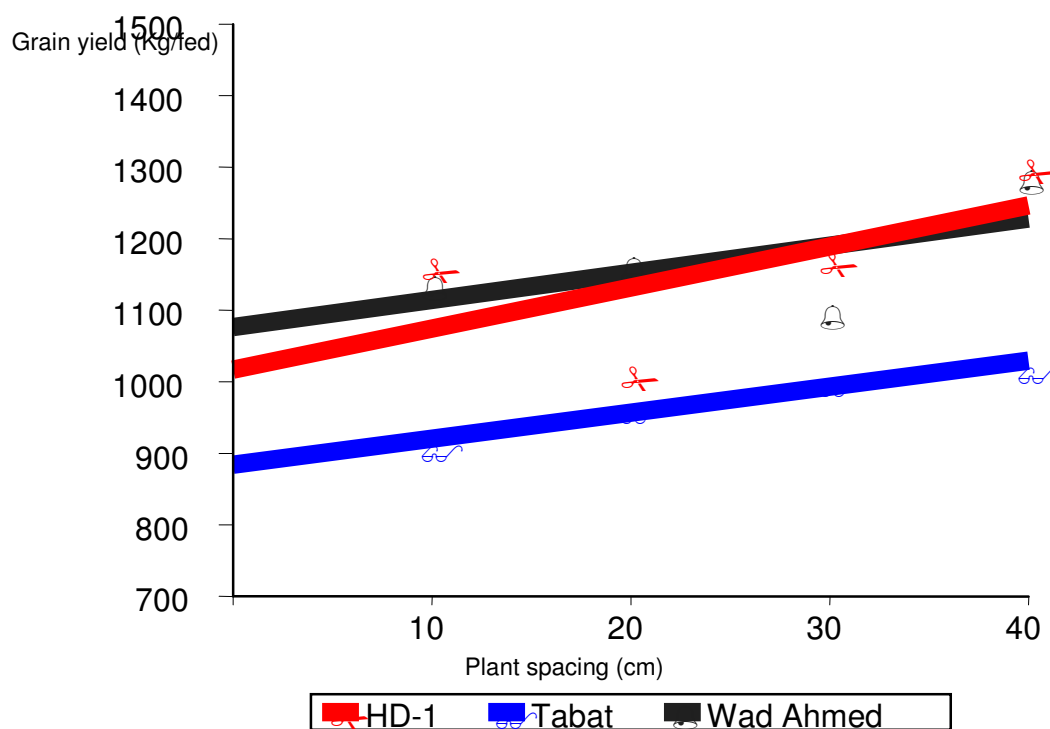


Table 8. Combined means for stover yield (ton/fed), seasons 2002-2004

Year	2002	2003	2004	
Yield	5.4	4.6		
PLS (cm)	10	20	30	40
Yield	4.1 <i>B</i>	5.0 <i>AB</i>	5.0 <i>AB</i>	5.9 <i>A</i>
LSD	0.94			
F	*			
Genotype	HD-1	Tabat	Wad Ahmed	
Yield	4.1 <i>C</i>	5.0 <i>B</i>	5.9 <i>A</i>	
LSD	0.68			
F	**			
Interaction	level of significance			
Year x PLS	NS			
Year x Geno	NS			
PLS x Geno	NS			
Year x PLS x Geno	NS			
CV(%)	23.2			

Table 9. Combined means for Harvest index (%), seasons 2002-2004

Year	2002	2003		
Yield	23.1	24.5		
PLS (cm)	10	20	30	40
Yield	20.6	17.5	18.7	18.6
LSD	4.7			
F	NS			
Geno	HD-1	Tabat	Wad Ahmed	
Yield	21.7	16.5	18.3	
LSD	2.1			
F	**			
Interaction	level of significance			
Year x PLS	NS			
Year x Geno	NS			
PLS x Geno	NS			
Year x PLS x Geno	NS			
CV(%)	18.8			