Effect of plant population on grain yield of sorghum in South Kordofan

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Abstract

A three-year experiment was carried out in south Kordofan region during 1999, 2000 and 2001 growing seasons to study the effect of four population densities on seed yield of four sorghum cultivars. The varieties did not show significant differences in the head weight and number of heads/m^2, but differed significantly in number of days to 50% flowering, plant height and grain yield per hectare. The effect of plant density was significant for plant height, number of heads/m^2 and seed yield/ha. All cultivars gave their highest yield under the highest density (125000 plants/ha), and the variety Wad Ahmed out- yielded the other three cultivars. The interaction between the cultivar and plant density did not significantly affect the grain yield.

Introduction

Sorghum-based cropping systems dominate the Sudan Savannah Zone of South and West Kordofan States, where the rainfall ranges from 550 to 800 mm/year with duration of 95 to 140 days (Abuelgasim *et al*. 1998). In these areas, the crop is usually grown on vertisols during the rainy season, which extends from June to October. Although drought spells in this zone are less frequent than those in the southern Sahel zone, crop productivity is still very low. The average yield of farmers was estimated at 227 kg/fed. (Department of statistics and agricultural economics, 1984). On the other hand, there is increasing evidence that the uses of poor cultural practices (especially the practice of wide spacing) as well as traditional cultivars are the main yield limiting factors. Presumably, the adoption of high population densities by farmers meant the avoidance of a climate risk (Karlen and Camp 1985; Steiner 1986). Yet, the improvement of yield through manipulation of plant density and use of early maturing cultivars is possible (Tabo *et al*. 2002). Accordingly, the present investigation was carried out to determine the effect of plant density on grain yield of some sorghum cultivars under the rainfed conditions of south Kordofan .

Materials and methods

The experiment was conducted at Lagawa research site of West Kordofan Research Station (latitude 11°30'N, Longitude 29°5'E) during 1999, 2000 and 2001 seasons. The soil is heavy cracking clay (vertisol). Three medium maturing sorghum cultivars were compared to one local landrace (Marcoob). Two of these cultivars (i.e., Wad Ahmed and Tabat) were released and recommended by the Agricultural Research and Technology Corporation (ARC) for both rainfed and irrigated agriculture. The third cultivar (Arose Elremal) was released by (ARC) State as a drought tolerant cultivar suited to the low rainfall environment. The control or check cultivar is a land race which dominates the high rainfall area of South and West Kordofan States (the dense savannah zone). Four different planting densities were

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tested along with these cultivars with the objective of determining the most suitable population density for this region, viz. 50000, 75000, 100000 and 125000 plants/ha.

The experimental design was a randomized complete block with three replications. The plot size was 4x5 m. The plant density was made by fixing the inter-row spacing at 80 cm and the intra-row spacing at 50 cm (near to traditional spacing). Hence, the different densities were achieved by adjusting the number of plants per hill through thinning to 2, 3, 4 and 5 plants for 50000, 75000, 100000 and 125000 plants per hectare, respectively. Since this was a rainfed experiment, the adjustment of sowing to a fixed date every season was not possible. Therefore, the sowing date was decided when the moisture depth reached 15 cm or more. Thus the sowing dates were 9 August 1999, 23 July 2000 and 27 July 2001 for the three successive seasons. Thinning to the required density was applied three weeks after sowing. Weeding was carried out as necessary.

Averages of number of days to 50% flowering, plant height and head weight were determined for the three seasons. The number of heads per square meter (m^2) was recorded in the third season only. In all seasons, the crop was harvested 100 days after sowing (DAS). At harvest, the number of plants/m^2 was counted. The three central rows of each plot were harvested for yield determination. Grain yield was adjusted to kilograms per hectare. The analysis of variance was applied to all recorded data using the SAS package. The treatment means were compared by the least significant difference (LSD). Grain yield was related to plant density by linear regression. Data of the seasonal rainfall were measured for the three seasons.

Results and discussion

The rainfall amount and distribution were not even through the three-year period of the study (Table 1). Similar results on the fluctuation of seasonal rainfall in western Sudan were reported by Mahmoud *et al.,* 1992. The precipitation in 1998 growing season was nearly twice (585 mm) the amount as that of the 1999- growing season (323 mm). Therefore, the large differences of grain yield between the seasons were mainly attributed to variations in seasonal rainfall. The mean plant density per unit area at harvest time was near to the actual densities (Table 2).

The mean number of days to 50% flowering and plant height (average of three seasons), are presented in Table 3. The number of heads/m^2 during 2001 crop season is shown in Table 4, whilst the head weight for the three seasons is presented in Table 5. The cultivars did not differ significantly in the head weight and number of heads/m^2, but differed in number of days to 50% flowering and plant height. The plant height was also affected by plant density. The effect of different cultivars and plant densities on grain yield during the three seasons is presented in Table 6. The effect of cultivars on grain yield was significant only in 2001 growing season (Table 6), where Wad Ahmed had the highest grain yield (2584 kg/ha). Also, the combined analysis of the three seasons has shown the same results and Wad Ahmed significantly out-yielded other cultivars, except Tabat, with an average grain yield of 2036 kg/ha. Both separate and combined analyses of variance have shown significant effects of plant density on grain yield per hectare (Table 6). In the first two seasons, the plant density of 125000 plants per hectare gave the highest values on grain yield per hectare (i.e. 3758 and 775 kg/ha), whilst in the third season, the highest grain yield (2409 kg/ha) was obtained at 100000 plants/ha. On the other hand, the average grain yield for the three seasons (combined) showed that the plant density of 125000 plants per hectare was the highest in grain yield (2286 kg/ha) and significantly differed from the other densities except that of 100000 plants per hectare (2021 kg/ha). In general, the yield

increments of the highest density (i.e., 125000 plants/ha) over those of 100000, 75000 and 50000 plants per hectare were 13%, 37% and 71%, respectively. This increase of grain yield with the highest plant density was mainly attributed to the higher number of plants and heads per unit area at harvest (Tables 2 and 4). Tabo *et al.* (2002) stated that sorghum varieties grown on vertisols of northeastern Nigeria produced the highest grain yields under the plant density of 12.5 plants m^2. The superiority of the highest density was attained through the ability of cultivars under study to maintain larger grains in spite of increased interplant competition for water (Blum, 1970). The correlation between the plant density and grain yield in each of the three seasons is significant (Figs. 1, 2 and 3). The correlation during the first season ($R^2 = 0.99$) is greater than that of the following two seasons due to the higher rainfall (i.e., 585 mm) in that particular season. On the other hand, the correlation between the plant density and average grain yield of the three seasons (Fig. 4) is highly significant.

Recommendations

Based on the results of this study, the following recommendations are proposed:

1. The optimum plant population for the best yield of sorghum in the vertisols of south Kordofan region lies between 100000-125000 plants per hectare. This can be achieved by planting sorghum on rows with 80 cm apart and 50 cm between hills of 4-5 plants each.
2. The superiority of the improved cultivar Wad Ahmed over the other cultivars suggests its adoption as one of the high yielding cultivars in this area.

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Table 1. Monthly and seasonal rainfall values for 1999, 2000 and 2001 growing seasons.

Month	Rainfall (mm)		
	1999	2000	2001
July	132	86	107
August	189	144	210
September	122	85	140
October	142	8	17
Total	585	323	474

Table 2. Number of plants per m^2 at harvest in each plant density during the Seasons of 1999, 2000 and 2001

Plant density	Number of plants/ m^2				Required
	1999	2000	2001	Mean	
50000 plants/ha	6	6	5	6	5
75000 plants/ha	8	6	7	7	8
100000 plants/ha	10	10	9	10	10
125000 plants/ha	11	11	11	11	13
Mean	9	8	8	9	9

Table 3. Effect of plant density and cultivar on flowering and plant height of sorghum, during 1999-2001 seasons.

Teatments	Days to 50% flowering	Plant height (cm)
Plant density:		
50000 plants/ha	50	122
75000 plants/ha	49	120
100000 plants/ha	48	121
125000 plants/ha	49	129
C.V. %	6.8	9.8
LSD (0.05)	2.0	6.9
F value	NS	*
Cultivar:		
Wad-Ahmed	47	96
Tabat	51	93
Arose-Aremal	48	91
Marcoob (local)	49	214
C.V. %	6.8	9.8
LSD (0.05)	2.0	6.9
F value	**	***

*, **,*** : Significant at probability level 0.05, 0.01 and 0.001, respectively.
NS : Not significant at 0.05

Table 4. Effect of plant density and cultivar on number of heads per square meter at harvest in 2001 season.

Treatments	No. of heads/m^2
Plant density:	
50000 plants/ha	7
75000 plants/ha	7
100000 plants/ha	10
125000 plants/ha	11
C.V. %	7
LSD (0.05)	0.5
F value	***
Cultivar:	
Wad-Ahmed	9
Tabat	8
Arose-Aremal	8
Marcoob (local)	9
C.V. %	7.1
LSD (0.05)	0.5
F value	NS

*** : Significant at probability level 0.001
NS : Not significant at 0.05

Table 5. Effect of plant density and cultivar on head weight of sorghum.

Treatments	**Head weight (g)**			
	1999	**2000**	**2001**	**combined**
Plant density:				
50000 plants/ha	32	9	23	22
75000 plants/ha	31	10	23	21
100000 plants/ha	31	9	24	21
125000 plants/ha	33	9	19	20
Mean	32	9	22	21
C.V. %	25	20	39	56
LSD (0.05)	6.7	1.5	7.2	5.5
F value	NS	NS	NS	NS
Cultivar:				
Wad-Ahmed	32	10	28	23
Tabat	33	9	22	21
Arose-Aremal	30	9	20	20
Marcoob (local)	32	9	19	20
Mean	32	9	22	21
C.V. %	25	20	39	56
LSD (0.05)	6.7	1.5	7.2	5.5
F value	NS	NS	*	NS

*: Significant at probability level 0.05
NS: Not significant at 0.05

Table 6. Effect of plant density and cultivar on grain yield of sorghum.

Treatments	Grain yield (kg/ha)			
	1999	2000	2001	combined
Plant density:				
50000 plants/ha	2019	527	1469	1338
75000 plants/ha	2570	543	1905	1673
100000 plants/ha	3037	618	2409	2021
125000 plants/ha	3758	775	2326	2286
Mean	2846	616	2027	1830
C.V. %	28	40	38	35
LSD (0.05)	610	204	637	298
F value	***	*	*	***
Cultivar:				
Wad-Ahmed	2900	623	2585	2036
Tabat	2953	631	1992	1858
Arose-Aremal	2622	661	1811	1698
Marcoob (local)	2910	547	1721	1726
Mean	2846	616	2027	1830
C.V. %	28	40	38	35
LSD (0.05)	610	204	637	298
F value	NS	NS	*	*

*, ***: Significant at probability level 0.05 and 0.001, respectively
NS: Not significant at 0.05

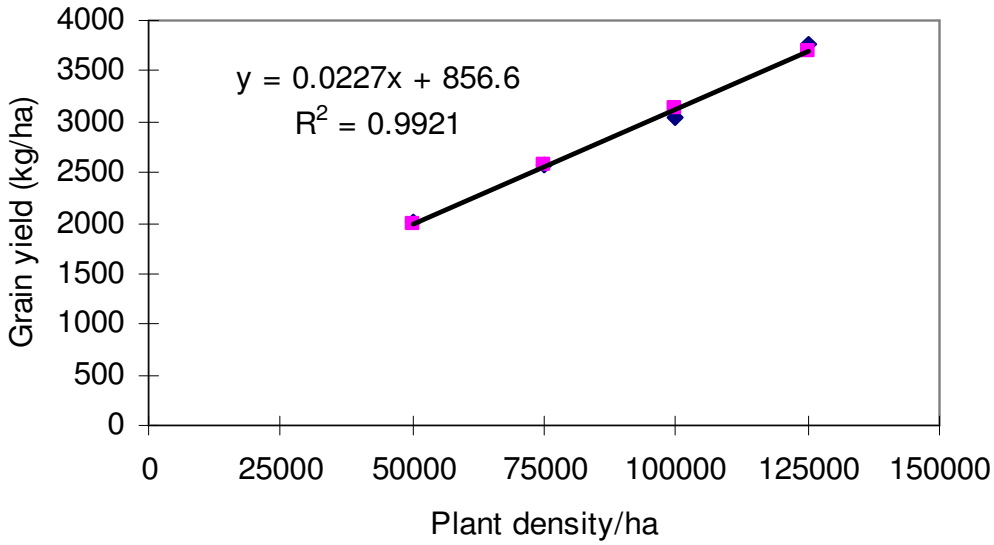

Figure 1. Linear regression of sorghum grain yield on plant density in 1999 season.

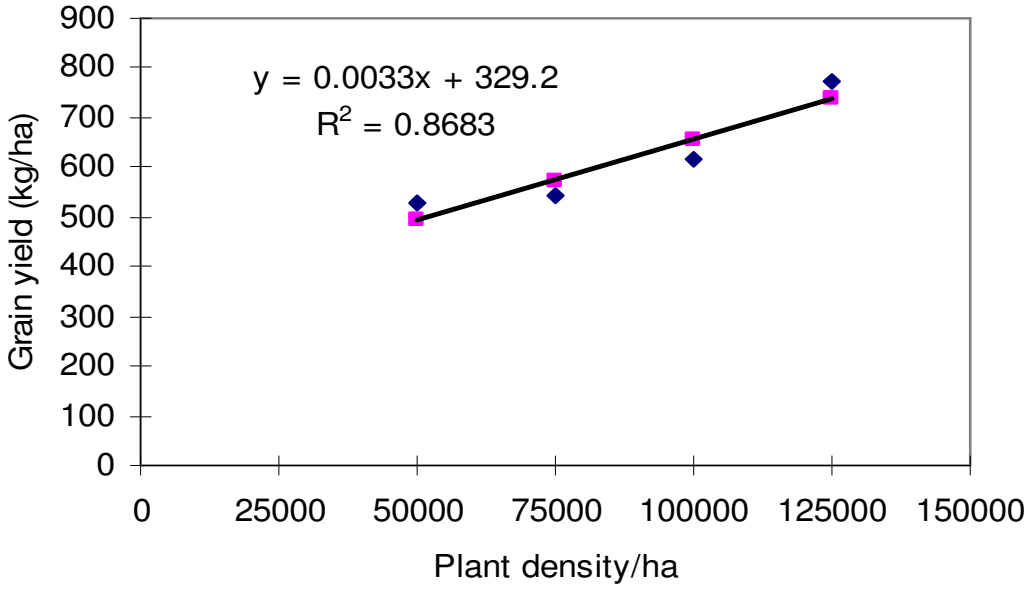

Figure 2. Linear regression of sorghum grain yield on plant density in 2000 season.

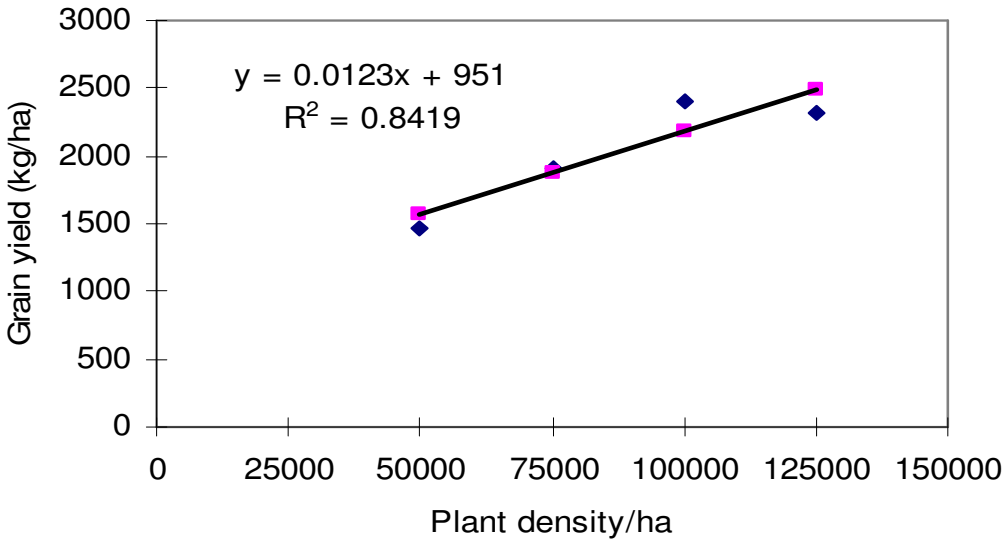

Figure 3. Linear regression of sorghum grain yield on plant density in 2001 season.

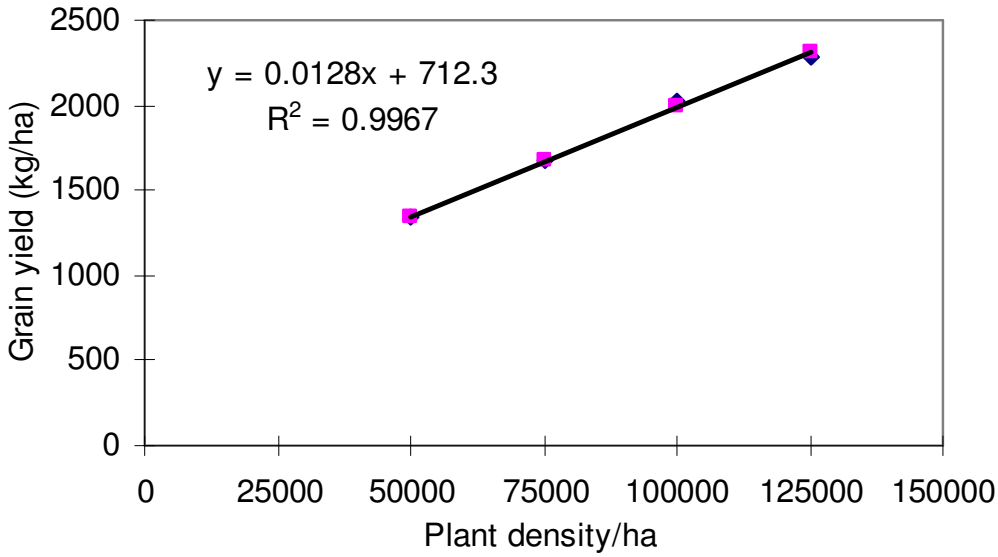

Figure 4. Linear regression of sorghum grain yield on plant density (average of three seasons).