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Effect of Plant Density and Nitrogen on the Agronomic Performance of Sunflower on Dry Land

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ABSTRACT. Field experiments were conducted for 2 years to determine the effects of planting density and nitrogen level on late sown sunflower, seed yield and other characteristics under the dry conditions of the central Sudan. In Exp. I, two cultivars (Hungarian A and Cerninka) were established at 83,333 and 166,666 plants ha^{-1} and 3 levels of nitrogen (0, 40 and 80 kg N ha^{-1}). In Exp. II, two cultivars (Bolero and Cerninka) were established at the same levels of nitrogen at 83,333 and 41,666 plants ha^{-1}. In both experiments, cultivars differed significantly from one another in seed yield. The average yields of Hungarian A and Bolero, being 1131 and 1008 kg ha^{-1}, were 32.7 and 29.1%, respectively, over that of Cerninka in the respective trials. Under the conditions of the first experiment, seed yield, plant height, number of harvested plants ha^{-1}, head diameter and 1000 seed weight were significantly increased by the 40 kg N ha^{-1}. Lower planting density (83,333 plants ha^{-1}) in contrast to higher density (166,666 plants ha^{-1}) significantly increased seed yield ha^{-1} and 1000-seed weight and decreased number of plants ha^{-1}. In the second experiment, application of 40 kg N ha^{-1} signifieantly reduced plant height, whereas planting density (41,666 plants $ha^{-1)}$) significantly reduced the actual number of harvested plants ha^{-1}. In both trials, application of 80 kg N ha^{-1} had no significant effect on any of the traits evaluated. Apart from number of filled seeds $head^{-1}$ (Exp. I), all the first order interactions (Exp. I) and the second order interactions (both trials) evaluated for the different traits among the three factors were significant, indicating that, in the course of a selection programme, testing of sunflower lines at several nitrogen levels and planting densities would be necessary for their best assessment. Apparently, a minimum number of 83,333 plants ha^{-1} and maximum dose of 40 kg N ha^{-1} would prove to be adequate for achieving maximum seed yield in late sown sunflower in the dry tropics.

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Introduction

Sunflower (*Helianthus annuus* L.) showed to be a potential oil seed crop in the Central Rainlands of the Sudan under both rain and supplementary irrigation (Khalifa, 1981). The previous studies, being restricted to evaluation of the conventional cultivars (*e.g.* Peredovik, Manchurian, Hungarian A and Hungarian B), indicated that planting densities of 60 × 45 cm (3.7 plants m^{-2}) under rain and those of 60 × 30 (5.5 plants m^{-2}) under irrigation were optimal for highest seed yield. These studies also indicated that delayed planting – as late as August 15 – adversely affected seed yield of sunflower cultivars under rainfed conditions but not under irrigated conditions. However, as more area was allotted for the crop, it soon became evident that the traditional cultivars, being tall and late maturing, were not considered the best candidates for large scale (mechanized) production in the central Sudan. This necessitated a shift to relatively early maturing and short stature cultivars such as Cerninka and Bolero that can be mechanically harvested. The agronomic requirements of these cultivars were anticipated to differ from those for the conventional types (Majid and Scheneiter, 1987b). In this respect, Alessi *et al.* (1977) and Radford (1978) achieved maximum seed yields with plant populations ranging from 25,000 to 100,000 plants ha^{-1}; whereas, Robinson *et al.* (1980) found that a minimum stand in the range of 25,000 to 62,000 was needed for achieving maximum seed yield. In evaluating densities in the range of 27777 to 222222 plants ha^{-1}, Hedge and Havanagi (1987) achieved highest seed yield at 138888 plants ha^{-1}, yet differences in yields at this density and those at 111111 or 166666 plants (Hedge and Havanagi, 1988a) or 55555 plants ha^{-1} (Hedge and Havanagi, 1988b) were not significant.

The inconsistent yield response of sunflower cultivars to increasing plant population densities (Miller and Fick, 1978; Holt and Campbell, 1984) were mostly attributable to the environmental differences under which the trials were conducted (Robinson, 1970).

Although, sunflower provides good yields over a wide range of nitrogen levels, no work was conducted to determine the crop requirements in the Central Sudan. Meanwhile, the highest yields of sunflower were achieved at 60 kg ha^{-1} (Narwal and Malik, 1985; Loubser *et al.* 1988); 50-75 kg ha^{-1} (Guar *et al.* 1987), and 30 kg ha^{-1} (Karunakaran and Palaniappan, 1989). The increase in yield with N application was mostly attributed to the increase of one or more of the following yield components: Leaf area, head diameter, number and per cent of filled seeds $head^{-1}$ and seed size (Narwal and Malik, 1985).

The present work was undertaken to examine the effect of plant density and nitrogen level on the performance of a traditional cultivar 'Hungarian A' and two, recently introduced cultivars (Cerninka and Bolero) under supplementary irrigation.

Materials and Methods

The study was conducted at Kenana Research Station (11°45′N, 34°00′E) during the period of mid August-mid January of 1983 and 1984. The soils of the experimental site are non-saline and have up to 70% mentmorillonite clay of pH 8.5-9.0 with free $CaCO_3$ in the profile and high phosphate and exchangeable calcium values. Carbon is about 0.4% and total N about 0.46 mg/L. The factors evaluated in this study consisted of three cultivars Hungarian A, Cerninka, and Bolero; three plant densities, 16.6 plants m^{-2}, (30 × 20 cm), 8.3 plants m^{-2}, (60 × 20 cm) and 4.1 plants m^{-2}, (60 × 40 cm), and three nitrogen rates (0, 40 and 80 kg N ha^{-1} as urea). Two separate factorial experiments consisting of 12 treatments each (*i.e.* two cultivars × 2 densities × three N levels) in four replications were conducted in each season during 1983 and 1984 to evaluate different factor combinations. A randomized block design with four replications was used in both experiments. Cultivars (Hungarian A and Cerninka) × densities 16.6 and 8.3 plants m^{-2} and three levels of N (0, 40 and 80 kg ha^{-1}) were included in one trial (Experiment I); whereas cultivars Cerninka and Bolero at 16.6 and 4.1 plants m^{-2}, at the same levels of N, were tested in another experiment (Experiment II). Harvestable plots (excluding marginal area) of 27.0 and 21.6 m^2 were allotted for each of the 12 treatments in the respective trials in each of the two seasons. Trials in each season were sown under supplementary irrigation on 15 August. The crop was sown by putting three seeds per hill by hand. Plants were thinned to one plant per hill after 15 days from sowing. Nitrogen was applied at the time of sowing and irrigation was given when critically needed. At maturity, five plants were randomly tagged and used to measure plant height, head diameter, number and per cent of filled seeds $head^{-1}$ in each plot; whereas actual number of harvested (erect) plants, seed yield and 1000 seed weight (experiment I) were determined on plot basis. Delayed planting of the trials (15 August) was anticipated to improve the percentage of filled seeds and minimize both the damage usually caused by birds on early sown crop and the competitive labour demand with other crops usually sown at an early date in the region.

Results and Discussion

Experiment I

Apart from the number of filled seeds $head^{-1}$, cultivar, nitrogen, planting density and their interactions means of squares were highly significant for all the variables evaluated in this experiment (Table 1). The 279 kg yield difference between Hungarian A (1131 kg ha^{-1}) and Cerninka (852 kg) was a consequence of higher yield components: actual number of plants harvested ha^{-1}, head diameter and seed size (1000 seed weight) in Hungarian A (Table 2). When averaged across cultivars and plant density, seed yield was significantly (P= 0.05) affected by nitrogen application (Table 2). A 20.7% yield increase with increased N until 40 kg ha^{-1} was a consequence of increased number of harvestable plants ha^{-1}, head diameter and 1000 seed weight. Similarly, application of comparative N levels e.g. 30 kg ha^{-1} (Karunakaran and Palaniappan, 1989) and 60 kg (Narwal and Malik, 1985) were reported to give maximum seed yield in sunflower. Application of nitrogen at levels above 40 kg ha^{-1} caused a significant reduction of (25.9% of that recorded at N_1) in seed yield due to increased lodging (reductions in number of harvested plants) and significant reductions in both head diameter and 1000-seed weight (Table 2).

TABLE 1. Analysis of variance for seed yield and other plant characters of supplementary irrigated sunflower averaged over seasons 1983 and 1984 (Exp. I).

Source	df	Seed yield (kg ha^{-1})	No. of plants (1000 ha^{-1})	Plant height (cm)	Head diameter (cm)	No. of full seeds head^{-1}	1000-seed wt (g)
			– Significance of F-values –				
Replication	3	–	–	–	–	–	–
Cultivar	1	**	**	**	**	*	**
Planting density (P)	1	*	**	NS	**	NS	**
C × P	1	**	**	**	**	NS	**
Nitrogen (N)	2	**	**	**	**	NS	**
P × N	2	**	**	**	**	NS	**
C × N	2	**	**	**	**	**	**
C × N × P	2	**	**	**	**	NS	**
Error	33	46392.0	125.4	256.0	1.4	4151.5	33.6
			Coefficient of variation				
		22.3	13.4	10.2	11.0	25.5	10.7

* and ** = significant at 5 and 1% levels, respectively.
df = degrees of freedom
NS = Not significant at the 5% level.

TABLE 2. Main effects of cultivar, N-fertilizer and row spacing on seed yield and other plant characters of supplementary irrigated sunflower averaged over seasons 1983 and 1984 (Exp. I).

	Seed yield (kg ha^{-1})	No. of plants (1000 ha^{-1})	Plant height (cm)	Head diameter (cm)	1000-seed weight (g)	Full seeds head^{-1} number	Full seeds head^{-1} %
Treatments							
Cultivar							
Hungarian A (V_1)	1131	94	221	14.6	68.3	320	78
Cerninka (V_2)	852	72	92	10.8	40.2	396	86
LSD 0.05	126.8	6.6	9.5	0.69	0.34	53.5	–
LSD 0.01	170.5	8.9	12.8	0.93	0.46	72.1	–
N-applied (kg ha^{-1})							
0	911	81	147	12.2	54.5	352	83
40	1100	90	165	13.4	55.3	357	82
80	864	79	157	12.7	53.0	366	80
LSD 0.05	155.3	8.1	11.5	0.86	0.43	65.5	–
LSD 0.01	208.9	10.8	15.5	1.16	0.58	88.3	–
Row spacing (cm)							
30 × 20 cm (P_1)	887	101	154	11.9	49.5	339	80
60 × 20 cm (P_2)	1096	65	159	13.5	59.0	377	84
LSD 0.05	126.8	6.6	9.5	0.96	0.35	53.6	–
LSD 0.01	170.5	8.9	12.8	0.93	0.46	72.1	–

On the other hand, the 19% yield loss associated with increasing planting density to 16.6 plants m^{-2} was a consequence of reduced seed yield plant^{-1} that mostly resulted from the significant (P = 0.01) reduction in both head diameter and seed size at the higher density with an indirect effect through seed yield/plant^{-1} (Table 2). Number and percentage of filled seeds head^{-1} and plant height also decreased with increasing density but these effects were insignificant. Similarly, reductions in seed yield (Vijayalakshmi *et al.* 1975); number of filled seeds plant^{-1} (Majid and Scheneiter, 1987a; Hedge and Havanagi, 1988a); head diameter (Zubriski and Zimmerman, 1974; Majid and Scheneiter, 1987a) and seed size (Massey, 1971) at high plant densities were reported in the literature.

In spite of the significant interactions between cultivar, nitrogen and density (Table 3) highest seed yield of both Hungarian A and Cerninka were attained on the application of 40 kg N ha^{-1} (N_1) at the lower (60 × 20 cm spacing or 8.3 plants m^{-2}) planting density. At this level (N_1P_2), Hungarian A (1343 kg ha^{-1}) outyielded Cerninka (1202 kg) by 11.7% but this difference was, however, insignificant (Table 3). The higher yields of Cerninka, at this level (N_1P_2) were mostly attributed to the favourable effects of nitrogen on plant height, head diameter and seed size (Narwal and Malik, 1985); whereas those of Hungarian A at the same level appeared to be due to an increase in head diameter (Karunakaran and Palaniappan, 1989) (Table 3). It is also evident from the cultivar × density interaction data (Table 3) that seed yield averaged over the cultivars, recorded at the higher planting density was significantly higher ($P \leq 0.05$) than that recorded at the lower density; whereas head diameter (Majid and Scheneiter, 1987a) and seed size (Rao and Reddy, 1985), in both cultivars, were significantly affected by changes in planting density.

Experiment II

The means of squares for the cultivars were highly significant for seed yield ($P < 0.01$) and significant for head diameter ($P < 0.05$) (Table 4). The 29% yield difference between the two cultivars (Bolero being 1008 and Cerninka 782 kg ha^{-1}) was directly related to differences in head diameter, as Cerninka, the lowest yielder, had the smallest head (Table 5).

It is evident from Table 4 that nitrogen, as reported by Narwal and Malik (1985), had significantly affected plant height and number of seeds head^{-1}; whereas planting density, as observed by Majid and Scheneiter (1987a), had significantly affected the actual number of harvested plants ha^{-1} and head diameter. The main effects of both factors on seed yield, unlike those of cultivar, were, however, not significant (Tables 4 and 5); whereas their interactions with one another and with cultivar on seed yield and on most of its components, as recorded by Holt and Campbell (1984) were significant (Table 4). Similarly, Miller and Fick (1978), Prunty (1981) and Holt and Campbell (1984) reported no significant effect of plant population on seed yield; whereas Loubser *et al.* (1988) indicated that yields of 1.3 t ha^{-1}, comparable to those reported in this study, could be obtained without N application. It is evident from the interaction data (Table 6) that both cultivars had their highest seed yield at the higher planting density (60 × 20 cm or 8.3 plants m^{-2}). At this density, cultivar Bolero had

TABLE 3. Interaction effects of cultivar, N-fertilizer and row spacing on seed yield and other plant characters of supplementary irrigated sunflower averaged over seasons 1983 and 1984 (Exp. I).

Cultivar row spacing	Hungarian A (V_1) 30 × 20 (P_1)	Hungarian A (V_1) 60 × 20 (P_2)	Mean	Cerninka (V_2) 30 × 20 (P_1)	Cerninka (V_2) 60 × 20 (P_2)	Mean	Mean N P_1	Mean N P_2
N-applied (kg ha^{-1})			– Seed yield (kg ha^{-1}) –					
0	1083	1245	1164	686	732	709	885	937
40	990	1343	1167	684	1202	1033	927	1273
80	1035	1090	1063	660	667	664	848	879
Mean	1036	1226		737	8672			
			No. of plants harvested (000 ha^{-1})					
0	123	66	94.5	77	59	68.0	100.0	62.5
40	124	67	95.5	102	67	84.5	112.7	67.0
80	120	67	93.5	620	65	63.5	91.7	66.5
Mean	122.3	66.7		80.3	63.7			
			Plant height (cm)					
0	194	221	207.5	87	85	85.5	140.5	153
40	228	227	227.5	101	103	102.0	164.5	165.0
80	224	231	227.5	88	86	87.0	156.0	159.0
Mean	215.3	226.3		92.0	91.3			
			Head diameter (cm)					
0	12.8	15.2	14.0	9.9	10.6	10.3	11.4	12.9
40	14.4	15.7	15.1	9.7	13.4	11.6	12.1	14.6
80	14.4	15.1	14.8	10.1	10.8	10.5	12.3	13.0
Mean	13.9	15.3		9.9	11.6	11		
			1000 seed weight (g)					
0	66.0	78.0	72.0	34.0	40.0	37.0	50.0	59.0
40	62.0	75.0	68.5	37.0	47.0	42.0	49.5	61.0
80	59.0	70.0	64.5	39.0	44.0	41.5	49.0	57.0
Mean	62.3	74.3		36.7	43.7			

LSD at :

	VP 0.05	VP 0.01	VN 0.05	VN 0.01	PN 0.05	PN 0.01	VPN 0.05	VPN 0.01
Seed yield (kg ha^{-1})	179.1	241.0	219.5	295.3	219.5	295.3	310.3	417.3
No. of plants (000 ha^{-1})	9.2	12.4	11.2	15.1	11.2	16.1	16.1	21.7
Plant height (cm)	13.8	17.8	16.1	21.7	16.1	21.7	23.0	31.0
Head diameter (cm)	0.97	1.3	1.21	1.6	1.21	1.6	1.7	2.3
1000-seed weight (g)	4.9	6.6	6.0	8.1	6.0	8.1	8.4	11.2

TABLE 4. Analysis of variance for seed yield and other plant characters of supplementary irrigated sunflower averaged over seasons 1983 and 1984 (Exp. II).

Source	df	Seed yield ($kg\,ha^{-1}$)	No. of plants ($1000\,ha^{-1}$)	Plant height (cm)	Head diameter (cm)	No. of full seeds $head^{-1}$
			– Significance of F-values –			
Replication	3	–	–	–	–	–
Cultivar (C)	1	**	NS	NS	*	NS
Planting density (P)	1	NS	**	NS	NS	NS
C × P	1	*	**	NS	*	NS
Nitrogen (N)	2	NS	NS	*	NS	*
P × N	2	*	**	*	NS	**
C × N	2	**	NS	NS	NS	*
C × N × P	2	**	**	*	*	*
Error	33	44268.0	92.2	88.4	4.0	18171.0
			– Coefficient of variation –			
		23.5	21.5	6.8	13.3	30.4

* and ** = significant at 5 and 1% levels, respectively.
NS = Not significant at the 5% level.

TABLE 5. Main effects of cultivar, N-fertilizer and row spacing on seed yield and other plant characters of supplementary irrigated sunflower averaged over seasons 1983 and 1984 (Exp. II).

	Seed yield ($kg\,ha^{-1}$)	No. of plants ($1000\,ha^{-1}$)	Plant height (cm)	Head diameter (cm)	Full seeds $head^{-1}$	
					number	%
Treatments						
Cultivar						
Cerninka (V_2)	781	43	138	14.4	434	82.2
Bolero (V_3)	1008	45	138	15.6	452	83.9
LSD 0.05	123.8	5.8	5.5	1.15	79.2	–
LSD 0.01	166.6	7.7	7.4	1.55	106.6	
N-applied ($kg\,ha^{-1}$)						
0	966	45	140	15.1	495	85.0
40	875	47	133	14.5	379	80.0
80	843	41	142	15.5	456	85.1
LSD 0.05	151.5	6.9	6.9	1.44	97.7	
LSD 0.01	203.5	9.3	9.3	1.93	131.4	
Row spacing (cm)						
60 × 20 (P_2) (P_1)	956	51	140	14.6	455	85.2
60 × 40 (P_2)	833	37	136	15.4	432	81.5
LSD 0.05	123.9	5.8	5.5	1.2	79.2	
LSD 0.01	166.6	7.7	7.4	1.5	106.6	

TABLE 6. Interaction effects of cultivar, N-fertilizer and row spacing on seed yield and other plant characters of supplementary irrigated sunflower averaged over seasons 1983 and 1984 (Exp. II).

Cultivar row spacing	Cerninka (V_2) 60 × 20 (P_1)	Cerninka (V_2) 60 × 40 (P_2)	Cerninka (V_2) Mean	Bolero (V_3) 60 × 20 (P_1)	Bolero (V_3) 60 × 40 (P_2)	Bolero (V_3) Mean	Mean P_1	N P_2
N-applied (kg ha^{-1})			Seed yield (kg ha^{-1})					
0	862	824.4	843	1179	998	1088	1021	911
40	745	752	749	1078	924	1001	912	838
80	819	680	750	1052	819	936	936	750
Mean	809	752		1103	914			
			No. of plants harvested (000 ha^{-1})					
0	49.8	35.9	42.9	55.7	39.0	47.4	52.8	37.5
40	52.4	41.9	47.1	56.7	36.0	46.4	54.6	39.0
80	44.0	34.8	39.5	50.0	34.8	42.4	47.0	34.8
Mean	48.8	37.6		54.0	36.7			
			Plant height (cm)					
0	147	138	142.5	135	139	137.0	141.0	139.0
40	133	128	130.5	134	138	136.0	134.0	133.0
80	144	140	142.0	149	133	141.0	147.0	137.0
Mean	141.3	135.3		139.3	136.7			
			Head diameter (cm)					
0	13.8	15.1	14.5	15.1	16.2	15.7	14.5	15.7
40	13.0	13.6	13.3	14.7	16.4	15.6	13.9	15.0
80	15.6	15.1	15.4	15.2	16.0	15.6	15.4	15.6
Mean	14.1	14.6		15.0	16.2			
			No. of full seeds head^{-1}					
0	573	432	503	577	396	487	575	414
40	300	367	334	417	430	424	359	399
80	480	450	465	380	514	447	430	482
Mean	451	416		458	447			

LSD at :

	VP 0.05	VP 0.01	VN 0.05	VN 0.01	PN 0.05	PN 0.01	VPN 0.05	VPN 0.01
Seed yield (kg ha^{-1})	175.1	235.6	214.3	288.3	214.3	288.3	303.0	407.6
No. of plants (000 ha^{-1})	7.8	10.5	9.8	13.2	9.8	13.2	13.8	18.6
Plant height (cm)	7.8	10.5	9.5	12.8	9.5	12.8	13.5	18.2
Head diameter (cm)	1.7	2.3	2.0	2.7	2.0	2.7	2.9	3.9
1000-seed weight (g)	112.1	150.7	137.4	184.8	137.4	184.8	192.2	261.2

consistently outyielded Cerninka at each level of N. Thus, an overall yield difference ($P = 0.01$) of 36% (Bolero, being 1103 and Cerninka 809 kg ha^{-1}) existed between the two cultivars at this density but not at the lower density. At higher density, cultivar Bolero also maintained a higher number of harvestable plants ha^{-1}, larger heads and higher number of filled seeds than Cerninka, but the difference, being insignificant, could not account for the significant yield difference recorded between the two cultivars at this planting density.

Conclusion

Data collected in the course of this study indicated that seed yields of the tall and late maturing cultivar Hungarian A, amounted to 41 per cent over Cerninka and to about 12 per cent over Bolero, indicating that semi-dwarf (Majid and Scheneiter, 1987a) and early maturing plant type (Wade and Foreman, 1988) had no yield superiority over the tall and late maturing type. The superiority of Hungarian A was apparently attributed to its thick stem diameter that enabled it to withstand lodging and maintain a relatively high number of harvestable plants and extra height that probably enabled it to have a relatively high number of leaves and consequently a high leaf area and a high net assimilation rate.

In general, application of 40 kg N ha^{-1} resulted in the highest seed yield ha^{-1}. The effect of this dose in seed yield was, however, significant at the higher (83,333-166,666) but not at the lower (83,333-41,666) density ranges. At higher ranges, nitrogen (40 kg ha^{-1}) had favourably effected most of the traits evaluated, whereas at the lower ranges, it had adversely affected plant height and number of seeds head^{-1}. Application of 80 kg N ha^{-1} tended to have an adverse effect on seed yield and most of its components, at the higher ranges but not at the lower ranges. Similarly Kovacik and Skaloud (1988) indicated that excess nitrogen application at high population densities (83000) reduced seed yield in sunflower.

When averaged over nitrogen and cultivar, seed yields were highest at the intermediate plant density (60 × 20 cm or 83,333 plants ha^{-1}). Reducing this density to 41,666 plant ha^{-1} (60 × 40 cm) or increasing it to 166,666 (30 × 20 cm) resulted in yield losses of 12 and 18 per cent at the respective densities. In a similar study, Rao and Reddy (1985) also reported highest seed yields in sunflower at 83,333 plants ha^{-1}. Apparently lower yields at the higher densities were mainly due to reduction in head diameter (Miller and Fick, 1978; Majid and Scheneiter, 1987a) and seed size (Miller and Fick, 1978; Rao and Reddy, 1985; Guar *et al.*, 1987, Majid and Scheneiter, 1987a), whereas reductions in yield at the lower density were attributable to lower number of harvestable plants ha^{-1} (Narwal and Malik, 1985).

The significant cultivar × density × nitrogen interactions observed in this study, in contrast with those reported by Narwal and Malik (1985), indicated that in selection programmes, different sunflower cultivars need to be evaluated at different plant densities and nitrogen levels.

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تأثير الكثافة النباتية والأزوت على السلوك الفلاحي لزهرة دوار الشمس بالمناطق الجافة

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المستخلص : اجريت التجارب الحقلية لمدة عامين لدراسة تأثير الكثافة النباتية ومستوى الأزوت على الزراعة المتأخرة لزهرة دوار الشمس ، وشملت الدراسة وزن المحصول وصفات أخرى بالمناطق الجافة بوسط السودان . ففي التجربة الأولى زرع الصنفان (Hungarian A, Cerninka) تحت كثافتين (٨٣,٣٣٣ و ١٦٦,٦٦٦ نبات للهكتار) وثلاثة مستويات أزوتية (صفر ، ٤٠ و ٨٠ كجم للهكتار) أما في التجربة الثانية فقد زرع الصنفان (Cerninka, Bolero) عند نفس المستويات الأزوتية وعند كثافة نباتية ٨٣,٣٣٣ و ٤١,٦٦٦ نبات للهكتار . اختلفت إنتاجية الصنف Hungarian A في التجربة الأولى معنويا عن الصنف Cerninka بزيادة قدرها ٣٢,٧٪ كما تفوق الصنف Bolero تفوقا معنويا وبزيادة ٢٩,١٪ على الصنف Cerninka في التجربة الثانية . وتحت ظروف التجربة الأولى أدت معاملة الأزوت الثانية (٤٠ كجم/هكتار) لزيادة معنوية في الإنتاجية وطول النبات ، عدد النباتات المحصودة للهكتار وقطر الرأس ووزن الألف حبة . كذلك أدت الزراعة عند المستوى الأدنى (٨٣,٣٣٣ نبات/هكتار) على العكس من الزراعة عند المستوى الأعلى (١٦٦,٦٦٦ نبات / هكتار) للزيادة المعنوية في الإنتاجية ووزن الألف حبة وإلى النقص المعنوي في عدد النباتات للهكتار . أما في التجربة الثانية فقد أدى التسميد بمعدل ٤٠ كجم أزوت للهكتار إلى نقص معنوي في طول النبات وعدد البذور المليئة بالرأس بينما أدت الكثافة النباتية الدنيا (٤١,٦٦٦) إلى نقص معنوي في عدد النباتات المحصودة . وفي كلا التجربتين لم يؤثر التسميد بمعدل ٨٠ كجم أزوت / هكتار معنويا على أي من الصفات التي درست . إذا استبعدنا صفة عدد البذور المليئة بالرأس (التجربة الأولى) فإن كل تفاعلات المستوى الأول (التجربة الأولى) والمستوى الثاني (التجربتين) بين العوامل الثلاثة التي درست كانت معنوية مما يدل على ضرورة إجراء البرامج الانتخابية لتحسين محصول زهرة دوار الشمس تحت معدلات سمادية وكثافات نباتية مختلفة . ويبدو من الدراسة أن المعدلات :

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٨٣,٣٣٣ نبات كحد أدنى و ٤٠ كجم أزوت كحد أقصى للهكتار هما أنسب المعدلات للحصول على إنتاجية أعلى للزراعات المتأخرة لزهرة دوار الشمس بالمناطق المدارية الجافة .