EFFECT OF PLANT DENSITY ON THE PERFORMANCE OF THREE NEW RELEASED LENTIL VARIETIES

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Abstract

The study aimed to investigate the effect of plant density (200, 300, 400 and 500 plants/m^2) on the economic lentil characters of the new released varieties Sinai 1, Giza 4 and Giza 51 in comparison with the old variety Giza 9 at north and south Egypt. A field experiment was carried out at Gemmiza (Middle Delta) and Mattaana (Upper Egypt) research stations in 2001/2002 and 2002/2003 seasons. Significant differences occurred among plant densities, varieties, and locations. 400 plants/m^2 produced the maximum yield/feddan, surpassing the yield of 200 plants/m^2 by 40.7 and 23.4% at Gemmiza and Mataan, respectively. The variety Giza 4 at 400 plants/m^2gave the highest seed yield at Gemmiza (5.19 ardab/fed) and Mataana (3.89 ardab/fed). Although low plant density of 200 plants/m^2 gave more branches, pods, seeds and seed weight/plant over all other plant densities, it was outweighed by the effect of population gradients on those characters and hence high plant density produced high seed yield/feddan. With consideration to differences in seed size among varieties, and the significance of variety x plant density interaction, the densities 300 plants/m^2 for Sinai 1 and 400 plants/m^2 for other varieties are recommended for higher yields of lentil. The equivalent seed rates/feddan are 45kg for Sinai 1, 37kg for Giza 4 and Giza 9 and 42kg for Giza 51.

INTRODUCTION

Lentil (*Lens culinaris* Medikus) is an old and a traditional crop in Egypt. Despite its small annual cultivated area (about 5000 feddan), it is planted in 14 Governorates in both north and south the country (Anonymous, 2003). Because lentil is mainly grown under irrigated conditions in Egypt, it is planted at high plant density. The recommended seed rate in irrigated lands for old varieties (Giza 9 and Giza 370) is 50kg/fed, while in rainfed lands in the north, lower seed rate of 20-25 kg/fed is recommended (Hamdi *et al.*, 1998).

Response of lentil to plant density varies according to growing conditions such as soil type, fertility, environment and genotypic differences as yield potential, growth vigor, plant height, branching type and plant plasticity (Saxena, 1981). Several researchers have reported that there is a general trend for increase in seed yield with increasing plant density and/or seed rate. A plant density of 300 to 450 plants/m^2 generally resulted in the highest yield (Ezzat, 1994). In south Egypt planting lentil (cultivar: Giza 9) with high seed rate ranged from 60 to 70kg/fed gave the highest seed yield/fed (Saleeb, 1990, El-Far, 2000 and Allam, 2002). A lower seed rate of 45-50kg/fed (cultivar: Giza 370) was optimal to produce the highest seed yield/fed in north Egypt (Amer *et al.*, 1990 and Ezzat, 1994). The previous results indicated that low plant densities tend to increase yield and yield components per plant (see also Dutta, 1998). In Egypt, when the variety Giza 9 was planted at Assiut with 30kg/fed, it gave the highest number of branches/plant, pods/plant, seeds/plant and seed weight/plant. But the tallest plants and the highest seed yield/fed were obtained when lentil was sown at 60 kg/fed (Allam, 2002 and El-Nagar, 2002).

The lentil improvement program has released three lentil varieties named Sinai 1 (Hamdi *et al.*, 2002), Giza 4, and Giza 51(Hamdi, 1998). Therefore, it is necessary to identify the optimum plant density for these new varieties to boost yields. Hence this study aimed to investigate the effect of plant density on the performance of new released varieties at north and south Egypt

MATERIALS AND METHODS

The new released lentil varieties Sinai 1, Giza 4 and Giza 51 and the wide spread local cultivar Giza 9 were grown in four field experiments under four plant densities at the Experimental Farms of the Agricultural Research Center at Gemmiza in Gharbia Governorate, and Mataana in Qena Governorate in the two-winter seasons 2001/2002, and 2002/2003. The plant densities used were 200, 300, 400, and 500 plants/m^2. Date of planting was during last week of October at Mataana and first week of November at Gemmiza in both seasons.

A split plot design with 4 replicates was used. The varieties were randomly set up in the main plots, while plant densities were arranged in the sub-plots. Each plot contained 6 rows, 4-m long and 0.3-m width (7.2 m^2). Fertilizers at 15kg N and 25kg P_2O_5/feddan were applied to the soil before planting. Three irrigations were applied,

at planting, at month and two months after planting. Days to 50% flowering and 90% maturity were recorded in each plot. At harvest, 15 individual plants were randomly taken from the central area of each plot to record plant height (cm), number of branches/plant, seed weight/plant, number of seeds/plant and number of pods/plant. The remaining plants in each plot were hand-pulled, air-dried, weighed, then threshed by hand. Seed yield/fed and 100-seed weight were estimated thereafter.

The analysis of variance was made separately for each season in each location then a combined analysis for seasons and locations was calculated (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

The combined analysis of variance indicated highly significant differences among seasons, locations, varieties and plant densities for all studied characters, except days to flowering and maturity for season, number of pods/plant for location, and 100-seed weight for plant density (Table 1). The significance and magnitude of interaction effects varied widely. However, the location x plant density and variety x plant density interactions were higher in magnitude than other interactions for most of the studied characters (Table 1), indicating their importance in this study.

Performance of varieties:

Data in Table (2) show significant differences among varieties at Gemmiza and Mataana for all studied characters, except number of branches/plant at Mataana. The variety Giza 4 had the highest values of yield and most of other characters, indicating its superiority. Giza 4 outyielded Sinai 1, Giza 51 and Giza 9 by 49, 11 and 36% at Gemmiza and 47, 14, and 5% at Mataana, respectively. The variety Sinai 1 had the largest seed size and it was the earliest in flowering and maturity at Gemmiza (it matured 14 days earlier than Giza 9). But at Mataana, it flowered and matured at the same time as Giza 9 (Table 2). Earliness in maturity of Sinai 1 in north Egypt was previously reported (Hamdi *et al.*, 2002). Yield superiority of Giza 4 was also reported by Ezzat *et al.* (1999).

Plant density effects:

Plant density had significant effects on all studied characters, except 100-seed weight at both locations (Tables 1 & 3). Plant height increased with increasing plant density at both locations. For example, plant height at Gemmiza has increased from

29.97 to 35.43 cm with increasing plant density from 200 to 500 plants/m^2 (Table 3). This might be due to competition among plants for light in dense populations. Supporting evidence comes from another lentil study (Dutta *et al.*, 1998), who found plant height increases with increasing plant density. They added also that the light limitation in dense plants (high plant density) leads to decrease total chlorophyll content in green parts of lentil plants comparing with competition-free plants in less-dense populations. Number of branches/plant was increased with the decreasing plant density as indicated in Table (3). In lower density, wide distances between plants allow them to produce more branches. Little effects of plant density on days to flowering and maturity occurred at the two locations as presented in Table (3).

Low plant density treatments resulted in higher seed weight/plant and better yield component characters. For example, at Gemmiza seed weight/plant at 200 plants/m^2 was 1.69 g then decreased gradually to be 1.02 g at 500 plants/m^2. Similarly, number of pods and seeds per plant decreased from 48.7 pods and 64.2 seeds at 200 plants/m^2 to 27.8 pods and 41.1 seeds at 500 plants/m^2. Siddique (1998) reported increasing yield/plant and improved yield components due to sowing lentil at low plant densities. However, seed yield/fed showed reverse trend as it was increased with increasing number of plants/m^2. At Gemmiza, seed yield/fed was 2.70, 3.19, 3.80, and 3.64 ardab for 200, 300, 400, and 500 plants/m^2, respectively (Table 3). The percentage increases in seed yield/fed at 300, 400 and 500plants/m^2 over 200 plants/m^2 were 18.2, 40.7 and 34.8%, respectively. Similar trend was observed at Mataana, where the percentage increases in seed yield/fed at 300, 400 and 500plants/m^2 over 200 plants/m^2 were 15.6, 23.4, and 12.1%, respectively. Data showed that the highest seed yields at Gemmiza and Mataana were 3.80 and 3.17 ardab/fed, respectively, which produced by planting lentil at 400 plants/m^2. Similar results were reported by Amer *et al.* (1990), where the maximum lentil yield/fed was obtained from 400 plants/m^2.

The results indicated that seed weight/plant and yield components as number of pods and seeds/plant were significantly higher in low plant densities than under higher plant densities due to better growth and development of individual plants occurred under lower densities. But the lower densities did not compensate yield advantage from more number of plants per feddan under higher plant densities.

Interaction effects:

The analysis of variance (Table 1) showed that the two interaction values of location x plant density and variety x plant density were the largest in magnitude among all seven interactions, for most of the studied characters, indicating their importance. Although the interaction of location x plant density had significant effects on most of studied characters, results indicated that the maximum yield/fed could be obtained from sowing lentil at 400 plants/m^2 in both locations (Table 3).

Regarding the variety x plant density interaction, the average performances of all varieties under all plant densities over locations for all studied characters are presented in Table (4). The results indicated that the maximum seed yield/fed of Sinai 1 was obtained using 300 plants/m^2, while 400 plants/m^2 was the optimum for maximum seed yield/fed for other varieties. This is probably because Sinai 1 matured earlier than other tested varieties, and hence it has fast growth rate and less vigor as indicated by its lower plant height and number of branches/plant (Tables 2 and 4). It is well known that a large dry matter yield in lentil is often associated with large growth rate and slow development (Summerfield, 1981). However, the relatively heavier seed index of Sinai 1 may contribute to seed yield per plant and per feddan. For other varieties, it seems that dense populations enable development of canopy, which can intercept most of the incident radiation, and thus results in higher build-up of yield.

The above results indicate that response of lentil to plant density varies depending upon the growing conditions (location) and variety. Seed yield/fed has been increased with increasing plant population till 300 to 400 plants/m^2. With consideration to differences in seed size among tested varieties and variety x plant density interaction, the equivalent seed rates per feddan to produce 300 plants/m^2 for Sinai 1 and 400 plants/m^2 for other tested varieties are: 45kg for Sinai 1, 37kg for Giza 4 and Giza 9 and 42kg for Giza 51.

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Table 1. Mean squares of season, location, varieties, plant density and their interactions for all lentil characters evaluated at Gemmiza and Mataana research stations in 2001/2002 and 2002/2003 seasons.

Source of variance	Plant height (cm)	No of branc-hes/ plant	Days to 50% flowering	Days to maturit y	No of pods/ plant	No of seeds/ plant	100-seed weight (g)	Seed weight / plant (g)	Seed yield ardab /fed
Season (S)	3891**	10.2**	0.66	0.004	13661**	19791**	0.833*	9.8**	13.6**
Error (a)	62.7	0.18	1.58	2.66	9.05	14.89	0.04	0.01	0.04
Location (L)	2704**	93.1**	15986**	14777**	129.3	335.5*	1.66**	0.86**	12.1**
S x L	114.5	0.42	10.97*	5.94	210.1	128.1	0.00	0.03	0.00
Error (b)	40.5	2.50	2.73	2.13	49.4	84.3	0.08	0.04	0.11
Varieties (V)	1057**	2.85**	1140**	819.2**	7009**	10904**	29.02**	2.19**	45.6**
S x V	27.9	0.38*	2.88*	1.85	689**	1294**	0.06	0.35**	0.02
L x V	152.4**	1.49**	494.6**	493.6**	549.9**	720.0**	0.05	1.61**	3.30**
S x L x V	17.2	0.26	3.17*	0.39	140.6**	276.8**	0.02	0.36**	0.02
Density (D)	621.2**	11.3**	22.7**	3.69*	3644**	5461**	0.06	4.29**	8.26**
S x D	7.924	0.05	5.23**	2.54*	36.87**	17.8	0.03	0.02*	0.05
L x D	32.40**	1.01**	30.9**	16.4**	117.9**	36.4*	0.03	0.06**	1.48**
S x L x D	2.38	0.11	2.40	1.35	35.2**	6.4	0.13*	0.01*	0.03
V x D	19.73**	0.17	8.21**	7.22**	43.2**	18.5	0.08	0.03**	0.92**
S x V x D	2.29	0.09	2.66*	1.59	49.7**	59.9**	0.10*	0.09**	0.06
L x V x D	8.25	0.30	6.62**	5.00**	38.0**	7.9	0.05	0.05**	0.27**
S x L x V x D	3.71	0.06	4.33**	0.62	25.5**	28.4*	0.10*	0.03**	0.05
Error (c)	8.56	0.15	1.14	1.09	8.7	14.4	0.06	0.01	0.03

**, * Significant at 0.01 and 0.05 levels of probability, respectively.

Table 2. Average performance of the tested varieties for all studied characters at Gemmiza and Mataana research stations over seasons.

Character	Sinai 1	Giza 4	Giza 51	Giza 9	LSD (0.05)
Gemmiza research station					
Plant height (cm)	27.36	36.08	34.16	34.13	1.54
No. of branches/plant	3.29	4.06	4.01	3.65	0.22
Days to 50% flowering	72.59	83.47	83.84	85.72	0.47
Days to 90% maturity No. of pods/plant	132.94	144.06	143.97	146.09	0.53
No of seeds/plant	22.46	48.25	45.79	33.17	0.91
100-seed weight (g)	30.61	65.47	61.31	48.51	1.18
Seed weight/plant (g)	3.64	2.23	2.62	2.28	0.16
Seed yield (ardab/fed)	1.09	1.74	1.48	1.02	0.04
	2.24	4.37	3.93	2.80	0.09
Mataana research station					
Plant height (cm)	34.85	45.35	41.27	40.71	1.36
No. of branches/plant	2.45	2.63	2.58	3.34	NS
Days to 50% flowering	62.88	63.25	71.38	64.91	0.58
Days to 90% maturity No. of pods/plant	125.03	125.41	130.03	125.81	0.51
No of seeds/plant	25.25	48.00	41.75	48.13	1.86
100-seed weight (g)	34.00	59.75	51.75	62.61	2.39
Seed weight/plant (g)	3.54	2.06	2.38	2.14	0.07
Seed yield (ardab/fed)	1.24	1.28	1.21	1.48	0.04
	1.83	3.48	3.31	3.93	0.10

NS: Not significant. One Ardab = 160kg.

Table 3. Effect of plant density on plant height (PHT), branches/plant (BR), Days to 50% flowering (FLO), days to 90% maturity (MAT), pods/plant (PP), seeds/plant (SP), 100-seed weight (SZ), seed weight/plant (SYP) and seed yield, ardab/feddan (SYF) over varieties at Gemmiza and Mataana research stations over seasons.

Plant density	PHT	BR	FLO	MAT	PP	SP	SZ	SYP	SYF
Gemmiza research station									
200 plants/m^2	29.97	4.44	81.50	141.5	48.7	64.2	2.73	1.69	2.70
300 plants/m^2	32.03	3.89	80.34	141.5	39.5	53.7	2.69	1.42	3.19
400 plants/m^2	34.30	3.51	80.66	141.3	33.7	46.9	2.64	1.21	3.80
500 plants/m^2	35.43	3.18	83.13	142.8	27.8	41.1	2.71	1.02	3.64
LSD 0.05	1.54	0.22	0.47	0.53	0.91	1.18	NS	0.04	0.09
Mataana research station									
200 plants/m^2	34.45	2.89	65.09	127.0	46.5	59.8	2.57	1.52	2.57
300 plants/m^2	38.62	2.70	65.88	126.3	40.6	51.8	2.55	1.26	2.97
400 plants/m^2	41.50	2.38	65.78	126.9	36.3	45.3	2.52	1.11	3.17
500 plants/m^2	43.15	2.23	65.66	126.2	32.0	40.0	2.48	0.98	2.88
LSD 0.05	1.36	0.17	0.58	0.51	1.86	2.39	NS	0.04	0.10

NS: Not significant. One ardab = 160kg.

Table 4. Effect of variety x plant density interaction on plant height (PHT), branches/plant (BR), days to 50% flowering (FLO), days to 90% maturity (MAT), pods/plant (PP), seeds/plant (SP), 100-seed weight (SZ), seed weight/plant (SYP) and seed yield ardab/feddan (SYF) for the tested varieties over seasons and locations.

Plant density	PHT	BR	FLO	MAT	PP	SP	SZ	SYP	SYF
Sinai 1									
200 plants/m^2	28.72	3.43	67.56	129.81	32.72	42.93	3.68	1.56	1.80
300 plants/m^2	30.40	2.90	67.94	128.88	25.89	34.80	3.59	1.24	2.22
400 plants/m^2	31.88	2.65	67.56	128.13	21.28	29.28	3.56	1.03	2.10
500 plants/m^2	33.43	2.50	67.88	129.13	15.53	22.23	3.59	0.83	2.03
Giza 4									
200 plants/m^2	37.35	3.88	73.63	135.44	60.63	74.84	2.13	1.87	3.21
300 plants/m^2	40.33	3.65	72.63	134.00	49.81	64.41	2.21	1.55	3.63
400 plants/m^2	42.18	3.05	72.13	134.25	44.26	58.58	2.15	1.39	4.54
500 plants/m^2	43.00	2.80	75.06	135.25	37.80	52.63	2.09	1.23	4.33
Giza 51									
200 lants/m^2	32.65	3.65	75.44	135.69	53.87	69.38	2.48	1.60	3.05
300 plants/m^2	36.14	3.40	74.31	135.87	44.08	59.10	2.49	1.42	3.47
400 plants/m^2	40.14	3.18	75.56	136.31	39.92	51.25	2.42	1.25	3.82
500 plants/m^2	42.13	2.95	75.94	135.94	37.20	46.40	2.63	1.22	3.49
Giza 9									
200 plants/m^2	30.15	3.70	76.56	136.06	43.19	60.83	2.29	1.40	2.51
300 plants/m^2	34.43	3.23	77.56	136.81	40.33	52.65	2.19	1.15	3.02
400 plants/m^2	37.56	2.40	77.63	137.63	34.38	45.18	2.19	0.98	3.49
500 plants/m^2	38.60	2.55	78.69	137.50	29.13	40.88	2.13	0.80	3.20
LSD (0.05)	2.02	0.27	0.74	0.72	2.03	1.86	0.12	0.05	0.09

تأثير الكثافة النباتية على أداء ثلاثة أصناف جديدة من العدس

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أجرى هذا البحث لدراسة تأثير أربع كثافات نباتية مختلفة وهى ٢٠٠، ٣٠٠، ٤٠٠، ٥٠٠ نبات/م^{2} على بعض الصفات الاقتصادية لأصناف العدس المستنبطة حديثا وهى سيناء ١وجيزة ٤وجيزة ٥١ مقارنة بالصنف المحلى جيزة ٩، وقد أقيمت التجربة بمحطتى بحوث الجميزة (وسط الدلتا) والمطاعنة (مصر العليا) خلال موسمي ٢٠٠١/٢٠٠٢ و ٢٠٠٢/٢٠٠٣.

وقد أوضحت النتائج وجود اختلافات معنوية بين الكثافات والاصناف والجهات التى تمت بها الدراسة، وقد حققت الكثافة النباتية ٤٠٠ نبات/م^{2} اعلا محصولا للفدان وأظهرت تفوقا كبيرا على كثافة ٢٠٠ نبات /م^{2} بلغت حوالي ٤٠,٧% في الجميزة و ٢٣,٤% في المطاعنة، وقدتم الحصول على أعلى إنتاجية بزراعة الصنف جيزة ٤ بكثافة نباتية ٤٠٠ نبات/م^{2} حيث بلغت ٥،١٩ إردب/فدان في الجميزة و ٣،٨٩ إردب/فدان في المطاعنة، وعلى الرغم من أن الكثافة النباتية المنخفضة (٢٠٠ نبات/م^{2}) حققت أعلى محصولا للنبات الفردي ومكوناته إلا أنها لم تستطيع تعويض نقص عدد النباتات بالفدان مقارنة بالكثافات النباتية الأعلى وبالتالي فإن محصول البذور للفدان قد زاد بزيادة الكثافة النباتية حتى ٤٠٠ نبات/م^{2}، وبناء على نتائج التفاعل بين الاصناف والكثافات والاختلاف في حجم بذور الأصناف المختبرة، فإننا نوصى بزراعة الصنف سيناء ١ بكثافة نباتية ٣٠٠ نبات /م^{2} وهى تعادل الزراعة بمعدل ٤٥ كجم تقاوى/فدان وزراعة الصنف جيزة ٤ وجيزة ٩ بكثافة ٤٠٠ نبات /م^{2} أي بمعدل ٣٧ كجم تقاوى/فدان وزراعة الصنف جيزة ٥١ بكثافة ٤٠٠ نبات /م^{2} أي بمعدل ٤٢ كجم تقاوى/فدان للحصول على أعلى إنتاجية للفدان.