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PERFORMANCE OF THREE SOYBEAN VARIETIES UNDER DIFFERENT POPULATION DENSITIES IN SANDY SOILS

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ABSTRACT

Two field experiments were conducted during 2001 and 2002 seasons in the Agricultural Farm of Suez Canal University at Ismailia to study the effect of two planting distances between hills i.e. 10 and 15 cm and three numbers of plants per hill, namely two, three and four plants per hill on yield, its components and yield quality of three soybean varieties, Giza21, Giza82 and DR101.

The results showed that Giza21 variety significantly surpassed the other varieties in plant height, number and weight of pods and seeds /plant, 100-seed weight and seed, straw and biological yields per fad as well as seed oil and protein yields/fad. Giza82 variety recorded the highest seed oil and protein percentages.

Increasing plant population density through decreasing planting distance from 15 to 10 cm and/or increasing number of plants per hill from two to three and four plants consistently and significantly increased plant height, seed protein percentage and seed, straw and biological yields/fad as well as seed oil and protein yields/fad. The reverse was true regarding the yield attributes; number of branches, pods and seeds/plant, weight of pods and seeds/plant and 100-seed weight as well as seed oil percentage where the highest values were recorded with the lowest plant density achieved by sowing in hills spaced 15 cm apart and/or leaving two plants per hill.

However, the highest seed yield per fad was obtained by sowing four plants of Giza21 variety in hills spaced 10 cm apart.

INTRODUCTION

Soybean (*Glycine max* "L."Merr.) is one of the most important crops in the world as a source of vegetable oil and protein. Its seed protein is the best nutritional available plant protein sources, because it contains all essential amino acids. The total production of soybean in Egypt is still far below its requirements. So, hard efforts should be undertaken to increase the area under the crop as well as to improve its productivity and seed oil and protein contents through applying

optimum cultural practices as suitable plant population density as well as growing high yielding varieties.

Several researchers mentioned that soybean varieties showed differences in plant height, number of branches, pods and seeds/plant, weight of pods and seeds/plant, 100-seed weight and seed, straw and biological yields/fad as well as seed oil and protein percentages and their yields (El-Attar, 1992; Sharaf and Salwau, 1992; Hassanein and Ahmed, 1996; Shafshak *et al.*, 1997; Shams El-Din *et al.*, 1997; El-Karamity, 1998; Kahil, 1998 and El-Metwally, 1999).

With respect to the effect of plant population density on soybean crop, El-Sheikh (1981) studied two plant spacings 10 and 20 cm with 1, 2 and 3 plants/hill on soybean and revealed that sowing soybean plants in hills of 10 cm apart with two plants/hill gave the highest seed and straw yields/fad as well as seed protein content. But the tallest plants were obtained at plant distance of 10 cm apart with three plants/hill. However, maximum number of branches and pods/plant were achieved by sowing in hills 20 cm apart with one plant/hill. Abul-Naas *et al.* (1986) recorded that increasing the distance between soybean plants from 2.5 to 10 cm on rows 60 cm apart increased number of pods and seeds/plant, 100-seed weight, seed weight/plant and seed oil percentage. Sowing plants at 5 cm apart, produced the highest seed yield/fad and seed protein percentage. El-Karamity (1988) found that over planting distances, plant height as well as biological, seed and straw yields/fad were increased with sowing two plants/hill compared to one plant/hill. One plant/hill produced higher number of branches and pods/plant and seed oil percentage. Salamah *et al.* (1988) evaluated the influence of one and two plants per hill and three planting spaces between hills i.e. 5, 10 and 15 cm on soybean and stated that seed, straw and biological yields per fad were increased by decreasing the distance between hills from 15 to 5 cm and leaving two plants per hill. While seed weight/plant and seed oil content were increased with increasing planting distance from 5 to 15 cm and sowing one plant per hill. Zeyada *et al.* (1988) reported that soybean seed yield/fad was increased with sowing two plants/hill compared to one plant/hill, but the yield components i.e. number of pods/plant, seed weight/plant and 100-seed weight were decreased. That was true over planting distances between hills. Ali (1989) studied four plant densities i.e. 105, 140, 175 and 210 thousand plants/fad and demonstrated that increasing plant density reduced number of branches, pods and seeds/plant, seed weight/plant and seed oil percentage, but increased plant height, seed protein percentage and seed, protein and oil yields/fad. The maximum seed yield/fad was obtained at plant density of 175 thousand plants/fad. El-Attar (1992) studied the effect of four numbers of soybean plants per meter (10, 15, 20 and 25 plants per meter) of row 60 cm apart providing plant populations of 70, 105, 140 and 175 thousand plants/fad. It was found that decreasing plant density increased number of branches and pods/plant, seed weight/plant and 100-seed weight, while plant height and seed yield/fad were decreased. Mohamed (1994) studied 35, 70, 105, 140 and 175 thousand plants/fad and found that increasing plant density increased plant height and seed, straw, oil and protein yields/fad as well as seed protein percentage, while number of branches, pods and seeds/plant, seed weight/plant, 100-seed weight and seed oil percentage decreased. Shafshak

et al. (1997) studied the effect of intra row spacings 5, 10, 15, 20 and 25 plants per meter of linear ridge 60 cm apart, resulting in plant population densities 35, 70, 105, 140 and 175 thousand plants per fad on soybean. They revealed that plant height, seed protein percentage and seed, protein and oil yields/fad were significantly increased with increasing plant densities, while number of branches and pods/plant, seed weight/plant, seed index and seed oil percentage were decreased. Shams El-Din *et al.* (1997) showed that increasing plant density from 93333 up to 280000 plants/fad significantly increased plant height, seed protein percentage and seed, oil and protein yields/fad while number of branches and pods/plant, seed weight/plant, 100-seed weight and seed oil percentage were significantly decreased. Abu-Zaid (1998) evaluated plant population densities 93, 140, 186 and 280 thousand plants/fad and stated that plant height, seed and straw yields/fad as well as seed protein percentage were increased with increasing plant population density, while number of branches and pods/plant, 100-seed weight, seed yield/plant and seed oil percentage were increased with decreasing plant densities. Salem *et al.* (2000) studied the response of soybean to four plant densities i.e. 93333, 140000, 186666 and 280000 plants/fad and found that increasing plant density from 93333 to 280000 plants/fad significantly increased plant height and seed, straw, oil and protein yields/fad whereas number of branches and pods/plant and seed index were reduced.

MATERIALS AND METHODS

Two field experiments were conducted during 2001 and 2002 seasons at the Agricultural Experimental farm of Suez Canal University at Ismailia to study the effect of planting density as planting distances between hills and number of plants per hill on growth, yield, yield components and seed quality of three soybean varieties.

The soil of the experiments was sandy, with pH values of 7.83 and 7.74 and contained 15.8 and 18.3 ppm available N, 1.92 and 1.96 ppm available P, 13.5 and 16.85 ppm available K and 0.076% and 0.088% organic matter in the first and second seasons, respectively.

The split-split plots design with four replications was used in every experiment which included 18 treatments resulted from the following:-

A-Varieties:-

A1- Giza82: maturity group III (growth season 90 days).
A2- Giza21: maturity group IV (growth season 125 days).
A3- DR101: maturity group V (growth season 140 days).

B- Planting distances between hills:-

B1- 10 cm.
B2- 15 cm.

C- Number of plants per hill:-

C1- Two plants /hill resulting 140000 and 93333 plants/fad with planting distances 10 and 15 cm, respectively.
C2- Three plants/hill resulting 210000 and 140000 plants/fad with planting distances 10 and 15 cm, respectively.

C3- Four plants/hill resulting 280000 and 186666 plants/fad with planting distances 10 and 15 cm, respectively.

The varieties were allocated randomly in the main plots, while planting spacings between hills were arranged randomly in the sub plots and number of plants per hill were distributed at random in the sub sub plots. Each experimental sub sub plot consisted of 5 ridges, 4.2 meter in length and 60 cm in width, i.e. 12.6 m^2.

Calcium superphosphate fertilizer (16% P_2O_5) was applied at the rate of 200 kg/fad during preparing experimental soil.

Seeds of soybean were inoculated with the specific Rhizobium and sown at one side of the ridges on May 24 and 15 in the first and second seasons, respectively.

A starter dose of 30 kg N/fad of ammonium sulphate (21% N) and 75 kg/fad of potassium sulphate (48% K_2O) were added to the soil after thinning. After 19 days from sowing plants were thinned at the previous densities.

The normal cultural practices for growing soybean crop at Ismailia Governorate were followed.

At harvest, ten guarded plants were taken randomly from the inner ridges in each sub sub plot to determine plant height (cm), number of branches, pods and seeds per plant, weight of pods and seeds per plant (g) and 100-seed weight (g). Seed, straw and biological yields (kg/fad) were determined from the plants of the two inner ridges in each plot and the yields per fad were calculated.

Seed oil content (%) was determined by using the Soxhelt continuous extraction apparatus with petroleum ether as an organic solvent according to A.O.A.C. (1975). Seed oil yield per fad was calculated by multiplying oil percentage and seed yield per fad. Seed crude protein content (%) was determined as a total nitrogen (%) of the seeds using the modified micro Kjeldahl apparatus according to the method described by A.O.A.C. (1975), then the obtained values were multiplied by 6.25 as used by Tripathi *et al.* (1971) and seed protein yield per fad was calculated by multiplying seed protein percentage and seed yield per fad.

Data obtained were statistically analyzed according to procedures outlined by Snedecor and Cochran (1982). The combined analysis of variance was performed for the data of the two seasons. Means followed by the same alphabetical letters are not statistically different according to Duncan's Multiple Range Test at the 5% level of significance (Duncan, 1955).

RESULTS AND DISCUSSION

A – Effect of varieties:-

Data in Table (1) reveal that the two varieties Giza21 and DR101 produced the tallest plants without significant differences between them in the second season and in the combined data. While Giza82 variety gave the shortest plants and differed significantly as compared with the two mentioned varieties in both seasons and over them. These results are in agreement with those reported by El-Attar (1992) and El-Karamity (1998).

The highest number of branches/plant was produced by DR101 variety followed by Giza21 followed by Giza82 and the differences among the three varieties were significant in the two seasons but in the combined data the difference between Giza21 and Giza82 did not attain the statistical significance (Table 1). Similar results were obtained by Sharaf and Salwau (1992) and Shafshak *et al.* (1997).

It is clear from Tables (1 and 2) that there were significant variations among the grown soybean varieties in number and weight of pods and seeds/plant. The tested varieties could be arranged in a descending order with regard to aforementioned traits as follows: Giza21, DR101 and Giza82 with significant differences between the three varieties in both seasons and the combined data. Such differences among soybean varieties may be due to their different genetic constitutions and their response to the prevailing environmental conditions. These results are confirmed with those recoded by Hassanein and Ahmed (1996) and Kahil (1998).

The data in Table (3) show that Giza21 variety gave the heaviest 100-seed weight as compared with DR101 and Giza82 varieties, respectively with significant differences between the three varieties. That was true in the both seasons and their combined average. Similar results were reported by El-Attar (1992) and El-Metwally (1999).

The results presented in Table (3) reveal significant differences among the tested soybean varieties in seed yield/fad where Giza21 variety exhibited significant increase in seed yield/fad compared to DR101 which in turn surpassed significantly Giza82 in this respect in both seasons and the combined data. Giza21 variety outyielded DR101 and Giza82 varieties by 18.08% and 32.04% in the first season, 25.02% and 42.35% in the second season and 21.79% and 37.50% in the combined data, respectively. Moreover, DR101 variety significantly surpassed Giza82 in seed yield/fad by 11.82%, 13.86% and 12.90% in the two seasons and over them, respectively. Such results were expected, since Giza21 variety developed more pods and seeds/plant as well as greater seed weight/plant and heavier 100-seed weight which subsequently increased seed yield per fad. These results are in conformity with those reported by Sharaf and Salwau (1992), Shafshak *et al.* (1997), Shams El-Din *et al.* (1997), El-Karamity (1998) and El-Metwally (1999).

Table (1): Effect of varieties, distances between hills and number of plants per hill on plant height, number of branches/ plant and number of pods/ plant of soybean.

Treatments	Plant height (cm)			No. of branches/ plant			No. of pods/ plant		
	2001	2002	Comb.	2001	2002	Comb.	2001	2002	Comb.
Varieties (V)									
Giza 21	54.41 a	60.00 a	57.20 A	1.63 b	2.07 b	1.85 B	38.08 a	43.50 a	40.79 A
Giza 82	47.00 c	49.00 b	48.00 B	1.35 c	1.63 c	1.49 B	31.58 c	36.58 c	34.08 C
DR101	51.50 b	55.83 a	53.66 A	2.22 a	2.83 a	2.52 A	35.16 b	39.16 b	37.16 B
F. test	*	*	*	*	*	*	*	*	*
Distances between hills (D)									
10 cm	55.38 a	58.66 a	57.02 A	1.58 b	2.02 b	1.80 B	32.16 b	37.38 b	34.77 B
15 cm	46.55 b	51.22 b	48.88 B	1.89 a	2.32 a	2.11 A	37.72 a	42.11 a	39.91 A
F. test	*	*	*	*	*	*	*	*	*
Number of plants/ hill (P)									
2 plants	45.58 c	48.66 c	47.12 C	1.99 a	2.42 a	2.20 A	38.66 a	44.83 a	41.75 A
3 plants	51.00 b	55.00 b	53.00 B	1.70 b	2.15 b	1.92 B	34.50 b	40.00 b	37.25 B
4 plants	56.33 a	61.16 a	58.75 A	1.51 c	1.95 c	1.73 C	31.66 c	34.41 c	33.04 C
F. test	*	*	*	*	*	*	*	*	*
V × D	*	NS	NS	NS	NS	NS	NS	NS	NS
V × P	*	NS	NS	NS	NS	NS	*	NS	NS
D × P	*	*	NS	*	NS	NS	NS	NS	NS
V × D × P	*	NS	NS	NS	NS	NS	NS	NS	NS

Table (2): Effect of varieties, distances between hills and number of plants per hill on number of seeds/ plant, weight of pods/ plant and weight of seeds/ plant of soybean.

Treatments	No. of seeds/ plant			Weight of pods/plant (g)			Weight of seeds/ plant (g)		
	2001	2002	Comb.	2001	2002	Comb.	2001	2002	Comb.
Varieties (V)									
Giza 21	61.91 a	77.00 a	69.45 A	15.80 a	20.14 a	17.97 A	8.08 a	10.26 a	9.17 A
Giza 82	45.08 c	64.83 c	54.95 C	8.63 c	12.63 c	10.63 C	4.83 c	7.27 c	6.05 C
DR101	54.58 b	69.00 b	61.79 B	12.28 b	15.50 b	13.89 B	6.47 b	8.27 b	7.37 B
F. test	*	*	*	*	*	*	*	*	*
Distances between hills (D)									
10 cm	48.61 b	66.11 b	57.36 B	10.89 b	14.27 b	12.58 B	5.75 b	7.78 b	6.76 B
15 cm	59.11 a	74.44 a	66.77 A	13.58 a	17.91 a	15.75 A	7.18 a	9.42 a	8.30 A
F. test	*	*	*	*	*	*	*	*	*
Number of plants/ hill (P)									
2 plants	60.41 a	78.75 a	69.58 A	14.51 a	19.87 a	17.19 A	7.80 a	10.53 a	9.16 A
3 plants	53.33 b	70.58 b	61.95 B	12.06 b	15.62 b	13.84 B	6.33 b	8.46 b	7.39 B
4 plants	47.83 c	61.50 c	54.66 C	10.14 c	12.79 c	11.47 C	5.25 c	6.81 c	6.03 C
F. test	*	*	*	*	*	*	*	*	*
V × D	NS	NS	NS	*	NS	NS	*	NS	NS
V × P	*	NS	NS	*	*	NS	*	*	NS
D × P	NS	NS	NS	*	*	NS	*	*	NS
V × D × P	NS	NS	NS	*	NS	NS	*	NS	NS

Table (3): Effect of varieties, distances between hills and number of plants per hill on 100-seed weight, seed yield/ fad and straw yield/ fad of soybean.

Treatments	100-seed weight (g)			Seed yield (kg/fad)			Straw yield (kg/fad)		
	2001	2002	Comb.	2001	2002	Comb.	2001	2002	Comb.
Varieties (V)									
Giza 21	12.36 a	13.61 a	12.99 A	928.16 a	1124.50 a	1026.33 A	1899.25 a	2222.00 a	2060.62 A
Giza 82	10.35 c	11.30 c	10.82 C	702.91 c	789.91 c	746.41 C	1416.50 c	1624.41 b	1520.45 B
DR101	11.40 b	12.44 b	11.92 B	786.00 b	899.41 b	842.70 B	1570.66 b	1776.66 b	1673.66 B
F. test	*	*	*	*	*	*	*	*	*
Distances between hills (D)									
10 cm	10.91 b	11.91 b	11.41 B	876.72 a	1040.50 a	958.61 A	1766.72 a	2052.94 a	1909.83 A
15 cm	11.83 a	13.00 a	12.41 A	734.66 b	835.38 b	785.02 B	1490.88 b	1695.77 b	1593.33 B
F. test	*	*	*	*	*	*	*	*	*
Number of plants/ hill (P)									
2 plants	12.34 a	13.51 a	12.92 A	687.66 c	802.00 c	744.83 C	1401.66 c	1633.91 c	1517.79 C
3 plants	11.31 b	12.37 b	11.84 B	823.00 b	968.50 b	895.75 B	1643.33 b	1938.50 b	1790.91 B
4 plants	10.46 c	11.47 c	10.96 C	906.41 a	1043.33 a	974.87 A	1841.41 a	2050.66 a	1946.04 A
F. test	*	*	*	*	*	*	*	*	*
V × D	NS	NS	NS	NS	NS	NS	NS	*	NS
V × P	*	*	*	*	*	NS	NS	*	NS
D × P	NS	NS	NS	*	*	NS	NS	*	NS
V × D × P	NS	NS	NS	*	*	*	NS	NS	NS

As shown in Tables (3 and 4) significant variations were detected among the tested soybean varieties in straw and biological yields/fad. The highest values were produced from Giza21 variety which significantly differed with the other varieties. While DR101 variety ranked the second, whereas, Giza82 variety ranked the third without significant differences between them in the second season and combined data. The superiority of Giza21 variety in biological yield/fad might be due to that it produced higher seed and straw yields per fad. These results are in accordance with those found by Hassanein and Ahmed (1996) and Kahil (1998).

It is clearly evident from Table (4) that seed oil and protein contents (%) appeared to differ significantly among the tested soybean varieties where Giza82 variety was the leading variety followed by DR101 variety, while the lowest values were obtained for Giza21 with significant differences among the three varieties, and that was true in both seasons and their combined averages. These results are in a good line with those reported by Hassanein and Ahmed (1996), Shafshak *et al.* (1997) and El-Karamity (1998).

Data recorded in Table (5) show that the variations between the grown soybean varieties in oil and protein yields/fad were significant. Giza21 variety outyielded significantly DR101 and Giza82 varieties, which did not differ significantly from each other in the two seasons and over them except that the difference between these two varieties in oil yield/fad in the second season was significant. The superiority of Giza21 variety in oil and protein yields/fad might be due to its high seed yield/fad. Similar results were obtained by Shafshak *et al.* (1997), Shams El-Din *et al.*(1997) and Kahil (1998).

B – Effect of planting distances between hills:-

Data in Table (1) indicate that planting distance had significant effect on plant height. Increasing plant population density by decreasing distance between hills from 15 to 10 cm significantly increased plant height in both seasons and over them. These results might be due to higher competition among plants for light in dense plant population, resulting in elongation of internodes and consequently gave taller plants. Similar results were reported by El-Attar (1992) and Shafshak *et al.*(1997).

It is obvious from Tables (1, 2 and 3) that distances between hills exhibited significant effects on number of branches, pods and seeds/plant, weight of pods and seeds/plant and 100-seed weight. There were consistent and remarkable increases in the aforementioned characters as planting distance was increased from 10 to 15 cm and that was true in both seasons and their combined data. These results were expected since that in wide planting distance there was a lower competition among plants for growth factors such as moisture, nutrients, space and light which in turn increased potentiality of soybean plants in producing more branches, pods and seeds per plant as well as heavier 100-seed weight and consequently increased seed yield per plant. Confirming results were obtained by Abul-Naas *et al.* (1986), Ali (1989) and Mohamed (1994).

Table (4): Effect of varieties, distances between hills and number of plants per hill on biological yield/fad, seed oil content (%) and seed protein content (%) of soybean.

Treatments	Biological yield (kg/fad)			Seed oil content (%)			Seed protein content (%)		
	2001	2002	Comb.	2001	2002	Comb.	2001	2002	Comb.
Varieties (V)									
Giza 21	2827.41 a	3346.50 a	3086.95 A	25.56 c	23.14 c	24.35 C	34.85 c	32.41 c	33.63 C
Giza 82	2127.75 c	2414.33 b	2271.04 B	27.37 a	25.67 a	26.52 A	39.73 a	37.36 a	38.54 A
DR101	2356.66 b	2676.08 b	2516.37 B	26.12 b	24.26 b	25.19 B	36.97 b	34.16 b	35.57 B
F. test	*	*	*	*	*	*	*	*	*
Distances between hills (D)									
10 cm	2643.44 a	3093.44 a	2868.44 A	25.76 b	24.02 b	24.89 B	38.62 a	36.04 a	37.33 A
15 cm	2231.11 b	2531.16 b	2381.13 B	26.94 a	24.69 a	25.82 A	35.75 b	33.25 b	34.50 B
F. test	*	*	*	*	*	*	*	*	*
Number of plants/ hill (P)									
2 plants	2097.66 c	2435.91 c	2266.79 C	27.51 a	25.25 a	26.38 A	35.23 c	33.09 c	34.16 C
3 plants	2466.33 b	2907.00 b	2686.66 B	26.35 b	24.32 b	25.34 B	37.28 b	34.61 b	35.95 B
4 plants	2747.83 a	3094.00 a	2920.91 A	25.18 c	23.49 c	24.34 C	39.04 a	36.24 a	37.64 A
F. test	*	*	*	*	*	*	*	*	*
V × D	NS	NS	NS	NS	NS	NS	NS	*	*
V × P	*	*	NS	*	NS	NS	NS	NS	NS
D × P	NS	*	NS	NS	NS	NS	NS	NS	NS
V × D × P	*	*	NS	*	NS	NS	*	NS	NS

The results in Tables (3 and 4) show that seed, straw and biological yields per fad increased significantly and consistently as planting distance was decreased from 15 to 10 cm in both seasons and their combined averages. Sowing soybean at close distance (10cm) outyielded wide distance (15 cm) in seed yield per fad by 19.33% in the first season, 24.55% in the second season and 22.11% in the combined data, respectively. The relative increases for straw yield/fad were 18.50%, 21.06% and 19.86% and for biological yield/fad were 18.48%, 22.21% and 20.46% in the two seasons and over them, respectively.

It is worthy to mention that yield increases recorded at higher plant population density might be due to rapid and even soil covering, which in turn resulted in more effective use of growth factors such as space, moisture, nutrients and light. Moreover, the greater number of soybean plants per unit area in narrow distance between hills could compensate the reduction in yield components of the individual plants such as number of pods and seeds/plant, pods weight/plant, 100-seed weight and seed weight/plant. It is with great importance that the unit land area not the individual plant, produces its maximum yield. These results are in a good line with those reported by Salamah *et al.* (1988), El-Attar (1992), Mohamed (1994), Shafshak *et al.* (1997), Shams El-Din *et al.* (1997), Abu-Zaid (1998) and Salem *et al.* (2000).

Data in Table (4) indicate that seed oil content (%) of soybean was inversely related to increasing plant density. There was significant increase in seed oil content (%) by increasing planting space from 10 to 15 cm and that was true in both seasons and over them. These results are in agreement with those recorded by Abul-Naas *et al.* (1986), Ali (1989), Mohamed (1994) and Shafshak *et al.* (1997).

The results in Table (4) show also that increasing plant population density via decreasing planting distance from 15 to 10 cm, significantly increased seed protein content (%) in the both seasons and their combined data. Similar results were reported by Abul-Naas *et al.* (1986), Ali (1989), Mohamed (1994), Shams El-Din *et al.* (1997) and Abu-Zaid (1998).

It is clearly evident from Table (5) that increasing plant population density through decreasing planting distance from 15 to 10 cm significantly increased seed oil and protein yields/fad in both seasons and over them. The increases in seed oil and protein yields/fad with higher plant population density are mainly due to the increase in seed yield per fad. These results are in accordance with those obtained by Mohamed (1994), Shams El-Din *et al.* (1997) and Salem *et al.* (2000).

C – Effect of number of plants per hill:-

Results in Table (1) show that soybean plant height was significantly increased also, with increasing plant population density through increasing number of plants from two to three and four per hill in both seasons and their combined data. Such effect may be due to higher competition between plants for light in dense plant populations, resulting in taller plants. These results are in harmony with those reported by El-Shaikh (1981) and El-Karamity (1988).

The data presented in Tables (1, 2 and 3) reveal that leaving two plants/hill resulted significant increases in number of branches, pods and seeds/plant, weight of pods and seeds/plant and 100-seed weight of soybean as compared with three and four plants/hill. That was true in the both seasons and their combined averages. This might be attributed to the low competition among plants for growth factors in lower plant population density. These results are in accordance with those obtained by El-Shaikh (1981), El-Karamity (1988), Zeyada *et al.* (1988) and Mohamed (1994).

It is clearly evident from Tables (3 and 4) that increasing plant population density by sowing four soybean plants per hill led to significant increases in seed, straw and biological yields/fad in comparison with growing three or two plants/hill. That held true in both seasons and their combined data. Leaving four plants/hill surpassed three and two plants/hill in seed yield/fad by 10.13% and 31.81% in the first season, 7.72% and 30.09% in the second season and 8.83% and 30.88% in the combined data, respectively. These results might be interpreted by the fact that increasing the plant population density implied well ramification of roots within the soil and this in turn results in more utilization of nutrients from soil. Moreover, a great amount of light energy was intercepted by plants and converted to dry matter in dense sowing per unit area. Furthermore, the greater number of soybean plants per unit area with dense planting was great enough to counterbalance the decrease in yield components. These results are confirmed with those found by El-Shaikh (1981) and El-Karamity (1988), Salamah *et al.* (1988), Zeyada *et al.* (1988), Abu-Zaid (1998) and Salem *et al.* (2000).

The obtained results in Table (4) show that seed oil and protein content (%) followed an opposite direction in their response to increasing plant population density. Sowing soybean in hills of two plants significantly surpassed those sown in hills with three or four plants regarding seed oil content (%) and vice versa in seed protein content (%). That held true in the both seasons and their combined data. Similar results were emphasized by El-Karamity (1988), Salamah *et al.* (1988), Ali (1989), Mohamed (1994), Shafshak *et al.* (1997), Shams El-Din *et al.* (1997) and Abu-Zaid (1998).

It is obvious from Table (5) that there were significant increments in seed oil and protein yields per fad with increasing number of plants per hill. Soybean plants grown at fours per hill outyielded significantly those sown at threes or twos/hill in seed oil and protein yields per fad in the both seasons and over them. The increases in seed oil and protein yields/fad with increasing plant density could be mainly due to the increase in seed yield/fad concerning oil yield/fad as well as to the increases in seed yield/fad and seed protein percentage concerning protein yield/fad. These results are confirmed by those recorded by Ali (1989), Mohamed (1994), Shafshak *et al.* (1997), Shams El-Din *et al.* (1997) and Salem *et al.* (2000).

Table (5): Effect of varieties, distances between hills and number of plants per hill on seed oil yield/ fad and seed protein yield/ fad of soybean.

Treatments	Seed oil yield (kg/ fad)			Seed protein yield (kg/ fad)		
	2001	2002	Comb.	2001	2002	Comb
Varieties (V)						
Giza 21	235.69 a	258.66 a	247.17 A	326.24 a	368.47 a	347.35 A
Giza 82	191.15 b	202.27 c	196.71 B	281.01 b	296.78 b	288.89 B
DR101	204.00 b	217.58 b	210.79 B	292.98 b	310.03 b	301.51 B
F. test	*	*	*	*	*	*
Distances between hills (D)						
10 cm	224.15 a	247.53 a	235.84 A	337.98 a	373.68 a	355.83 A
15 cm	196.41 b	204.81 b	200.61 B	262.17 b	276.49 b	269.33 B
F. test	*	*	*	*	*	*
Number of plants/ hill (P)						
2 plants	187.99 c	201.46 c	194.73 C	241.66 c	264.35 c	253.00 C
3 plants	215.83 b	233.86 b	224.84 B	305.89 b	333.72 b	319.81 B
4 plants	227.02 a	243.18 a	235.10 A	352.68 a	377.19 a	364.94 A
F. test	*	*	*	*	*	*
V × D	NS	NS	NS	NS	NS	NS
V × P	*	*	NS	*	*	NS
D × P	NS	*	NS	*	*	*
V × D × P	*	*	NS	*	NS	NS

D – Interactions effects:-

The combined analysis of variance for the data of the two seasons indicated that the all possible interactions among the three studied factors were not significant regarding the effects on the studied characters except varieties x planting distances on seed protein percentage, varieties x number of plants/hill on 100-seed weight, distances between hills x number of plants/hill on protein yield/fad and varieties x planting distances x number of plants/hill on seed yield/fad (Tables 1- 6).

Results in Table (6) show that the highest protein percentage was obtained by sowing Giza82 variety in hills spaced 10 cm apart, while the lowest value was achieved by growing Giza21 in hills spaced 15 cm apart. The highest 100-seed weight was produced by growing two plants of Giza21 variety per hill, while the lowest value was obtained from Giza82 sown in hills with four plants/hill. Sowing four plants in hills spaced 10 cm apart produced the highest protein yield/fad, whereas two plants in hills spaced 15 cm apart gave the lowest value.

Concerning the significant interaction of the second order interaction on seed yield/fad, the highest value was achieved by sowing four plants of Giza21 variety in hills spaced 10 cm apart. Meanwhile, the lowest seed yield/fad was produced by growing two plants of Giza82 variety in hills spaced 15 cm apart (Table 6).

Table (6): Seed protein percentage, 100-seed weight, protein yield/fad and seed yield/fad of soybean as significantly affected by the interaction between the studied factors (the combined data).

Character	Highest value	Treatment	Lowest value	Treatment
Seed protein percentage	39.61	Giza82 x 10 cm	32.12	Giza21 x 15 cm
100 - seed weight (g)	14.16	Giza21 x 2 plants/ hill	9.82	Giza82 x4 plants/ hill
Protein yield (kg/fad)	416.78	10 cm x 4 plants/ hill	217.33	15 cm x 2 plants/ hill
Seed yield (kg/fad)	1296	Giza21 x 10cm x 4 plants/hill	584.25	Giza82 x 15cm x 2plants/hill

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سلوك ثلاثة أصناف من فول الصويا تحت كثافات نباتية مختلفة في الاراضي الرملية

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أجريت تجربتان حقليتان بمزرعة كلية الزراعة- جامعة قناة السويس بالاسماعيلية خلال الموسمين الزراعيين ٢٠٠١ و ٢٠٠٢ بهدف دراسة إستجابة ثلاثة أصناف من فول الصويا هي جيزة ٢١ و جيزة ٨٢ و DR101 لمسافتين بين الجور هي ١٠سم و١٥سم وثلاثة أعداد من النباتات في الجورة هي نباتين وثلاثة وأربعة نباتات بالجورة. أستخدم في هذه الدراسة تصميم القطع المنشقة مرتين في أربع مكررات حيث وزعت أصناف فول الصويا في القطع الرئيسية والمسافات بين الجور

في القطع المنشقة وعدد النباتات بالجورة في القطع تحت المنشقة. ويمكن تلخيص النتائج كما يلي:-

١- حقق الصنف جيزة ٢١ زيادة معنوية في إرتفاع النبات وعدد القرون/النبات وعدد البذور/النبات ووزن القرون/النبات ووزن البذور/النبات ووزن المائة بذرة ومحصول البذور/فدان ومحصول القش/فدان والمحصول البيولوجي/فدان ومحصول الزيت/فدان ومحصول البروتين/فدان وذلك بالمقارنة بباقي الاصناف: في حين أظهر الصنف جيزة ٨٢ تفوقا معنويا علي باقي الأصناف في النسبة المئوية للزيت والبروتين بالبذور.

٢- أدت زيادة الكثافة النباتية سواء عن طريق تقليل مسافة الزراعة من ١٥سم إلي ١٠ سم أو عن طريق زيادة عدد النباتات بالجورة من نباتين إلي ثلاثة أو أربعة نباتات بالجورة إلي زيادة معنوية في إرتفاع النبات ومحصول البذور/فدان ومحصول القش/فدان والمحصول البيولوجي/فدان والنسبة المئوية للبروتين بالبذور ومحصول البروتين/فدان ومحصول الزيت/فدان. في حين أدي تقليل الكثافة النباتية سواء عن طريق زيادة مسافة الزراعة من ١٠سم إلي ١٥ سم أو عن طريق تقليل عدد النباتات بالجورة من أربعة إلي ثلاثة أو نباتين بالجورة إلي زيادة عدد الافرع/النبات وعدد القرون/النبات وعدد البذور/النبات ووزن القرون/النبات ووزن البذور/النبات ووزن المائة بذرة والنسبة المئوية للزيت بالبذور.

٣- أمكن الحصول علي أعلي محصول بذور من الفدان بزراعة صنف جيزة ٢١ علي مسافة ١٠سم بين الجور مع ترك أربعة نباتات في الجورة الواحدة.