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How Soybean Cultivars Canopy Affect Yield and Quality

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Abstract: Appropriate canopy as plant distributions and densities are the key for maximizing soybean productivity due to its main role in fixing energy. Two field experiments were performed at El-Garayda Village, Bialla district, Kafr El-Sheikh Governorate, Egypt during 2010 and 2011 summer seasons to studying the effect of soybean cultivars plant densities and distributions on growth, seed yield and its oil and protein contents. Results showed that Giza 22 cultivar surpassed other studied cultivars followed by Giza 21 then Giza 111 and later by Crawford cultivar in both seasons. Plant population densities and distributions showed a significant effect on all studied characters in both seasons. Highest plant density produced the tallest plants in both seasons. Whereas, the highest values of stem diameter and total chlorophyll content, number of branches/plant, number of pods/plant, pod length, number of seeds/pod, number of seeds/plant, 100-seed weight, seed yield/plant, oil and protein percentages produced from planting 112 000 plants/fed as two sides of ridge in hills 25.0 cm apart in both seasons. However, the highest LAI and seed yield/fed were obtained by planting soybean on two sides of ridge in hills 15.0 cm apart, resulting 186 667 plants/fed in both seasons. In conclusion, sowing Giza 22 or Giza 21 cultivars on two sides of ridge in hills 15.0 cm apart in order to maximize seed yield/fed.

Key words: Soybean, cultivars, varieties, plant density, cultivars canopy plant distribution, LAI, yield, seed quality

INTRODUCTION

Soybean (*Glycine max* (L.) Merr.) is considering as very important source of edible vegetable oil and protein, where seeds contains about 40% protein and 20% edible vegetable oil as well as 30% carbohydrates, 10% total sugar and 5% ash (IITA, 1993). The nutritional quality of protein in soybean, as indicated by its amino acid distribution is nearly as good as meat proteins (IITA, 1992). The soybean meal is rich in minerals, particularly calcium, phosphorus and iron (IITA, 1992) and also has good content of the vitamins, thiamins, riboflavin and niacin (Tiamigu and Idowu, 2001). The oil of soybean is rich in essential fatty acids and devoid of cholesterol and also increasingly being used for biodiesel (Acikgoz *et al*., 2009). Soybean cultivation has recently been increased due to the greater consumption of soybean products, because it has been linked to decrease some dangerous diseases such as heart diseases and certain types of cancer (Wu *et al*., 1998). In Egypt, soybean is considered one of the relatively new crops introduced into Egyptian agriculture, which contributes to reducing the shortage in oil production and to reduce the gap for the protein and oil. So, all efforts are being exerted to improve and increase its seed yield and quality, among these planting the best cultivar with suitable plant density and distribution.

There are wide variations among soybean cultivars in seed yield, yield components and seed quality. Therefore, the main factor affecting soybean production is selecting the suitable soybean cultivar. In this respect, Al-Assily *et al*. (2002) evaluated eight soybeans genotypes viz. H2L12, H2L24, H15L17 Giza 21, Giza 35, Giza 83, Giza 111 and Crawford and found that Giza 21 followed by the two genotypes Giza111 and H2L12 recorded the highest seed yield with an average of 1.764,1.749 and 1.745 t/fed, respectively. Hassan *et al*. (2002) indicated that Giza 22 cultivar surpassed all tested cultivars in number of pods and seeds and seeds weight/plant followed by Giza 35. However, Giza 111 had the heaviest weight of 100 seeds followed by Giza 22, Giza 35 and Crawford. Mehasen and Saeed (2005) reported that soybean Giza 22 cultivar recorded significantly higher values for pods and seeds weight/plant, 100-seed weight, seed yield/fed and oil yield/fed compared with cv. Giza 111. Shaheen (2010) indicated that Crawford and Giza 22 cultivars had the tallest plants than the Toano cultivar. Moreover, Giza 22 cultivar gave the highest protein %, while Toano cultivar recorded the highest oil %. Shairef *et al*. (2010) reported that Giza 21 produced the highest number of branches, number of pods/plant, number of seeds/pod, number of seeds/plant, seeds weight/plant, 100-seed weight, seed yield (t/fed), oil and protein contents. While, Crawford yielded the highest

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straw yield (t/fed). However, Giza 111 produced the highest stem diameter as compared to the other cultivars. Mostafa (2011) showed that Giza 21 cultivar had highest values of leaf area index, total chlorophyll content of leaves, number of pods and seeds yield/plant and higher seed yield/fed, than Giza 22 cultivar. While, Giza 22 cultivar gave maximum values of plant height, number of branches/plant and protein content in seeds, than Giza 21 cultivar. Kandil *et al.* (2012) stated that Giza 21 cultivar significantly superior other studied varieties (H30, H32, H2L12, Giza 22 and Giza 111) in seed yield and its components in both seasons. Whereas, the highest oil and protein contents in seed were obtained from H2L12 or H32 lines.

Plant densities and distributions are critical practices for determining the productivity of soybean. Where, adjusting planting density and distribution are important tools to optimize crop growth and maximize seed yield and quality (Biabani, 2010). Plant density affects modulating crop environment (Khan *et al.*, 2003), therefore adjusting plant density is critical factor to optimize crop growth and canopy closure, which attains the maximum dry matter accumulation and productivity (Liu *et al.*, 2008). The soybean crop has the ability to produce near-optimum yields over a great range of plant population, because the individual plant is a vigorous competitor for space. In this regard, Bullock *et al.* (1998) stated that narrow rows of soybean gave highest yield compared with wide rows due to early light interception. However, decreased light interception led to decreased branching, number of pods and seeds/plant, which provided the yield advantage in narrow row soybean. Therefore, optimum plant density of soybean mostly depends on cultivar. Ball *et al.* (2000), Blumenthal *et al.* (1988); Liu *et al.* (2010) and Shamsi and Kobraee (2011) concluded that increasing plant density reduced number of branches, pods and seeds per plant and yield of individual plants, but increased seed yield per unit area of soybean plants. Mathew *et al.* (2000) revealed that light enrichment initiated at early flowering stages increased number of productive pod and resulting in a 144-252% increase in seed yield. Epler and Staggenborg (2008) reported that as plant density increased number of pods/plant steadily decreased. Nevertheless, seed yield was not reduced by loss number of pods/plant, because number of pods/m^2 increased. Mehmet (2008) stated that the highest soybean seed yield was recorded at a very low plant density of 12.8 and 28.5 plants m^{-2}. However, increasing plant density of soybean was associated with increases in plant height and seed yield per unit area and the optimum plant density ranged from 30 to 50 plants m^{-2} (Shafshak *et al.*, 1997; Kang *et al.*, 1998; Rahman *et al.*, 2004; Grichar, 2007). While, Daroish *et al.* (2005), Cho and Kim (2010) and Singh (2010) found that highest seed yield of soybean was recorded with a plant density of 60-66 plants m^{-2}. Also, Rahman and Hanif (2006) and Rahman *et al.* (2011) revealed that soybean seed yield was increased with increasing plant density and the highest seed yield and lowest seed protein content were recorded at 80 to 100 plants m^{-2} depending on cultivar and season. They added that the further increases in plant density reduced seed yield. Worku and Astatkie (2011) reported that seed yield and its components were significantly affected by both row and plant spacing. The highest seed yield and its components were resulted from highest plant density (50 cm row spacing and 2.5 cm plant spacing), although the highest individual plant and pod were obtained with wider plant spacing (10 cm). Regarding to nutritional seed quality, Weber *et al.* (1966) showed that wide row spacings and decreased plant population resulted in small decrease in protein and small increase in oil content of the seed over that in narrow rows and closely spaced plants. Jadhav *et al.* (1994) and Rahman *et al.* (2005) indicated that seed protein and oil contents significantly decreased with increasing plant density from 17 to 44 plant m^{-2}. In contrast, El-Din *et al.* (1997) recorded that seed protein content was increased with increasing plant density from 39 to 117 plants m^{-2}.

The objectives of this study were: (1) to investigate the effect of plant densities and distributions on growth, seed yield and its attributes, oil and protein contents and (2) to determine appropriate canopy as plant density and distribution for each cultivar to achieve high seed yield under the environmental conditions of Kafr El-Sheikh Governorate, Egypt.

MATERIALS AND METHODS

Study site and objective: A field experiment was carried out at El-Garayda Village, Bialla district, Kafr El-Sheikh Governorate during the two growing summer seasons of 2010 and 2011. The main objectives of this study were aimed to study the performance of some soybean cultivars as affected by plant density and distribution and their effect on growth, yield and its attributes, oil and protein contents in seeds.

Experimental design and treatments: The experiments were laid-out in strip plot design with four replications. The vertical plots were occupied with four soybean cultivars (Giza 21, Giza 22, Giza 111 and Crawford). The pedigree of studied soybean cultivars was presented in Table 1.

The horizontal plots were assigned to six canopy treatments as three plant densities (112000, 140000 and 186667 plants fed^{-1}). These densities implemented in two distributions as follows:

Table 1: Pedigree, maturity group and days to maturity of studied soybean cultivars

Cultivars	Pedigree	Maturity group	Days to maturity (days)
Giza 21	Crawford×celest	IV	120-125
Giza 22	Crawford×celest	IV	120-125
Giza 111	Crawford×celest	IV	120-125
Crawford	Williams×columbus	IV	120-125

- D_1-7.5 cm between hills on one side of the ridge, resulting 186 667 plants fed^{-1}
- D_2-10.0 cm between hills on one side of the ridge, resulting 140 000 plants fed^{-1}
- D_3-12.5 cm between hills on one side of the ridge, resulting 112 000 plants fed^{-1}
- D_4- 15.0 cm between hills on both sides of the ridge, resulting 186 667 plants fed^{-1}
- D_5-20.0 cm between hills on both sides of the ridge, resulting 140 000 plants fed^{-1}
- D_6-25.0 cm between hills on both sides of the ridge, resulting 112 000 plants fed^{-1}

Agricultural practices: Each experimental unit area included 5 ridges each of 60 cm width and 3.5 m length and the total area was 10.5 m^2. The preceding winter crop was Egyptian clover in both seasons. The experimental field was well prepared and calcium superphosphate (15.5% P_2O_5) was applied during soil preparation at the rate of 150 kg fed^{-1}. Soybean seeds were thoroughly mixed with nodulating bacteria (*Bradyrhizobium japonicum*) then sown in hills as previously described on May 5th and 7th in the first and second seasons, respectively. After three weeks, only two healthy plants remained in each hill. Nitrogen and potassium fertilizers were applied in the forms of urea (46.5% N) and potassium sulphate (48% K_2O) at the rate of 60 kg N fed^{-1} and 48 kg K_2O fed^{-1} in two equal portions (after thinning and three weeks later). The rest of the cultural practices for growing soybean according to Ministry of Agriculture recommendation were followed.

Studied characters: Five guarded plants were chosen at random from the outer ridges of each plot at R_5 stage i.e. beginning of seed formation (70 days from sowing) to determine the following growth characters:

- Total chlorophyll (SPAD): Leaf chlorophyll content was assessed by SPAD-502 (Minolta Co. Ltd., Osaka, Japan)
- Leaf area index (LAI): It was measured as described by Watson (1958) and then following equation was used:

$$\text{LAI} = \frac{\text{Leaf area per plant (cm}^2)}{\text{Plant ground area (cm}^2)}$$

Leaf area/plant (cm^2) was determined using Field Portable Leaf Area Meter AM-300 (Bio-Scientific, Ltd., Great Am well, Herefordshire, England).

At harvest time i.e. 125 days from sowing, a sample of ten randomly guarded plants from outer ridges of each experimental plot was taken and the following characteristics were recorded, plant height (cm), stem diameter (cm), number of branches plant^{-1}, number of pods plant^{-1}, pod length (cm), number of seeds/pod, number of seeds/plant, 100-seed weight (g) and seed yield plant^{-1} (g). Seed yield (kg fed^{-1}) was determined from the rest of the ridges of each experimental unit. Seed oil content (%) estimated in dried seeds sample taken from each plot, cleaned and ground into very fine powder by grinder to determine seed oil percentage as described by AOAC (1990) using Soxhelt apparatus and petroleum hexane as an organic solvent. Seed crude protein percentage was estimated according the improved Kjeldahl method of AOAC (1990).

All data were statistically analyzed according to the technique of analysis of variance (ANOVA) for the strip plot design as published by Gomez and Gomez (1984), using MSTAT statistical package (MSTAT-C with MGRAPH version 2.10, Crop and Soil Sciences Department, Michigan State University, USA). Least Significant Difference (LSD) method was used to test the differences between treatment means at 5% level of probability as described by Snedecor and Cochran (1980).

RESULTS AND DISCUSSION

Cultivars performance: The results indicated that studied soybean cultivars i.e. Giza 21, Giza 22, Giza 111 and Crawford significantly differed in total chlorophyll content in leaves, leaf area index (LAI), plant height, stem diameter, number of branches/plant (Table 2), number of pods plant^{-1}, pod length, number of seeds per pod and plant, 100-seed weight (Table 3), seed yield per plant (g) and feddan (kg), oil and protein contents in seeds as percentages (Table 4) during 2010 and 2011 seasons. Giza 22 cultivar significantly surpassed other studied cultivars in most studied traits during the two growing seasons. Whereas, the differences between Giza 22 and Giza 21 cultivars were insignificant on number of branches/plant, number of seeds/plant (in the second season only) and protein percentage (in both seasons). Giza 21 cultivar came in the second rank after Giza 22 cultivar followed by Giza 111 then later Crawford cultivars with regard all studied characters in both seasons. It could be noticed that Giza 22 cultivar exceeded Giza 21, Giza 111 and Crawford cultivars by 6.29, 27.16 and 45.24%, respectively in seed yield per plant and by 7.46, 14.10 and 37.24%,

Table 2: Means of total chlorophyll, leaf area index (LAI), plant height, stem diameter and number of branches/plant as affected by plant densities and distributions of some soybean cultivars and their interaction during 2010 and 2011 seasons

Characters Seasons treatments	Total chlorophyll (SPAD) 2010	2011	Leaf area index (LAI) 2010	2011	Plant height (cm) 2010	2011	Stem diameter (cm) 2010	2011	No. of branches/plant 2010	2011
Cultivars										
Giza 21	40.69	42.35	2.96	3.01	100.2	103.5	0.807	0.823	2.55	3.16
Giza 22	44.07	45.56	3.45	3.50	114.0	115.5	0.887	0.919	3.16	3.55
Giza 111	35.70	36.99	2.95	2.94	85.1	88.3	0.760	0.781	2.22	2.61
Crawford	32.35	33.25	2.73	2.76	77.5	79.3	0.594	0.606	2.00	2.38
LSD at 5%	2.94	2.24	0.17	0.15	3.7	4.4	0.038	0.034	0.47	0.51
Plant density and distribution:										
D_1:7.5 cm/1 side (186 667 plants fed^{-1})	28.51	30.00	3.05	3.10	104.7	107.0	0.583	0.611	1.75	2.16
D_2:10.0 cm/1 side (140 000 plants fed^{-1})	34.52	35.73	2.70	2.66	96.8	99.3	0.725	0.736	2.16	2.58
D_3:12.5 cm/1 side (112000 plants fed^{-1})	41.95	43.04	2.54	2.56	88.0	90.6	0.830	0.844	2.58	3.00
D_4:15 cm/2 side (186667 plants fed^{-1})	37.97	39.60	3.85	3.92	99.8	101.9	0.629	0.640	2.41	2.91
D_5:20 cm/2 side (140000 plants fed^{-1})	41.90	43.10	3.20	3.25	92.2	93.1	0.834	0.852	2.75	3.25
D_6:25 cm/2 side (112000 plants fed^{-1})	44.35	45.75	2.80	2.83	83.8	88.0	0.971	1.009	3.25	3.66
LSD at 5%	2.03	1.85	0.12	0.13	1.7	1.7	0.032	0.031	0.31	0.42
C- Interaction:	*	*	*	*	*	*	*	*	NS	NS

Table 3: Means of number of pods plant^{-1}, pod length, number of seeds pod^{-1}, number of seeds plant^{-1} and 100-seed weight as affected by plant densities and distributions of some soybean cultivars and their interaction during 2010 and 2011 seasons

Characters seasons treatments	No. of pods plant^{-1} 2010	2011	Pod length (cm) 2010	2011	No. of seeds pod^{-1} 2010	2011	No. of seeds plant^{-1} 2010	2011	100-seed weight (g) 2010	2011
Cultivars:										
Giza 21	69.88	71.37	5.55	5.87	3.04	3.18	195.3	212.7	19.04	19.46
Giza 22	76.89	77.77	6.21	6.80	3.38	3.58	209.8	218.2	20.20	20.72
Giza 111	62.38	63.35	4.97	5.10	2.73	2.97	183.0	187.6	17.68	18.00
Crawford	49.60	50.74	4.51	4.70	2.53	2.73	123.4	137.0	15.89	16.18
LSD at 5%	3.57	3.26	0.22	0.21	0.07	0.06	9.8	8.1	0.55	0.51
Plant density and distribution:										
D_1:7.5 cm/1 side (186 667 plants fed^{-1})	56.55	57.63	4.58	5.02	2.66	2.81	139.1	177.1	16.44	16.75
D_2:10.0 cm/1 side (140 000 plants fed^{-1})	60.50	61.41	5.10	5.40	2.80	2.97	184.6	187.8	17.47	17.91
D_3:12.5 cm/1 side (112000 plants fed^{-1})	64.31	65.69	5.60	5.86	3.02	3.20	192.3	195.1	18.67	19.05
D_4:15 cm/2 side (186667 plants fed^{-1})	64.41	65.71	4.98	5.35	2.82	3.05	176.0	180.4	17.76	18.18
D_5:20 cm/2 side (140000 plants fed^{-1})	68.30	69.41	5.51	5.78	2.99	3.20	182.1	191.4	18.69	19.10
D_6:25 cm/2 side (112000 plants fed^{-1})	74.05	74.99	6.09	6.27	3.25	3.49	193.2	201.4	20.19	20.55
LSD at 5%	1.82	1.59	0.17	0.16	0.09	0.11	4.4	3.0	0.54	0.59
C- Interaction:	*	*	*	*	NS	NS	*	*	*	*

Table 4: Means of seed yield/plant, seed yield/fed, oil and protein percentages as affected by plant densities and distributions of some soybean cultivars and their interaction during 2010 and 2011 seasons

Characters seasons treatments	Seed yield plant^{-1} (g) 2010	2011	Seed yield (kg fed^{-1}) 2010	2011	Oil (%) 2010	2011	Protein (%) 2010	2011
Cultivars:								
Giza 21	33.10	34.38	1722.1	1754.3	20.06	20.45	39.52	39.96
Giza 22	35.52	36.49	1861.9	1894.9	20.57	20.87	39.96	40.17
Giza 111	24.65	27.80	1536.9	1690.1	19.86	19.94	38.69	39.28
Crawford	18.92	20.51	1163.1	1194.7	19.59	19.72	36.45	36.76
LSD at 5%	2.25	1.74	65.6	64.5	0.18	0.31	0.46	0.38
Plant density and distribution:								
D_1:7.5 cm/1 side (186 667 plants fed^{-1})	25.42	26.86	1664.7	1741.0	19.66	19.95	36.69	37.32
D_2:10.0 cm/1 side (140 000 plants fed^{-1})	26.98	28.70	1552.8	1620.9	19.89	20.18	38.40	38.64
D_3:12.5 cm/1 side (112000 plants fed^{-1})	29.08	30.53	1420.1	1513.3	20.12	20.36	39.16	39.34
D_4:15 cm/2 side (186667 plants fed^{-1})	26.93	29.74	1714.5	1761.1	19.91	20.10	38.35	38.65
D_5:20 cm/2 side (140000 plants fed^{-1})	28.94	30.45	1594.5	1633.7	20.15	20.34	39.35	39.74
D_6:25 cm/2 side (112000 plants fed^{-1})	30.94	32.50	1479.3	1531.2	20.39	20.54	39.98	40.57
LSD at 5%	1.01	1.67	44.6	37.9	0.07	0.14	0.34	0.37
C- Interaction:	*	*	*	*	NS	NS	*	*

respectively in seed yield per feddan calculated as average for both seasons. The superiority of Giza 22 cultivar in seed yield over than other studied cultivars might be related to genetic factors which resulted from genetic makeup relations for the cultivars. Moreover, the increase in all growth, yield attributes of Giza 22 cultivar reflected increases in seed yield per unit area. The obtained results of this study are partially agreement with those noticed and discussed by Hassan *et al.* (2002); Mehasen and Saeed (2005); Shaheen (2010) and Kandil *et al.* (2012).

Plant densities and distributions effect: The results showed that plant densities and distributions showed a significant effect on total chlorophyll content in leaves, Leaf Area Index (LAI), plant height, stem diameter, number of branches/plant, number of pods/plant, pod length, number of seeds per pod and plant, 100-seed weight, seed yield per plant (g) and feddan (kg), seed oil and protein contents (%) in both seasons (Table 2 and 4). It can be observed that planting soybean on two sides of ridge in hills 25.0 cm apart, resulting 112 000 plants fed^{-1} (D_6) significantly recorded the highest total chlorophyll, stem diameter, number of branches/plant, number of pods/plant, pod length, number of seeds/pod, number of seeds/plant, 100-seed weight, seed yield/plant, oil and protein percentages in both seasons, except number of branches/plant in the second season and number of seeds/plant in the first season only. These results may be due to the fact that individual plants at low plant densities and well distribution on two sides of ridge adjust to low populations by increasing the vegetative growth in wide plant spacing and low plant density and this support producing more chlorophyll content, branches, pods and other yield attributes (Worku and Astatkie, 2011). Jadhav *et al.* (1994); Ball *et al.* (2000); Blumenthal *et al.* (1988); Rahman *et al.* (2005) and Epler and Staggenborg (2008) confirmed these results. Whereas, the lowest values of total chlorophyll, stem diameter, number of branches/plant, number of pods/plant, pod length, number of seeds/pod, number of seeds/plant, 100-seed weight, seed yield/plant, oil and protein percentages were resulted from D_1 (7.5 cm between hills on one side of ridge, resulting 186 667 plants fed^{-1}) in both growing seasons. These results reflected to the individual plants at high plant densities and planting on one side of ridge may be exposed to considerable competition, which lead to reduction in vegetative growth and produce fewer branches, pods and seeds per plant (Lueschen and Hicks, 1977). The tallest soybean plants were produced from D_1 (highest plant density and planting on one side of ridge) in both seasons. On the other hand, the shortest plants were resulted from D_6 (lowest plant density and planting on two sides of ridge) during the two growing seasons. Plants grown in high densities are taller more sparsely branches, more prone to lodge and set few pods and seeds at lower internodes. The increases in plant height due to increasing plant density may be due to more competition in the dens population for light, consequently lead to more plant elongation Mehmet (2008). The highest values of LAI and seed yield per feddan were obtained by planting soybean on two sides of ridge in hills 15.0 cm apart, resulting 186 667 plants fed^{-1} (D_4) followed by D_1 treatment in both seasons without significant differences between them in seed yield per feddan in the second season. On the other side, the lowest values of LAI and seed yield per feddan were recorded from D_3 treatment (lowest plant density and planting on one side of ridge) in both seasons. It can be concluded that using D_4 treatment caused an increases in seed yield per feddan reached about 2.01, 8.69, 15.60, 7.12 and 13.38% as compared by using D_1, D_2, D_3, D_5 and D_6, respectively as an averages over both seasons. Maximum seed yield per unit area of soybean could be obtained at high plant density which distributed on two sides of ridge (D_4) possible due to early canopy closure, reaching maximum leaf area index consequently increasing dry matter accumulation and number of pods per unit area. Shibles and Weber (1996) reported that dry matter production increased as lea area increased, up to the Critical Leaf Area Index (LAI) and was directly related to the amount of light absorbed. They also fund that seed yield was not correlated with dry matter production, indicating that a stimulation of the conversion of photosynthate to seed instead of vegetative growth would be agronomically useful. These results are in agreement with those reported by Bullock *et al.* (1998); Epler and Staggenborg (2008); Liu *et al.* (2010) and Shamsi and Kobraee (2011).

Interaction effect: Many significant interaction effects between studied factors on most studied characters in both seasons. The significant interaction between studied factors on seed yield per plant and seed yield per feddan were presented in Fig. 1 and 2.

As seems to appear from illustrated data in Fig. 1, highest seed yield per plant was obtained when planting Giza 22 cultivar on two sides of ridge in hills 25.0 cm apart,

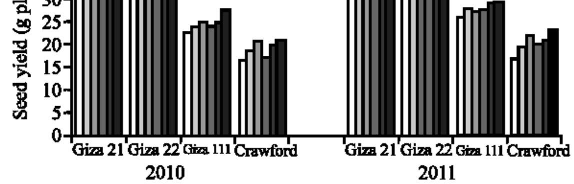

Fig. 1: Means of seed yield/plant as affected by the interaction between plant densities and distributions and soybean cultivars during 2010 and 2011 seasons

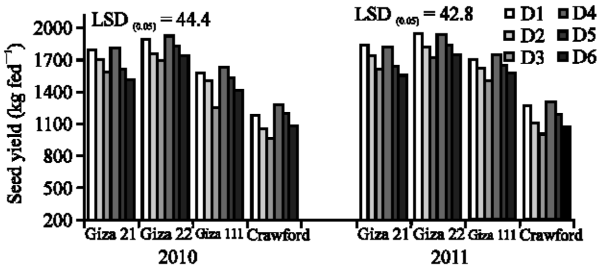

Fig. 2: Means of seed yield/fed as affected by the interaction between plant densities and distributions and soybean cultivars during 2010 and 2011 seasons

resulting 112 000 plants fed^{-1} (D_6) in the first and second seasons. On the other hand, the lowest seed yield per plant was resulted from sowing Crawford cultivar on one side of ridge in hills 7.5 cm apart, resulting 186 667 plants fed^{-1} (D_1) in both growing seasons.

Highest seed yield per feddan was obtained from planting Giza 22 cultivar on two sides of ridge in hills 15.0 cm apart, resulting 186 667 plants fed^{-1} (D_4) in the first and second seasons (Fig. 2). On the contrary, lowest seed yield per feddan was resulted from Crawford cultivar by using D_3 treatment (12.5 cm between hills on one side of ridge, resulting 112 000 plants fed^{-1}) in both seasons.

CONCLUSION

It could be concluded that sowing soybean cultivars Giza 22 or Giza 21 on two sides of ridge in hills 15.0 cm apart, resulting 186 667 plants fed^{-1} in order to maximize seed yield per feddan. While, for obtaining higher seed oil and protein contents, sowing Giza 22 or Giza 21 cultivars on two sides of ridge in hills 25.0 cm apart, resulting 112 000 plants fed^{-1} (D_6) under the environmental conditions of Northern Delta of Egypt.

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