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RESPONSE OF SOYBEAN YIELD AND ITS COMPONENTS TO *Rhizobium* INOCULATION AND NITROGEN FERTILIZATION UNDER DIFFERENT PLANT SPACING IN THE NEWLY RECLAIMED CALCAREOUS SOIL

Salih, S.A. and F.R.R. Nawar
Field Crops Research Institute, Agric. Res. Center, Giza, Egypt.

ABSTRACT

Two field experiments were conducted at Nubaria Agric. Res. Station during 1999 and 2000 seasons to investigate the effect of two plant densities (10 15 cm between hills i.e. 32 and 22 plants/m^2) and six fertilization treatments: 1) control - uninoculation + no nitrogen fertilizer, 2) inoculation + no nitrogen fertilizer; 3) inoculation + 30 kg N/fed; 4) inoculation + 60 kg N/fed; 5) inoculation + 90 kg N/fed, and 6) uninoculation + 90 kg N/fed, as well as their interactions on soybean yield and its components.

The obtained results showed that increasing the distance between plants significantly decreased seed yield/fed and plant height and increased number of seeds/plant.

All studied characters were significantly increased by increasing nitrogen fertilizer levels. The economic treatment was obtained by inoculation + 30 kg N/fed for all studied characters with 32 plants/m^2. In the same time, this treatment save 60 kg N/fed as compared with 90 kg N/fed + inoculation.

INTRODUCTION

Soybean [*Glycine max* (L.) Merr.] is grown for its numerous utilization and considered as an important source for oil and protein. In new areas of soybean production, inoculation with *Rhizobium japonicum* is necessary for economical soybean yield.

Karbachach (1972) reported that inoculation with *Rhizobium japonicum* increased soybean yield and was more effective than applying 120 kg N/ha. Abo-Khadrah and Zahran (1984) found that significant differences among soybean cultivars in plant height, plant pod number and seed yield per feddan, but three cultivars of soybean studied (Harossy, Clark and Williams) were not significantly different in number of branches/plant, number of seeds/pod and 100-seed weight. Fayed *et al.*(1986) concluded that increasing nitrogen rates caused significant increases in number of seeds/plant, protein and oil yields per feddan of three different soybean cultivars (Calland, Mitchell and Davis), whereas 100-seed weight was not significantly affected by N level.

Many investigators reported that applied N significantly increased seed yield of both uninoculated and inoculated soybeans. Sekhon *et al.*(1984) stated that a basal dose of not more than 15 kg N/ha increased the yield of inoculated soybean, but the uninoculated plants responded positively to the increase in N-addition up to 180 kg N/ha. Hammam (1986) reported that application of 20 or 40 kg N/fed along with *Rhizobium* inoculation gave taller plants, more branches/plant, better yield component parameters, greater seed yield/feddan and higher seed protein content. Similar results were obtained by Salwau (1989), Nenadic and Slovic (1994), Singh *et al.*(1994), Vara *et al.* (1994) Bhosale *et al.*(1995), Haider (1995), Gomaa (1996), Hong and Rajagopal (1996) and Sarkar and Tripathi (1996).

Many research workers reported that increasing plant density increased seed yield (Esechi, 1993; Mimbar and Wardhani, 1993; Nakagawa *et al.*, 1993; Bhosale *et al.*, 1994; Ikeda *et al.*, 1994; Jadhav *et al.*, 1994; Zaric, 1994; Bhosale *et al.*, 1995 and Szukala *et al.*, 1995).

The objective of this study was to investigate the response of soybean to plant spacing, *Rhyzobium* inoculation and N fertilizer levels on yield and its components of soybean in the newly reclaimed calcareous soil.

MATERIALS AND METHODS

Two field experiments were carried out at Nubaria Agric. Res. Station during the two successive growing seasons of 1999 and 2000. The major objectives of this study were to investigate the effect of plant spacing and *Rhizobium* inoculation alone or belong with nitrogen levels ranging from 30 to 90 kg N/feddan on yield, yield components, seed oil and seed protein content of soybean plants.

Each experiment included 12 treatments which were the combination of two plant densities: T_1 = 32 plants/m^2 (60 cm between ridges, 10 cm between hills and two plants per hill on one side of the ridges) and T_2 = 22 plants/m^2 (60 cm between ridges, 15 cm between hills and two plants per hill on one side of the ridges) with six treatments of inoculation and nitrogen levels. The treatments of inoculation and nitrogen levels were as follows:

1. Uninoculation received no N-fertilizer.(control)
2. Inoculation received no N-fertilizer.
3. Inoculation + 30 kg N/fed.
4. Inoculation + 60 kg N/fed.
5. Inoculation + 90 kg N/fed.
6. Uninoculation received 90 kg N/fed.

The treatments in the two seasons were arranged in a split-plot design with four replications. Plant spacings were arranged at random in the main plots. The treatments of inoculation with nitrogen levels were arranged at random in the sub-plots.

The sub-plot area was 12 m^2 (4x3 m). The physical and chemical analyses of the soil are presented in Table 1. Sowing dates were May 5 and 7 in the first and second seasons, respectively. Nitrogen was applied in split application one half before the first irrigation and the rest before the second irrigation with the previously mentioned rates. Seeds were mixed at sowing with the recommended soybean inoculation. Plants were thinned to two plants per hill. Other cultural practices were carried out as recommended.

At harvest, 10 plants were randomly taken from the middle ridges of each plot to measure plant height (cm), number of pods/plant, number of seeds/plant, weight of seeds/plant and 100-seed weight.

Seed yield/fed. was estimated from the whole plot. Oil content of soybean seeds was determined by Soxhlet apparatus on dry weight basis as described by Sorenson (1947). Protein was determined as total nitrogen by micro-Kjeldahl method according to A.O.A.C. (1970), then N was multiplied by 6.25 (Tripathi *et al.*, 1971) to obtain protein content in soybean seeds.

The collected data wee statistically analyzed according to Snedecor and Cochran (1967).

Table 1: Mechanical and chemical analyses of the experimental soil in 1999 and 2000 seasons.

Soil properties	Seasons	
	1999	2000
Soil particles (%)		
Sand	52.9	53.3
Silt	21.8	20.8
Clay	25.3	25.9
Soil texture	sandy clay loam	sandy clay loam
Chemical properties		
Total N (%)	0.046	0.051
Available N (ppm)	26.30	28.60
Available P (ppm)	9.68	8.40
Available K (ppm)	425.0	403.0
pH	8.2	8.1
E.C. (mmhos/cm)	2.21	1.95
O.M. (%)	0.95	0.98
$CaCO_3$ (%)	22.9	22.5

RESULTS AND DISCUSSION

1. Effect of plant spacing

Data presented in Table 2 revealed that plant height was decreased due to increasing plant spacing from 10 to 15 cm between plants in both seasons. This increment may be attributed to the competition between plants for light within the dense plant population. The tallest plants were obtained by 10 cm between plants. Similar results were obtained by Esechi (1993), Mimbar and Wardhani (1993), Bhosale *et al.*(1995) and Hong and Rajagopal (1996).

Also, the same table showed that number of seeds/plant was significantly affected by plant spacing in the two seasons. The highest number of seeds/plant was obtained by 15 cm spacing, whereas the lowest one was obtained from 10 cm spacing. Similar results were obtained by Esechi (1993), Nakagawa *et al.*(1993), Jadhav *et al.*(1994), Ikeda *et al.*(1994) and Nenadic and Slovic (1994).

Table 2: Average values of plant height, number of pods/plant, number of seeds/plant and 100-seed weight as affected by plant spacing, nitrogen levels and inoculation in 1999 and 2000 seasons.

Characters / Treatments	Plant Height(cm)		Number of pods/plant		Number of seeds/plant		100-seed weight(g)	
	1999	2000	1999	2000	1999	2000	1999	2000
Plant spacing (cm)								
10	96.48	96.02	51.60	51.53	115.50	116.86	17.94	17.54
15	92.03	91.95	50.30	49.41	118.30	118.05	17.68	17.43
F-test	*	*	NS	NS	*	*	NS	NS
Nitrogen fertilizer:								
Control	65.60	65.50	21.35	21.75	42.15	44.25	16.38	16.01
Inoculation + zero N	87.60	88.10	44.95	46.40	103.65	107.85	17 27	16.86
Inoculation + 30 kg N/fed.	104.15	101.90	63.80	62.20	143.50	145.60	18.42	18.37
Inoculation + 60 kg N/fed.	105.25	103.70	62.10	60.70	140.80	143.25	18.41	18.26
Inoculation + 90 kg N/fed.	109.50	109.85	64.70	63.45	149.85	148.90	19.19	18.69
Uninoculation + 90 kg N/fed.	93.45	94.85	48.40	48.35	121.45	114.85	17.20	16.72
$L.S.D_{0.05}$	11.03	12.45	11.30	6.65	8.83	3.46	1.83	1.14

Data presented in Table (3) indicated that seed yield/fed was affected by plant spacing in the two seasons. Increasing plant spacing decreased seed yield/fed in the two seasons. These results are in agreement with those reported by Mimbar and Wardhani (1993), Nakagawa (1993), Bhosale *et al.*(1994), Ikeda *et al.*(1994), Szukala *et al.*(1995) and Hong and Rajagopal (1996).

Table 3: Average values of seed yield/plant, seed yield/fed, oil percentage and seed protein content as affected by plant spacing, nitrogen levels and inoculation in 1999 and 2000 seasons.

Characters / Treatments	Seed yield/plant(g)		Seed yield/fed.(ton)		Seed oil content(%)		Seed protein content(%)	
	1999	2000	1999	2000	1999	2000	1999	2000
Plant spacing (cm)								
10	20.76	21.22	1.107	1.182	20.15	20.28	41.05	41.77
15	21.24	21.12	0.904	0.897	20.82	20.72	41.67	41.31
F - test	NS	NS	*	*	NS	NS	NS	NS
Nitrogen fertilizer:								
Uninoculation (control)	7.87	8.11	0.366	0.409	19.01	18.54	37.92	37.97
Inoculation + zero N	18.27	18.93	0.824	0.871	19.77	20.26	41.28	41.33
Inoculation + 30 kg N/fed.	26.81	27.22	1.271	1.251	20.93	21.02	42.12	42.62
Inoculation + 60 kg N/fed.	26.42	25.82	1.210	1.215	20.98	20.87	42.64	42.58
Inoculation + 90 kg N/fed.	27.74	27.79	1.383	1.457	21.94	21.44	42.67	42.74
Uninoculation + 90 kg N/fed.	18.90	19.15	0.980	1.028	20.28	20.88	40.30	40.51
$LSD_{0.05}$	3.56	4.12	0.135	0.256	0.86	0.53	1.93	1.37

Plant spacing did not show any significant effect on number of pods/plant, 100-seed weight, seed yield/plant, seed oil percentage and seed protein content of soybean in the two seasons.

2. Effect of inoculation and nitrogen fertilizer levels

All studied characters were significantly affected by inoculation + nitrogen fertilizer levels in the two seasons, as shown in Tables 2 and 3. In general, increasing inoculation + nitrogen fertilizer levels from inoculation + 30 kg N/fed to inoculation + 90 kg N/fed increased all studied characters in both seasons. This increase might be due to the role of nitrogen on meristemic activity and cell division which, in turn, increased cell number and size. The tallest plants, highest number of pods and seeds/plant, 100-seed weight, seed yield/plant, seed yield/fed, seed oil percentage and seed protein content of soybean plants were obtained by inoculation + 90 kg N/fed in both seasons. Whereas, the lowest values were obtained by control in all studied characters. The statistical analysis (Tables 2 and 3) indicate no significant increase in soybean yield per feddan and other studied characters due to the increase in N-levels plus inoculation from 30 to 90 kg N/fed. These results are in good agreement with those obtained by Sekhom *et al.*(1984), Hammam (1986), Salwau (1989), Bhosale (1995), Haider *et al.*(1995), Gomaa (1996), Hong and Rajagopal (1996) and Sarkar and Tripathi (1996).

3. Effect of the interaction between plant spacing and nitrogen fertilizer levels with inoculation

It was clear that the interaction between plant spacing and nitrogen fertilizer levels with inoculation was statistically significant for plant height, number of pods/plant, number of seeds/plant, 100-seed weight and seed yield/fed (Tables 4 and 5). However, the other characters were not affected by the interaction between the two factors in the two seasons.

The highest values of plant height were obtained from spacing 10 cm and inoculation + 90 kg N/fed, but the lowest one were obtained from spacing 10 or 15 cm between hills and uninoculation with no fertilizer (control).

Table (4): Average values of plant height, number of pods/plant, number of seeds/plant and 100-seed weight as affected by the interaction between plant spacing, nitrogen levels and inoculation in 1999 and 2000 seasons.

Plant spacing (cm)	Inoculation and nitrogen levels	Plant height (cm)		Number of pods/plant		Number of seeds/plant		100-seed weight(g)	
		1999	2000	1999	2000	1999	2000	1999	2000
10	control	67.0	65.3	22.0	23.7	40 7	42 7	16 71	15 99
	Inoculation + zero N	87 ꜵ	89.7	44 3	45.6	106.3	108 2	17 21	16 78
	Inoculation 30 kg N/fed.	107 3	103 3	65 3	63 9	140.7	145.9	18.44	18 41
	Inoculation + 60 kg N/fed	107 9	104.7	62 3	62 1	135.7	143 8	18 36	18.23
	Inoculation + 90 kg N/fed.	112.7	114 4	64 2	64.2	149 4	148 2	19 48	18 86
	Uninoculation + 90 kg N/fed.	96 2	98 7	50 7	49 7	120.2	112 3	17 46	16 98
Mean		96 48	96.02	51 60	51 53	115.5	116 86	17 94	17 54
15	Control	64 2	65 7	20.7	19.8	43 6	45.8	16.05	16 03
	Inoculation + zero N	87 4	68 5	45 6	47 2	101 0	107 5	17 33	16 95
	Inoculation 30 kg N/fed.	101 0	100 5	62 3	60 5	146.3	145 3	18 41	18 33
	Inoculation + 60 kg N/fed.	102.6	102 7	61 9	59 3	145.9	142.7	18 46	18 30
	Inoculation + 90 kg N/fed	106 3	105 3	65 2	62.7	150.3	149 6	18.91	18 53
	Uninoculation + 90 kg N/fed	90 7	91 0	46 1	47.0	122.7	117 4	16.95	16.46
Mean		92 03	91.95	50 3	49 41	118 3	118 05	17 68	17 43
L S $D_{0.05}$ S x N		13.36	14 06	16.95	9 34	12.65	8 77	1 19	1.34

Table (5): Average values of plant height, number of seed yield/plant, seed yield/fed, oil percentage and seed protein content as affected by the interaction between plant spacing, nitrogen levels and inoculation in 1999 and 2000 seasons.

Plant spacing (cm)	Inoculation and nitrogen levels	Seed yield/plant (g)		Seed yield/fed (ton)		Seed oil content(%)		Seed protein content(%)	
		1999	2000	1999	2000	1999	2000	1999	2000
10	Control	7.74	7.76	0.414	0.430	18.99	18.04	38 00	38.94
	Inoculation + zero N.	18.49	18.95	0.934	0.959	19.01	20.01	41.01	40 83
	Inoculation 30 kg N/fed.	26.31	27.91	1.425	1.499	20.05	20.98	42 09	42 57
	Inoculation + 60 kg N/fed.	25.91	25.84	1.321	1.432	20.91	20.54	42.83	42 63
	Inoculation + 90 kg N/fed.	27.63	27.63	1.544	1.661	21 95	21 32	42.51	42 57
	Uninoculation + 90 kg N/fed.	18.49	19.44	1.005	1.110	20.03	20.83	40.42	40 09
Mean		20.76	21.22	1.107	1.182	20.15	20.28	41 05	41.77
15	Control	8.01	8.43	0.319	0.399	19.04	19.04	37 84	37 01
	Inoculation + zero N	18.05	18.91	0.715	0.733	20.53	20.52	41.56	41.83
	Inoculation 30 kg N/fed.	27.32	26.53	1.117	1.004	21.82	21.06	42.15	42 67
	Inoculation + 60 kg N/fed.	26.93	25.81	1.099	0 999	21.06	21.21	42.45	42 53
	Inoculation + 90 kg N/fed.	27.85	27.95	1 223	1.254	21.94	21.56	42.83	42.91
	Uninoculation + 90 kg N/fed.	19.31	18.86	0.955	0.946	20.53	20.93	40 18	40.93
Mean		21.24	21.12	0.904	0.897	20.82	20 72	41.67	41.31
L.S $D_{0.05}$ S x N		NS	NS	0 174	0.349	NS	NS	NS	NS

The interaction between plant spacing 15 cm and inoculation + 90 kg N/fed gave the highest values for number of seeds/plant in the two seasons.

The highest values of number of pods/plant and 100-seed weight were obtained from spacing 15 cm and inoculation + 90 kg N/fed in the first season and the highest values for number of pods/plant and 100-seed weight were obtained from spacing 10 cm between hills and inoculation + 90 kg N/fed in the second season.

The highest seed yield/fed was obtained from spacing 10 cm between hills and inoculation + 90 kg N/fed in the two seasons, but the lowest ones was obtained from spacing 15 cm between hills and uninoculation with no fertilizer (control).

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إستجابة محصول فول الصويا و مكوناته للتلقيح البكتيرى والتسميد النيتروجينى تحت كثافات نباتية مختلفة فى الأراضى الجديدة

سيد عبدالعزيز صالح ، فتحى رجب رمضان نوار

معهد بحوث المحاصيل الحقلية - مركز البحوث الزراعية - الجيزة - مصر.

أجريت تجربتان حقليتان بمحطة البحوث الزراعية بالنوبارية خلال الموسمين ١٩٩٩ و ٢٠٠٠ لدراسة تأثير كثافتين للزراعة هما ٣٢ نبات/م٢ و ٢٢ نبات/م٢ (١٠ و ١٥ سم بين الجور) وست معاملات من التسميد النتروجينى و الحيوى (كنترول - غير ملقح وبدون تسميد نتروجينى، ملقح وبدون تسمد نتروجينى، ملقح + ٣٠ كجم نتروجين/فدان، ملقح + ٦٠ كجم نتروجين/فدان، ملقح + ٩٠ كجم نتروجين/فدان، و غير ملقح واضافة ٩٠ كجم نتروجين/فدان) والتفاعل بينهم على المحصول ومكوناته فى الأراضى الجديدة.

ويمكن تلخيص أهم النتائج المتحصل عليها فيما يلى:

١- أدت زيادة المسافة بين الجور إلى نقص المحصول معنويا وارتفاع النبات بينما زاد عدد البذور/نبات و لم يكن هناك تأثير معنوى على كل من الصفات عدد القرون لكل نبات وزن ١٠٠ بذرة محصول البذور لكل نبات و النسبة المئوية للزيت و النسبة المئوية للبروتين.

٢- فإن للتسميد النيتروجينى و التلقيح البكتيرى تأثير معنوى على جميع الصفات تحت الدراسة و قد أعطت المعاملة ٩٠ وحدة بيتروجين + التلقيح أعلى القيم إلا أنه لم يكن هناك فرق معنوى بين المعاملات ٣٠ + تلقيح ، و ٦٠ + تلقيح ، و ٩٠ + تلقيح لجميع الصفات تحت الدراسة.

٣- توصى الدراسة بأن أفضل معاملة إقتصادية هى ٣٠ وحدة نتروجين + تلقيح بكتيرى مع الكثافة النباتية ٣٢ نبات/م٢ حيث أن هذه المعاملة وفرت ٦٠ وحدة أزوت بالمقارنة بالمعاملة ٩٠ وحدة نتروجين + التلقيح البكتيرى.