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RESPONSE OF SOME SOYBEAN CULTIVARS TO BACTERIAL INOCULATION COMBINED WITH N FERTILIZATION

El-Karamity, A. E.; M. A. Salem and A. A. Mohamed
Faculty of Agriculture, Minia University, Egypt

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ABSTRACT

A field experiment was conducted during 2013 and 2014 at the Educational Farm of Fac. Agric., Mania Univ. to study the response of some soybean cultivars to bacterial inoculation combined with N fertilizer. The obtained results revealed significant or highly significant differences among studied cultivars in number of pods and seeds/plant, seed yield/plant, seed and straw yields/fed and days to maturity in both seasons in addition to plant height, branch number/plant, pod seed number and seed index in the second season with superiority of Giza 35 followed by Giza 21 or Giza 111 cultivars in most studied traits in both seasons. Bacterial inoculation combined with N fertilization treatments caused significant or highly significant effect on all studied traits in both seasons except plant height in the first season. The highest values of the most studied traits were recorded for inoculated plants received starter dose of N fertilizer (20 kg N/fed) followed by those received the full dose of N fertilizer (60 kg N/fed), while the lowest values were recorded for uninoculated and unfertilized plants in both seasons. So, 40 kg N/fed could be saved during growing season of soybean. The interaction effect between cultivars and inoculation with N fertilizer was highly significant and significant for straw yield/fed in 2013 and days to maturity in 2014, respectively.

INTRODUCTION

Soybean is one of the most important legume crops in the world mainly cultivated for its seeds which is very useful as human food, animal and poultry feed. In Egypt, the dramatic decrease in the area and production in the last twenty years attributed to strong competition with other strategic summer crops on the limited cultivated area and higher production costs with

lower net income which related to marketing problems and the damage resulted from leaf feeding insects. So, increasing the production for such crop is a must. This could be achieved via cultivating high yielding cultivars combined with application appropriate cultural practices.

Several studies aimed at measuring the performance of new released high yielding and early maturing soybean cultivars. In this concern, significant differences in yield and yield components were detected among studied cultivars including Giza 21, Giza 22, Giza 35, Giza 81, Giza 111 and Crawford (El-Douby et al, 2002, El Haggan and Mekkei, 2014). Giza 22 cultivar significantly surpassed Giza 111 cultivar in plant height, number of pods and seeds/plant, 100-seed weight and seed yield per plant and feddan (Mehasen and Saeed, 2005; Metwally et al, 2009 and Ibrahim, 2014). However, Giza 22 gave the highest yield and its components followed by Giza 35 and Giza 111 (El Haggan, 2014). On the contrary, Giza 22 gave similar yield of Giza 111 (Al- Assily and Mohamed, 2002). In evaluation of eight cultivars including Giza 21 and Giza 35, Giza 21 cultivar significantly surpassed other cultivars in plant height, pod number/plant and 100-seed weight (Amer, 2005) and produced the highest yield and its components (Shairef *et al*, 2010).

Legume plants have a marvelous system to fix atmospheric nitrogen and use it as a natural source of nitrogen fertilization in a symbiotic relationship with nodule bacteria. Soybean has the most effective system of nitrogen fixation with *Bradyrhizobium japonicum* among legume species. So, many attempts have been done on soybean to show the effect of nitrogen and *Bradyrhizobium* inoculation on nodulation, yield and its components.

Inoculation with *Bradyrhizobium* spp. promotes soybean yield increases without adding any chemical N fertilizer even in soils where soybean *Bradyrhizobium* exist (Hungria *et al*, 2015). Bacterial inoculation with starter dose of nitrogen fertilizer (15 or 20 kg N/fed) gave the highest values for seed yield and yield components characters (Badran, 2003 and Hussein and El-Melegy, 2005). Concerning the effect of mineral N fertilizer without bacterial inoculation, it could be concluded that an increases in yield and yield components characters were detected with increasing N fertilizer rate up to 45 kg N/fed (El Murshedy *et al*, 2008), 60 kg N/fed (El-Douby and Shams El-Din, 1997 and Allam, 2005) and 75 kg N/fed (Nawar and Abdel-Galil, 2008).

The present study aimed at measuring the effect of bacterial inoculation combined with N fertilizer on yield and its components of some soybean cultivars.

MATERIALS AND METHODS

Two field experiments were conducted at the Educational farm of Faculty of Agriculture, Minia University, during two successive seasons of 2013 and 2014 to study the effect of inoculation with

Bradyrizobium Japonicum bacteria and nitrogen fertilization on yield and its components of four soybean cultivars.

The soil type of the experimental farm was clay loam in texture, with pH of 8.05, organic matter (1.46%) and Total N (0.09%).

The Experimental design was Randomized Complete Blocks in split-plot arrangement with three replicates. The main plots were devoted to soybean cultivars and sub-plots were assigned to the inoculation and N fertilization. Each experimental plot comprised five ridges of four meter in long and 60 cm apart occupying an area of 12 m^2 (1/350 feddan). Sowing was done using dry method (Afir) on 15^{th} of May in both seasons in hills of 15cm-apart on both sides of the ridges. Irrigation took place immediately after sowing; the first irrigation was conducted, 15 days after sowing. Seedlings were thinned to two plants/hill before the first irrigation. Phosphorus fertilizer at rate of 150 kg/fed. In form of Calcium superphosphate, 15.5%P_2O_5 was added during the preparation of soil to planting. All other cultural practices except the treatments under study were performed as recommended and follow by the farmers in the district of El-Minia.

Factors under study will be described in details as follows:

A. Soybean cultivars (main- plots)

1. Giza 21: an early maturing genotype belongs group III, matures at 125-130 days after sowing.
2. Giza 35, an early maturing genotype belongs group III, matures at 110-115 days after sowing.
3. Giza 111: released in 1995 as a highly resistant cultivars to cotton leaf worm.
4. Giza 22, an early maturing genotype belongs group III, matures at 110-115 days after sowing.

B. Inoculation and N fertilization (sub-plots)

1. un-inoculation and un-fertilization (control).
2. Inoculation with *Bradyrizobium Japonicum* (mixture of several active strains) obtained from Bio-fertilizers Center of Minia University.
3. Inoculation + 20 kg N/fed at planting (as starter dose).
4. N-fertilization with 60 kg N/fed applied in three doses (1/4 at sowing + ½ before first irrigation + ¼ before second irrigation).

I- Yield components:

At harvest time, ten plants were selected at a random from the third and fourth ridges of each plot to determine the following characters:

1. Plant height (cm.).
2. Number of branches/plant.
3. Number of pods/plant.
4. Number of seeds/pod.
5. Number of seeds/plant.
6. Seed index (g.): (weight of 100-seed).
7. Seed yield/ Plant (g).

II- Yield:

At harvest, all plants of the third and fourth ridges from each plot were harvested in addition to the previous ten plants sample to estimate the following traits:

1- Seed yield (kg/feddan).
2- Straw yield (kg/feddan).
3- Harvest index. It was calculated according to the following formula:

$$\text{Harvest index} = \frac{\text{Seed yield}}{\text{Biological yield (seed + straw)}}$$

III- Days to maturity and land use efficiency:

Days to maturity from sowing to mature 95% of pods was estimated on the basis of whole plots. Land Use efficiency (LUE) kg seeds/day was determined as the following equation:

$$\text{LUE} = \frac{\text{Seed yield kg/fed}}{\text{Number of days from sowing to maturity}}$$

Statistical analysis:

All data recorded in each season were subjected to proper statistical analysis according to procedures outlined by Steel and Torrie (1980). The differences among treatment means were compared using Least Significant differences test (L.S.D.) at level of 5% probability.

RESULTS AND DISCUSSION

1. Yield/plant and yield components:

1.1. Varietal differences:

Data presented in Tables 1 and 2 reveal that cultivars exhibited highly significant differences for number of pods and seeds/plant in 2013 and 2014 seasons and significant differences for seed yield/plant and seed index in 2013 and 2014, respectively. As well as, highly significant differences in plant height, number of branches/plant and seeds/pod and seed yield/plant were detected among cultivars in 2014 season. On the contrary, plant height, number of branches/plant and seeds/pod and seed index were not significantly affected by cultivars in the first season.

The tallest cultivars were Giza 22 and Giza35 in the first and second seasons, respectively, while the shortest one was Giza 21 in both seasons. These differences in cultivars plant height may be attributed to growth habit of each genotype which is governed by genetical and environmental factors. Similar results were obtained by Amer, 2005.

Giza 111 gave the highest number of branches/plant, while Giza 22 recorded the lowest branches/plant in 2014. The greatest number of pods and seeds per plant of 56.72 and 165.06 in 2013, 66.88 and 189.27 in 2014 were recorded for Giza 35 followed by accounted by Giza 21; 44.29 and 129.77 in 2013 and accounted by Giza 21 (46.38 pods) and Giza 111 (131.28 seeds) in 2014. However, the lowest number of pods and seeds/plant were estimated for Giza 111 and Giza 22 in the first and second seasons, respectively. Among the studied cultivars, Giza 111 produced the highest values of seed number/pod and seed index of 2.90 and 15.08 g., respectively in 2014 season, while these traits did not reach

to significant level in the first season. Giza 35 ranked the second after Giza 111 for seed number/plant (2.83) and Giza 21 ranked the second for seed index (14.95 g.) in 2014 season. The lowest values for the two traits were recorded for Giza 22 in 2014 season. These results may be due to different potentiality in forming branches, pods and seeds of cultivars used in this study, while the increase in seed index is mainly due to ability of cultivars in forming metabolites and its translocation from source to sink which in turn in seed size and mass.

Table (1): Effect of cultivars, inoculation with nitrogen fertilizer on plant height (PH), number of branches/plant (BN), pod number/plant (PN/P), pod seed number (PSN), seed number/plant (SN/P), seed index (SI) and seed yield/plant (SY/P) in 2013 season:

Treat.		PH (cm.)	BN/P	PN/P	PSN	SN/P	SI (g.)	Y/P (g.)
Cultivars	Giza (21)	83.41	3.51	44.29	2.93	129.77	14.91	19.35
	Giza (35)	88.99	3.70	56.72	2.91	165.06	14.45	23.85
	Giza(111)	90.23	3.41	37.92	2.88	109.21	15.08	16.47
	Giza(22)	94.04	4.02	43.53	2.92	127.11	14.75	18.75
F-test, LSD 0.05		NS	NS	17.14**	NS	51.44**	NS	2.87*
Inoc. + N Fert.	Control	86.23	2.94	38.58	2.84	109.57	13.91	15.24
	Inoc.	88.67	3.45	43.27	2.88	124.62	14.54	18.12
	Inoc.+20 kg/f	90.86	4.27	51.18	2.95	150.98	15.20	22.95
	Inoc.+60 kg/f	91.04	3.7	47.91	2.97	142.29	15.54	22.11
F-test, LSD 0.05		NS	0.69**	12.49**	0.04**	37.50**	0.58**	1.78**

Table (2): Effect of cultivars, inoculation with nitrogen fertilizer on plant height (PH), number of branches/plant (BN),pod number/plant (PN/P), pod seed number (PSN),seed number/plant (SN/P), seed index (SI) and seed yield/plant (SY/P) in 2014 season:

Treat.		PH (cm.)	BN/P	PN/P	PSN	SN/P	SI (g.)	SY/P (g.)
Cultivars	Giza (21)	106.25	1.65	46.38	2.77	128.47	14.95	19.21
	Giza (35)	121.53	1.84	66.88	2.83	189.27	14.62	27.67
	Giza(111)	116.31	2.87	45.27	2.90	131.28	15.08	19.80
	Giza(22)	121.30	1.60	40.88	2.56	104.61	14.37	15.04
F-test, LSD 0.05		4.51**	0.60**	12.69**	0.13**	17.58**	0.59*	2.49**
Inoc. + N Fert.	Control	112.40	1.57	40.26	2.62	105.48	13.91	14.67
	Inoc.	114.33	2.10	53.40	2.75	146.85	14.54	21.35
	Inoc+20 kg	117.66	2.36	57.80	2.90	167.62	15.54	26.05
	Inoc+60 kg	120.99	1.92	47.95	2.79	133.78	15.04	20.12
F-test, LSD 0.05		4.88**	0.38**	8.47**	0.12**	14.17**	0.55*	2.08**

These results are in agreement with those recorded by Amer, 2005 and El Haggan, 2014. Giza 35 gave the heaviest seed yield/plant of 23.85 and 27.67 g. in 2013 and 2014 seasons, respectively followed with significant differences by Giza 21 (19.35 g.) and Giza 111 (19.80 g.) in the first and second seasons, respectively. However, the lowest seed yield/plant was recorded for Giza 111 and Giza 22 in the first and second seasons, respectively. The increase in seed yield/plant of cultivars is mainly due to the increase in number and weight of seeds as discussed previously. These results took similar trend with obtained by Amer, 2005 and Shairef *et al*, 2010.

1.2. Effect of inoculation combined with N fertilizer:

As shown in Tables 1 and 2, all the previous mentioned traits in both seasons except plant height in 2013 were significantly or highly significantly affected by bacterial inoculation accompanied with N fertilizer treatments.

Inoculated plants received starter dose of nitrogen (20 kg N/fed.) had the greatest number of branches, pods and seeds/plant in addition to seed yield/plant i.e., 4.27, 51.18, 150.98 and 22.95 in 2013 and 2.36, 57.80, 167.62 and 26.06 in 2014 season, followed with significant or insignificant differences by those received full dose of nitrogen (60 kg N/fed) and inoculated plants only in 2013 and 2014 seasons, respectively. Application full dose of nitrogen gave the tallest plants followed with no significant differences by those inoculated and received starter dose of nitrogen, while the shortest plants recorded for uninoculation and unfertilized plants in both seasons.

In 2013 season, plants received the full dose of nitrogen recorded the highest number of seeds/pod and heaviest seed index followed with no significant differences by those inoculated and received starter dose of nitrogen. The reverse trend was true in 2014 season. However, the lowest values for the two traits were recorded for uninoculated and unfertilized plants in both seasons. The addition of nitrogen at proper plant growth stages ever as the support to plants in the form of a starter dose with inoculation or as the full dose enhanced plant vigor and increased both number of pods and seeds per plant which in turn in increase plant seed yield. On the light of these results, 40-60 kg N/fed could be saved during growing season of soybean. The present findings are in a good line with those reported by Badran, 2003; Hussein and El-Melegy, 2005 and Allam, 2005.

1.3. The interaction effect:

The interaction effect between cultivars and inoculation combined with N fertilizer on seed yield/plant and yield components traits was not significant in both seasons. This may be due to all studied cultivars belong the same maturity group which did not different in behavior and growth habit and its interaction with inoculation combined N fertilizer.

2. Yield/fed and land use efficiency:

2.1. Varietal differences:

Results of Tables 3 and 4 revealed that seed and straw yields per feddan and days to maturity were significantly and highly significantly affected by cultivars in 2013 and 2014 seasons, respectively. However, harvest index did not significantly affected in both seasons.

Table (3): Effect of cultivars and inoculation with N fertilizer on seed and straw yields/feddan, harvest index (HI), days to maturity (MD) and land use efficiency (LUE) in 2013 season:

Treat.		Seed yield/fed (kg.)	Straw yield/fed (kg.)	HI %	MD	LUE Kg seed/day
Cultivars	Giza (21)	1290.25	3581.08	26.49	112.08	11.51
	Giza (35)	1590.83	3521.58	31.69	112.00	14.20
	Giza(111)	1098.16	2595.16	29.73	110.83	9.91
	Giza(22)	1250.33	2795.50	30.90	111.08	11.26
F-test, LSD 0.05		278.54*	765.09*	NS	0.82*	NS
Inoc. + N Fert	Control	1016.83	2299.16	26.94	111.33	9.13
	Inoc.	1208.00	3391.75	26.82	111.41	10.84
	Inoc+20 kg/f	1530.08	3534.91	33.62	111.91	13.67
	Inoc+60 kg/f	1474.66	3267.50	30.72	111.33	13.25
F-test, LSD 0.05		NS	661.12**	5.29**	0. 42*	NS

Table (4): Effect of cultivars and inoculation with N fertilizer on seed and straw yields/feddan, harvest index (HI), days to maturity (MD) and land use efficiency (LUE) in 2014 season:

Treat.		Seed yield/fed (kg.)	Straw yield/fed (kg.)	HI %	MD	LUE Kg seed/day
Cultivars	Giza (21)	1429.16	3668.75	28.03	112.07	12.75
	Giza (35)	1710.33	4283.83	28.53	112.01	15.27
	Giza(111)	1443.08	3696.41	28.08	110.66	13.04
	Giza(22)	1110.83	2959.33	27.29	111.08	10.00
F-test, LSD 0.05		250.34**	555.42**	NS	0.72**	NS
Inoc. + N Fert.	Control	1059.16	2843.00	27.14	111.08	9.54
	Inoc.	1484.75	3788.83	28.15	111.41	13.33
	Inoc+20 kg/f	1817.50	4524.08	28.66	111.58	16.29
	Inoc+60 kg/f	1332.00	3451.75	27.84	111.75	11.92
F-test, LSD 0.05		208.60**	463.73**	0.24**	0. 41*	NS

The earliest cultivar in maturity was Giza 111, whereas the latest one was Giza 21 in both seasons. This confirms the differences among cultivars in their maturation due to their different genetic behavior. These results are in agreement with those reported by Abdel Hafez, 1999.

Among studied cultivars, Giza 35 recorded the highest seed yield/fed of

1590.83 and 1710.33 kg followed with significant differences by Giza 21 (1290.25 kg) and Giza 111 (1443.08) in 2013 and 2014 seasons, respectively. Giza 21 followed by Giza 35 gave the highest straw yield/fed. in 2013 season and the reverse was true in 2014 season. However, Giza 111 and Giza 22 recorded the lowest values of seed and straw yields/fed in the first and second seasons, respectively. The highest values of harvest index were recorded for Giza 35 in both seasons whereas the lowest values were recorded for Giza 21 and Giza 22 in the first and second season, respectively. The different of seed and straw yields/feddan due to cultivars are corresponding with yield components as discussed previously. The performance of cultivars in yield and its components from year to other may be attributes to the environmental conditions prevailed during growing season. These results are confirmed by those obtained by Amer, 2005 and El-Haggan 2014.

Concerning Land use efficiency (LUE), it could be concluded that Giza 35 gave the highest values of LUE of 14.20 and 15.27 kg seeds/day in 2013 and 2014 seasons, respectively, followed by Giza 21 (11.5 kg seeds/day) and Giza 111 (13.04 kg seeds/day) in first and second seasons, respectively. However, the lowest values for this measurement were recorded for Giza 111 and Giza 22 in the first and second seasons, respectively. These results are expected since the values of LUE are corresponding with seed yields/fed. Similar results were recorded by El-Karamity, 1998.

2.2. Effect of inoculation combined with N fertilizer:

All the previous mentioned traits were significantly or highly significantly affected by inoculation combined with N fertilizer in both seasons. The latest plants in maturity were recorded for inoculated plots received starter dose of N (20 kg N/fed) and those received the full dose of N (60 kg N/fed) in the first and second seasons, respectively, while the earliest plants recorded for uninoculated and unfertilized plots in both seasons. These results confirm the role of N in extending the vegetative growth period, consequently retarding maturity. These results took the same trend with Hussein and El-Melegy (2005).

Inoculated plants received starter dose of N (20 kg N/fed) produced the highest values of seed and straw yields per feddan as well as harvest index and Land Use efficiency of 1530.08 kg, 3534.91 kg., 33.62% and 13.67 kg seeds/day in the first season, while the corresponding values in the second season were 1817.50 kg, 4524.08, 28.66% and 16.29 kg seeds/day followed by those received full dose of N (60 kg N/fed) and those inoculated only in the first and second seasons, respectively. However, the lowest values for the four traits were recorded in uinoculated and unfertilized plants in both seasons. These results confirmed the role of N in promoting the growth and formation the metabolites and its translocation from

source to sink which in turn in yield components characters and consequently seed and straw yields per feddan. From the view of these results, 40-60 kg N/fed could be saved during growing season of soybean. These results took a good line with those reported by El Douby and Shams El-Din, 1997; Bdran, 2003 and Hussein and El-Melegy (2005).

2.3. Effect of interaction:

The interaction effect between cultivars and inoculation combined with N fertilizer was highly significant on straw yield/fed in 2013 and significant on days to maturity in 2014(Table 5). The latest plants in maturity were recorded for Giza 21 received full dose of (60 N/fed), while the earliest ones were recorded for Giza 22 with un-inoculation and un-fertilization. However, the heaviest straw yield/fed were recorded for inoculated of Giza 21 plants received starter dose of N (20kg N/fed), while the lightest straw yield/fed was recorded for of Giza 21 uninoculated and unfertilized plants of Giza 21.

Table (5): Effect of interaction between cultivars and inoculation with N fertilizer on straw yield/fed. in 2013 and days to maturity in 2014:

Treat. Cultivars Inoc. + N Fert.	Straw yield/fed (2013)				Days to maturity (2014)			
	Giza (21)	Giza (35)	Giza (111)	Giza (22)	Giza (21)	Giza (35)	Giza (111)	Giza (22)
Control	1980.66	2349.00	2394.00	2473.00	112.00	111.66	110.33	110.33
Inoc.	2944.66	4671.00	2921.66	3028.66	112.00	112.00	110.33	111.33
Inoc. +20 kg N/fed	5647.00	2974.00	2778.66	2770.00	112.00	112.37	110.66	111.00
Inc. + 60 kg N/fed	3782.00	4092.33	2285.33	2910.33	112.28	111.66	111.33	111.66
F-test LSD 0.05	1313.46**				0.94*			

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الملخص العربي

إستجابة بعض أصناف فول الصويا للتلقيح البكتيرى والتسميد النيتروجيني

عبد الحميد السيد القراميطي ، منصور عبد المجيد سالم ، أسماء أبوبكر محمد
جامعة المنيا – كلية الزراعة – قسم المحاصيل

أجريت تجربة حقلية خلال موسمي 2013 ، 2014 بالمزرعة التعليمية بكلية الزراعة- جامعة المنيا لدراسة استجابة بعض أصناف فول الصويا للتلقيح البكتيري مع السماد النيتروجيني.

أظهرت النتائج إختلافات معنوية أو عالية المعنوية بين أصناف الدراسة لصفات عدد القرون والبذور/نبات، محصول البذور للنبات، محصول البذور والقش للفدان و عدد الايام حتي النضج في كلا الموسمين بالإضافة الي طول النبات وعدد الفروع/نبات، عدد البذور بالقرن، وزن 100 بذره في الموسم الثاني مع تفوق الصنف جيزه 35 يليه جيزه 21 أو جيزه 111 في معظم صفات الدراسة في الموسمين.

أدي التلقيح البكتيري مع السماد النيتروجيني إلي تأثير معنوي أو عالي المعنوية علي كل صفات الدراسة في كلا الموسمين ماعدا طول النبات في الموسم الأول وأمكن الحصول علي أعلي القيم لمعظم صفات الدراسة من النباتات الملقحة بالبكتريا والمسمدة بالجرعة المنشطة (20 كجم نيتروجين/فدان) يليها المسمدة بالجرعة الكاملة للسماد الأزوتي (60 كجم نيتروجين/فدان) في كلا الموسمين، بينما سجلت النباتات الغير ملقحة والغير مسمده أقل القيم لجميع صفات الدراسة في كلا الموسمين، وفي ضوء هذه النتائج يمكن توفير 40 كجم نيتروجين/فدان أثناء موسم نمو فول الصويا.

أظهر التفاعل بين الأصناف والتلقيح البكتيري مع السماد النيتروجيني تأثيرا عالي المعنوية علي محصول القش/فدان في الموسم الأول وتأثيرا معنويا علي عدد الأيام حتي النضج في الموسم الثاني.