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EFFECT OF RHIZOBIUM INOCULATION, NITROGEN FERTILIZATION AND PLANT DENSITY ON GROWTH, YIELD AND MINERAL CONTENT OF PEAS UNDER SANDY SOIL CONDITIONS

Sarg, Sawsan M. H. and M. A. Hassan
Faculty of Agriculture, Suez Canal University, Ismailia (A.R.E.)

ABSTRACT

This study was conducted during two successive seasons (2000 / 2001 and 2001 / 2002) at the Experimental Farm of Faculty of Agriculture, Suez Canal University, Ismailia to investigate the effect of Rhizobium inoculation, four levels of nitrogen fertilization (0, 20, 40 and 60 Kg .N/ feddan) as ammonium sulphate and two plant density treatments (2 and 3 lines per ridge) on vegetative growth parameters, number of nodules, chlorophyll's a, b and total, N, P and K contents in the leaves and yield of pea (*Pisum sativum L.*). Vegetative growth parameters increased with inoculation alone or in combination with nitrogen application.

Nitrogen application significantly increased vegetative growth parameters. Increasing plant density decreased vegetative growth parameters except plant height, which increased with high density. Number of nodules on the roots was higher in inoculated plants than uninoculated ones. Nitrogen application and wide spacing enhanced nodule number per root. The yield parameters (pods number and weight per plant, yield per plant, yield per fed. and weight of 100 seeds) showed a significant increase with inoculation or nitrogen application over their control. However, with higher density all yield parameters decreased except those of the total yield.

Photosynthetic pigments significantly increased with Rhizobium inoculation, nitrogen application compared with the control. Lower density also increased those pigments. Leaves contents of N, P, and K increased as a result of both inoculation and nitrogen application. Higher plant density decreased leaves mineral content.

INTRODUCTION

Pea (*Pisum sativum* L.) is one of the most important and popular winter vegetable crops In Egypt either for local consumption or export.

It is well known that peas like other leguminous crops have the ability to fix atmospheric- N in the soil via Rhizobium bacteria. Since this bacteria is completely absent in new sandy soils, growers tend to overuse nitrogen fertilizers to obtain a maximum yield. Improving production of pea crops in sandy soils could be achieved through the enhancement of nitrogen fixation by using biofertilizers such as Rhizobium, in addition to nitrogenous fertilization, which is an essential factor for better yield and plant growth. Rolfe and Gresshoff (1988) stated that depending on plant sp. and environmental factors, N_2 fixation starts at the earliest between 10 and 12 days after infection.

Several investigators studied the response of leguminous crops to Rhizobium inoculation and nitrogen fertilization [El-Oksh *et al.* (1991) on beans; Abdel-Ghaffar and Mohamed (1992) on pea; El-Awag (1998) on broad bean; Farghaly (1998) on cow pea; Hanna and Eisa (1998) on soybean; Merghany (1998) on snap bean; Hanafy *et al.* (1999) on pea and Abd-Alla *et*

al. (2000 a & b) on pea]. It is worth noting that the more plant density the more competition on light, nutrition and other factors affecting plant growth. Many investigators mentioned that higher plant density reduced plant growth and dry matter content. However plant density may increase the total yield/ fed. owing to the plant population [El-Afifi and Darweesh (1992) on bean; El-Ghamriny & Arisha (1992) on pea ; El-Habbasha *et al.*(1996) on pea ; Amer (1998) on pea ; Abdalla *et al.* (2000 a & b) on pea; El-Mansi *et al.*(2000) on pea and Amer *et al.* (2001) on pea.

Therefore the present work was designed to study the response of peas to inoculation with Rhizobium, nitrogen fertilization and plant density in new reclaimed sandy soil.

MATERIALS AND METHODS

Two field experiments were carried out at the Experimental Farm of Faculty of Agriculture, Suez Canal University, Ismailia Governorate.

The physical and chemical properties of the experimental soil were as follows; sand 95.8 and 95.7, silt 2.9 and 3.0, clay 1.3 and 1.3, pH 8.01 and 8.11, organic matter 0.70 and 0.85, total N (g / kg) 0.06 and 0.08, P (mg/kg) 5.8 and 6.11, K (m Eq /L) 0.43 and 0.49 and calcium carbonate (%) 0.55 and 0.68 for the first and second seasons, respectively.

Each experiment included 16 treatments resulting from the combinations of two Rhizobium inoculations of seeds (inoculated and uninoculated), four nitrogen levels; 0, 20, 40 and 60 kg N/fed. and two levels of plant population i.e. two or three lines per ridge. The experimental treatments were arranged in split split plot in randomized block design with three replicates. The main plot were devoted for Rhizobium inoculation, nitrogen levels were allocated at random in the sub plot, whereas planting density treatments were presented randomly in the sub sub plot. Every sub sub plot area was 10.5 m^2 and included 6 ridges. Each was 3.5 m length and 50 cm width.

Pea seeds Master B cv. were inoculated with root nodules bacteria (*Rhizobium leguminosarium*) at a dose of 5gm / kg seeds (Arabic gum was used as an adhesive agent) then the inoculated and uninoculated seeds were sown on 28th of October at both seasons. All plots received farmyard manure at a rate of 30 m^3/ Fed. and equal amounts of Calcium superphosphate and potassium at the rates of 150 and 100 kg / fed., respectively. Nitrogen was applied as ammonium sulphate (20.5 %). One third of the amounts of chemical fertilizers was added with FMY at soil preparation. The other two thirds were added with all other agricultural practices as recommended for growing pea in sandy soils.

Data recorded:

Vegetative growth:

Six plants from each treatment were taken, 50 days after planting. The following data were recorded:

- Stem length (cm) , both leaves and branches number / plant, Nodules number / plant root, shoot fresh and dry weights (g) and leaves area/ plant (cm^2).
- Chlorophyll's a, b and total chlorophyll were determined according to A.O.A.C. (1975).
- Leaf mineral contents: 50 days after sowing, samples of leaves were oven dried at 70 C^0 till constant weight to determine the following chemical contents:
- Total nitrogen in leaves as described by A.O A.C (1975).
- Phosphorous, determined colorimetrically by the standard method of Jackson (1967).
- Potassium, determined using flame photometer as described by Jackson (1967).
- Yield and yield components: the following data were recorded
- Number of pods/ plant.
- Average pod weight.
- Weight of 100 seeds.
- Fresh pod yield / plant in g.
- Total yield (ton / Feddan).

Statistical analysis:

The obtained data were subjected to statistical analysis according to Snedecor and Cochran (1989). Treatment means were compared using L.S.D. test as described by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

1-Vegetative growth

Data in Table (1) indicate that vegetative growth was affected by each of Rhizobium inoculation, nitrogen fertilization and plant density.

1-a- Effect of Rhizobium inoculation:

Data in Table (1) show the effect of Rhizobium inoculation on vegetative growth parameters. Plant height, number of both leaves and branches, leaves area / plant, shoot fresh and dry weight and number of nodules significantly increased with Rhizobium inoculation as compared with the control in both season of study. Roy and Basu (1992) reported that nodules contain higher levels of IAA and other growth hormones. These growth hormones might be the cause of the increment in plant, nodule growth and dry matter in different parts. These results are in agreement with those of El-Oksh *et al.* (1991) on bean; Abdel-Ghafar and Mohamed (1992) on pea; El-Ghamriny and Arisha (1992) on pea El-Awag (1998) on broad bean; Farghaly (1998) on cow pea; Merghany (1999) on snap bean and El-Mansi *et al.* (2000) on pea.

Table (1): Effect of Rhizobium inoculation (A), nitrogen fertilization (B)and plant density (C) on plant height,number of leaves, number of branches, leaves area, shoot fresh weight, shoot dry weight and numer of nodules of pea plants under sandy soil during(2000/ 2001 - 2001/ 2002) seasons.

Inoculation	A	Plant height		No. of leaves		No. of branches		Leaves area		Shoot fresh weight		Shoot dry weight		No. of nodules	
Inoculated		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Inoculated		34.11	31.96	13.92	13.42	2.05	1.95	219.79	208.56	16.03	13.96	2.00	1.74	34.69	31.780
Uninoculated		31.11	27.04	12.76	12.06	1.55	1.43	184.66	172.56	13.95	12.97	1.67	1.53	8.50	7.330
Nitrogen levels	B														
0		25.15	23.04	11.43	10.81	1.29	1.20	155.45	145.68	10.70	9.86	1.43	1.29	14.60	13.070
20		29.87	27.72	12.63	11.77	1.56	1.41	188.08	175.20	13.63	11.79	1.76	1.51	19.80	17.440
40		36.10	29.71	14.22	13.59	2.07	1.92	224.48	210.83	16.77	14.84	2.01	1.77	27.03	24.450
60		39.33	37.54	15.07	14.80	2.28	2.24	240.89	230.53	18.87	17.38	2.15	1.98	24.96	23.260
Density	C														
2 lines		30.89	28.65	13.70	13.13	1.91	1.86	211.13	198.57	15.85	14.19	1.89	1.68	22.73	20.660
3 lines		34.33	31.46	12.94	12.34	1.69	1.52	193.20	182.57	14.14	12.75	1.79	1.60	20.47	18.450
L.S.D. 5%															
Inoculation	A	0.67	0.71	0.65	0.53	0.08	0.06	5.60	4.98	0.16	0.15	0.06	0.05	0.33	0.31
Nitrogen levels	B	1.08	1.15	0.89	0.79	0.14	0.11	10.24	8.87	0.22	0.20	0.06	0.06	0.38	0.38
Density	C	0.62	0.58	0.08	0.07	0.18	0.16	12.62	11.12	0.28	0.25	0.08	0.04	0.59	0.56

1-b-Effect of nitrogen fertilization:

Table (1) indicates that the vegetative growth parameters significantly increased as a result of nitrogen application The increments were corresponding to the level of nitrogen application. Result has similar trend in the two seasons. Russell (1973) indicated that as the level of nitrogen supply increases, the extra protein produced allows the plant leaves to grow larger and hence to have a large surface. Nitrogen application significantly increased the number of nodules compared with the control. The highest nitrogen level, however, decreased the number of nodules. This might be attributed to the deleterious effect of high rates of nitrogen application on nodule formation. These results are in harmony with the findings of Khalil (1990) on pea; El-Ghamriny and Arisha (1992) on pea; Hanafy *et al.* (1999) on pea and Merghany (1999) on snap bean.

1-c- Effect of plant density:

Data in Table (1) reveal that plant density negatively affected the vegetative parameters except plant height. Results of the two seasons ensure that sowing pea seeds on three lines/ ridge enhanced the height of plants over the treatment of sowing two lines / ridge. This may be due to the high competition between plant for light. The negative effect of high density on other growth parameters might be due to the competition between plants for light, space available for plant growth, mineral nutrition and other environmental factors. These results coincided with those of El-Afifi and Darweesh (1990) on French bean; Shekhar and Sharma (1991) on pea; El-Habbasha et al. (1996) on pea; Abd-Alla *et al.* (2000, a) on pea and Amer *et al.* (2001) on pea.

1-d-Effect of interaction:

Data in Tables (2 & 3) show the interaction effects of Rhizobium inoculation, nitrogen application and plant density on vegetative growth parameters in the first and second seasons, respectively. Statistical analysis showed that the interaction effects of the three factors were not significant on plant height, number of leaves and number of branches. The interaction effects on leaves area were not significant except that of inoculation x density which was significant. On the other hand, all interactions appeared highly significant on each of shoot fresh and dry weight. The interaction effects on the number of nodules were highly significant except that of inoculation * density which was not significant.

2- Yield and its components:

2-a- Effect of Rhizobium inoculation:

Data in Table (4) show that number of pods/ plant, pods weight, yield / plant, yield/ feddan and weight of 100 seeds significantly increased by Rhizobium inoculation higher than the check. This was evident in the two seasons of study. Increasing the yield and its components is a result of enhancing vegetative growth by inoculation. These results are in agreement with those of Abdel-Ghaffar and Mohamed (1992) on pea; El-Awag (1998) on broad bean; Hanna and Eisa (1998) on soybean; Hanafy *et al.* (1999) on pea; Merghany (1999) on snap bean and El-Mansi *et al.* (2000) on pea.

Table (2): Effect of Rhizobium inoculation (A), nitrogn fertilization (B) and plant density (C) interactions on plant height, number of leaves, number of branches, leaves area,shoot fresh weight, shoot dry weight and number of nodules.(2000 / 2001)

inoculation	N.levels kg	Plant height			Nnumber of leaves			No. of branches		
		2 lines	3 lines	mean	2 lines	3 lines	mean	2 lines	3 lines	mean
	0	26.01	28.55	27.27	12.55	11.51	12.03	1.58	1.44	1.51
inoculated	20	29.12	33.69	31.41	13.59	13.01	13.26	1.72	1.88	1.81
	40	35.31	39.82	37.57	15.02	14.51	14.75	2.63	2.07	2.36
	60	38.70	41.71	40.21	15.76	15.51	15.63	2.81	2.22	2.51
0mean		32.28	35.94	34.11	14.21	13.64	13.92	2.19	1.90	2.05
	0	21.86	24.18	23.02	11.21	10.44	10.83	1.06	1.08	1.09
uninoculated	20	25.76	30.91	28.33	12.51	11.51	12.01	1.38	1.24	1.31
	40	33.11	36.12	34.62	14.01	13.34	13.67	1.88	1.66	1.77
	60	37.22	39.68	38.45	15.02	14.01	14.51	2.15	1.95	2.07
mean		29.49	32.72	31.11	13.19	12.33	12.76	1.62	1.48	1.56
total mean		30.89	34.33	32.61	13.71	12.94	13.32	1.91	1.69	1.81
F test										
A * B		NS	NS		NS	NS		NS	NS	
A * C		NS	NS		NS	NS		NS	NS	
B * C		NS	NS		NS	NS		NS	NS	
A * B* C		NS	NS		NS	NS		NS	NS	

inoculation	N.levels kg	Leaves area			Shoot fresh weight			Shoot dry weight			Number of nodules		
		2 lines	3 lines	mean	2 lines	3 lines	mean	2 lines	3 lines	mean	2 lines	3 lines	mean
	0	####	####	####	12.34	11.12	11.73	1.64	1.52	1.58	25.22	23.02	24.12
inoculated	20	####	####	####	16.44	14.43	15.44	2.14	1.83	1.99	33.15	30.73	31.94
	40	####	####	####	18.81	17.57	18.19	2.18	2.15	2.17	45.19	41.80	43.54
	60	####	####	####	19.21	18.31	18.76	2.26	2.23	2.25	40.20	38.11	39.16
0mean		####	####	####	16.71	15.36	16.03	2.06	1.93	2.01	35.94	33.44	34.69
	0	####	####	####	10.22	9.12	9.67	1.32	1.24	1.28	6.10	4.07	5.08
uninoculated	20	####	####	####	12.62	10.99	11.81	1.61	1.43	1.52	8.12	7.18	7.65
	40	####	####	####	17.02	13.67	15.35	1.91	1.76	1.85	11.73	9.30	10.51
	60	####	####	####	20.11	17.86	18.98	1.98	2.11	2.04	12.08	9.45	10.76
mean		####	####	####	14.99	12.91	13.95	1.71	1.64	1.67	9.51	7.50	8.50
total mean		####	####	####	15.80	14.14	14.99	1.89	1.79	1.84	22.73	20.47	21.60
F test													
A * B		NS	NS		***	***		***	***		***	***	
A * C		**	**		***	***		***	***		NS	NS	
B * C		NS	NS		***	***		***	***		***	***	
A * B* C		NS	NS		***	***		***	***		**	**	

Table (3): Effect of Rhizobium inoculation (A), nitrogn fertilization (B) and plant density (C) interaction on plant height, number of leaves, number of branches, leaves area, shoot fresh weight, shoot dry weight and number of nodules (2001-2002).

Inoculation	N.kg levels	Plant height			Number of leaves			No. of branches			Leaves area			Shoot fresh weight		
		2 lines	3 lines	mean	2 lines	3 lines	mean	2 lines	3 lines	mean	2 lines	3 lines	mean	2 lines	3 lines	mean
Inoculated	0	23.56	26.92	25.24	11.66	11.00	11.33	1.50	1.22	1.36	162.25	153.17	157.71	10.89	10.22	15.56
	20	30.17	31.76	30.97	12.27	12.00	12.14	1.66	1.60	1.63	197.62	191.68	194.65	13.77	11.82	12 80
	40	32 13	34.66	33.40	15.65	13.66	14.66	2.70	1.99	2.35	249.18	216.28	232.73	15.92	15.70	15.81
	60	37 24	39.18	38.21	16.11	15.00	15.56	2.91	2.02	2.47	258.80	239.46	249.13	17.00	16.34	16.67
Mean		30 78	33.13	31.96	13.92	12.92	13.42	2.19	1 71	1.95	216.96	200.15	208.56	14.40	13 52	13.96
Unioculated	0	19 46	22.19	20.83	10.36	10.22	10.29	1.07	0.99	1.03	138.19	129.11	133.65	9.71	8.60	9.16
	20	22.80	26.11	24.46	11.66	11.11	11 39	1.23	1.12	1.18	161.71	149.77	155.74	11.43	10.11	10.77
	40	28.11	32.91	26.01	12.86	12.18	12.52	1.62	1.34	1.48	196.22	181.62	188.92	15.68	12.06	13.87
	60	35.72	38.00	36.86	14.50	13.55	14.03	2.20	1.82	2.01	224.43	199.43	211.93	19.07	17.12	18.10
Mean		26.52	29.80	27.04	12.34	11.76	12.06	1.53	1.32	1.43	180.14	164.98	172.56	13.97	11.97	12.97
Total mean		28.65	31.46	29.50	13.13	12.34	12.74	1.86	1.52	1.69	198.55	182.57	190.56	14.19	12.75	13.47
F test																
A*B		NS	NS		NS	NS		NS	NS		NS	NS		***	***	
A*C		NS	NS		NS	NS		NS	NS		**	**		***	***	
B*C		NS	NS		NS	NS		NS	NS		NS	NS		***	***	
A*B*C		NS	NS		NS	NS		NS	NS		NS	NS		***	***	

Table (4): Effect of Rhizobium inoculation, nitrogen fertilization and plant density on number of pods / plant, pod weight, yield / plant (gm), yield / feddan (ton) and weight of 100 seeds of pea plants under sandy soil during (2000/ 2001 - 2001/ 2002) seasons.

Inoculation	A	No. of pods/ plant		Pod weight (gm)		Yield/ plant (gm)		Yield/ feddan (ton)		Weight of 100 seeds	
Inoculated		1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Inoculated		5.44	4.89	5.05	5.19	30.35	25.47	4.19	3.50	26.12	24.480
Uninoculated		4.47	4.08	4.01	4.32	19.93	16.84	2.72	2.29	22.39	20.510
Nitrogen level	B										
0		3.84	3.54	3.32	3.59	15.20	11.86	1.91	1.69	19.16	17.680
20		4.67	4.20	4.09	4.44	20.89	17.30	2.88	2.62	22.13	20.730
40		5.53	4.92	5.15	5.27	29.38	25.64	4.02	3.82	25.87	23.970
60		5.81	5.28	5.57	5.75	35.11	29.83	4.81	4.49	29.82	27.610
Density	C										
2 lines		5.16	4.68	4.28	5.12	27.46	19.17	3.07	2.64	25.47	3.520
3 lines		4.73	4.28	3.72	4.39	22.82	14.84	3.83	3.15	23.04	21.470
L.S.D 5%											
Inoculation	A	0.34	0.30	0.02	0.02	0.15	0.13	0.02	0.02	0.20	0.21
Nitrogen level	B	0.36	0.33	0.03	0.03	0.11	0.11	0.03	0.03	0.23	0.22
Density	C	0.53	0.49	0.03	0.03	0.12	0.11	0.05	0.04	0.43	0.52

2-b-Effect of nitrogen fertilization:

Data in Table (4) revealed that yield and its components significantly increased with nitrogen application over the control. The increments were corresponding to the increase of nitrogen levels. This was noticed in the two seasons of study These increments are due to the fact that nitrogen application encourages vegetative growth These results are in harmony with those of Khalil (1990) on pea; El-Ghamriny and Arisha (1992) on pea: El-Awag (1998) on broad bean; Hanna and Eisa (1998) on soybean and Abdalla et al. (2000) on pea.

2-c- Effect of plant density:

Table (4) represents the effect of plant density on yield and its components. All yield parameters of plants grown in 2 lines / ridge gave higher values than those grown in 3 lines / ridge except the total yield / feddan. Increasing plant population in feddan increased total pod yield during the two experimental seasons. These results are in agreement with those of El-Afifi and Darweesh (1990) bean; El- Habbasha *et al.* (1996) on pea; Abdalla *et al.* (2000, a) on pea and. Amer *et al.* (2001) on pea.

2-d- Effect of interaction:

Tables (5 & 6) indicate the effect of the interaction of Rhizobium inoculation, nitrogen application and plant density. Data show that the highest number of pods per plant occurred in inoculated plants that received 60 units of nitrogen and were grown in 2 lines per ridge.

Similar trends could be observed within the other yield components. The highest yield per feddan appeared in plants that were inoculated with Rhizobium and received 60 units of nitrogen but were grown in 3 lines per ridge. The least values were obtained in control plants followed by those receiving the lower and the medium nitrogen levels.

3-Chemical components:

3-a- Effect of Rhizobium inoculation:

Data in Table (7) show that chlorophyll a, b and total chlorophylls significantly increased in plants treated with Rhizobium inoculation compared to the control. Nitrogen content also increased significantly in the inoculated plants compared with the control. The increase in nitrogen content is a result of nitrogen fixation by the Rhizobium bacteria from the atmospheric nitrogen in the roots media since more than 90% of the fixed nitrogen is rapidly translocated from the bacteria to the different plant organs (Marschner, 1995). Phosphorus and potassium contents also showed a significant increase with Rhizobium inoculation. The above mentioned results were evident in the two seasons of the study. These results are in harmony with those of Merghany (1999) on snap bean and El-Mansi *et al.* (2000) on pea.

Table (5): Effect of Rhizobium inoculation (A), nitrogen fertilization (B) and plant density (C) interaction on umber of pods/ plant, pod weight, yield/plant (gm), yield/feddan (ton)and weigt of 100 seeds of peaplants under sandy soil (2000 / 2001).

Inoculation	N.kg levels	Number of pods/ plant			Pod weight (gm)			Yield / plant (gm)			Yield / feddan (ton)			weight of 100 seeds		
		2 lines	3 lines	mean	2 lines	3 lines	mean	2 lines	3 lines	mean	2 lines	3 lines	mean	2 lines	3 lines	mean
Inoculated	0	4.36	3.86	4.11	4.45	3.63	4.04	19 40	19.01	19.20	2.17	2.35	2.26	22.44	19.21	20.82
	20	5.12	4.92	5.02	5.07	4.68	4.87	25.96	23.02	24.49	2.91	3.87	3.39	24.52	23.06	23.79
	40	6.33	5.87	6.15	6.12	5.29	5.70	38.74	31.05	34.92	4.35	5.22	4.78	28.81	26.73	27.77
	60	6.88	6.12	6.50	6.72	5.62	٦.١٧	46.23	39.39	42.81	5.18	6.62	5.9	33.34	30.8	32.09
Mean		5.67	5.17	5.44	5.59	4.80	5.19	32.59	28.12	30.35	3.65	4.72	4.19	27.28	24.96	26.12
Uninoculated	0	3.72	3.40	3.56	3.23	3.05	3.14	12.01	10.37	11.19	1.35	1.74	1.55	18.51	16.62	17.56
	20	4.48	4.14	4.31	4.32	3.68	4.00	19.35	15.23	17.29	2.17	2.56	2.37	21.74	19.21	20.47
	40	5.12	4.69	4.90	5.17	4.52	4.84	26.47	21.20	23.83	2.96	3.56	3.26	25.67	22.28	23.97
	60	5.33	4.92	5.12	5.92	4.73	5.32	31.55	23.27	27.41	3.53	3.91	3.72	28.76	26.34	27.55
Mean		4.66	4.30	4.47	4.66	3.99	4.32	22.34	17.52	19.93	2.15	2.94	2.72	23.67	21.11	22.39
Total mean		5.16	4.73	4.95	5.12	4.39	4.75	27.46	22.82	25.14	3.07	3.83	3.45	25.47	23.04	24.26
F test																
A*B		***	***		NS	NS		***	***		***	***		***	**	
A*C		NS	NS		***	***		***	***		***	***		NS	NS	
B*C		NS	NS		**	***		***	***		***	***		***	**	
A*B*C		NS	NS		***	***		***	***		***	***		***	***	

Table (6): Effect of Rhizobium inoculation (A), nitrogen fertilization (B) and plant density (c) interaction on number of pods/ plant, pod weight, yield/ plant (gm), yield/feddan (ton) and weigt of 100 seeds of pea plants under sandy soil (2001 / 2002).

Inoculation	N.kg levels	Number of pods/ plant			Pod weight(gm)			Yield / plant (gm)			Yield / feddan (ton)			Weight of 100 seeds
		2 lines	3 lines	mean	2 lines	3 lines	mean	2 lines	3 lines	mean	2 lines	3 lines	mean	2 lines
Inoculated	0	4.00	3.56	3.78	4.24	3.11	3.68	16.96	11.07	14.02	1.90	1.86	1.88	20.55
	20	4.52	4.47	4.50	5.10	4.14	4.62	23.05	18.50	20.78	2.58	3.11	2.85	23.72
	40	5.56	5.22	5.39	5.98	5.36	5.67	33.25	27.98	30.62	3.72	4.70	4.21	27.11
	60	6.02	5.71	5.87	6.36	6.07	6.22	38.29	34.66	36.47	4.29	5.82	5.06	30.91
Mean		5.03	4.74	4.89	5.42	4.67	5.05	27.89	23.06	25.47	3.12	3.87	3.50	25.57
Uninoculated	0	3.47	3.11	3.29	3.00	2.89	2.95	10.41	8.99	9.70	1.17	1.51	1.34	16.88
	20	3.97	3.81	3.89	3.76	3.33	3.55	14.93	12.65	13.81	1.67	2.13	1.90	19 76
	40	4.79	4.11	4.45	4.97	4.26	4.62	23.81	17.51	20.66	2.67	2.94	2.81	22.94
	60	5.11	4.26	4.69	5.39	4.42	4.91	27.54	18.83	23.19	3.08	3.16	3.12	26.27
Mean		4.33	3.82	4.08	4.28	3.72	4.01	19.17	14.51	16.84	2.15	2.44	2.29	21.46
Total mean		4.68	4.28	4.49	4.85	4.20	4.53	23.53	18.79	21.16	2.64	3.15	2.90	23.52
F test														
A*B		**	*		NS	NS		***	***		***	***		***
A*C		NS	NS		***	***		***	***		***	***		NS
B*C		NS	NS		***	***		***	***		***	***		*
A*B*C		NS	NS		***	***		***	***		***	***		***

Table (7): Effect of Rhizobium inoculation, nitrogen fertilization and plant density on chlorophyll a, chlorophyll b, total chlorophylls, nitrogen,phosphorus and potassium cotents in the leaves of pea plants under sandy soil during (2000/ 2001 and 2001/ 2002) seasons.

		Chlorophyll a		Chlorophyll b		Total chlorophylls		Nitrogen		Phosphorus		Potassium	
Inoculation	A	1st. seaseon	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Inoculated		4.01	3.60	3.19	2.77	7.20	6.37	3.37	2.97	0.346	0.327	1.75	1.62
Uninoculated		3.49	3.20	2.84	2.56	6.34	5.76	3.10	2.72	0.336	0.318	1.65	1.57
N. kg. Levels	B												
0		3.35	2.95	2.80	2.36	6.14	5.38	2.93	2.56	0.321	0.304	1.54	1.44
20		3.72	3.39	2.95	2.54	6.67	6.02	3.07	2.66	0.335	0.318	1.69	1 54
40		3.93	3.58	3.09	2.70	7.01	6.28	3.33	2.97	0.350	0.333	1.75	1.65
60		4.05	3.70	3.22	2.90	7.27	6.59	3.61	3.17	0.359	0.348	1.82	1.76
Density	C												
2 lines		3.96	3.59	3.07	2.78	7.06	6.37	3.51	2.94	0.299	0.325	1.76	1.63
3 lines		3.54	3.21	2.95	2.56	6.49	5.77	2.98	2.74	0.333	0.323	1.65	1.57
L.S.D. 5 %													
Inoculation	A	0.24	0.22	0.01	0.01	0.01	0.01	0.07	0.06	0.02	0.01	0.06	0.05
Nitrogen level	B	0.47	0.46	0.01	0.01	0.02	0.03	0.15	0.13	0.02	0.01	0.07	0.06
Density	C	0.09	0.09	0.01	0.01	0.03	0.02	0.05	0.04	0.01	0.01	0.02	0.02

3-b- Effect of nitrogen application:

Data in Table (7) show that chlorophyll a, b and total chlorophyll significantly increased in plants that received different levels of nitrogen compared with the control. Marschner (1995) indicated that the content of lipids in green leaves is closely related to the N supply. Galactolipids act as structural components of chlorophylls. Correspondingly, an enhancement of protein synthesis and chloroplast formation leads to an increase in chloroplast constituents such as chlorophylls.

Nitrogen, phosphorus and potassium contents also appeared to increase significantly in the treated plants compared with the control. The increments were adherent to the increase in the applied nitrogen level. This was evident in the two seasons of the study. These results are in harmony with those of Khalil (1990) on pea; El-Ghamriny and Arisha (1992) on pea and Merghany (1999) on snap bean.

3-c- Effect of plant density:

Data in Table (7) illustrate that chlorophyll a, b and total chlorophyll significantly decreased with the higher plant density. Nitrogen, phosphorus and potassium contents showed similar trends to that of chlorophyll. This was evident in the two seasons of the study. The decrease in chlorophyll and N, P and K contents could be due to the higher competition for light and nutrients between plants. These results are in agreement with those of El-Afifi and Darweesh (1990) on bean and Abdalla et al (2000, b) on pea.

3-d- Effect of the interaction:

Data in Tables (8 and 9) show that chlorophyll was significantly higher in all treatment interactions compared with the control. This was clear in the two seasons. The higher chlorophyll contents were obtained in plants treated with Rhizobium inoculation and receiving the medium and the highest levels of nitrogen application. Nitrogen contents were significantly affected by all the interactions except the interaction of inoculation x nitrogen application x plant density, which was not significant. The interaction effect showed no significant differences for phosphorus or potassium contents. This was evident in the two seasons.

Table (8): Effect of Rhizobium inoculation (A), nitrogen fertilization (B) and plant density (C) interaction on chlorophyl a, chlorophyl b, total chlorophylls, nitrogen, phosphorus and potassium cotents in the leaves of pea plants under sandy soil (2000/ 2001).

Inoculation	N.kg levels	Chlorophyll a			Chlorophyll b			Total chlorophylls			Nitrogen			Phosphorus		
		2 lines	3 lines	mean	2 lines	3 lines	mean	2 lines	3 lines	mean	2 lines	3 lines	mean	2 lines	3 lines	mean
Inoculated	0	3.65	3.44	3.55	2.94	3.02	2.98	6.59	6.46	6.53	3.22	2.89	3.06	0.332	0.317	0.325
	20	4.20	3.66	3.93	3.20	3.11	3.16	7.40	6.77	7.09	3.41	2.97	3.19	0.349	0.330	0.340
	40	4.48	3.91	4.20	3.38	3.15	3.27	7.86	7.06	7.46	3.85	3.11	3.48	0.362	0.345	0.354
	60	4.60	4.11	3.36	3.40	3.28	3.34	8.00	7.39	7.70	4.11	3.38	3.75	0.380	0.350	0.365
Mean		4.23	3.78	4.01	3.23	3.14	3.19	7.46	6.92	7.20	3.69	3.09	3.37	0.356	0.336	0.346
Unioculated	0	3.33	2.96	3.15	2.65	2.56	2.61	5.98	5.52	5.75	2.91	2.66	2.79	0.320	0.311	0.316
	20	3.80	3.22	3.51	2.82	2.66	2.74	6.62	5.88	6.25	3.09	2.82	2.96	0.338	0.320	0.329
	40	3.86	3.45	3.66	2.96	2.84	2.90	6.82	6.29	6.56	3.44	2.91	3.18	0.351	0.340	0.346
	60	3.94	3.52	3.73	3.22	2.96	3.09	7.16	6.51	6.84	3.85	3.08	3.47	0.360	0.345	0.353
Mean		3.68	3.29	3.49	2.91	2.76	2.84	6.65	6.05	6.35	3.32	2.87	3.10	0.342	0.329	0.336
Total mean		3.96	3.54	3.75	3.07	2.95	3.01	7.06	6.49	6.76	3.51	2.98	3.24	0.299	0.333	0.341
F test																
A*B		***	***		***	***		***	***		*	*		NS	NS	
A*C		*	***		**	***		***	***		**	***		NS	NS	
B*C		*	**		***	**		***	***		***	**		NS	NS	
A*B*C		***	***		***	***		***	***		NS	NS		NS	NS	

Table (8): Effect of Rhizobium inoculation (A), nitrogen fertilization (B) and plant density (C) interaction on chlorophyl a, chlorophyl b, total chlorophylls, nitrogen, phosphorus and potassium cotents in the leaves of pea plants under sandy soil (2000/ 2001).

Inoculation	N.kg levels	Chlorophyll a			Chlorophyll b			Total chlorophylls			Nitrogen			Phosphorus		
		2 lines	3 lines	mean	2 lines	3 lines	mean	2 lines	3 lines	mean	2 lines	3 lines	mean	2 lines	3 lines	mean
Inoculated	0	3.65	3.44	3.55	2.94	3.02	2.98	6.59	6.46	6.53	3.22	2.89	3.06	0.332	0.317	0.325
	20	4.20	3.66	3.93	3.20	3.11	3.16	7.40	6.77	7.09	3.41	2.97	3.19	0 349	0.330	0.340
	40	4.48	3.91	4.20	3.38	3.15	3.27	7.86	7.06	7.46	3.85	3.11	3.48	0.362	0.345	0.354
	60	4.60	4.11	3.36	3.40	3 28	3.34	8.00	7.39	7.70	4.11	3.38	3.75	0.380	0.350	0.365
Mean		4.23	3.78	4.01	3.23	3.14	3.19	7.46	6.92	7.20	3.69	3.09	3.37	0 356	0 336	0.346
Unioculated	0	3.33	2.96	3.15	2.65	2.56	2.61	5.98	5.52	5.75	2.91	2.66	2.79	0.320	0.311	0.316
	20	3.80	3.22	3.51	2.82	2.66	2.74	6.62	5 88	6.25	3.09	2.82	2.96	0.338	0 320	0.329
	40	3.86	3.45	3.66	2.96	2.84	2.90	6.82	6.29	6.56	3.44	2.91	3.18	0.351	0.340	0.346
	60	3.94	3.52	3.73	3.22	2.96	3.09	7.16	6.51	6.84	3.85	3.08	3.47	0.360	0.345	0.353
Mean		3.68	3.29	3.49	2.91	2.76	2.84	6.65	6.05	6.35	3.32	2.87	3.10	0.342	0.329	0.336
Total mean		3.96	3.54	3.75	3.07	2.95	3.01	7.06	6.49	6.76	3.51	2.98	3.24	0.299	0.333	0.341
F test																
A*B		***	***		***	***		***	***		*	*		NS	NS	
A*C		*	***		**	***		***	***		**	***		NS	NS	
B*C		*	**		***	**		***	***		***	**		NS	NS	
A*B*C		***	***		***	***		***	***		NS	NS		NS	NS	

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تأثير المعاملة ببكتيريا العقد الجذرية و التسميد النيتروجيني و الكثافة النباتية على النمو و المحصول و المحتوى الكيماوى فى البسلة تحت ظروف الأراضى الرملية

سوسن محمد حسن سرج و محمود عبد المحسن حسن
كلية الزراعة – جامعة قناة السويس – الاسماعيلية

أجريت هذه الدراسة خلال موسمي ٢٠٠٠/٢٠٠١- ٢٠٠١ /٢٠٠٢ بمزرعة كلية الزراعة جامعة قناة السويس بالإسماعيلية لدراسة تأثير المعاملة ببكتيريا العقد الجذرية و أربعة مستويات من النيتروجين (صفر ،٢٠،٤٠ و ٦٠ كجم نيتروجين للفدان) والكثافة النباتية (صفين وثلاثة صفوف/مصطبة) على قياسات النمو الخضري و عدد العقد الجذرية و المحصول و المحتوي الكيماوي للأوراق في البسلة تحت ظروف الأراضي الرملية.

١- أظهرت النتائج زيادة معنوية في النمو الخضري نتيجة المعاملة ببكتيريا العقد الجذرية أو بالتسميد النيتروجيني كل على حدة أو بكليهما معا.

٢- أدت زيادة الكثافة النباتية إلى نقص قياسات النمو الخضري ما عدا ارتفاع النبات الذي زاد في النباتات الأكثر كثافة.

٣- زاد عدد العقد البكتيرية على الجذور في النباتات المعاملة ببكتيريا العقد الجذرية وتلك المسمدة بالسماد النيتروجيني ما عدا المستوى العالي من هذا السماد كما زاد عدد هذه العقد البكتيرية في النباتات ذات الكثافة النباتية الأقل.

٤- زاد وزن المحصول وقياساته في النباتات المعاملة ببكتيريا العقد الجذرية أو التسميد النيتروجيني أو المعاملتين معا.

٥- أدت زيادة الكثافة النباتية إلى نقص قيم قياسات المحصول بينما زاد المحصول الكلي للفدان الناتج من هذه النباتات نتيجة زيادة عدد النباتات بالفدان .

٦- زاد محتوي الأوراق من الكلوروفيل والنيتروجين والفوسفور والبوتاسيوم في النباتات المعاملة بكل من بكتيريا العقد الجذرية أو السماد النيتروجيني بينما نقص المحتوى الكيماوي للأوراق من هذه المكونات في النباتات ذات الكثافة العالية.