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RESPONSE OF FABA BEAN (*Vicia faba* L.) TO *Rhizobium* INOCULATION AS AFFECTED BY NITROGEN AND PHOSPHORUS FERTILIZATION

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ABSTRACT

Four on-farm trials were carried out in farmers fields at the old and newly reclaimed lands (two sites each) in Minia Governorate through the two successive winter growing seasons 1995/1996 and 1996/1997. This is to evaluate the effect of inoculation with *R. leguminosarum* (biovar) *Viceae* as affected by nitrogen and phosphorus fertilization, used as soil or foliar application, on nodulation, growth, N-uptake and yield of faba bean.

At the old land (clay loam soil), *Rhizobium* inoculation did increase the number and dry weight of nodules as well as dry weight and N-content of shoots by 12.2, 24.8, 31.1 and 25.6%, respectively.

Inoculation of faba bean with rhizobia combined with foliar application of N and P fertilizers in particular gave the highest significant increases in seed yield. The inoculated plants that received urea twice, 60 and 90 DAP and P_2O_5, three times 30, 60 and 90 DAP recorded the highest seed yield of 4.87 ton/ha

The inoculated faba bean grown in newly reclaimed areas (sandy soil) without fertilization led to an increase in number and dry weight of nodules by 15.6 and 23.5%, respectively. Such increase reached 30.4 % and 55.3 % in number and dry weight of nodules when inoculation was combined with foliar application of

nitrogen and phosphorus fertilizers. The inoculated faba bean plants gave significant increases in shoot dry weight and N-content as compared to the uninoculated ones. Also, inoculation with rhizobia combined with the application of urea, twice, 60 and 90 DAP + 0.67 P_2O_5, three times, 30, 60 and 90 DAP gave the highest seed yield (5.59 ton/ha). This amounts to an increase of 0.67 ton/ha (13. 6%) in seed yield compared to treatment without inoculation .

Key words *: faba bean , Rhizobium.*

1. INTRODUCTION

Mineral N generally inhibits legume nodulation; however, small quantities have a beneficial effect as a result of improved plant vigor (Schomberg and Weaver, 1990). Allos and Bartholomew (1959) found that the quantity of N_2-fixed by clover (*Trifolium repens*) increased by 25% due to the addition of low but not high N levels. Addition of mineral N stimulates plant growth and may increase or decrease N_2-fixation by soybean (Morris and Weaver, 1987). *Rhizobium* inoculation combined with a starter dose of N (10 kg N/fed.) at planting and foliar application of micronutrients significantly increased growth, nodulation and N-uptake by soybean (Tarrad and Saleh, 1995 and Ragab, 1998).

Mineral nutrient deficiencies are major constraints that limit legume nitrogen fixation and yield (O'Hara *et al*., 1988). Among the necessary nutrients, legumes need relatively large amounts of phosphorus and if these requirements are not met, nodule formation and function are both adversely affected (Van Schreven, 1958). Phosphorus application gave highly significant increases in faba bean seed yield (Hussein *et al*., 1993). Amer (1978) found that foliar application of phosphorus up to 500 ppm significantly increased dry matter of both maize and faba bean. Hussein *et al*., (1993) noticed that soil and foliar application of phosphorus significantly increased yield components which was reflected on faba bean seed yield. Cheng (1980) concluded that foliar application of urea at early pod formation increased seed yield of soybean by 5.3%.

This work was carried out to evaluate the effect of *Rhizobium* inoculation and different application methods of nitrogen and phosphorus fertilization on nodulation, growth, N-uptake and yield of faba bean.

2. MATERIALS AND METHODS

Four on-farm trials were carried out in farmers' fields at the old and newly reclaimed lands (two sites each) in Minia Governorate during 1995/1996 and 1996/1997 seasons. A major objective was to study the response of faba bean to rhizobial inoculation as affected by soil and foliar fertilization with nitrogen and phosphorus. The following treatments were excuted :-

1- Un-inoculated + un N-fertilized.
2- Inoculated.
3- Inoculated +23.8 kg N/ha slow release fertilizer (SRF) + 71.0 kg P_2O_5/ha.
4- Inoculated +23.8 kg N/ha ammonium sulphate (AS) + 71.0 kg P_2O_5/ha.
5- Inoculated + urea (1% foliar application) at 60 days of planting.
6- Inoculated + urea (1% foliar application) at 60 days of planting + P_2O_5 (200 ppm foliar application) at 30, 60 and 90 days of planting.
7- Inoculated + urea (1% foliar application) twice, 60 and 90 days of planting.
8- Inoculated + urea (1% foliar application) twice, 60 and 90 days of planting + P_2O_5 (200 ppm foliar application) at three times, 30, 60 and 90 days of planting.

Complete randomized block design with four replications was used.The plot size was 14.4 m^2 and harvested area was 10.5m^2. Faba bean seeds(cv. Giza 674)were inoculated with vermiculite-based inoculant containing *R. leguminosarum* biovar *viceae* at a rate of 400 g inoculant per 40 kg seeds using 16% Arabic gum solution. Faba bean plants were up-rooted after 70 days of sowing and assayed for number and dry weight of nodules , dry weight and N-content of shoots. At harvest, faba bean seed and straw yields (ton/hectare) were estimated.

Statistical combined analysis was applied according to McIntosh (1983).

3. RESULTS AND DISCUSSION

3.1. Old lands (clay loam soil)

3.1.1. Effect of *Rhizobium* inoculation and NP fertilizers on faba bean nodulation, growth and N-uptake

Data in Table (1) show that rhizobial inoculation did not have any significant effect on nodulation. The highest number and dry weight of nodules (39.7 nodules/plant and 189.3 mg/plant) were obtained by inoculated plants that received urea twice at 60 and 90 DAP as a foliar application.

The inoculated plants and fertilized by ammonium sulphate (AS) did not record any significant differences in nodule numbers and dry weight as compared to those fertilized by N-slow release fertilizer. Significant increases in dry weight of nodules (189.3 mg/plant) were obtained by the inoculated plants received urea twice compared to the other treatments. In general, *Rhizobium* inoculation increased the number and dry weight of nodules as well as dry weight and N-content of shoots, by 12.2, 24.8, 31.1 and 25.6%, respectively as compared to the uninoculated control.The results are in agreement with those obtained by Monib *et al*,. (1994) and Hussein *et al*., (1997) who recorded that rhizobial inoculation significantly increased nodulation of faba bean.

Concerning shoot dry weight, there were no significant differences among all NP-fertilized treatments under investigation (Table 1). On the other hand, inoculated plants yielded an increase of 31.1% in plant dry weight over the uninoculated ones.

Regarding shoot N-content, the untreated plants had the lowest amounts. Inoculation increased N-content by 25.6% over the control plants (Table 1). These results are in harmony with those obtained by Jacobsen (1985) who reported that shoot biomass and N-content often increase with increasing nitrogen, phosphorus and rhizobial inoculation. Also , Monib *et al*., (1994) found that N- fertilization or inoculation had the highest stimulating effect in increasing shoot

Table (1): Effect of *Rhizobium* inoculation, nitrogen and phosphorus fertilization on nodulation, growth and N-uptake of faba bean grown in old lands at Minia Governorate (combined two years of 95/96 and 96/97).

Treatments	No. of nodules/plant		Mean	D.Wt. of nodules (mg/plant)		Mean	D.Wt. of shoots (g/plant)		Mean	N-content of shoots (mg/plant)		Mean
	95/96 mean of 2 sites	96/97 mean of 2 sites	of 4 sites	95/96 mean of 2 sites	96/97 mean of 2 sites	of 4 sites	95/96 mean of 2 sites	96/97 mean of 2 sites	of 4 sites	95/96 mean of 2 sites	96/97 mean of 2 sites	of 4 sites
Uninoculated un N-fertilized	30.0	25.6	27.8	122.3	119.8	121.1	11.3	9.1	10.2	488.38	318.71	403.54
Inoculated	50.5	31.9	31.2	151.8	150.3	151.1	13.6	13.5	13.5	378.26	435.33	506.79
Inoculated + 23.8 kg N/ha (SRF)* + 71.0 kg P_2O_5/ha	27.0	28.4	27.2	98.2	113.6	105.9	9.2	10.9	10.1	480.06	353.19	416.63
Inoculated + 23.8 kg N/ha (AS)** + 71.0 kg P_2O_5/ha	20.8	21.4	21.1	96.3	120.3	108.4	12.2	11.5	11.9	524.31	409.84	467.17
Inoculated + urea applied at 60 DAP	30.2	36.0	33.1	108.8	144.9	126.9	11.5	11.5	11.5	613.99	413.66	514.82
Inoculated + urea applied at 60 DAP + P_2O_5 at three times at 30, 60 and 90 DAP	34.2	33.6	33.9	125.3	128.2	126.8	13.3	11.6	12.6	492.23	376.99	434.61
Inoculated + urea applied twice at 60 and 90 DAP	48.3	31.0	39.7	231.7	146.8	189.3	10.7	7.4	9.1	506.43	234.36	370.40
Inoculated + urea applied twice at 60 and 90 DAP + P_2O_5 at three times at 30, 60 and 90 DAP	32.5	19.1	25.8	118.8	91.1	105.0	10.0	10.0	10.0	491.17	302.54	396.85
Mean	31.7	28.4		131.7	126.9		11.5	10.7		522.13	353.58	
L.S.D. 0.05 Treat. Season Treat x season	N.S	N.S	N.S N.S N.S	81.2	N.S	50.3 N.S N.S	N.S	N.S	N.S N.S N.S			N.S 82.34 168.70

* SRF = Slow release fertilizer

** AS = Ammonium sulphate

dry matter and shoot N-content of faba bean plants.

3.1.2. Effect of *Rhizobium* inoculation and NP fertilizers on faba bean yield

Data in Table (2) demonstrate that inoculation with rhizobia increased faba bean seed yield by 0.28 ton/ha (8.8%) compared with uninoculated treatments. There were no significant differences among inoculation treatments alone or those combined with NP fertilizers applied to soil. Whereas, *Rhizobium* inoculation combined with foliar application of urea once or twice and P_2O_5 three times gave significant increases in seed yield over inoculated one. *Rhizobium* inoculation combined with foliar application of urea once or twice resulted in no differences (4.35 and 4.33 ton/ha, respectively). These values were respectively increased with 0.22 ton/ha (5.1%) and 0.54 ton/ha (12.5%) by receiving foliar application of P_2O_5 three times. These results are in agreement with those obtained by Hussein *et al.*, (1997) who reported that the rhizobial inoculation increased seed and straw yields of faba bean by an average of 0.69 ton/ha and 1.08 ton/ha, respectively.

3.2. Newly reclaimed lands (sandy soils)

3.2.1. Effect of *Rhizobium* inoculation and NP fertilizers on faba bean nodulation, growth and N-uptake

Data of faba bean nodulation (Table 3) revealed that inoculation without fertilization led to increases in number and dry weight of nodules by 15.6 and 23.5% over the uninoculated plants, respectively. On the other hand, such increases levelled to 30.4 and 55.3% when inoculation combined with foliar application of NP fertilizers. In addition, urea applied to the inoculated plants at 60 DAP or 60 and 90 DAP recorded similar results in number and dry weight of nodules. Both treatments in the presence of P-fertilization resulted in no significant increases in nodules number and dry weight.

The inoculated plants received urea, twice (60 and 90 DAP) and P_2O_5, three times (30, and 90 DAP) scored increases in number and dry weight of nodules being 30.4% and 55.4%, respectively, over the uninoculated control plants. These results are in harmony with those obtained by Bottomly (1992) and Hussein *et al.*, (1997) who

reported that phosphorus fertilization combined with rhizobial inoculation led to better nodulation and higher increases in yield of soybean and faba bean grown in clay loam soil.

Table (2):Effect of *Rhizobium* inoculation, nitrogen and phosphorus fertilization on yields (ton/hectare)* of faba bean grown in old land at Minia Governorate (combined two years of 95/96 and 96/97).

Treatments	Seed yield (t/ha.)		Mean of 4 sites	Straw yield (t/ha.)		Mean of 4 sites
	95/96 mean of 2 sites	96/97 mean of 2 sites		95/96 mean of 2 sites	96/97 mean of 2 sites	
Uninoculated on N-fertilized	2.65	3.70	3.18	8.72	12.06	10.39
Inoculated	2.63	4.29	3.46	7.84	11.18	9.51
Inoculated + 23.8 kg N/ha (SRF)** + 71.0 kg P_2O_5/ha	3.08	4.11	3.60	7.92	10.66	9.29
Inoculated + 23.8 kg N/ha (AS)*** + 71.0 kg P_2O_5/ha	2.48	4.93	3.71	6.00	9.43	7.72
Inoculated + urea applied at 60 DAP	2.99	5.71	4.35	8.23	10.51	9.37
Inoculated + urea applied at 60 DAP + P_2O_5 at three times at 30, 60 and 90 DAP	3.48	5.64	4.57	8.22	8.28	8.25
Inoculated + urea applied twice at 40 and 90 DAP	4.12	4.53	4.33	12.54	10.93	11.74
Inoculated + urea applied twice at 60 and 90 DAP + P_2O_5 at three times at 30, 60 and 90 DAP	4.18	5.55	4.87	9.34	10.39	9.87
Mean	3.20	4.81		8.60	14.43	
L.S.D. 0.05 Treat. Season Treat x season	N.S	1.17	0.85 0.88 N.S	N.S	N.S	N.S 1.78 N.S

* Hectare = 2.38 feddan ** SRF = Slow release fertilizer *** AS = Ammonium sulphate

Table (3):Effect of *Rhizobium* inoculation, nitrogen and phosphorus fertilization on nodulation, growth and N-uptake of faba beans grown in newly reclaimed area at Minia Governorate (combined two years of 95/96 and 96/97).

Treatments	No. of nodules/plant		Mean	D.W. of nodules (mg/plant)		Mean	D.W. of shoots (g/plant)		Mean	N-content of shoots (mg/plant)		Mean
	95/96 across of 2 sites	96/97 across of 2 sites	of 4 sites	95/96 across of 2 sites	96/97 across of 2 sites	of 4 sites	95/96 across of 2 sites	96/97 across of 2 sites	of 4 sites	95/96 across of 2 sites	96/97 across of 2 sites	of 4 sites
Uninoculated on N-fertilized	45.3	46.8	46.1	163.6	189.9	176.8	9.5	8.8	9.2	514.57	396.34	455.46
Inoculated	54.8	51.8	53.3	223.6	213.3	218.5	15.4	12.1	13.8	497.31	484.68	491.00
Inoculated + 23.8 kg N/ha (SRF)* + 71.0 kg P_2O_5/ha	54.9	50.6	52.8	214.8	255.9	235.4	14.5	12.9	13.7	494.21	484.19	489.20
Inoculated + 23.8 kg N/ha (AS)** + 71.0 kg P_2O_5/ha	56.4	52.0	54.2	225.6	210.4	218.0	14.3	13.9	14.1	631.01	641.86	463.04
Inoculated + urea applied at 60 DAP	59.9	53.1	56.5	277.9	206.4	242.2	16.2	14.3	15.3	473.46	470.28	471.87
Inoculated + urea applied at 60 DAP + P_2O_5 at three times at 30, 60 and 90 DAP	58.4	54.4	56.4	275.5	230.3	252.9	15.6	14.9	15.3	487.77	478.14	482.96
Inoculated + urea applied twice at 60 and 90 DAP	56.3	54.9	55.6	264.6	234.9	249.8	15.4	14.2	14.8	462.55	473.51	468.03
Inoculated + urea applied twice at 60 and 90 DAP + P_2O_5 at three times at 30, 60 and 90 DAP	62.0	58.2	60.1	309.5	239.9	274.7	16.8	15.0	15.9	378.32	535.68	457.00
Mean	56.0	52.7		248.6	218.3		14.8	13.2		467.40	470.49	
L.S.D. 0.05 Treat. Season Treat x season	N.S	N.S	N.S N.S N.S	78.5	N.S	64.3 N.S N.S	4.8	3.2	3.5 N.S N.S			N.S N.S N.S

* SRF = Slow release fertilizer ** AS = Ammonium sulphate

The inoculated-unfertilized plants gave significant increases in shoots dry weight and N-content as compared to the uninoculated ones. Also, inoculation combined with NP- fertilization resulted in significant increases in shoot dry weight and insignificant increases in shoot N-content. Values of shoot dry weight ranged from 13.7 - 15.9 g/plant and shoot N-content from 463.04 to 491.00 mg /plant

Table (4): Effect of *Rhizobium* inoculation, nitrogen and phosphorus fertilization on yields (ton/hectare)* of faba bean grown in newly reclaimed area at Minia Governorate (combined two years of 95/96 and 96/97).

Treatments	Seed yield (t/ha.)		Mean of 4 sites	Straw yield (t/ha.)		Mean of 4 sites
	95/96 mean of 2 sites	96/97 mean of 2 sites		95/96 mean of 2 sites	96/97 mean of 2 sites	
Uninoculated on N-fertilized	4.26	4.93	4.15	10.44	6.09	8.27
Inoculated	5.75	4.08	4.92	10.89	6.25	8.57
Inoculated + 23.8 kg N/ha (SRF)** + 71.0 kg P_2O_5/ha	5.47	4.16	4.82	10.33	6.55	8.44
Inoculated + 23.8 kg N/ha (AS)*** + 71.0 kg P_2O_5/ha	5.80	4.04	4.92	9.27	5.85	7.56
Inoculated + urea applied at 60 DAP	5.59	4.54	5.07	8.31	6.73	7.52
Inoculated + urea applied at 60 DAP + P_2O_5 at three times at 30, 60 and 90 DAP	5.78	4.97	5.38	8.58	6.74	7.66
Inoculated + urea applied twice at 60 and 90 DAP	5.69	4.98	5.34	9.99	5.05	7.52
Inoculated + urea applied twice at 60 and 90 DAP + P_2O_5 at three times at 30, 60 and 90 DAP	6.19	4.98	5.59	8.81	7.53	8.17
Mean	5.59	4.21		9.58	6.38	
L.S.D. 0.05 Treat. Season Treat x season	1.16	0.61	0.75 0.78 1.64	N.S	N.S	N.S 1.50 N.S

*feclare = 2.38 feddan ** SRF = Slow release fertilizer *** AS = Ammonium sulphate

The results of shoots dry weight and N-content are in agreement with those obtained by Tarrad and Saleh (1995) and Monib *et al*., (1994) who reported that N-fertilization or rhizobial inoculation had the highest stimulating effect in increasing shoot dry matter and N-content of soybean and faba bean plants grown in clay loam and sandy soils, respectively.

3.2.2. Effect of *Rhizobium* inoculation and NP fertilizers on faba bean yield

Data in Table (4) reveal that inoculated unfertilized plants gave significant increases in seed yield and non - significant increases in straw yield by 0.77 ton/ha (18.55%) and 0.30 ton/ha (3.63%) over the uninoculated ones, respectively. Six out of seven inoculated treatments recorded significant increases in seed yield over the uninoculated control. On the other hand, there were no significant differences in seed yield between the inoculated treatments combined with soil application of N and P fertilizers. Inoculation with rhizobia combined with foliar application of urea (twice, 60 and 90 DAP) and P_2O_5, three times (30, 60 and 90 DAP) recorded the highest seed yield (5.59 ton/ha). The latter treatment significantly increased seed yield as compared to the inoculated treatments which were combined with soil application of NP fertilizers. This could be due to the stimulative effect of foliar application of N and P fertilizers on nodulation, growth and N-uptake which was consequently reflected on seed yield. These results are in agreement with those obtained by Idris *et al*., (1989) who reported that application of phosphorus significantly increased the grain and straw yields of chickpea as compared to the control . The same trend was obtained by Atta and Rabie (1986) for lupine plants grown in sandy soil and Monib *et al*., (1994) for faba bean plants.

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استجابة الفول البلدي للتلقيح بالريزوبيا متأثرا بالتسميد النيتروجيني والفوسفاتي

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ملخص

يهدف هذا البحث إلى دراسة استجابة محصول الفول البلدي لمعاملات التلقيح بريزوبيا الفول البلدي *R. leguminosarum* biovar *Viceae* وإضافة الأسمدة النيتروجينية والفوسفاتية للتربة أو في صورة رش ورقي على نمو النباتات وتكوين العقد الجذرية وامتصاص النيتروجين. حيث نفذت أربعة تجارب حقلية ، إثنين بكل من الأراضي القديمة (أرض طينية طمية) والأراضي حديثة الاستصلاح (أرض رملية) خلال الموسمين الشتويين 1995/1996 ، 1996/ 1997 بمحافظة المنيا.

أوضحت النتائج المتحصل عليها تحت ظروف الأراضي الطينية أن تلقيح الفول البلدي بالريزوبيا مع التسميد الأرضي أو الورقي بالأسمدة النيتروجينية والفوسفاتية لم تظهر أي فروق معنوية في أعداد العقد الجذرية وأوزانها الجافة. أما بالنسبة لأوزان النباتات الجافة فقد أشارت النتائج إلى أنه لا توجد فروق معنوية بين المعاملات التي تم تلقيحها بالريزوبيا في وجود التسميد النيتروجيني والفوسفاتي. ومن ناحية أخرى أدى التلقيح بالريزوبيا إلى زيادة في المادة الجافة للنباتات بنسبة 11.1% عن النباتات غير الملقحة. أما بالنسبة للمحتوى النيتروجيني لنباتات الفول البلدي فقد سجلت معاملات التلقيح بدون تسميد وكذلك معاملات التلقيح مع الرش الورقي لليوريا زيادة وصلت إلى 75.5%، 27.5% على التوالي عن نباتات المقارنة.

وقد أشارت نتائج المحصول إلى أن التلقيح بالريزوبيا مع التسميد الورقي للنيتروجين والفوسفور قد أعطى زيادة معنوية في محصول البذور وذلك بالمقارنة بالنباتات الملقحة مع التسميد الأرضي للنيتروجين والفوسفور. وقد سجلت معاملة التلقيح بالريزوبيا مع الرش الورقي بكل من النيتروجين والفوسفور أعلى محصول للبذور حيث بلغ 4.87 طن/هكتار.

أما بالنسبة للنتائج المتحصل عليها تحت ظروف الأراضي حديثة الاستصلاح (الأراضي الرملية) فقد أوضحت أن التلقيح بالريزوبيا بدون تسميد أدى إلى زيادة في أعداد العقد الجذرية المتكونة على نباتات الفول البلدي وأوزانها الجافة إلى 15.6%، 21.5%، على التوالي عن تلك النباتات غير الملقحة. ومن ناحية أخرى فقد وصلت هذه الزيادات إلى 30.4%، 55.1% على التوالي في حالة التلقيح بالريزوبيا مع التسميد الورقي للنيتروجين والفوسفور. كذلك أعطت النباتات الملقحة زيادة معنوية في المادة الجافة للنباتات ومحتواها من النيتروجين عند مقارنتها بتلك غير الملقحة. كما أن معاملة التلقيح بالريزوبيا مع الرش الورقي للنيتروجين والفوسفور أعطت أعلى محصول للبذور ليصل إلى 5.59 طن/هكتار. وقد أدت نفس المعاملة السابقة إلى زيادة معنوية في محصول البذور للفول البلدي عند مقارنتها بمعاملات التلقيح بالريزوبيا وكذا مع التسميد الأرضي للنيتروجين والفوسفور.