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RESPONSE OF SOYBEAN PLANTS TO FOLIAR APPLICATION WITH IRON AND MOLYBDENUM AND SOIL FERTILIZATION WITH ROCK - PHOSPHATE AND PHOSPHATE DISSOLVING BACTERIA.

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ABSTRACT: *Two field experiments were carried out in Research and Experimental Center of the Faculty of Agriculture at Moshtohor during 1999 and 2000 seasons in order to study the effect of spraying aqueous solutions of iron (Fe) at 20mg L^{-1} and molybdenum (Mo) at 5mg L^{-1}, and rock phosphate (RP) and phosphate dissolving bacteria (PDB) treatments on nodulation N_2-ase fixation, available-P, some macro and micro-nutrients content, growth characters, yield and yield components of soybean.*

Results of this study showed that spraying with Fe or Mo solutions gave higher records of soybean nodulation, N_2ase activity, ammonical and nitrate nitrogen, available phosphorus and CO_2 evolution in rhizosphere. Moreover, macro- and micro- nutrients content in shoots of soybean plants were higher due to spraying with Fe or Mo solutions in both seasons. Also, application of Fe or Mo statistically increased leave area, dry weight of stem and leaves, number of pods/plant, weight of pods and seeds /plant, seed and protein yields / fed during the two growing seasons.

Combined inoculation of PDB and application of RP (RP + PDB) gave the highest nodulation, nitrogenase activity, ammonical and nitrate nitrogen, available phosphorus and CO_2 evolution in rhizosphere as well as the macro and micro- nutrients content in shoots of soybean plants in the two seasons. All growth characters, yield and yield components as well as chemical composition of soybean seeds in both seasons were significantly increased by application of RP + PDB or inoculation with PDB alone except number of branches/plant and oil percentage in the second season only.

The interaction between micronutrients and RP combined with PDB had significant effect on seed yield / fed in both seasons and weight of seeds/plant and protein yield/fed in the first season only. The highest values were recorded when soybean plants were sprayed with Mo at 5mg L^{-1} or Fe at 20 mg L^{-1} and treated with RP + PDB.

Key words: *Foliar application, Fe, Mo, Rock phosphate, phosphate dissolving bacteria, soybean*

INTRODUCTION

The importance of soybean as an indispensable source of plant protein is became more vital. To ensure high yields, the plant requirements should be furnished in its environment. It is well known that inoculation of legumes with both rhizobia and phosphate dissolving bacteria and phosphate fertilization as well as foliar application with some micronutrients increases plant growth, yield and yield components. Iron (Fe) deficiency may limit symbiotic N_2- fixation through survival and growth of Rhizobia in the soil, nodule initiation and development, nodule function and host plant growth (Tang *et al.*, 1992). Amara and Nasr (1995) reported that spraying Fe or a mixtur of Zn, Mn and Fe increased number and weight of nodules, dry weight /plant N- content of plants and seeds of soybean plants. Foliar application of soybean plants with Mn, Zn and Fe or their combination increased significantly plant height, dry weight of roots, stem and leaves, seed yield and no. of pods/plant, while the highest protein percentage was obtained from using Fe alone. (Zaki *et al.*, 1993). El- Mansi *et al.* (2000) found that number and dry weight of nodules and dry weight/plant at 90 days age as well as plant height and number of branches/ plant at harvest were gradually and significantly increased with the increase of sprayed Mo solution with concentration from 0.0 to 20mg L^{-1}. Nassar *et al.*, (2000 a&b) showed that application of Zn, Mn and Fe either separately or in mixed preparations markedly increased number of branches and leaves/ plant, plant height, weight of seeds/plant and 100-seed weight of faba bean. Ahmed *et al.* (2001) found that application of micro-elements (Zn, Fe and Mn) increased significantly growth, yield, yield components and chemical composition of seeds of soybean as compared to control: Fe So_4 recorded the highest values in both seasons. Hanna and Eisa (1998) demonstrated that molybdenum application to soybean increased seed yield and straw yield, pods/plant, dry weight, nitrogen and molybdenum contents in seeds.

On the other hand, seeds or soil inoculation with phosphate dissolving bacteria and simultaneous application of rock- phosphate to soil have been reported as a possible substitute for super-phosphate application without reduction in the crop yield (Gaur *et al.*, 1980). The phosphate- solubilizing bacteria utilize organic compounds as carbon and energy source and produce organic acids thereby solubilize insoluble inorganic phosphates (Pareek and Gaur *et al.*, 1973, Gaur *et al.*, 1979, Gained and Gaur, 1991). The possibilities of saving half the dose of N and replacing superphosphate with rock- phosphate and inoculation with "phosphate- solubilizers" were discussed by EL- Sayed (1998).

Amara and Nasr (1995) found that total N-content of plants and seeds of soybean considerably increased by foliar application with two deferent micronutrient preparations (Fe or Zn + Mn + Fe) and biofertilizers application using nitrogen fixing and phosphate dissolving bacteria.

The present investigation was undertaken in order to study the response of soybean growth, yield, yield components and chemical contents to inoculation with phosphate dissolving bacteria combined with rock-phosphate and foliar application with iron and molybdenum.

MATRIALS AND METHODS

Two field experiments were carried out in the Agricultural Research and Experimental Center of Fac. Agric. Moshtohor, Zagazig. Univ., during 1999 and 2000 seasons to study the effect of iron (Fe) or molybdenum (Mo) foliar application and rock- phosphate (RP) siol fertilization separately or combined with phosphate dissolving bacteria (PDB) on growth, yield, yield components and chemical contents of soybean c.v. giza 83. The physical and chemical properties of the tested soil sample were determined according to Jackson (1973) as shown in Table (1). The precedlng crop was clover in both seasons.

Each experiment included 12 treatments which were the combination of three spraying with micronutrients i.e., water (control), Fe at 20 mg L^{-1} Mo at 5 mg L^{-1} and four treatments of RP and/or PDB i.e., control, RP, PDB and RP+ PDB.

Bradyrhizobium *jopanicum* strain USDA 110 and *bacillus megatherium* var. Phosphaticum (Pure local strain) used in this study were obtained from Biofertilizers Production Unit and Agric. Microbiology. Dept., Soils, Water and Environment Res. Inst., Agric. Res. Center, Giza, Egypt.

Preparation of Inocula

For preparation of Bradyrhizobium inoculum, yeast mannitol broth medium (Vincent,1970) was inoculated with effective strain (*Bradyrhizobium Japonicum*) and incubated at 32°C for 7 days.

For preparation of phosphate dissolving bacteria, the medium of Bunt and Rovira (1955) modified by Abdel-Hafez (1966) was inoculated with effective straln (*Bacillus megatherium*), then incubated at 30°C for 7 days.

Before cultivation, rock- phosphate treatments (26.4% P_2O_5) at a rate of 30 kg P_2O_5/fed was applied to the experimental soil. Soybean seeds were washed with water, air dried and soaked in cell suspension of *Bacillus meyatherium* ($1.2x10^8$ viable cell /ml) for 30 min. Thereafter, soybean seeds were inoculated by *Bradyrhizobium Japonicum* $8x10^7$ viable cell/ml) for 30min. for all treatments.Gum arablc (16%) was added as an adhesive agent prior to inoculation .

With respect to foliar treatments , iron (20 mg L^{-1})was applied as sequestrene 6% and molybdenum (5 mg L^{-1}) as ammonium molybdate were sprayed onto the plants at 35 and 70 days from planting. Spraying solution for each treatment was 200L/fed., while control plants were sprayed with water.

Table (1): Some physical and chemical properties of the investigated soil.

Properties	Season	
	1999	2000
Particle size Distribution %:		
Coarse sand	16.10	16.88
Fine sand	14.2	14.96
Silt	16.51	15.60
Clay	53.19	52.56
Textural class	clay	Clay
Organic matter (%)	1.98	2.08
E.C (dS m^{-1})	2.3	2.20
PH (1: 2.5 suspension)	8.06	8.10
Ca CO_3 (%)	0.46	0.51
T.N (%)	0.18	0.20
Soluble Ions (mel^{-1})		
Ca^{2+}	10.9	11.3
Mg^{2+}	6.70	6.62
Na^{2+}	4.87	3.75
K^{2+}	0.53	0.33
HCO_3^-	7.81	7.36
CO_3^{2-}	-	-
Cl^-	10.2	9.93
SO_4^{2-}	4.99	4.71
Available – P mg Kg^{-1})	7.40	7.52
Available micoonutoients (mg kg^{-1})		
Fe	3.80	3.92
Mo	0.23	0.34

- Experimental design

A split plot design with four replicates was used. The main plots were assigned to the three treatments of foliar application while PDB combined with or without RP (the four treatments) were randomly distributed in the sub plots. The sub plot area was 1/400 fed., 10.5m^2 (3x3.5 m) with five ridges which were 60cm width and 3.5m long .

Soybean seeds "Giza 83" cultivate was planted on May 23th and 25th in 1999 and 2000 seasons, respectively. The distance between hills was 10 cm apart and soybean plants were thinned to two plants per hill. Nitrogen fertilizer was applied in form of ammonium nitrate (33.5%) at a rate of 30 KgN/fed were applied in two equal doses (before the first and second irrigations).Agronomic practices were followed according to the standard recommendation for soybean.

- Sampling and analysis

Rhizosphere soil samples of the developed plants were taken at vegetative (40 days) and flowering (80 days) stages. The samples were analyzed for CO_2 evolution according to Page *et al.*, (1982), NH_4-N and NO_3 – N according to Bremner and keeny (1965) and available phosphorus according to A.P.H.A. (1992).

Data of nodules number, nodules weight/plant, nitrogenase (N_2–ase) activity in nodules were estimated at flowering stage. N_2- ase activity was estimated according to Hardy et al (1973). Total nitrogen, phosphorus and potassium contents were determined in soybean shoots at vegetative and flowering stages by using microkjeldahl A.O.A.C (1980), A.P.H.A.(1992) and Dewis and Freitas (1970), respectively.

Iron and molybdenum were determined colorimetrically using atomic absorption spectro- photometer, Perkin elmer model 3110. determined according to Jackson (1973).

Total nitrogen, crude protein and oil content were estimated in soybean seeds according to A.O.A.C. (1980). Protein and oil yields (Kg/fed) were calculated by multiplying protein and oil percentage in seeds by the seed yield /fed.

- Growth characters

The following data were recorded on five plants taken at random after 85 days from planting in the two seasons, plant height (cm), numbers of branches and pods/plants, leaf area/ plant (cm^2) and dry weights of stem, leaves and pods/ plant (g).

- Yield and its components

At harvest, five plants were taken at random from each subplot to determine the following yield and its components, i.e no. of pods/ plant, weight of pods/ plants (g), no. of seeds/ pod, weight of seeds/ plant (g) and weight of 1000- seed (g). The seed and biological yields were determined from whole subplot in four replications.

- Statiatical analysis

Statiatical analysis was carried out according to Snedecor and Cochran (1989). The differences between the mean values of various treatments were compared by Duncan's multiple range test (Duncan, 1955).

RESULTS AND DISCUSSION

1-Nodulation and Nitrogenase activity:-

Data presented in Table (2) show that number and dry weight of nodules / plant and N_2- ase activity were remarkably increased by spraying with iron (20 mg L^{-1}) or molybdenum (5 mg L^{-1}) compared to control in both seasons. The highest values of nodule number, dry weight of nodules/ plant and N_2- ase were observed by spraying with molybdenum over the two seasons. The effect of molybdenum is more pronounced with *Bradyrhizobium* inoculation for all treatments. This could be attituded to the improvement in nitrogen fixing activity .. Similar results were reported by Tang et al. (1992), El-Karamity (1996), Mohan and Rao (1997), Sunita et al. (1998) and El- Mansi et al.(2000).

Table (2): Effect of spraying with Fe and Mo as well as rock- phosphate fertilization and phosphate dissolving bacteria on nodulation and N_2- ase activity in rhizosphere of soybean plant at vegetative growth (40 days after sowing)

Parameters / Treatments	No of nodules/plant	Dry weight of nodules (mg/plant)	N2- ase activity (m moles C_2H_4 / hr /g dry nodules)
Micronutrients	1999 season		
Control	20.3	218.5	64.8
Fe	24.5	312.8	74.4
Mo	26.8	348.5	83.7
Fert. & Inocu.			
Control	14.0	158.0	53.1
RP	19.7	270.7	62.7
PDB	25.0	330.7	82.8
RP+ PDB	36.7	414.0	98.7
Micronutrients	2000 season		
Control	22.3	228.5	68.7
Fe	26.5	331.8	79.8
Mo	29.5	378.8	85.9
Fert. & Inocu.			
Control	16.3	174.7	56.6
RP	21.3	286.3	62.1
PDB	27.7	351.7	88.5
RP+ PDB	29.0	439.3	105.3

RP. Rock- Phosphate fertilization
PDB: Phosphate dissolving bacteria inoculation.
Fert: Fertilization Inocu: Inoculation.

On the other hand, soybean plants feitilzed with RP, inoculated with PDB and RP + PDB treatments gave higher record of number and dry weight of nodules/ plant and N_2- ase activity as compared with control treatment in both seasons. The highest values of these triats were obtained by RP + PDB inoculation treatment of soybean plants in the two seasons. These results are in agreement with those obtained by Patil and Shinde, (1980) and El-Sayed(1998).

2- NH_4- N, NO_3 – N, available –P and CO_2 evolution:-

Results obtained in Table (3) show that ammonical and nitrate nitrogen, available- P and CO_2 evolution values in rhizosphere of soybean plants increased by spraying iron (20 mg L^{-1}) or molybdenum (5 mg L^{-1}) compared to check treatment in the two seasons. Molybdenum at 5 mg L^{-1} gave the highest values for ammonical and nitrate nitrogen and CO_2 evolution. The highest value of available-P was resulted from foliar application of iron 20 mg L^{-1} in both seasons. This could be due to the high records of nodules number and dry weights of nodules as well as N_2 – ase activity which were observed with soybean plants sprayed with molybdenum at 5 mg L-1 (Table 2).

Data presented in Table (3) also show that in both seasons ammonical and nitrate nitrogen, available- P and CO_2 evolution in rhizospher were

increased with RP fertilizer, PDB bacteria inoculation and RP + PDB treatments in comparison with control treatment. The highest values for these traits were obtained by RP + PDB while the lowest ones were attained by the untreated plants. In this connection, these results are in accordance with those obtained by El- Sayed, (1998).

Ammonical and nitrate nitrogen, available-P and CO_2 evolution values in rhizosphere were higher at flowering stage than vegetative one. This could be attributed to the high multiplication of ammonifying and nitrifying bacteria during flowering stage as a results of the root exudates of the plant during different growth stages. The same trend of results was observed due to all application treatments as well as in the two growing seasons. These results are in accordance with the findings of Neweigy et al., (1997) who reported that the ammonifying and nitrifying bacteria densities in rhizosphere were higher at heading stage of plant growth rather than other plant growth stages.

Table (3): Effect of spraying with Fe or Mo supply and rock- phosphate fertilization separately or combined with phosphate dissolving bacteria on NH_4- N, No_3-N available-P and Co_2 evolution in rhizosphere of soybean plants.

Parameters	NH_4-N (mg L^{-1})		No_3- N (mg L^{-1})		Available-P (mg L^{-1})		Co_2 (mg g^{-1})	
Treatments	vegitative	Flowering	vegitative	Flowering	Vegitative	flowering	Vegitative	Flowering
Micronutrients	1999 season							
Control	45.5	63.3	56.2	74.3	80.8	85.3	42.3	54.2
Fe	55.9	64.3	79.9	89.1	99.7	108.8	51.7	64.4
Mo	58.0	63.2	81.5	103.7	92.5	96.7	60.6	63.6
Fert. & Inocu.								
Control	37.8	49.8	60.4	69.2	74.5	77.9	28.7	35.5
RP	44.1	61.7	66.4	79.5	82.0	87.3	46.3	54.6
PDB	62.2	68.2	73.9	101.1	95.0	101.8	58.8	71.7
RP+ PDB	68.6	74.8	89.4	106.4	112.7	120.8	72.4	81.2
Micronutrients	2000 season							
Control	50.5	69.0	60.2	79.8	83.3	90.1	52.2	57.1
Fe	59.4	72.4	85.8	102.9	102.1	113.7	55.6	64.7
Mo	60.7	72.5	83.9	101.3	91.3	99.7	61.8	67.6
Fert. & Inocu.								
Control	44.1	55.8	58.7	71.5	75.3	81.4	37.9	40.2
RP	51.8	70.9	70.3	81.8	81.4	90.8	48.0	78.3
PDB	61.4	78.3	81.5	112.5	98.0	108.4	66.4	73.6
RP+ PDB	70.3	80.3	96.1	112.9	114.0	124.3	73.7	80.5

Abbreviations: as those stated for Table (2).

3- Macronutrients and micronutrients contents:-

Results in table (4) indicate that N, P and K contents in shoots were at the highest values when soybean plants were sprayed with solution of Fe (20 mg L^{-1}) or Mo (5 mg L^{-1}), while content of Fe and Mo in shoots of soybean plants were at their maximum values by sprayed with Fe (20 mg L^{-1}) and Mo (5 mg L^{-1}) respectively compared with non- treated plants in the two growing seasons. The increment of nitrogen content by iron and molybdenum treatments may be ascribed to the activation in root nodules which due to Fe and Mo application and hence increasing the fixed nitrogen. The present

results coincide with those obtained by Bhanavase and Patil (1994), Amara and Nasr (1995), Gupta (1995) and hanna and Eisa (1998).

Data presented in Table (4) reveal also that N,P,K, Fe and Mo concentrations in shoots of soybean plants increased with the application of RP and/or PDB compared to control treatment in both seasons. RP + PDB treatment was superior as compared to any other treatments. Maximum increases in N,P,K,Fe and Mo concentrations were reported by RP + PDB inoculation in the two seasons. The basis for the increase in N content could be through higher N_2 fixation. Also, phosphate dissolving bacteria may have a stimulatory effect on the nodule formation and nitrogen fixation.

Table (4): Effect of spraying with Fe or Mo supply and rock- phosphate fertilization separately or combined with phosphate dissolving bacteria on some macronutrients and micronutrients content in shoots of soybean plants.

Parameters	N %		P %		K %		Fe (mg L^{-1})		Mo (mg L^{-1})	
Treatments	Vegitative	Flowering	vegitative	Flowering	Vegitative	Flowering	vegitative	Flowering	Vegitative	Flowering
Micronutrients	1999 season									
Control	2.99	3.21	0.23	0.25	2.18	2.36	482.5	476.7	52.5	58.0
Fe	3.10	3.35	0.26	0.28	2.34	2.46	635.9	680.9	79.8	86.4
Mo	3.17	3.37	0.25	0.27	2.43	2.50	575.4	588.2	106.6	124.4
Fert. & Inocu.										
Contro	2.82	3.13	0.17	0.20	2.17	2.31	474.4	497.6	62.4	70.8
RP	2.97	3.23	0.23	0.25	2.24	2.36	523.5	530.5	78.6	90.2
PDB	3.17	3.33	0.28	0.29	2.24	2.48	568.0	602.4	85.4	95.6
RP+ PDB	3.41	3.56	0.31	0.33	2.35	2.61	665.8	670.4	92.1	101.7
Micronutrients	2000 season									
Control	2.33	3.44	0.27	0.29	2.29	2.43	486.8	500.3	59.4	98.2
Fe	3.51	3.72	0.29	0.31	2.39	2.61	658.3	687.4	83.6	91.2
Mo	3.64	3.78	0.28	0.32	2.52	2.61	592.7	612.5	113.6	180.4
Fert. & Inocu.										
Contro	3.34	3.56	0.21	0.23	0.24	2.44	500.3	528.5	98.4	94.1
RP	3.40	3.67	0.26	0.27	0.35	2.53	546.1	556.5	86.4	111.5
PDB	3.56	3.60	0.31	0.35	0.46	2.63	593.0	622.7	89.0	120.9
RP+ PDB	3.69	3.76	0.34	0.37	0.55	2.68	677.6	692.5	98.5	126.7

Abbreviations: as those stated for Table (2).

These results can be attributed to the effect of phosphate dissolving bacteria on conversion of insoluble phosphate into soluble form by secreting of organic acids which led to reduce the P^H of soil. These results are in harmony those of with Saad and Hammad (1998) and El- Toukhy et al. (2002).

The obtained results also indicate that N,P,K, Fe and Mo concentrations in shoots of soybean plants were higher at flowering rather than vegetative stage in all application treatments in the two growing seasons. This might be due to an increase in ammonical, nitrate nitrogen and available-P in the rhizoshere (Table 3).

4- Growth Characters:-

As shown in Table (5) spraying soybean plants with Fe (20mg L^{-1}) or Mo (5mgL^{-1}) increased significantly leaves area, dry weight of stem/plant and dry weight of leaves/ plant in both seasons. Also, plant height and dry weight of pods/plant in the first season. The effect seemed to be more obvious upon using molybdenum foliar application at 5 mg L^{-1} compared to other

treatments. These results are in harmony with those reported by Zaki *et al.* (1993), Amara and Nasr (1995), El-karamity (1996), El- Mansi *et al.* (2000).

With respect to fertilization treatments, all growth characters of soybean plants i.e. plant height, numbers of branches and pods/plant, leaves area and dry weights of stem, leaves and pods / plant in both seasons were significantly increased by RP fertilizer application, PDB inoculation and RP + PDB as compared with control treatment, except for number of branches/ plant in the second season only. The highest values were recorded when soybean plants were treated with RP + PDB followed by that of phosphate dissolving bacteria inoculation and RP fertilizer treatments, respectively. This might be due to combined stimulating effect of phosphate dissolving bacteria and nitrogen fixing of *Bradyrhizobium japonicum* for all treatments in supplying the growing plants with their phosphorus and nitrogenous requirements. Similar results were obtained by EL- Sayed (1998), Saad and Hammed (1998) and El- Toukhy *et al.* (2002).

Table (5): Effect of spraying with Fe or Mo supply and rock-phosphate fertilization separately or combined with phosphate dissolving bacteria on some growth characters of soybean plants.

Parameters / Treatments	Plant height (cm)	No. of branches/ plant	No. of pods/ Plant	Leaves area/ Plant cm^2	Dry weight of stem/plant (g)	Dry weight of leaves/plant (g)	Dry weight of pods/plant (g)
Micronutrients			1999 season				
Control	81.9 b	3.01 a	37.56 a	1888 c	13.13 b	13.35 b	15.31 b
Fe	82.3 ab	3.03 a	38.44 a	1924 b	13.38 ab	13.51 a	15.46 a
Mo	82.8 a	3.03 a	38.13 a	1943 a	13.58 a	13.62 a	15.58 a
Fert. & inocu							
Control	80.6d	2.90b	35.67d	1719d	12.07d	12.86d	14.18d
RP	81.8c	3.01a	37.25c	1869c	13.08c	13.22c	14.98c
PDB	82.9b	3.08a	38.83b	1943b	13.76b	13.67b	15.84b
RP+ PDB	84.1a	3.09a	40.42a	2142a	14.54a	14.23a	16.80 a
Micronutrients			2000 season				
Control	87.5a	3.18a	39.63a	2037c	13.89b	14.69b	16.64a
Fe	87.7 a	3.17a	40.13a	2064b	14.01ab	14.77b	16.64a
Mo	87.7a	3.19a	40.63a	2087a	14.09a	14.94a	16.76a
Fert. & inocu							
Control	86.1d	3.09a	37.42d	1803d	12.34d	13.92d	15.11d
RP	87.1c	3.18a	39.17c	2012c	13.51c	14.49c	16.21c
PDB	87.9b	3.20a	41.00b	2121b	14.64b	15.01b	17.22b
RP+ PDB	89.4a	3.24a	42.92a	2315a	15.51a	15.78a	18.25a

Abbreviations: as those stated for Table (2).

Means followed by the same letter (s) with each column are not significantly different from each other at 5% leavel.

5-Yield and yield components:-

Data of soybean yield and its components as affected by micronutrients, rock- phosphate and phosphate dissolving bacteria treatments in both 1999 and 2000 seasons are recorded in Table (6).

The results indicate that number of pods/plant, weight of pods/plant, weight of seeds/plant, weight of 100- seed, seed and biological yields/fed were significantly increased by foliar application with Fe at 20 mg L^{-1} and Mo at 5 mg L^{-1} as compared with the control treatment in both seasons, except

biological yield/fed in the first season and weight of 100 seed in the second season. The highest values of the previous characters were recorded when soybean plant were sprayed by Mo (5 mg L-1) followed by Fe (20 mg L-1) treatments. On the contrary, number of seeds/ pod was not affected by foliar application with Fe and Mo. Similar findings were obtained by El-Karamity (1996). The favorable effect of Fe or Mo on yield and yield components may be attributed to their effect on growth parameters, which in turn improve yield and yield components. Confirming results were reported by EL-Karamity (1996), Hanna and Eisa (1998), EL- Mansi *et al.* (2000) and Nassar *et al.* (2000 a&b) and Ahmed *et al.*(2001).

Table (6): Effect of spraying with Fe or Mo supply and rock- phosphate fertilization separately or combined with phosphate dissolving bacteria on yield and yield components of soybean plants.

Parameters / Treatments	No. of pods/ plant	Weight of pods/plant (g)	No. of seeds/ Pod	Weight of seeds/plant (g)	Weight of 100-seed (g)	Seed yield (Kg/fed)	Biological yield (ton/fed)
Micronutrients			1999 season				
Control	47.38b	39.88c	2.98a	17.08b	15.67b	1081c	3.713a
Fe	48.50ab	40.50b	3.01a	18.11a	15.78ab	1114b	3.727a
Mo	49.65a	40.99a	3.04a	18.14a	15.96a	1129a	3.734a
Fert. & inocu							
Control	45.08d	36.85d	2.98b	16.22d	15.04d	933d	3.487d
RP	47.67c	39.28c	2.99ab	17.07c	15.57c	1066c	3.678c
PDB	50.00b	41.93b	3.05a	18.32b	16.07b	1133b	3.807b
RP+ PDB	51.17a	43.76a	3.08a	19.51a	16.53a	1241a	3.927a
Micronutrients			2000 season				
Control	50.25b	41.75b	3.06a	18.73b	16.61a	1128b	3.789b
Fe	51.38ab	43.22a	3.08a	19.12a	16.64a	1150a	3.803a
Mo	52.31a	42.91ab	3.09a	19.14a	16.74a	1155a	3.808a
Fert. & inocu							
Control	47.38d	40.00d	2.98b	17.38d	15.88d	1014d	3.598d
RP	50.25c	41.28c	3.06ab	18.28c	16.76c	1102c	3.749c
PDB	52.25b	43.82b	3.11a	19.67b	16.97b	1176b	3.874b
RP+ PDB	54.92a	45.40a	3.13a	20.66a	17.34a	1285a	3.977a

Abbreviations: as those stated for Table (2).
Means followed by the same letter (s) with each column are not significantly different from each other at 5% leavel.

Data in Table (6) showed also that number of pods/ plant, weight of pods/plant, number of seeds/pod, weight of seeds/plant, weight of 100- seed, seed and biological yields/ fed were significantly increased with RP fertilizer and PDB inoculation treatments compared to the check treatment in both seasons. The greatest values for yield and yield components were recorded by RP+PDB treatment followed with significant difference by PDB inoculation and RP fertilizer treatments except for number of seeds/pod. The increases in seed yield/fed were 308,200 and 133 kg/fed in the first season and 271, 162 and 88 kg/fed in the second season for RP+PDB, PDB and RP treatments over the control treatment, respectively. These increases represent 33%, 21.4 % and 14.3 % in the first season and 26.7%, 16.0% and 8.7% in the second one, respectively. The high seed yield/ fed at RP+PDB treatment could be attributed the increases of yield components for the same treatment. Similar conclusion was reported by Pareek and Gaur (1973), Gaur *et al.* (1979), Gaur

et al. (1980), Gained and Gaur (1991), El-Sayed (1998), Saad and Hammad (1998) and EL- Toukhy *et al.* (2002).

6-Protein and oil content of seeds.

Data presented in Table (7) show the effect of spraying with Fe and Mo as well as RP and PDB on protein, oil percentages and yields/fed of soybean seeds.

Results indicate that spraying with Fe and Mo had significant effect on protein yield/fed in both seasons and oil yield/fed in the first season as compared to control treatment, while oil percentage decreased significantly by the same treatments in the second season only. These results are supported by the finding of Zaki *et al* . (1993), Sunita *et al.* (1998) and Ahmed *et al.* (2001).

Table (7): Effect of spraying with Fe or Mo supply and rock- phosphate fertilization separately or combined with phosphate dissolving bacteria on protein %, protein yield, oil % and oil yield of soybean seeds.

Parameters / Treatments	Protein (%)	Protein yield (Kg/fed)	Oil (%)	Oil yield (Kg/fed)
Micronutrients	1999 season			
Control	33.59a	363.2c	21.31a	230.4b
Fe	33.77a	376.5b	21.37a	237.7a
Mo	33.83a	382.7a	21.39a	242.1a
Fert. & inocu				
Control	33.47d	333.0d	20.96b	208.5d
RP	33.66c	358.7c	21.26b	266.5c
PDB	33.82b	383.1b	21.67a	244.7b
RP+ PDB	33.97a	421.6a	21.54a	267.3a
Micronutrients	2000 season			
Control	34.12a	384.8b	22.30a	251.8a
Fe	34.21a	393.3a	22.08b	247.8a
Mo	34.69a	400.2a	22.20ab	256.5a
Fert. & inocu				
Control	34.45a	349.5d	21.76ab	220.5d
RP	34.14a	376.1c	22.13ab	243.8c
PDB	34.32a	403.5b	22.42a	263.5b
RP+ PDB	34.44a	442.5a	22.47a	280.3a

Abbreviations: as those stated for Table (2).
Means followed by the same letter (s) with each column are not significantly different from each other at 5% leavel.

Data in Table (7) indicated also that RP and/or PDB treatments caused significant increases in protein yield/fed, oil percentage and oil yield/fed in both seasons as well as protein percentage in the first season only over the untreated plants (control). The highest values of protein and oil yields/fed were achieved for RP + PDB treatment, followed by PDB inoculation and RP fertilizer treatments in both seasons. The increases in protein yield/ fed were 26.6%, 15.0% and 7.7% in first season and 26.7%, 15.5% and 7.7% in the second season, respectively, while the increases in oil yield/fed were 28.2%, 17.4% and 8.6% in the first season and 27.1%, 19.5% and 10.7% in the second season, respectively RP + PDB, PDB and RP treatments over the control treatment, respectively. This superiority for the combined inoculum of RP

+PDB might be attributed to the associated increase in seed yield/fed as shown in Table (6).

7-Effect of the interaction.

Results of interaction between spraying with microutricnts and rock-phosphate combined with phosphate dissolving bacteria (Table 8) showed significant effect on weight of seeds/plant and protein yield/fed in the first season, as well as seed yield/fed in both seasons reaching their maximum by spraying soybean plants with Mo at 5 mg L^{-1} or Fe at 20 mg L^{-1} with RP + PDB treatment, whereas the lowest values for these traits were obtained by untreated plants (control treatments).These results are in harmony with those recorded by Amara and Nasr (1995).

On the light of the obtained results, it could be concluded that under the conditions during this investigation, enrichment of soybean plants with spraying of Mo or Fe solutions and rock-phosphat fertilizer combined with phosphate dissolving bacteria inoculation gave a considerable increase in the growth, yield components and yield of soybean plants.

Table (8): Effect of interaction between spraying of micronutrients and rock-phosphate combined with phosphate dissolving bacteria on weight of seed/plant, seed yield/fed and protein yield/fed of soybean.

Characters Micronutents x Fert& inocu.		Weight of seeds/ plants (g)	Seed yield (kg/fed)		Protein yield (kg/fed)
		1999	1999	2000	1999
Zero	Control	15.93e	986 j	1006 h	329.4 j
	RP	16.38d	1052 h	1090 f	352.0h
	PDB	17.30 c	1088 f	1155 d	365.9 f
	RP+PDB	18.70 b	1197 c	1260 e	405.5 c
Fe 20mg L^{-1}	Control	16.33d	993ig	1015gh	332.6ij
	RP	17.45c	1068g	1106e	360.0g
	PDB	18.80b	1144e	1183c	387.6e
	RP+PDB	19.88a	1252b	1295a	425.8b
Mo 5 mg L^{-1}	Control	16.40d	1001i	1020g	337.1i
	RP	17.38c	1077fg	1110e	364.1fg
	PDB	18.85b	1166d	1190c	395.8d
	RP+PDB	19.95a	1277a	1299a	433.6a

Abbreviations: as those stated for Table (2).
Means followed by the same letter (s) with each column are not significantly different from each other at 5% leavel.

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استجابة نباتات فول الصويا للرش بالحديد والموليبدينم والتسميد الأرضي بالفوسفات الصخري مع البكتريا المذيبة للفوسفات "

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الملخص العربي

أجريت هذه الدراسة بمركز البحوث والتجارب الزراعية بكلية الزراعة بمشتهر جامعة الزقازيق خلال موسمي ١٩٩٩و ٢٠٠٠ م بهدف دراسة تأثير الرش بالحديد و الموليبدينم والتسميد الأرضي بالفوسفات الصخري مع التلقيح بالبكتريا المذيبة للفوسفات على النمو والمحصول والتركيب الكيماوي لمحصول فول الصويا. وقد تضمنت الدراسة ١٢ معاملة عبارة عن التوافيق بين ٣ معاملات للرش وهى (الرش بالماء ككنترول للمقارنة – الرش بالحديد بتركيز ٢٠ جزء في المليون – الرش بالموليبدينم بتركيز ٥ جزء في المليون) وأربع معاملات للتسميد الفوسفاتي مع البكتريا المذيبة للفوسفات وهى (بدون تسميد فوسفاتي وبدون تلقيح بالبكتريا المذيبة للفوسفات ككنترول للمقارنة – تسميد بالفوسفات الصخري بالمعدل الموصى به– تلقيح بالبكتريا المذيبة للفوسفات فقط – تسميد بالفوسفات الصخري + تلقيح بالبكتريا المذيبة للفوسفات) وذلك في تصميم القطع المنشقة مرة واحدة في أربعة مكررات وتمت دراسة الصفات الآتية:–

تكوين العقد البكتيرية – نشاط إنزيم النيتروجينيز– الفوسفور الميسر – معدل انطلاق ثاني أكسيد الكربون في منطقة الريزوسفير – ومحتوى النبات من العناصر الكبرى (نتروجين–فوسفور–بوتاسيوم) والصغرى (حديد–موليبدينم) وصفات النمو والمحصول ومكوناته وكذلك نسبة ومحصول كل من البروتين والزيت في بذور فول الصويا ويمكن إيجاز أهم النتائج المتحصل عليها من هذه الدراسة فيما يلي:–

١–أعطت نباتات فول الصويا التي رشت بالحديد أو الموليبدينم أعلى قيم لكل من الوزن الجاف وعدد العقد البكتيرية– نشاط إنزيم النيتروجينيز والنيتروجين الامونيومى والنتراتى والفوسفور الميسر ومعدل انطلاق ثانى أكسيد الكربون في منطقة الريزوسفير وكذلك أعلى قيم للعناصر الكبرى والصغرى فى المجموع الخضرى لنباتات فول الصويا في موسمي النمو. هذا وقد أدى أيضا الرش بالحديد أو الموليبدينم إلى زيادة معنوية في كل من المساحة الورقية والوزن الجاف لكل من سوق وأوراق النبات

وعـدد قرون النبات ووزن قرون وبذور النبات ومحصول البذور للفدان ومحصول البروتين فى البذور خلال موسمى الزراعة وذلك مقارنةً بمعاملة الكنترول .

٢-أدى التلقـيح بالبكتريا المذيبة للفوسفات مع الفوسفات الصخرى إلى زيادة في العقد البكتيرية من حيـث العـدد والوزن الجاف ونشاط إنزيم النيتروجينيز والنيتروجين الامونيومى والنتراتى والفوسفور الميسـر ومعـدل انطلاق ثانى أكسيد الكربون في منطقة الريزوسفير لنباتات فول الصويا وكذلك أيضا محتوى المجموع الخضرى من العناصر الكبرى والصغرى فى كلا الموسمين. هذا وقد تأثرت كل صفات النمو والمحصول ومكونات المحصول والتركيب الكيماوي للبذور تأثيراً معنويا بالتلقيح بالبكتريا المذيبة للفوسفات مع الفوسفات الصخرى والتلقيح بمفردة فى الموسمين مقارنة بمعاملة الكنترول ما عدا عدد أفرع النبات والنسبة المئوية للزيت فى الموسم الثانى فقط.

٣- كـان للـتفاعل بيـن الرش بالعناصر الصغرى والتسميد الأرضي بالفوسفات الصخري مع البكتريا المذيـبة للفوسـفات تأثير معنوي على محصول البذور للفدان في موسمي الدراسة ووزن بذور النبات ومحصـول البروتين في الموسم الأول فقط وقد سجلت أعلى قيم لهذه الصفات عندما رشت نباتات فول الصـويا بالموليبديـنم عند تركيز ٥ جزء في المليون أو الحديد عند تركيز ٢٠ جزء في المليون مع التسميد بالفوسفات الصخري + التلقيح بالبكتريا المذيبة للفوسفات.