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EFFECT OF POTASSIUM DISSOLVING BACTERIA AND FOLIAR APPLICATION WITH SOME MICROELEMENTS ON GROWTH, YIELD AND QUALITY OF PEA PLANT UNDER SANDY SOIL CONDITIONS

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ABSTRACT

This work was carried out during the two successive winter seasons of 2009/ 2010 and 2010/2011 , to investigate the effect of inoculation with *Bacillus circulans* or without and foliar spray with some microelements (B or Mo at 25 and 50ppm of each and Fe at 50 and 100ppm, as well as the control treatment) and their interactions on plant growth , total dry weight of plant, yield and it's components , chemical constituents as well as root system parameters of pea (*Pisum sativum* L.), cv. Victory Freezer. The obtained results showed that inoculation of pea plants with *Bacillus circulans* recorded the highest values for each of plant height, number of leaves per plant, total dry weight of plant, number of seeds per pod, total dry weight of roots, root volume, main root length and number of nodules per plant and P content in seeds as compared to untreated plants. Spraying pea plants with Mo at 50ppm or Fe at 100ppm gave the highest values for each of growth characters per plant, number of pods per plant, green pods yield per plant and feddan, netting percentage, P content in seeds, fresh and dry weight of roots, root volume, number and dry weight of nodules per plant. The interaction between *Bacillus circulans* and foliar spray with Mo at 50ppm or Fe at 100ppm gave the maximum vegetative growth parameters, total dry weight of plant, green pods yield per plant and feddan, netting percentage, P content in seeds and root system parameters.

Keywords: *Bacillus circulans*, microelements, yield, pea.

INTRODUCTION

It is well known that plants grown in sandy soil, particularly those of the newly reclaimed area, are facing several problems due to micronutrients deficiency, since the producers pay attention only to the macronutrients.

As essential element, boron plays a great role in plant metabolism and carbohydrate translocation and in sequence the uptake and translocation of sugars. In addition, boron deficiency causes death of shoot tip, flowers don't form and root growth is stunted. Spraying pea plants with boron at 5ppm gave the best results for vegetative growth and yield with respect to the features of both pods and pea seeds as compared with untreated plants (El-Hefny and Mahmoud, 1999).

Boron is one of these elements, generally, considered essential for various plant development processes, especially in vascular plants (Reguera *et al.*, 2010). Number, size and weight of nodules exhibited great improvement by boron treatment on pea plants (Mehmood *et al.*, 2011). Application of B at 25ppm increased vegetative growth parameters, dry weight of plant and yield as well as minerals content of pea plants (Nour, 2004).

Moreover, molybdenum has a direct and important role on nitrate assimilation and reduction, it improves plant growth, and also Mo has along been implicated in nitrogen fixation. Molybdenum deficiency caused leaf wilt, inhibition in flower formation and flowers abscise before setting fruit (Devlin and Witham, 1972).

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Spraying pea plants with molybdenum at 75 or 150ppm as sodium molybdate form gave the best results for vegetative growth yield with respect to the features of both pods and pea seeds as compared with untreated plants (El-Hefny and Mahmoud, 1999).

Molybdenum plays an important role in increasing chickpea yield through it's effects and the plant itself and on the nitrogen fixing symbiotic process because Mo is directly involved in nitrogen fixation by legumes (Roy *et al.*, 2006).

Spraying chickpea plants with Mo increased significantly total dry weight per plant and yield and its components (Valenciano *et al.*, 2011). Spraying pea plants with Mo at 25 or 50ppm were the favorable treatments to enhance root and foliage parameters, vegetative growth, minerals content, yield and seed quality (Nour, 2004).

Due to iron redox properties and it's ability to form complexes with diverse legends, this element is constituent of many electron carriers and enzymes, thus playing an important role in plant metabolism. On the other hand, low solubility of inorganic iron at physiological pH and it's high reactivity in presence of oxygen, which brings to generation of toxic hydroxyl radicals; represent severe difficulty (Hell and Stephan, 2003).

Application of iron at 2 mg/l to pea plants, grown hydroponically increased significantly dry biomass (leaves, stems and roots) and pigment content (Nenova, 2006).

Spraying brood bean plants with Fe at 100g/fed. increased plant growth; i.e., stem length, number of branches, leaves and flowers per plant, pod setting percentage and seed index in comparison with the control (Mohamed and Helal,1999). Application of Fe at 100ppm increased vegetative growth parameters, dry weight of plant and yield of pea as well as improving seed quality (Nour, 2004).

Nowadays, attention was focused on the use of organic and biofertilizers instead of chemical ones to produce clean vegetable crops. Moreover, bio and organic fertilizer encouraged plant growth through improving soil conditions which led to higher yield with good quality (Borin *et al.*, 1987). Also, biofertilizers which can be defined as preparations containing live cells of efficient strains of potassium solubizing bacteria could be used with a relatively low amounts of chemical fertilizers instead of chemical fertilizers alone.

Furthermore, biofertilizers increased the availability of nutrients in form which can be easily assimilated by plants (Subba Rao, 1984). In this regard, it is very important to increase the productivity of onion yield per unit area under sandy soil conditions.

Many investigators concluded that application of biofertilizers caused amerced effect on the growth rate, total nutrients uptake, and productivity (Ruban, 2007).

Fertilization of onion plants with some biofertilizers mixture, i.e., Rhizobacterine + Phosphorein + Potassumag (*Bacillus circulans*) at a rate of 1.5kg per fedden caused a significant effect on growth rate, total nutrients uptake (N,P and K) and yield and its components, (Ibrahem *et al.*, 2010).

Applications of potassumag at 50g / pot to mungbean plants enhanced significantly fresh and dry weights, as well as yield (Tawfik, 2008). Inoculation potato plants with *Bacillus circulans* in the presence of different potassium sources increased potato tuber yield, tuber content of carbohydrate and soluble sugar, as well as soil available P and K as compared to the sole use of K- sources (Khalil *et al.*, 2010).

MATERIALS AND METHODS

The present investigation was conducted at the Experimental Farm, El-Kassasein Horticultural Research Station, Ismailia Governorate, to investigate the effect of inoculation with *Bacillus circulans* (silicate potassium) dissolving bacteria on the availability of potassium from potassium sulfate (48% K_2O) and foliar application with some microelements; i.e., boron at 25 and 50ppm, molybdenum at 25 and 50ppm, as well as iron at 50 and 100ppm on plant growth, total dry weight, yield and chemical constituents of pea plants (*Pisum sativum* L.) cv. Victory Freezer grown under sandy soil conditions using drip irrigation system. The physical and chemical properties of the experimental soil field are presented in Table 1.

Table 1. The physical and chemical properties of the tested soil during 2009/2010 and 2010/2011 seasons

Physical properties	2009/ 2010 season	2010/ 2011 season	Chemical properties	2009/ 2010 season	2010/ 2011 season
Sand (%)	96.5	95.6	**Organic matter (%)**	0.05	0.08
Silt (%)	1.7	1.6	**Available K (ppm)**	52	64
Clay (%)	1.8	2.8	**Available P (ppm)**	5.5	6.2
Field capacity	6.5	6.8	**Available N (ppm)**	5.4	6.9
Wilting point	2.4	2.5	**Calcium carbonate (%)**	0.18	0.26
Available water	4.5	4.5	**pH**	8.1	8.1
Water holding capacity	13.8	14.5			

This experiment included 14 treatments, resulted from the interaction between inoculation with or without *Bacillus circulans* and seven different sources and rates of microelements. The treatments were arranged in a split plot design with three replicates. Inoculation with or without *Bacillus circulans* were assigned at random in the main plots, while sub-plots were devoted to foliar application with microelements ;i.e. control treatment B at 25 and 50ppm, Mo at 25 and 50ppm and Fe at 50 and 100ppm.

Seeds of pea cv. Victory Freezer were obtained from Horticultural Research Institute, Agriculture Research Center, Egypt and sown on October 24th and 21st in 2009/2010 and 2010/2011seasons, respectively. The area of experimental plot was 10.5m^2. Every plot consisted of five dripper lines 3m in length and 0.7m in width. Seeds were sown in hills 20 cm apart on one side of dripper lines and two seeds per hill with about 150 plants in every plot. One dripper line was left between each two experimental plots without spraying as a guard row to avoid the overlapping (contamination) of spraying solution. Two dripper lines (4.2m^2) was earmarked for samples and the other three dripper lines (6.3m^2) were earmarked for estimating yield and it's components. Normal agriculture practices of pea under drip irrigation system were followed according to the recommendations of Agriculture Ministry.

The foliar spray treatments were sprayed three times during the growth period of plant at 30, 40 and 50 days after sowing, while the untreated plants (control) were sprayed with tap water.

Bacillus circulans Inoculum

The used bacterial strain in this experiment was *Bacillus circulans* (potassium dissolver), it was kindly supplied by the Dept. Agric. Microbiol. Res., Soils, Water & Environ. Res. Inst., ARC, Giza, Egypt.

Vermiculite supplemented with 10 % Irish peat was packed into polyethylene bags (200 g carrier per bag), then sealed and sterilized with gamma irradiation (5.0×10^6 reds). *Bacillus circulans* was grown on nutrient broth medium (Difico, 1984) incubated for 48 hr at 28°C to ensure population density of 5×10^9 cfu/ml culture and injected into sterilized carrier as mentioned before.

The efficiency of used strain of *Bacillus circulans* for dissolving silicate minerals was assayed using powdered mica in the Aleksandrov's liquid medium (Zahara, 1969).

Data Recorded

Growth parameters

A random sample of three plants from each experimental unit were taken at 80 days after sowing in both seasons of study for measuring the growth characters of pea plants expressed as follows:

1. Plant height (cm),

2.Number of both leaves and branches/plant and

3.Total dry weight (leaves + branches)/plant (g).

Yield and it's components

Mature green pods were continuously harvested at suitable maturity stage and the following data were calculated.

1- Number of pods/plant,

2- Average pod weight (gm),

3- Number of seeds/ pod,

4- Average weight of green pods/plant (gm),

5- Green pod yield/fed and

6- Netting percentage.

Seeds chemical constituents

Dried seeds were finely grounded separately and digested with sulfuric acid and percholoric acid (3:1). Nitrogen, phosphorus and potassium were determined according to the method described by Kock and Mc Meekin (1924), Murphy and Riley (1962) and Brown and Lilliland (1946), respectively.

Total crude protein (%)

The previously determined nitrogen in dry seeds was used for calculating total crude protein by multiplying N- values by 6.25 (A.O.A.C., 1980).

Statistical Analysis

The collected data were subjected to proper statistical analysis of variance according to Snedecor and Cochran (1980), and means were done according to LSD at 0.05 level of probability.

RESULTS AND DISCUSSION

Vegetative Growth Characters

The effect of *Bacillus circulans* and foliar spray with microelements on the vegetative growth characters of pea plants is shown in Table 2. It is obvious from the data that treating pea plants with *Bacillus circulans* increased significantly plant height and number of leaves in second season only. But it did not reflect any significant effect on the other studied vegetative growth characters in the two seasons.

The promotion effect of *Bacillus circulans* may be attributed to the fact that K nutrient play an active role in building new merestematic cells, cell elongation and increasing photosynthesis activity which lead to increase the vegetative growth (Nour *et al.*, 2010). These results are in harmony with those obtained by many researchers such as Tawfik (2008) on mung bean, Ibrahem *et al.* (2010) on onion and Khalil *et al.* (2010) on potato. As for the effect of foliar spray with some microelements, the results in Table 2 show the effect of microelements; viz., control treatment , B, Mo at 25 and 50ppm and Fe at 50and 100ppm on the vegetative growth characters of pea plants, expressed as plant height, number of leaves and branches per plant and total dry weight.

The results show that application of B, Mo and Fe increased plant height, number of leaves and branches per plant and total dry weight, while the highest values were recorded from spraying plants with Mo at 50 ppm and Fe at 100 ppm. These results may be due to that molybdenum is essential constituent of nitrogenase in legume nodules, and hence increase growth of root nodules, and has function in N fixations which enhance plant height and growth (Xia and Xiong, 1985).

The obtained results are agreeable with those reported by El-Hefny and Mahmoud (1999) and Nour (2004) on pea plants, as well as Valenciano *et al.* (2011) on chickpea.

In addition, the obtained results with Fe foliar spray agreed with those of Nour (2004) and Nenova (2006) on pea and Mohamed and Helal (1999) on broad bean.

The illustrated data in Table 3 indicate that the interaction between *Bacillus circulans* and foliar spray with microelements had promotive effect on all parameters except number of branches as compared to the control treatment. These results are true in both growing seasons. In general, the interaction between *Bacillus circulans* and Mo at 50ppm or Fe at 100ppm gave the highest values of plant height, number of leaves per plant and total dry weight as compared to the control treatment which recorded the lowest values in both seasons of study.

Yield and its Components

The results in Table 4 show the effect of *Bacillus circulans* on the yield and it's components; i.e., number of pods per plant, average pod weight, number of seeds per pod,

Table 2. Effect of *Bacillus circulans* and foliar spray with some microelements on vegetative growth and total dry weight of pea plants during 2009/2010 and 2010/2011seasons

Treatments	Growth characters / plant							
	2009/2010 season				2010/2011 season			
	Plant height (cm)	Leaves No.	Branches No.	Total dry weigh (g)	Plant height (cm)	Leaves No.	Branches No.	Total dry weigh (g)
Bacillus circulans								
Without	66.5	29.9	3.57	10.3	68.0	32.3	3.76	10.9
With *B. circulans*	70.69	31.1	3.57	10.6	72.6	37.2	3.86	11.6
LSD at 0.05 level	0.71	N.S.	N.S.	N.S.	1.52	1.06	N.S.	N.S.
Microelements								
Control	57.4	19.2	2.67	9.6	60.5	23.9	3.17	10.4
B 25ppm	61.8	30.9	4.00	10.3	64.7	34.1	4.33	10.8
B 50ppm	65.15	32.6	4.00	10.6	68.3	38.7	4.50	11.2
Mo 25ppm	70.25	29.3	3.33	10.8	70.9	33.0	3.50	11.9
Mo 50ppm	77.15	37.0	3.84	10.9	76.9	40.7	4.00	11.6
Fe 50ppm	70.85	28.2	3.17	10.8	72.2	33.0	3.17	11.5
Fe 100ppm	77.6	36.5	4.00	10.4	78.7	39.9	4.00	11.7
LSD at 0.05 level	2.24	1.79	1.01	0.6	1.81	1.73	1.18	0.4

green pod yield per plant , total yield per feddan and netting percentage. It is obvious from such data that treating pea plants with *Bacillus circulans* recorded the highest values of those characters as compared to untreated plants which recorded the lowest values of all the above mentioned characters of yield and its components. This may be attributed to the results obtained previously in Table 2.

The obtained results are agreeable with those reported by Tawfik (2008) on mungbean, Ibrahem *et al.* (2010) on onion plants, and Khalil *et al.* (2010) on potato plants.

Regarding the effect of foliar spray with some microelements, it is clear from the same data in Table 4 that spraying pea plants with B at 50ppm, Mo at 50ppm or Fe at 100ppm, in general, were the most favorable treatments for enhancing number of pods per plant, green pod yield per plant, total green pod yield per feddan as well as netting percentage in both seasons of study.

These results may be due to the effect of molybdenum and boron on stimulation physiological processes, photosynthetic rate, carbohydrate accumulation, sugars translocation in plant, sequence increase pod weight and seed weight per pod, as well as green yield per plant (Xia and Xiong, 1985 and Brhada, 1988).

The favorable effect of foliar spray with B, Mo and Fe on yield and it's components of pea plants was in harmony with the results reported by El-Hefny and Mahmoud (1999) and Nour (2004) on pea and Valenciano *et al.* (2011) on chickpea.

In addition, the obtained results with Fe foliar spray agreed with those of Nour (2004) and Nenova (2006) on pea, and Mohamed and Helal (1999) on broad bean plants.

The results listed in Table 5 clearly show the effect of interaction between *Bacillus circulans* and foliar spray with microelements on the yield and its components. It is obvious from such data that the interaction between *Bacillus circulans* and foliar spray with microelements had promotive effect on all parameters and increased significantly green pod yield per plant, total green pod yield per feddan and netting percentage. These results are true in both growing seasons.

Table 3. Effect of interaction between *Bacillus circulans* and foliar spray with some microelements on vegetative growth and total dry weight of pea plants during 2009/2010 and 2010/2011seasons

Treatments		Growth characters / plant							
		2009/2010 season				2010/2011 season			
		Plant height (cm)	Leaves No.	Branches No.	Total dry weigh (g)	Plant height (cm)	Leaves No.	Branches No.	Total dry weigh (g)
B. circulans	Microelements								
Without *B. circulans*	Control	55.6	18.6	2.67	9.4	57.6	21.6	3.00	10.2
	B 25ppm	60.1	30.1	4.00	10.1	51.8	32.7	4.33	10.6
	B 50ppm	64.5	34.9	4.33	10.3	67.4	36.5	4.33	10.9
	Mo 25ppm	68.2	28.4	3.33	10.7	68.5	31.4	3.67	11.4
	Mo 50ppm	75.2	37.6	4.00	10.6	75.0	37.5	4.00	11.3
	Fe 50ppm	67.3	25.4	3.00	10.7	69.6	30.9	3.33	10.8
	Fe 100ppm	74.8	34.3	3.67	10.2	76.2	35.8	367	11.2
With *B. circulans*	Control	59.2	19.8	2.67	9.8	63.3	26.2	3.33	10.6
	B 25ppm	63.5	31.7	4.00	10.4	67.5	35.5	4.33	11.0
	B 50ppm	65.8	30.2	3.67	10.9	69.2	40.9	4.67	11.4
	Mo 25ppm	72.3	30.1	3.33	10.8	73.4	34.6	3.33	12.3
	Mo 50ppm	79.1	36.4	3.67	11.2	78.9	43.9	4.00	11.9
	Fe 50ppm	74.4	30.9	3.33	10.9	74.8	35.1	3.00	12.2
	Fe 100ppm	80.5	38.6	4.33	10.6	81.2	43.9	4.33	12.1
LSD at 0.05 level		3.17	2.5	N.S.	0.8	3.6	2.4	N.S.	0.9

Table 4. Effect of *Bacillus circulans* and foliar spray with some microelements on yield and it's components of pea plants during 2009/2010 and 2010/2011seasons

Treatments	Yield and it's components											
	2009/2010 season						2010/2011 season					
	No. of pods/ plant	Pod weight (g)	No. of seeds/ pod	Green pods yield Plant (g)	Green pods yield fed. (Kg)	Netting (%)	No. of pods/ plant	Pod weight (g)	No. of seeds/ pod	Green pods yield Plant (g)	Green pods yield fed. (Kg)	Netting (%)
Bacillus circulans												
Without	22.71	4.17	6.21	94.9	2846	56.29	21.81	4.06	6.27	88.8	2663	54.69
With *B. circulans*	22.87	4.30	7.09	98.5	2955	56.93	21.87	4.39	7.07	96.2	2885	56.61
LSD at 0.05 level	N.S.	N.S.	0.47	N.S.	N.S.	0.42	N.S.	N.S.	0.40	N.S.	N.S.	1.10
Microelements												
Control	20.50	3.62	6.00	73.7	2213	52.30	20.00	3.63	6.15	72.2	2165	51.58
B 25ppm	21.45	4.02	6.40	86.2	2587	54.77	21.55	3.82	6.45	82.5	2474	53.16
B 50ppm	23.40	4.07	6.95	94.9	2850	55.35	22.45	3.96	7.05	88.3	2649	56.63
Mo 25ppm	23.55	4.21	6.55	99.6	2989	54.88	21.85	4.25	6.55	92.7	2780	53.66
Mo 50ppm	23.70	4.50	6.75	105.2	3157	60.28	22.55	4.48	6.65	100.4	3013	57.79
Fe 50ppm	22.95	4.21	6.80	97.7	2932	58.14	21.70	4.46	6.50	98.9	2967	55.48
Fe 100ppm	24.00	5.02	7.10	119.3	3580	60.54	22.80	4.41	7.35	112.4	3373	61.28
LSD at 0.05 level	2.77	N.S.	N.S.	29.6	896	1.39	N.S.	N.S.	N.S.	25.5	764	3.65

Table 5. Effect of interaction between *Bacillus circulans* and foliar spray with some microelements on yield and it's components of pea plants during 2009/2010 and 2010/2011seasons

Treatments		Yield and it's components											
		2009/2010 season						2010/2011 season					
		No. of pods/ plant	Pod weight (g)	No. of seeds/ pod	Green pods yield Plant (g)	Green pods yield fed. (Kg)	Netting (%)	No. of pods/ plant	Pod weight (g)	No. of seeds/ pod	Green pods yield Plant (g)	Green pods yield fed. (Kg)	Netting (%)
B. circulans	Microelements												
Without *B.*	Control	20.4	3.59	5.6	73.4	2202	50.12	19.7	3.56	5.8	69.2	2076	50.87
circulans	B 25ppm	21.6	3.96	6.2	85.4	2561	54.41	21.3	3.77	6.0	814	2443	52.01
	B 50ppm	23.1	4.01	6.5	92.6	2779	57.01	22.5	3.89	6.5	86.6	2598	56.53
	Mo 25ppm	23.3	4.24	6.1	99.1	2972	53.81	22.0	4.14	6.0	90.3	2709	52.65
	Mo 50ppm	23.8	4.31	6.3	101.0	3031	60.16	22.7	4.16	6.5	94.8	2845	57.29
	Fe 50ppm	22.7	4.18	6.2	96.1	2884	58.44	21.6	4.28	6.3	92.8	2785	53.21
	Fe 100ppm	24.1	4.92	6.6	116.7	3500	60.05	22.9	4.62	6.8	106.3	3189	60.29
With *B.*	Control	20.6	3.65	6.4	74.2	2224	54.47	20.3	3.69	6.5	75.1	2254	52.28
circulans	B 25ppm	21.3	4.08	6.6	87.1	2613	55.13	21.8	3.86	6.9	83.5	2506	54.31
	B 50ppm	23.7	4.12	7.4	97.3	2920	53.68	22.4	4.02	7.6	90.0	2701	56.72
	Mo 25ppm	23.8	4.17	7.0	100.2	3007	55.94	21.7	4.36	7.1	95.1	2852	54.66
	Mo 50ppm	23.6	4.69	7.2	109.5	3284	60.40	22.4	4.80	6.8	106.0	3181	58.29
	Fe 50ppm	23.2	4.24	7.4	99.3	2979	57.83	21.8	4.81	6.7	104.9	3148	57.74
	Fe 100ppm	23.9	5.12	7.6	122.0	3660	61.03	22.7	5.20	7.9	118.6	3557	62.27
LSD at 0.05 level		N.S.	N.S.	N.S.	40.8	1236	1.97	N.S.	N.S.	N.S.	35.1	1054	5.11

In general, the interaction between *Bacillus circulans* and foliar spray with Mo at 50ppm or Fe at 100ppm gave the highest values of yield and its components as compared to control treatment which recorded the lowest values in both seasons of study.

Chemical Constituents of Seeds

The effect of *Bacillus circulans* and foliar spray with microelements on chemical constituents of seeds are shown it Table 6. It is obvious from the data that treating pea plants with *B. circulans* caused significant effect on P percentage but it did not record any significant effect on N, K and protein percentage. Similar results were obtained by Ibrahem *et al.* (2010) on onion.

As for the effect of foliar spray with some microelements; viz., control, B, Mo at 25 and 50ppm and Fe at 50 and 100ppm on chemical constituents of seeds (N, P, K and protein percentage). The results show that spraying pea plants with Mo at 50ppm or Fe at 100ppm increased significantly P percentage, but they did not record any significant effect on N,K and protein percentage. The obtained results are in harmony with those reported by Nour (2004) on pea. The results listed in Table 7 clearly show that, the interaction between *Bacillus circulans* and foliar spray with Mo at 50ppm or Fe at 100ppm gave the highest values of P content in pea seeds. On the other hand, the interaction treatments did not reflect any significant effect on the content of N, K and protein in pea seeds in both seasons of study.

Root System

Data in Table 8 show the effect of *Bacillus circulans* on pea root system expressed as fresh and dry weight of root per plant, main root length, root volume, number of nodules per plant and dry weight of nodules per plant. It is obvious from the data that, treating pea plants with *Bacillus circulans* recorded higher values of these characters as compared to untreated plants which recorded the lowest values of all

Table 6. Effect of *Bacillus circulans* and foliar spray with some microelements on chemical constituents of pea plants during 2009/2010 and 2010/2011seasons

Treatments	Chemical constituents (%)							
	2009/2010 season				2010/2011 season			
	N	P	K	Protein	N	P	K	Protein
Bacillus circulans								
Without	3.75	0.312	2.49	23.44	3.67	0.316	2.53	22.95
With *B. circulans*	3.86	0.304	2.56	24.15	3.83	0.298	2.59	23.95
LSD at 0.05 level	N.S.	0.018	N.S.	N.S.	N.S.	0.018	N.S.	N.S.
Microelements								
Control	3.44	0.245	2.35	21.52	3.46	0.261	2.42	21.60
B 25ppm	3.64	0.267	2.56	22.73	3.61	0.282	2.61	22.58
B 50ppm	3.98	0.267	2.63	24.88	3.84	0.298	2.67	24.00
Mo 25ppm	3.81	0.341	2.55	23.80	3.71	0.301	2.58	23.22
Mo 50ppm	3.94	0.333	2.62	24.63	3.83	0.303	2.62	23.88
Fe 50ppm	3.84	0.357	2.45	24.00	3.84	0.359	2.47	24.12
Fe 100ppm	4.00	0.344	2.52	25.00	3.97	0.346	2.54	24.83
LSD at 0.05 level	N.S.	0.020	N.S.	N.S.	N.S.	0.020	N.S.	N.S.

Table 7. Effect of interaction between *Bacillus circulans* and foliar spray with some microelements on chemical constituents of pea plants during 2009/2010 and 2010/2011 seasons

Treatments		Chemical constituents (%)							
		2009/2010 season				2010/2011 season			
		N	P	K	Protein	N	P	K	Protein
B. circulans	**Microelements**								
Without *B. circulans*	**Control**	3.33	0.239	2.30	20.8	3.30	0.267	2.36	20.6
	B 25ppm	3.59	0.271	2.55	22.4	3.47	0.296	2.58	21.7
	B 50ppm	3.97	0.278	2.60	24.8	3.79	0.302	2.64	23.7
	Mo 25ppm	3.74	0.347	2.52	23.4	3.66	0.289	2.55	22.9
	Mo 50ppm	3.87	0.336	2.58	24.2	3.80	0.302	2.60	23.8
	Fe 50ppm	3.96	0.361	2.40	23.5	3.72	0.393	2.45	23.3
	Fe 100ppm	3.97	0.350	2.48	24.8	3.95	0.365	2.51	24.7
With *B. circulans*	**Control**	3.55	0.251	2.40	22.2	3.61	0.256	2.47	22.6
	B 25ppm	3.98	0.263	2.57	23.0	3.75	0.267	2.64	23.4
	B 50ppm	3.99	0.256	2.65	24.9	3.89	0.295	2.69	24.3
	Mo 25ppm	3.87	0.236	2.58	24.2	3.76	0.313	2.60	23.5
	Mo 50ppm	4.01	0.330	2.65	25.1	3.85	0.305	2.64	24.1
	Fe 50ppm	3.92	0.353	2.49	24.5	3.96	0.324	2.49	24.8
	Fe 100ppm	4.03	0.339	2.55	25.2	3.99	0.328	2.57	24.9
LSD at 0.05 level		N.S.	0.028	N.S.	N.S.	N.S.	0.028	N.S.	N.S.

Table 8. Effect of *Bacillus circulans* and foliar spray with some microelements on root system of pea plants during 2010/2011season

Treatments	Root system					
	Root fresh weight (g)	Root dry weight (g)	Root volume (cm^3)	Root length (cm)	No. of nodules /plant	Dry weight of nodules (g)
Bacillus circulans						
Without	10.73	1.86	12.88	34.67	13.68	0.714
With *B. circulans*	14.08	2.23	23.77	35.20	14.89	0.868
LSD at 0.05 level	1.43	0.18	N.S	0.54	0.12	0.12
Microelements						
Control	7.75	1.36	16.90	29.15	9.64	0.520
B 25ppm	10.51	1.90	19.20	36.35	15.15	0.730
B 50ppm	12.57	2.24	21.33	36.85	16.83	0.855
Mo 25ppm	11.44	1.97	24.15	34.25	13.75	0.755
Mo 50ppm	13.48	2.13	25.50	34.40	14.96	0.840
Fe 50ppm	13.81	2.18	25.00	34.75	14.28	0.840
Fe 100ppm	17.28	2.53	27.70	38.80	15.37	0.998
LSD at 0.05 level	0.9	0.09	0.81	0.24	0.13	0.017

the above mentioned characters of root system. As for the effect of foliar spray with microelements, the same results in Table 8 show the effect of microelements on root system of pea plants, results show that, application of B, Mo or Fe increased the fresh and dry weight of root, main root length, root volume, number of nodules per plant and dry weight of nodules per plant. The highest values were recorded from the plants which were sprayed with B at 50ppm, Mo at 50 ppm or Fe at 100 ppm.

These results may be due to that boron is one of some elements, generally, considered essential for various plant development processes especially in vascular plants (Reguera *et al.*, 2010). The obtained results are agreeable with those reported Nour (2004) and Mehmood *et al.* (2011) on pea plants.

The results listed in Table 9 clearly show that the interaction between *Bacillus circulans* and foliar spray with microelements had significant effect on root system parameters expressed as fresh and dry weight of root per plant, main root length, root volume, number of nodules per plant and dry weight of nodules per plant, the interaction between *Bacillus circulans* and foliar spray with Mo at 50ppm, Fe at 100ppm or B at 50ppm gave the highest values of all root system parameters. On the other side, the interaction between without *Bacillus circulans* and control recorded the lowest values of all root system parameters.

Conclusion

From the previous results of this investigation, it could be concluded that inoculation of pea plants grown under sandy soil condition with *Bacillus circulans* and foliar spray with molybdenum at 50ppm or iron at 100ppm, three times at 30, 40 and 50 days after planting was sufficient to produce the highest vegetative growth parameters, yield and its components, chemical constituents of seeds and root system parameters.

Table 9. Effect of interaction between *Bacillus circulans* and foliar spray with some microelements on root system of pea plants during 2010/2011 season

Treatments		Root system					
		Root fresh weight (g)	Root dry weight (g)	Root volume (cm^3)	Root length (cm)	No. of nodules /plant	Dry weight of nodules (g)
B. circulans	Microelements						
Without *B. circulans*	Control	6.28	1.13	15.2	28.1	9.16	0.43
	B 25ppm	9.01	1.74	18.3	36.2	14.82	0.67
	B 50ppm	10.54	1.93	20.4	37.9	16.40	0.73
	Mo 25ppm	9.57	1.80	23.7	35.3	13.15	0.69
	Mo 50ppm	11.05	1.95	25.1	34.2	14.11	0.75
	Fe 50ppm	12.73	2.10	23.8	33.6	13.65	0.81
	Fe 100ppm	15.94	2.35	26.9	37.4	14.45	0.92
With *B. circulans*	Control	9.22	1.59	18.6	30.2	10.11	0.61
	B 25ppm	12.02	2.06	20.2	36.5	15.48	0.79
	B 50ppm	14.61	2.54	22.4	35.8	17.26	0.98
	Mo 25ppm	13.29	2.13	24.6	33.2	14.34	0.82
	Mo 50ppm	15.87	2.31	25.9	34.6	15.81	0.93
	Fe 50ppm	14.94	2.25	26.2	35.9	14.91	0.87
	Fe 100ppm	18.65	2.71	28.5	40.2	16.29	0.1.08
LSD at 0.05 level		1.30	0.12	1.13	0.34	0.18	0.024

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تأثير البكتريا الميسرة للبوتاسيوم والرش الورقى ببعض العناصر الصغرى على النمو والمحصول والجودة فى نباتات البسلة النامية تحت ظروف الأراضى الرملية

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أجريت تجربتان حقليتان خلال الموسم الشتوى لعامى ٢٠٠٩ / ٢٠١٠و ٢٠١٠ /٢٠١١ ، وذلك لدراسة تأثير التلقيح بالبكتريا الميسرة للبوتاسيوم (باسيللس سيركيولانس) وبدون التلقيح، والرش الورقى ببعض العناصر الصغرى (البورون والموليبدنم بتركيز ٢٥ ، ٥٠ جزء فى المليون من كل منهما ، والحديد بتركيز ٥٠ ، ١٠٠ جزء فى المليون بالإضافة إلي معاملة المقارنة) والتفاعل بينهما، على النمو، والوزن الجاف الكلى، والمحصول ومكوناته، والتركيب الكيماوى وكذلك قياسات المجموع الجذرى لنباتات البسلة صنف فيكتورى فريزرتحت ظروف الأراضى الرملية ، وقد أوضحت النتائج المتحصل عليها ما يلى : معاملة تلقيح نباتات البسلة بالبكتيريا الميسرة للبوتاسيوم سجلت أعلى القيم بالنسبة لارتفاع النبات، وعدد الأوراق/ نبات ، والوزن الجاف الكلى، وعدد البذور/قرن، والنسبة المئوية للتصافى، والوزن الطازج والجاف للجذور، وحجم الجذر، وطول الجذر الرئيسى، وعدد العقد البكتيرية/نبات، وكذلك محتوى البذور من الفوسفور بالمقارنة مع النباتات الغير معاملة (الكنترول)، كما أدى رش نباتات البسلة بكلا من الموليبدنم بتركيز ٥٠ جزء فى المليون أوالحديد بتركيز ١٠٠ جزء فى المليون إلى تسجيل أعلى القيم بالنسبة لصفات النمو الخضرى/نبات، وعدد القرون/نبات، ومحصول القرون الخضراء/نبات وكذلك للفدان، النسبة المئوية للتصافى، محتوى البذور من الفوسفور، الوزن الطازج والجاف للجذور، حجم الجذر وعدد العقد البكتيرية ووزنها الجاف/نبات، كما سجلت معاملة التفاعل بين التلقيح بالبكتيريا الميسرة للبوتاسيوم والرش الورقى بكلا من الموليبدنم بتركيز ٥٠ جزء فى المليون والحديد بتركيز ١٠٠ جزء فى المليون أعلى القيم بالنسبة لقياسات النمو الخضرى، والوزن الجاف الكلى/نبات، ومحصول القرون الخضراء/نبات وكذلك للفدان، والنسبة المئوية للتصافى، وأيضاً محتوى البذور من الفوسفور وقياسات المجموع الجذرى.