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Effect of Inoculation with Rhizobium, Plant Growth Promoting Rhizobacteria and Foliar Spraying with Boron and Molybdenum on Growth, Nodulation and Productivity of Faba Bean

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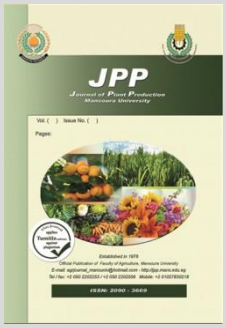

ABSTRACT

A field trial was conducted at El-Gemmeiza Agricultural Research Station Elgharbia Governorate, Egypt, during the two successive seasons of 2017/2018 and 2018/2019 to study the response of faba bean (*Vicia faba*) to inoculation with *Rhizobium leguminosarum*, rhizobacteria *Bacillus polymyxa* [as plant growth promoting rhizobacteria (PGPR)] either solely or in combination and foliar spraying of boron (B), molybdenum (Mo) either alone or in combination and their effect on nodulation, growth and productivity. Results could be summarized as follows: Inoculated faba bean plants with *Rhizobium leguminosarum* + *Bacillus polymyxa* obtained the maximum values of plant height, leaf area index, total dry matter plant^{-1}, crop growth rate, pods number plant^{-1}, seed yield plant^{-1}, 100-seed weight, seeds and straw yields/fad, as well as number and dry weight of nodules, total chlorophyll of leaves, phosphorus, nitrogen and protein of seeds. The foliar spraying of 30 ppm B + 15 ppm Mo on faba bean plants gave the maximum values for plant height, leaf area index, total dry matter plant^{-1}, crop growth rate, pods number plant^{-1}, seed yield plant^{-1}, 100-seed weight, seeds and straw yields/fad, as well as nodules number and dry weight, total chlorophyll of leaves, phosphorus, nitrogen and protein of seeds. inoculated faba bean plants with *Rhizobium leguminosarum* + *Bacillus polymyxa* plus foliar spraying by 30 ppm B + 15 ppm Mo obtained the highest values for all mentioned traits, such treatment increased seeds and straw yields as well as protein content of seeds by 42.92, 33.08 and 21.32%, respectively compared to control.

Keywords: Faba bean, inoculation, foliar spraying, PGPR, chlorophyll, phosphorus, and protein

INTRODUCTION

Legumes are used for a wide variety of purpose mainly as human food and animal feed. In addition, to being rich in protein (26.28%), legumes are also high in bone building minerals and vitamins essential for good health (FAO, 1984). Faba bean (*Vicia faba* L.) is one of the most important legume crops in Egypt. It is considered one of the basic sources of protein for the Egyptian diet with relatively low price. In addition, it has good role in enriching and improving chemical, physical and biological properties of the newly reclaimed soils. High yield production of faba bean is urgently needed to meet the increasing population and growing demand for protein food in Egypt.

Biological nitrogen fixation is considered the second important biological process after photosynthesis and it can contribute by about 40-48 million tons of N/year via agricultural crop. This process accomplishes in nature by few genera of prokaryotic organisms via their ownership genetic information to convert the di-nitrogen molecules to ammonia under mild temperature and normal atmospheric pressure. These nitrogen fixing organisms can fix atmospheric nitrogen through different systems, including free living, associative and symbiotic. Biological nitrogen fixation of *Rhizobium*-legume symbiosis considered the more efficient and important for agricultural environment, particularly sustainable agricultural systems (Jensen and Hauggaard, 2003).

Plant growth promoting Rhizobacteria (PGPR) is known as beneficial soil rhizospher to promote plant growth. *Bacillus Polymyxa*, which is now called *Paenibacillus polymyxa*, is a Gram-positive bacterium capable of fixing nitrogen. It is found in soil, plant roots, and marine sediments (Lai and Silvia, 2009). It has range of reported properties, including nitrogen fixation (Coelho *et al*., 2003; Cakmakci *et al*. 2006), phosphate solubilisation (De Freitas *et al*. 1997), cytokinin production (Timmusk *et al*., 2009) , and increased root and shoot growth (Sudha *et al*., 2009). *Bacillus Polymyxa* is used as a soil inoculant in agriculture and horticulture. Biofilms of *B. Polymyxa* on plant roots have been shown to produce exopolysaccharides which protect the plants from pathogens (Yegorenkova *et al*., 2013). Some strains of *B. Polymyxa* produce polymyxin antibiotic compounds (Shaheen *et al*., 2011). Co-inoculation of rhizobia with phosphate-solubilizing bacteria i.e. *Bacillus polymyxa* revealed a synergistic effect on symbiotic parameters such as increasing nodule number and plant biomass, which resulted in high grain yield of legumes (Saharan and Nehra, 2011).

In Egypt soils suffer from micronutrients deficiency especially after building Aswan Dam. Foliar application of

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micronutrients was found to be more effective than soil application (Alley *et al*., 1978).

Boron is an important micronutrient not only human life but also the animal and plant. The essential nature role of B still understood, the evidence given by scientists showed that it is essential for plant growth and important in cell division (Kamal and Abd AL-Gaid, 2008). Boron is effectiveness in biological regulation which involves enzyme and hormone system. Bolanos *et al*. (1996) reported that pea (*Pisum Sativum*) grown in B-deficient nodules the proportion of infected host cells was much lower than in nodules from plants supplied with normal quantities of B. Also, Molybdenium (Mo) play an important role in root nodules formation Rubes (1974) concluded that the application of Mo increased number of formed nodules on soybean roots. Hugar and Kurdikeri (2000-a) reported that foliar spray of Mo at the flowering stage of soybean plants resulted the highest yield, 100-seed weight and number of seeds per pod.

This investigation aimed to study the response of faba bean (Giza 716) to inoculation with *Rhizobium leguminosarum*, *Rhizobacteria* (*Bacillus polymyxa*) either solely or in combination and foliar spraying of born, molybdenum either alone or in combination and their effects on growth, nodulation, productivity and protein content of seeds.

MATERIALS AND METHODS

A field trail was conducted during the two successive winter growing seasons of 2017/2018 and 2018/2019 at El-Gemmeiza Agricultural Research Station Elgharbia Governorate, Egypt; to study the response of faba bean (*Vicia faba*) to inoculation with *Rhizobium leguminosarum*, *Rhizobacteria i.e. Bacillus polymyxa* [as plant growth promoting Rhizobacteria (PGPR)] either solely or in combination and foliar spraying of born, molybdenum either alone or in combination on growth, nodulation, productivity and protein (%) in seeds. Seeds of faba bean (Giza 716) were kindly provided by Leguminous Crop Research Department, Field Crop Research Institute, ARC, Giza, Egypt.

Microorganisms used:

Rhizobium leguminosarum bv. Viceae strain (ICARDA 441) was the most suitable for producing biological nitrogen fixation but Bacillus polymyxa strain was active in solubizing phosphate being 1.79 mg / 100 ml. These strains were supplied by Biofertilizer Production Unit, Soils, Water and Environment Research Institute, Agric. Res. Center (ARC), Giza, Egypt.

Inoculants preparation:

Rhizobium strain was cultured in yeast mannitol broth medium (Vincent, 1970), Bacillus polymyxa was grown in kings medium B (Atlas, 1995). All bacterial cultures were incubated at 28 ^{o}C for three days on a rotary shaker until early log phase was developed of 10^9 CFU/ml culture. Vermiculite supplemented with 10% pea Irish was packed into polyethylene bags (300 g carrier per bag) then sealed and sterilized with gamma irradiation (5.0 x 10^6 rads). Cultures were injected into the carrier to satisfy 60% of maximum water holding capacity.

The experiments were laid out in split plot design with four replicates. The main plots were occupied by inoculation treatments, while sub-plots contained the foliar spraying of born (B) at the concentration of 30 ppm and, molybdenum (Mo) at the concentration of 15 ppm. Each sub-plot was 10.5 m^2 (3 x 3.5) and included 5 ridges, 3.0 m long and 70 cm apart. The main physical and chemical properties of the experimental site in both growing seasons were analyzed according to Page *et al.*, (1982), and total microbial counts in the soil samples determined before sowing according to Bunt and Rovira (1955). Also, CO_2 evaluation (µg/g dry soil / hr.) was determined according to Pramer and Schmidt (1964). Such data of the soil analysis were recorded in Table 1.

Table 1. Mechanical and chemical analyses of the experimental site in both growing seasons 2017/2018 and 2018/2019.

Properties	seasons	
	2017/2018	2018/2019
Particle size distribution		
Coars sand (%)	1.60	1.50
Fine sand (%)	12.91	14.40
Silt (%)	37.23	35.90
Clay (%)	42.79	43.02
$CaCo_3$ (%)	3.90	3.20
Organic matter (%)	1.57	1.98
Texture	Silt clay loam	Silt clay loam
PH (1:2.5)	7.88	7.97
Available nutrients (ppm)		
N	33.00	35.00
P	8.00	8.80
K	420	440
B	0.10	0.12
Mo	0.08	0.09
Total microbial counts x 10^6 (CFU/g dry soil)	80.00	89.00
Co_2 evolution (µ/g dry soil/hr.)	18.40	21.41

The treatments are as follows:

1- Main plots (inoculation):

1- Uninoculated (control)
2- *Bacillus polymyxa* (*B. poly*.)
3- *Rhizobium leguminosarum* (*Rhizo*.)
4- Bacillus polymyxa + Rhizobium leguminosarum

II - Sub-plots (foliar spraying of B and Mo):

1- Spraying with water (control)
2- Spraying with 30 ppm of boron (B)
3- Spraying with 15 ppm of molybdenum (Mo)
4- Spraying with 30 ppm of B + 15 ppm Mo

Faba bean seeds (Giza 716) were sown on 12/11/2017 and 8/11/2018 in hills 20 cm apart and treated with different inoculants at the rate of 300 g / 35 kg seeds, prior to sowing using arabic gum solution (16%) as an adhesive agent and irrigated immediately after inoculation.

Foliar application of B and Mo treatments were sprayed two times, the first at 30 DAS and the second at 45 DAS. Boron was sprayed in the form of boric acid (30 ppm B), whereas molybdenum was sprayed in the form of ammonium molybdate (15 ppm Mo). The volume of water was one liter/plot, 0.5% wetting agent of tween 20 was used. Normal agricultural practices for faba bean production were done in both growing season at the proper time.

At 60 and 90 days after sowing (DAS), sample of five plants random uprooted from the outer ridges of the four replications and washed carefully with tap water, then plants were separated into their components i.e. roots,

leaves, stems and dried at 70 °C in a ventilated oven to a constant weight to determine the following traits:

1- Nodules number/plant at 60 and 90 DAS
2- Nodules dry weight (mg/plant) at 60 and 90 DAS
3- Total dry matter (TDM) (g/plant) at 60 and 90 DAS
4- Leaf area index (LAI) at 90 DAS.

To calculate leaf area/plant a disks for twenty leaves equal 40.19 cm^2 [$(0.8\ cm)^2$ x 3.14x20] were determine according to Watson (1952) as the following formula:

LA = 40.19 x dry weight of leaves per plant/dry weight of leaves disks

LAI = unit leaf area per plant/unit ground area occupied by plant

5- Crop growth rate (CGR) (60-90) DAS (g/m^2/day).

The following formula was used to determine CGR according to Watson (1952)

$$CGR = 1/\text{planting area } [(W_2-W_1) / (T_2-T_1)]$$

Where:

$w_2 - w_1$ = **differences in dry matter accumulation between two successive samples in grams.**

$t_2 - t_1$ = **the number of days between two successive samples in day.**

Harvesting took place 16/4/2018 and 13/4/2019 in the first and second seasons, respectively. At harvest ten guarded plants were randomly taken from central ridges in each sub-plot to determine:

1- Plant height (cm) 2- Branches number/plant
3- Pods number/plant 4- Seeds yield/plant (g)
5- 100-seed weight (g)

Seeds yield (ardb) and straw yield (ton)/feddan were calculated from central area (4.8 m^2) in each sub-plot to avoid the border effect.

Chemical composition:

Total chlorophyll of leaves:

At 90 days after sowing, leaves samples were taken to determined total chlorophyll content of leaves (mg/m^2) according to (Moran, 1982). Nitrogen, phosphorus and protein contents:

Mature seeds for the two growing seasons were subjected to determine N, P and protein % according to A.O.A.C. (1990).

Data were statistically analyzed according to Snedecor and Cochran (1980) and treatments means were compared by lest significant difference test (LSD) at 0.05 level of probability .Bartlett test was done according to Bartlett (1937) to test the homogeneity of error variances. The test was not significant for all assessed traits, so, the two season's data were combined. The discussions of the results were carried out on basis of combined analysis for the two seasons.

RESULTS AND DISCUSSION

1- Growth traits and growth analysis

Results of Tables 2&3 show the effect of inoculation for faba bean with *Rhizobium leguminosarum*, Rhizobacteria (*Bacillus polymyxa*) either solely or in combination and foliar spraying of boron (B), molybdenum (Mo) either alone or in combination on growth and growth analysis of faba been expressed as plant height, leaf area index (LAI), branches number/plant, total dry matter/plant (TDM) at 60 and 90 DAS as well as crop growth rate (CGR) (60-90 DAS). Results indicated that both factors under study had a significant effect on all growth and growth analysis traits.

Table 2. Response of faba bean to inoculation with *Rhizobium leguminosarum* and Rhizobacteria (*Bacillus polymyxa*) as well as foliar spraying of boron (B) and molybdenum (Mo) on plant height, leaf area index (LAI) and branches number $plant^{-1}$ in 2017/2018 and 2018/2019 seasons.

Inoculation	Foliar spraying of micronutrients	Plant height (cm)			LAI (90 DAS)			Branches number/plant		
		2017/18	2018/19	Comb.	2017/18	2018/19	Comb.	2017/18	2018/19	Comb.
Uninoculation (control)	Spraying water	98.40	110.70	104.55	4.44	5.01	4.73	2.96	4.23	3.60
	30 ppm (B)	106.10	116.10	111.10	5.02	5.62	5.32	3.86	5.04	4.45
	15 ppm (Mo)	104.90	114.50	109.70	4.74	5.39	5.07	3.51	4.75	4.13
	B + Mo	109.70	119.70	114.70	5.42	5.98	5.70	4.23	5.35	4.79
Mean		104.78	115.25	110.01	4.91	5.50	5.21	3.64	4.84	4.24
Bacillus polymyxa (B. poly.)	Spraying water	107.10	118.30	112.70	5.71	6.14	5.93	3.77	5.03	4.40
	30 ppm (B)	112.80	124.00	118.40	6.47	6.57	6.52	4.66	5.64	5.15
	15 ppm (Mo)	110.10	122.10	116.10	6.21	6.38	6.30	4.29	5.44	4.87
	B + Mo	114.90	125.20	120.05	6.61	6.65	6.63	5.09	5.95	5.52
Mean		111.23	122.40	116.81	6.25	6.44	6.35	4.45	5.52	4.99
Rhizobium leguminosarum (Rhizo.)	Spraying water	103.10	119.80	111.45	5.38	5.56	5.47	3.68	4.85	4.27
	30 ppm (B)	111.40	121.60	116.50	5.88	6.27	6.08	4.27	5.41	4.84
	15 ppm (Mo)	107.60	121.10	114.35	5.79	6.06	5.93	4.11	5.11	4.61
	B + Mo	116.80	123.50	120.15	6.05	6.67	6.36	4.65	5.71	5.18
Mean		109.73	121.50	115.61	5.78	6.14	5.96	4.18	5.27	4.73
Rhizo. + B.poly.	Spraying water	113.50	122.20	117.85	6.04	6.70	6.37	4.70	5.51	5.11
	30 ppm (B)	118.70	127.80	123.25	7.20	7.73	7.47	5.32	6.56	5.94
	15 ppm (Mo)	117.30	126.80	122.05	6.76	7.29	7.03	5.06	6.14	5.60
	B + Mo	120.60	129.30	124.95	7.64	8.33	7.99	5.51	6.79	6.15
Mean		117.53	126.53	122.03	6.91	7.51	7.22	5.15	6.25	5.70
General mean of foliar spray by micronutrients (M. n.)	Spraying water	105.53	117.75	111.64	5.39	5.86	5.63	3.78	4.91	4.35
	30 ppm (B)	112.25	122.38	117.31	6.14	6.55	6.35	4.53	5.66	5.10
	15 ppm (Mo)	109.98	121.13	115.55	5.88	6.28	6.08	4.24	5.36	4.80
	B + Mo	115.50	124.43	119.96	6.43	6.91	6.67	4.87	5.95	5.41
L.S.D 0.05	Inoculation	4.53	4.61	3.12	0.30	0.33	0.22	0.36	0.39	0.26
	M. n.	4.31	4.38	3.01	0.28	0.30	0.20	0.35	0.37	0.25
	Inoc. X M. n.	8.62	8.77	6.02	0.57	0.61	0.41	0.66	0.70	0.47

Table 3. Response of faba bean to inoculation with *Rhizobium leguminosarum* and rhizobacteria (*Bacillus polymyxa*) as well as foliar spraying of boron (B) and molybdenum (Mo) on total dry matter/plant (TDM) and crop growth rate (CGR) in 2017/2018 and 2018/2019 seasons.

Inoculation	Foliar spraying of micronutrients	Total dry matter (TDM) g/plant						CGR (60-90) DAS (g/m^2/day)		
		60 DAS			90 DAS					
		2017/18	2018/19	Comb.	2017/18	2018/19	Comb.	2017/18	2018/19	Comb.
Uninoculation (control)	Spraying water	8.33	11.12	9.73	29.04	34.72	31.88	4.93	5.62	5.28
	30 ppm (B)	9.92	12.78	11.35	34.33	38.39	36.36	5.81	6.10	5.96
	15 ppm (Mo)	9.38	11.87	10.63	32.51	36.30	34.41	5.51	5.81	5.66
	B + Mo	10.75	13.41	12.08	35.63	40.86	38.25	5.92	6.53	6.23
Mean		9.60	12.30	10.95	32.88	37.57	35.23	5.54	6.02	5.78
Bacillus polymyxa (B. poly.)	Spraying water	12.18	13.34	12.76	36.68	41.58	39.13	5.83	6.72	6.28
	30 ppm (B)	13.99	16.80	15.40	41.50	46.36	43.93	6.55	7.03	6.79
	15 ppm (Mo)	13.52	15.58	14.55	40.82	44.54	42.68	6.50	6.90	6.70
	B + Mo	14.45	17.68	16.07	42.60	49.62	46.11	6.70	7.60	7.15
Mean		13.54	15.85	14.70	40.40	45.53	42.96	6.40	7.06	6.73
Rhizobium leguminosarum (Rhizo.)	Spraying water	11.38	13.04	12.21	35.47	38.91	37.19	5.73	6.16	5.95
	30 ppm (B)	14.49	15.77	15.13	39.68	42.79	41.24	5.99	6.43	6.21
	15 ppm (Mo)	13.77	14.95	14.36	37.33	41.65	39.49	5.61	6.35	5.98
	B + Mo	15.31	16.94	16.13	43.38	46.59	44.99	6.68	7.06	6.87
Mean		13.73	15.18	14.46	38.97	42.49	40.73	6.00	6.50	6.25
Rhizo. + B.poly.	Spraying water	13.68	15.81	14.75	40.95	46.15	43.55	6.49	7.22	6.86
	30 ppm (B)	15.74	18.71	17.23	44.97	52.23	48.60	6.95	7.98	7.47
	15 ppm (Mo)	15.28	17.12	16.20	43.45	49.63	46.54	6.71	7.74	7.23
	B + Mo	17.18	20.18	18.68	46.59	55.70	51.15	7.00	8.45	7.73
Mean		15.47	17.96	16.72	43.99	50.93	47.46	6.79	7.85	7.31
General mean of foliar spray by micronutrients (M.n.)	Spraying water	11.39	13.33	12.36	35.54	40.34	37.94	5.75	6.43	6.09
	30 ppm (B)	13.54	16.02	14.78	40.12	44.94	42.53	6.33	6.89	6.61
	15 ppm (Mo)	12.99	14.88	13.94	38.53	43.03	40.78	6.08	6.70	6.39
	B + Mo	14.42	17.05	15.74	42.05	48.19	45.13	6.58	7.41	6.99
LSD 0.05	Inoculation	0.87	0.82	0.58	2.60	2.55	1.78	0.44	0.41	0.30
	M. n.	0.83	0.78	0.57	2.48	2.43	1.70	0.42	0.90	0.28
	Inoc.X M. n.	1.56	1.49	1.06	4.75	4.63	3.21	0.79	0.73	0.53

The maximum values of all growth characters were obtained from inoculated plants with *Rhizobium leguminosarum* plus *B. polymyxa* followed by inoculated plants by *B. polymyxa* alone with a significant difference between such two treatments. These results due to a high proportion of rhizobacteria (*B. polymyxa*) are capable to exhibit the plant growth hormone (i.e, indole acetic acid), which acts to stimulate root growth and provides it with more branching and larger surface area. Many investigators consider the indole secretion by PGPRs, as vital mechanism to clarity the plant promotion (Verma *et al*., 2010 and Badawi *et al*., 2011).

Glick, 1995 reported that plant growth promoting Rhizobacteria (PGPR) i.e. Bacillus sp. are a heterogeneous group of bacteria that can be found in the rhizosphere, at root surfaces and in association with roots, which can improve the extent or quality of plant growth and/or indirectly. It could be observed that the lowest values of such characters were gained when faba bean plants uninoculated with microorganisms (control).

Concerning the effect of foliar spraying with boron (B), molybdenum (Mo) either solely or in combination on all growth and growth analysis traits of faba bean under study recorded a significant effect i.e. plant height, leaf area index (LAI), branches number/plant, total dry matter/plant (TDM) at 60 and 90 DAS as well as crop growth rate (CGR) at (60-90 DAS). The highest values of all such growth and growth analysis traits were scored from spraying plants by (30 ppm B + 15 ppm Mo) followed by foliar spraying of (B) only with significant difference between such two treatment on all growth and growth analysis traits except plant height trait. Such increment may be attributed to the effectiveness of B in the biological regulation which involves in enzyme and hormone system (Khattab *et al*., 2016), in addition Mo had a great effect on nitrogenase activity, which plays the main role in transforming N_2 to NH_3 (Pate and Atkins, 1983). In this connection Abdel-Aziz and El-Shafie (2005) reported that the foliar spraying of 30 ppm B+ 15 ppm Mo on soybean plants significantly increased plant height, branches number/plant, leaf area index and crop growth rate (CGR) at the first period compared with control.

The interaction between co-inoculation microorganisms used and foliar spraying of B and Mo was found to be significant on all growth and growth analysis traits under study. The maximum values of plant height, leaf area index (LAI), branches number/plant, total dry matter/plant (TDM) at 60 and 90 DAS and crop growth rate (CGR) were obtained when faba bean received inoculation with *Rhizo. + B. poly*. and foliar spraying with B+Mo.

2- Yield and yield components

Data in Tables 4&5 show that inoculated faba bean plants with *Rhizobium leguminosarum*, rhizobacteria (*Bacillus polymyxa*) either alone or in combination resulted significant effects on pods number $plant^{-1}$, seed yield $plant^{-1}$, 100-seed weight, seeds and straw yields /fed. The highest values of such traits were scored from inoculated plants with *Rhizo. + B. poly*. (31.15, 79.03 g, 96.51 g, 13.01 ard. and 3.28 ton, respectively) followed by inoculation with *B. poly*. only with significant difference between such two treatments, except 100-seed weight which recorded

insignificant difference. It is worthy to mention that inoculated faba bean plants with *Rhizo. + B. poly.* increased seeds and straw yields by 24.85 and 15.49 %, respectively compared to uninoculated plants (control). Dileep Kumar *et al*., 2001; Garcia *et al*., 2004 and Abdel-Wahab *et al*., 2006 explained such finding to co-inoculation of legumes with rhizobia and rhizobacteria can improve nodulation, plant growth resulting in increasing the productivity and quality of yield. EL-Shaboury and Abo El-Ela (2015) explained the same results on soybean plant that, the synergistic effect of Rhizobacteria on soybean yield may be elucidated by their ability to enhance the nodulation development, nitrogen fixation performance and nutrients availability uptake from soil such as phosphorus and micronutrients, which resulted in various mechanisms mainly the production of substances like hormones, siderophores, phosphate solubilization and improvement nutrients and water uptake by increasing the root proliferation, which leading to high seed yield of soybean. In this respect Yadegari and Asadi Rahmani (2010) found that co-inoculation strains with *Pseudomonas fluorescence* as PGRP (plant growth promoting Rhizobacteria) gave the highest number of seed pods^{-1}, number of pods plant^{-1}, 100-seed weight and seed yield fad^{-1} of bean (*Phaseolus vulgaris*). Also, Nassef *et al*. (2005) found that, triple inoculation of faba bean by *Rhizobium leguminosarum + Pseudomonas fluoresces + Herbaspirillum* increased straw and seed yields.

Regarding the effect of foliar spraying by boron (B), molybdenum (Mo) either alone or in combination on yield and its components, data in Tables 4&5 show that pods number plant^{-1}, seed yield plant^{-1} as well as seeds and straw yields recorded significant effect. The highest values of such traits were obtained from spraying faba bean plants by 30 ppm B + 15 ppm Mo i.e. 29.71, 76.03 g, 95.20 g, 12.73 ard./fed and 3.26 ton/fed, respectively, followed by spraying plants with 30 ppm B alone with significant difference between such two treatments with respect to seeds and straw yields. It can be observed that the foliar spraying of B+ Mo increased seeds and straw yields by 15.20 and 12.41 %, respectively compared to plants sprayed with water (control). It is interesting to mention that the increase of yield and yield components resulting from foliar spraying by B, Mo and B +Mo could be arrange as the following descending order B + Mo > B > Mo > control. These results due to the role of B and Mo, where, Shil *et al.* (2007) explained such role, that molybdenum is required for the formation of nitrate reductase enzyme in the legumes plants and it plays an additional role in symbiotic nitrogen fixation, that nitrogen fixing enzyme, nitrogenase is composed of molybdenum and iron without adequate quantities of these elements, nitrogen fixation can not occur.

Table 4. Response of faba bean to inoculation with *Rhizobium leguminosarum* and rhizobacteria (*Bacillus polymyxa*) as well as foliar spraying of boron (B) and molybdenum (Mo) on pods number/plant, seed yield/plant and 100-seed weight in 2017/2018 and 2018/2019 seasons.

Inoculation	Foliar spraying of micronutrients	Pods number/plant			Seed yield/plant (g)			100-seed weight (g)		
		2017/18	2018/19	Comb.	2017/18	2018/19	Comb.	2017/18	2018/19	Comb.
Uninoculation (control)	Spraying water	20.42	24.55	22.49	55.62	68.18	61.90	82.22	84.77	83.50
	30 ppm (B)	23.56	27.22	25.39	61.36	74.76	68.06	86.40	88.13	87.27
	15 ppm (Mo)	22.09	25.88	23.99	59.13	71.02	65.08	84.07	86.12	85.10
	B + Mo	24.88	28.72	26.80	63.61	76.45	70.03	88.34	89.90	89.12
Mean		22.74	26.59	24.67	59.93	72.60	66.27	85.26	87.23	86.25
Bacillus polymyxa (B. poly.)	Spraying water	22.48	30.32	26.40	62.09	79.87	70.98	89.93	92.17	91.05
	30 ppm (B)	26.82	32.35	29.59	67.15	82.57	74.86	94.21	97.28	95.75
	15 ppm (Mo)	24.16	31.84	28.00	65.79	81.49	73.64	92.20	95.69	93.95
	B + Mo	27.16	33.43	30.30	71.32	84.45	77.89	96.28	99.84	98.06
Mean		25.16	31.99	28.57	66.59	82.10	74.34	93.16	96.25	94.70
Rhizobium leguminosarum (Rhizo.)	Spraying water	21.97	28.67	25.32	61.15	76.80	68.98	84.32	87.06	85.69
	30 ppm (B)	24.34	30.63	27.49	65.52	80.10	72.81	91.71	94.51	93.11
	15 ppm (Mo)	23.73	29.50	26.62	63.57	78.09	70.83	87.38	90.76	89.07
	B + Mo	26.82	31.02	28.92	67.29	81.66	74.48	94.01	96.10	95.05
Mean		24.22	29.96	27.09	64.38	79.16	71.77	89.36	92.11	90.73
Rhizo. + B.poly.	Spraying water	25.30	33.24	29.27	68.17	84.53	76.35	93.07	95.49	94.28
	30 ppm (B)	28.56	34.89	31.73	73.23	86.44	79.84	95.21	99.63	97.42
	15 ppm (Mo)	27.30	34.21	30.76	70.62	85.90	78.26	94.38	97.08	95.73
	B + Mo	30.46	35.20	32.83	75.95	87.45	81.70	96.76	100.41	98.59
Mean		27.91	34.39	31.15	71.99	86.08	79.03	94.86	98.15	96.51
General mean of foliar spray by micronutrients (M.n.)	Spraying water	22.54	29.20	25.87	61.76	77.35	69.55	87.39	89.87	88.63
	30 ppm (B)	25.82	31.27	28.55	66.82	80.97	73.89	91.88	94.89	93.38
	15 ppm (Mo)	24.32	30.36	27.34	64.78	79.13	71.95	89.51	92.41	90.96
	B + Mo	27.33	32.09	29.71	69.54	82.50	76.03	93.85	96.56	95.20
LSD 0.05	Inoculation	1.71	1.68	1.18	4.46	4.38	3.05	5.14	5.02	3.08
	M. n.	1.70	1.63	1.17	4.37	4.32	3.03	5.09	4.95	3.02
	Inoc.X M. n.	3.31	3.26	2.33	7.00	6.83	4.75	NS	NS	NS

Table 5. Response of faba bean to inoculation with *rhizobium leguminosarum* and rhizobacteria (*Bacillus polymyxa*) as well as foliar spraying of boron (B) and molybdenum (Mo) on seed yield and straw yield in 2017/2018 and 2018/2019 seasons.

Inoculation	Foliar spraying of micronutrients	Seed yield (ard/fad)			Straw yield (ton/fad)		
		2017/18	2018/19	Comb.	2017/18	2018/19	Comb.
Uninoculation (control)	Spraying water	8.90	10.58	9.74	2.65	2.60	2.63
	30 ppm (B)	10.19	11.19	10.69	2.81	2.98	2.90
	15 ppm (Mo)	9.42	10.94	10.18	2.71	2.80	2.76
	B + Mo	10.64	11.45	11.05	3.00	3.13	3.07
Mean		9.79	11.04	10.42	2.79	2.88	2.84
Bacillus polymyxa (B. poly.)	Spraying water	10.73	11.96	11.35	3.04	2.96	3.00
	30 ppm (B)	11.73	13.43	12.58	3.18	3.20	3.19
	15 ppm (Mo)	11.41	12.34	11.88	3.12	3.02	3.07
	B + Mo	12.27	14.16	13.22	3.27	3.32	3.30
Mean		11.54	12.97	12.26	3.15	3.13	3.14
Rhizobium leguminosarum (Rhizo.)	Spraying water	10.24	11.59	10.92	2.86	2.89	2.88
	30 ppm (B)	11.37	12.73	12.05	2.95	3.13	3.04
	15 ppm (Mo)	10.84	12.30	11.57	2.94	2.98	2.96
	B + Mo	12.03	13.41	12.72	3.11	3.23	3.17
Mean		11.12	12.51	11.82	2.97	3.06	3.01
Rhizo. + B.poly.	Spraying water	11.61	12.77	12.19	3.06	3.11	3.09
	30 ppm (B)	12.45	13.81	13.13	3.26	3.40	3.33
	15 ppm (Mo)	12.17	13.39	12.78	3.15	3.24	3.20
	B + Mo	12.67	15.17	13.92	3.44	3.55	3.50
Mean		12.23	13.79	13.01	3.23	3.33	3.28
General mean of foliar spray by micronutrients (M. n.)	Spraying water	10.37	11.72	11.05	2.90	2.89	2.90
	30 ppm (B)	11.44	12.79	12.11	3.05	3.18	3.12
	15 ppm (Mo)	10.96	12.24	11.60	2.98	3.01	3.00
	B + Mo	11.90	13.55	12.73	3.21	3.31	3.26
LSD 0.05	Inoculation	0.65	0.63	0.41	0.16	0.19	0.13
	M. n.	0.62	0.60	0.43	0.14	0.17	0.11
	Inoc. X M. n.	1.17	1.19	0.85	0.29	0.34	0.17

Also, boron is very important in cell division as well as pod and seed formation. The same investigators (Shil *et al.*, 2007), found that on chickpea plants, the combined application of Mo and B was found superior than the single applications, which contributed to 30-50% yield increase over control. In addition, Abdel-Aziz and El-Shafie (2005) concluded that the maximum values of number and weight of pods/plant, 100-seed weight, straw and seed yields fad^{-1} of soybean plants were gained when plants sprayed with 30 ppm B + 15 ppm Mo.

The interaction effect between inoculation by *Rhizo.*, *B. poly*., foliar spraying of boron (B) and molybdenum (Mo) on yields and its components was found to be significant except 100-seed weight traits. The highest values of pods number plant^{-1}, seed yield plant^{-1}, 100-seed weight, seed yields fad^{-1} and straw, 32.83, 81.70 g, 98.59 g, 13.92 ard./fed and 3.50 ton/fed, respectively, were obtained when plants received inoculation with *Rhizo. +B. poly*. plus foliar spraying with 30 ppm B + 15 ppm Mo. It's worthy to mention that seeds and straw yields were increased by 42.92 and 33.08 %, respectively when plants treated with *Rhizo. + B.Poly*. plus foliar application with B + Mo compared to untreated plants (spraying with water) (control).

3- Faba bean nodulation

Number and dry weight of root nodules plant^{-1} at 60 and 90 day from sowing as affected by microorganisms' inoculation are shown in Table 6. Results show that number and dry weight of nodules plant^{-1} were increased with advancing faba bean plants in age (from 60 up to 90 day after sowing). Number and dry weight of nodules plant^{-1} at 60 and 90 DAS were significantly affected by inoculated faba bean plants by *Rhizobium leguminosarum* and *Bacillus polymyxa* either solely or in combination. The maximum values of number and dry weight of nodules at 60 and 90 DAS were obtained from plants received inoculated by *Rhizo, + B. poly*. followed by inoculated plants by *B. poly*. alone with significant difference between such two traits except nodules number plant^{-1} at 60 DAS which recorded insignificant difference between such two traits. In this connection Deshwal, *et al*. (2003) reported that *rhizobia* are known to increase nodulation and nodule dry weight in legumes along with increase in host plant growth and development. Also, Abo EL-Soud, *et al*. (2003) reported that, inoculated faba bean plants by *Rhizobium leguminosarum* + *Bacillus megatherium* + *Aztobacter chroocoum* recorded significant increases in nodules number and dry weight compared to the other inoculation treatments. Nassef, *et al.* (2005) reported that triple inoculation of faba bean with (*Rhizobium leguminosarium* + *Pseudomonas fluoresces* + *Herbaspirillum*) caused significant increases in nodules number and dry weight compared to the alone inoculation with *Rhizobium*.

As for the effect of foliar spraying by B or Mo alone or in combination B + Mo data presented in Table 6 show that nodules number and dry weight at 60 and 90 DAS recorded significant effect. The maximum values of such traits at 60 and 90 DAS were obtained when faba bean plants sprayed with B + Mo followed by spraying B alone with insignificant difference between such two treatments. There results due to the role of B and Mo which reported by Riad, H. Fardoos and Ali (2001) on soybean plant, that the increased of number and dry weight

of nodules was more when mixture of B + Mo was used compared with B or Mo or control treatments. These results may prove that the presence of B with Mo is important for the improvements of soybean productivity, they added, such finding may attributed to that boron is closely associated with cell division in meristematic tissues and controls the enzymatic system which reflected on soybean production. Also, Mo is essential for the soil microorganisms including rhizobia which increase nitrogen supply, fixed by high number of root nodules which required for soybean production. Abdel-Aziz and El-Shafie (2005) found that foliar spraying of B +Mo gave the highest values of nodules number and dry weight at 65 and 90 DAS of soybean plants over using B or Mo alone and control.

Table 6. Response of faba bean to inoculation with *Rhizobium leguminosarum* and rhizobacteria (*Bacillus polymyxa*) as well as foliar spraying of boron (B) and molybdenum (Mo) on number and dry weight of nodules/plant at 60 and 90 days after sowing (DAS) in 2017/2018 and 2018/2019 seasons.

Inoculation	Foliar spraying of micronutrients	Nodules No./plant						Nodules dry weight/plant (mg)					
		60 DAS			90 DAS			60 DAS			90 DAS		
		2017/18	2018/19	Comb.	2017/18	2018/19	Comb.	2017/18	2018/19	Comb.	2017/18	2018/19	Comb.
Uninoculation (control)	Spraying water	62.00	69.20	65.60	86.50	98.00	92.25	172.58	206.92	189.75	271.92	307.67	289.80
	30 ppm (B)	66.50	74.00	70.25	96.60	108.50	102.55	201.40	226.50	213.95	294.58	336.17	315.38
	15 ppm (Mo)	65.10	71.30	68.20	91.80	106.20	99.00	191.08	217.67	204.38	286.65	326.10	306.38
	B + Mo	67.90	76.10	72.00	100.60	112.30	106.45	213.33	238.75	226.04	310.00	347.33	328.67
Mean		65.38	72.65	69.01	93.88	106.25	100.06	194.60	222.46	208.53	290.79	329.32	310.05
Bacillus polymyxa (B. poly.)	Spraying water	70.80	75.20	73.00	108.40	123.40	115.90	226.83	249.50	238.17	334.67	359.05	346.86
	30 ppm (B)	75.30	82.70	79.00	118.80	132.20	125.50	241.17	260.67	250.92	362.50	377.93	370.22
	15 ppm (Mo)	73.90	79.60	76.75	115.20	130.50	122.85	233.00	257.37	245.19	355.33	374.73	365.03
	B + Mo	80.40	85.80	83.10	123.80	138.40	131.10	245.17	269.25	257.21	370.50	382.33	376.42
Mean		75.08	80.83	77.96	116.55	131.13	123.84	236.54	259.20	247.87	355.75	373.51	364.63
Rhizobium leguminosarum (Rhizo.)	Spraying water	68.30	74.30	71.30	101.70	119.30	110.50	219.00	245.00	232.00	319.17	343.73	331.45
	30 ppm (B)	74.00	80.20	77.10	115.90	132.10	124.00	233.50	256.20	244.85	337.50	370.90	354.20
	15 ppm (Mo)	72.70	78.50	75.60	111.80	128.40	120.10	228.18	253.17	240.68	331.83	369.00	350.42
	B + Mo	76.70	82.60	79.65	122.00	134.20	128.10	238.88	266.67	252.78	359.88	373.67	366.78
Mean		72.93	78.90	75.91	112.85	128.50	120.68	229.89	255.26	242.58	337.10	364.33	350.71
Rhizo. + B.poly.	Spraying water	75.00	78.50	76.75	121.30	132.80	127.05	247.36	277.50	262.44	360.00	380.40	370.20
	30 ppm (B)	77.50	85.20	81.35	130.00	142.20	136.10	260.13	291.17	275.65	377.08	412.53	394.81
	15 ppm (Mo)	76.70	83.10	79.90	127.40	140.90	134.15	254.68	286.00	270.34	373.42	400.80	387.11
	B + Mo	79.80	91.10	85.45	134.20	147.10	140.65	275.63	308.08	291.86	382.00	436.67	409.34
Mean		77.25	84.48	80.86	128.23	140.75	134.49	259.46	290.69	275.07	373.13	407.60	390.37
General mean of foliar spray by micronutrients (M.n.)	Spraying water	69.03	74.30	71.66	104.48	118.38	111.43	216.45	244.73	230.59	321.44	347.71	334.58
	30 ppm (B)	73.33	80.53	76.93	115.33	128.75	122.04	234.05	258.64	246.34	342.92	374.38	358.65
	15 ppm (Mo)	72.10	78.13	75.11	111.55	126.50	119.03	226.74	253.55	240.15	336.81	367.66	352.24
	B + Mo	76.20	83.90	80.05	120.15	133.00	126.58	243.25	270.69	256.97	355.60	385.00	370.30
LSD 0.05	Inoculation	6.23	5.92	4.25	12.08	12.59	8.63	20.84	20.29	14.39	22.12	21.61	15.29
	M. n.	5.80	5.59	4.00	11.84	12.34	8.46	20.52	19.95	14.16	21.86	21.35	15.09
	Inoc.X M. n.	11.65	11.38	7.89	NS	22.16	16.35	19.22	NS	28.27	23.10	NS	30.19

Concerning the interaction effect between inoculation with *Rhizo., B. poly*. and foliar spraying of B and Mo on faba bean number and dry weight of nodules plant^{-1} at 60 and 90 DAS, data in Table 6 show that such traits were recorded a significant effect. The maximum values for number and dry weight of nodules plant^{-1} at 60 and 90 DAS were obtained when faba bean plants treated with *Rhizo. + B. poly*. plus foliar spraying by B + Mo.

4- Chemical composition

Table 7 show total chlorophyll of leaves as well as P, N and protein content of seeds.

a- Total chlorophyll of leaves

Results in Table 7 indicated that the total chlorophyll of leaves at 90 DAS in (mg m^{-2}) recorded a significant effect when faba bean plants inoculated by *Rhizobium leguminosarum* and *Bacillus polymyxa*. The maximum value for total chlorophyll of leaves was scored from inoculated plants with *Rhizo. + B. poly*., (24.42 mg m^{-2}) followed by plants received inoculation with *B. poly*. only (22.51 mg/m^2) with a significant difference between such two treatments. In this respect, El-Sayed *et al*. (2015) found that on faba bean plant, co-inoculation with (*Rhizobium leguminosarum* + *Pseudomonas fluorescence*) increased chlorophyll content of leaves. Also, EL-Nahrawy and Omara (2017) reported that inoculation of common bean with *Rhizobium* plus *Pseudomonas* spp. increased chlorophyll content of leaves compared to those inoculated with *Rhizobium* alone.

As for the effect of foliar spraying of B and Mo on total chlorophyll of leaves, Table 7 show a significant effect on such trait. The maximum value of such trait (23.17 mg m^{-2}) was scored when faba bean plants sprayed by 30 ppm B + 15 ppm Mo followed by spraying with 30 ppm B only (22.47 mg m^{-2}) with significant difference between such two treatments. These findings stand with those of Hemantaranjan *et al*. (2000) who found that spraying soybean plants with 50 ppm B increased chlorophyll b content of leaves than using 100 ppm B. In addition, Abdel-Aziz and El-Shafie (2005) reported that, spraying soybean plants with mixture of B + Mo increased total chlorophyll of leaves by about 23%, 8% and 13% compared to control, B and Mo treatments, respectively. Such results due to the stimulative effect of B and Mo on chlorophyll formation.

Table 7. Response of faba bean to inoculation with *Rhizobium leguminosarum* and rhizobacteria (*Bacillus Polymyxa*) as well as foliar spraying of boron (B) and molybdenum (Mo) on nitrogen, phosphorus and protein of seeds % as well as total chlorophyll of leaves in 2017/2018 and 2018/2019 seasons.

Inoculation	Foliar spraying of micronutrients	Nitrogen % of seeds			Phosphorus % of seeds			Protein % of seeds			Total chlorophyll of leaves at 90 DAS (mg/m^2)		
		2017/18	2018/19	Comb.	2017/18	2018/19	Comb.	2017/18	2018/19	Comb.	2017/18	2018/19	Comb.
Uninoculation (control)	Spraying water	4.17	4.13	4.15	0.299	0.276	0.288	26.06	25.81	25.94	15.97	19.85	17.91
	30 ppm (B)	4.30	4.44	4.37	0.464	0.438	0.451	26.88	27.75	27.32	18.19	21.35	19.77
	15 ppm (Mo)	4.19	4.37	4.28	0.444	0.404	0.424	26.19	27.31	26.75	17.37	20.60	18.99
	B + Mo	4.42	4.52	4.47	0.497	0.441	0.469	27.63	28.25	27.94	19.00	22.32	20.66
Mean		4.27	4.37	4.32	0.426	0.390	0.408	26.69	27.28	26.99	17.63	21.03	19.33
Bacillus polymyxa (B. poly.)	Spraying water	4.37	4.44	4.41	0.503	0.474	0.489	27.31	27.75	27.53	19.67	22.28	20.98
	30 ppm (B)	4.56	4.68	4.62	0.576	0.542	0.559	28.50	29.25	28.88	21.45	24.51	22.98
	15 ppm (Mo)	4.43	4.59	4.51	0.531	0.502	0.517	27.69	28.69	28.19	20.97	23.73	22.35
	B + Mo	4.68	4.90	4.79	0.615	0.593	0.604	29.25	30.63	29.94	22.35	25.08	23.72
Mean		4.51	4.65	4.58	0.556	0.528	0.542	28.19	29.08	28.64	21.11	23.90	22.51
Rhizobium leguminosarum (Rhizo.)	Spraying water	4.22	4.45	4.34	0.469	0.404	0.437	26.38	27.81	27.10	18.61	20.81	19.71
	30 ppm (B)	4.43	4.58	4.51	0.518	0.475	0.497	27.69	28.63	28.16	20.68	23.66	22.17
	15 ppm (Mo)	4.33	4.52	4.43	0.484	0.430	0.457	27.06	28.25	27.66	20.02	23.10	21.56
	B + Mo	4.58	4.70	4.64	0.545	0.502	0.524	28.63	29.38	29.01	21.72	23.68	22.70
Mean		4.39	4.56	4.48	0.504	0.453	0.479	27.44	25.52	27.98	20.26	22.82	21.54
Rhizo. + B.poly.	Spraying water	4.68	4.83	4.76	0.578	0.537	0.558	29.25	30.19	29.72	21.28	24.66	22.97
	30 ppm (B)	4.85	5.00	4.93	0.602	0.586	0.594	30.31	31.25	30.78	23.19	26.70	24.95
	15 ppm (Mo)	4.76	4.93	4.85	0.600	0.566	0.583	29.75	30.81	30.28	22.55	25.81	24.18
	B + Mo	4.93	5.14	5.04	0.643	0.606	0.625	30.81	32.13	31.47	23.81	27.36	25.59
Mean		4.81	4.98	4.90	0.606	0.574	0.590	30.03	31.10	30.56	22.71	26.13	24.42
General mean of foliar spray by micronutrients (M.n.)	Spraying water	4.36	4.46	4.42	0.462	0.423	0.443	27.25	27.89	27.57	18.88	21.90	20.39
	30 ppm (B)	4.54	4.68	4.61	0.540	0.510	0.525	28.35	29.22	28.79	20.88	24.06	22.47
	15 ppm (Mo)	4.43	4.60	4.52	0.515	0.476	0.495	27.67	28.77	28.22	20.23	23.31	21.77
	B + Mo	4.65	4.82	4.74	0.575	0.536	0.556	29.08	30.10	29.59	21.72	24.61	23.17
LSD 0.05	Inoculation	0.16	0.15	0.11	0.310	0.032	0.022	1.01	0.98	0.68	0.92	0.90	0.65
	M. n.	0.15	0.13	0.10	0.033	0.034	0.223	1.05	0.92	0.63	0.83	0.84	0.57
	Inoc.X M. n.	0.25	0.23	0.17	0.042	0.060	0.045	1.85	1.89	1.30	1.71	1.68	1.18

The interaction effect between inoculations with *Rhizo.*, *B. poly*., foliar application of boron (B) and molybdenum (Mo) on total chlorophyll of leaves recorded a significant effect. The maximum value (25.59 mg m^{-2}) was obtained when faba bean plant inoculated with *Rhizo. + B. poly*. plus foliar application by 30 ppm B + 15 ppm Mo.

b- Phosphorus nitrogen and protein of seeds (%)

Table 7 show the P, N and protein contents of faba bean seeds. Results of inoculated faba bean plants with *Rhizobium leguminosarum*, *Rhizobacteria* (*B. poly*.) either alone or combination recorded a significant effects on P, N and protein contents of seeds. The highest values of the previous characters were scored from inoculated plants with *Rhizo. + B. poly*. (0.590, 4.90 and 30.56%, respectively) followed by inoculation of *B. poly*. only with significant difference between such two treatments. In addition, inoculated faba bean plants with *Rhizo. + B. poly*. increased protein content of seeds by 13.23% compared to uninoculated plants (control). In this connection, Dashadi *et al.*(2011) on faba bean plant found that co-inoculation of *Rhizobium* + *Azotobacter* increased total nitrogen content. In addition, Abo El-Soud *et al*. (2003) concluded that on faba bean plants, triple inoculation with *Rhizobium leguminosarum* + *Bacillus megatherium* + *Azotobacter chroococcum* recorded significant increase in N-content of shoots compared to the other inoculated treatment. They added, inoculated plants with *Rhizobium leguminosarum* only obtained the maximum value of shoots P-content. Dashti *et al*. (1998) explained such finding that the increase in dry matter and nitrogen content of co-inoculated plants may be attributed to increased nodulation, higher N_2-fixation and improvement of root development under field conditions. Also, Gyaneshwar *et al*. (2002) reported that plant growth promoting *Rhizobacteria* (PGPR) can increase P availability to plants through solubilizing insoluble phosphates and this may improve biological nitrogen fixation and availability of other nutrients. Jia *et al.* (2004) found that inoculated faba bean plant by *Rhizobium* had positive effects on P and N accumulation. Yadegari and Asadi Rahmani (2010) found that on bean (*Phaseolus volugaris*) the co-inoculation of *Rhizobium phaseolia* plus plant growth promoting *Rhizobacteria* (PGPR) (*P. fluoresces*) gave the highest seed protein yield.

Concerning the effect of foliar application by boron (B), molybdenum (Mo) either alone or in combination on phosphorus, nitrogen and protein % of seeds, results in Table 7 show a significant effects were recorded for such three traits. The maximum values of P, N and protein % of seeds were recorded when faba bean plants sprayed by 30 ppm B + 15 ppm Mo (0.556, 4.74 and 29.59%), respectively followed by treated plants by 30 ppm B alone with significant difference between such two treatments. Valenciano *et al.* (2011) explained such finding, that the interaction between B and Mo, interpreted as indicating that Mo can counteract the effect of B application. In this connection, Riad Fardoos and Ali (2001); Abdel-Aziz and El-Shafie (2005) found that on soybean plants the foliar spraying of (B + Mo) increased protein content of seeds.

The interaction effect between the two studied factors i.e. inoculation with microorganisms and foliar spray by B and Mo on P, N and protein content of faba bean seeds were found to be significant on such three traits. The maximum values of such three traits obtained when faba bean plants treated with *Rhizo. + B. poly.* plus foliar spraying by B + Mo. It can be observed that seeds protein content increased by 21.32% when plants inoculated with *Rhizo. + B. poly*. plus foliar spraying by B + Mo compared to control.

CONCLUSION

In the light of the present results, it clearly that inoculated faba bean plants with (*Rhizobium leguminosarum* + *Bacillus polymyxa*) plus foliar spraying by 30 ppm B + 15 ppm Mo increased seeds and straw yields as well as protein content of seeds by 42.92 %, 33.08 % and 21.32 %, respectively compared to untreated plants (control).

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تأثير التلقيح بالريزوبيا والريزوبكتيريا والرش الورقى بالبورون والموليبدنيم على النمو وتكوين العقد الجذرية والانتاجية للفول البلدى

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أجريت تجربة حقلية بمحطة بحوث الجميزة بمحافظة الغربية – مصر خلال موسمى 2018/2017 و 2019/2018 لدراسة استجابة الفول البلدى للتلقيح البكتيرى بالريزوبيا و الباسيلاس بوليمكسا (بكتيريا مذيبة للفوسفور) سواء منفردين أوبالتشارك وكذلك للرش الورقى بالبورون (30 جزء فى المليون) والموليبدنيم (15 جزء فى المليون) سواء منفردين أو مجتمعين على النمو وتكوين العقد الجذرية والانتاجية وأظهرت النتائج الآتى:- أدى التلقيح المشترك الريزوبيا + باسيلاس بوليمكسا إلى الحصول على أعلى قيمة لإرتفاع النبات ودليل مساحة الأوراق والمادة الجافة الكلية / نبات ومعدل نمو المحصول وعدد القرون/ نبات ومحصول البذرة / نبات ووزن الـ100 بذرة ومحصولى البذور والقش /فدان وعدد ووزن العقد الجذرية والكلوروفيل الكلى للاوراق وكذلك النسبة المئوية للفوسفور والنيتروجين والبروتين فى البذور. أدى الرش الورقى للفول البلدى بـ (30 جزء فى المليون بورون + 15 جزء فى المليون موليبدنيم) الى الحصول على أعلى قيمة لإرتفاع النبات ودليل مساحة الاوراق والمادة الجافة الكلية / نبات ومعدل نمو المحصول وعدد القرون / نبات ومحصول البذرة / نبات ووزن الـ 100 بذرة ومحصولى البذور والقش /فدان وعدد ووزن العقد الجذرية. كما تم الحصول على أعلى قيمة للكلوروفيل الكلى للاوراق وكذلك النسبة المئوية للفوسفور والنتيروجين والبروتين فى البذور. أدى معاملة نباتات الفول البلدى بالتلقيح البكتيرى بـ الريزوبيا + الباسيلاس بوليمكسا بالاضافة للرش الورقى بـ (30 جزء فى المليون بورن + 15 جزء فى المليون موليبدنيم) إلى الحصول على أعلى القيم للصفات السابقة الذكر, وقد وجد أن هذه المعاملة أدت الى زيادة محصول البذور والقش ومحتوى البذرة من البروتين بمعدل 42,92 , 33,08 , 21,32 % على الترتيب مقارنة بالنباتات الغير معاملة (الكنترول)