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Influence of Rhizobium Inoculation, Iron and Boron on Growth and Pod Yield of Snap Bean (*Phaseolus vulgaris* L.)

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Abstract

The study was conducted at the experimental farm of Horticultural Research Station, Kassasin Region, Ismailia Governorate, Agricultural Research Centre, Egypt to investigate the effect of rhizobium inoculation and Fe and B concentrations as foliar application on growth, and pod yield of snap bean cv. Bolista under sandy soil conditions, during 2021/2022 and 2022/2023 seasons. The layout of the experiment was laid out in randomized complete block design (RCBD) with three replicates. The experiment included 10 treatments as follows: T_1 (control). T_2 foliar application with Boron (B) at 25 ppm. T_3 foliar application with Boron (B) at 50 ppm. T_4 foliar application with iron (Fe) at 50 ppm. T_5 foliar application with iron (Fe) at 100 ppm. T_6 Seed inoculation with rhizobium. T_7 Rhizobium seed inoculation + foliar application with B at 25 ppm. T_8 Rhizobium seed inoculation + foliar application with B at 50 ppm. T_9 Rhizobium seed inoculation + foliar application with Fe at 50 ppm. T_{10} Rhizobium seed inoculation + foliar application with Fe at 100 ppm. Results indicated that Rhizobium inoculation + Boron (B) at the rate of 50 ppm, being the most effective on growth, and pod yield of snap bean. Conclusively: it can be concluded that that Rhizobium inoculation with Boron at the rate of 50 ppm, increased growth and, pod yield of snap bean.

Keywords: Rhizobium inoculation - B - Fe- growth - pod yield - snap bean.

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1. Introduction

Snap bean (*Phaseolus vulgaris* L.) belongs to the Fabaceae Family, which is one of the largest plant families. It is considered as one of the most important vegetable crops grown in Egypt for both local consumption and exportation. It plays important role in human nutrition as a cheap source for protein, carbohydrates, vitamins and minerals. The protein of beans contains essential amino acids and high concentrations of folic acid [1]. The bean plant is characterized by its need for large quantities of major nutrients to obtained high production, which prompts farmers to add a large quantities of chemical fertilizers that have a negative effect on the environment, increase the pollution, and their exaggeration leads to a decrease in the productivity of the crop [2]. Hence, the feeding with micro-organisms, like Rhizobium inoculation and using a lowest quantities of micro-nutrients like, Fe and B are not only a means to improve productivity, but also an important tools to reduce the amount of chemical fertilizers added and decrease the environment pollution.

Rhizobium spp are nitrogen-fixing bacteria in the soil, providing nitrogen to the existing crop, increase fertility, texture and structure of the soil [3]. [4] Illustrated that Rhizobium spp inoculation in mung bean significantly increased photosynthetic rate, plant height, leaf area and dry matter. Iron (Fe) plays a vital role in physiological processes and limiting the yield of plant, that plays a crucial role, being a cofactor of enzymes of the reductive assimilatory pathway. [5] Concluded that foliar application of Fe, significantly increased composition and yield components of bean. Boron (B) is on essential micro-nutrient have an important role in the normal growth of plant and in absorption of nitrogen from soil, translocation of sugars, cell wall synthesis, root elongation and nucleic acid synthesis [6]. [7] Confirmed that boron significantly increased growth and yield performance of bean. The objectives of this study were to lest the use of rhizobium inoculation, micronutrients of Fe and B on growth, chemical content and pod yield of snap bean.

2. Materials and Methods

2.1. Experimental sites and soil analysis

The study was conducted at the experimental Farm of Horticultural Research Station, Kassasin Region, Ismailia

Governorate, Agricultural Research Centre, and Egypt to investigate the effect of rhizobium inoculation and Fe and B as foliar application on growth, chemical composition, pod yield and pod quality of snap bean cv. The Bolista under sandy soil conditions, during 2021/2022 and 2022 /2023 seasons. The physical and chemical properties of the soil are presented in Table (1). The system of irrigation was the drip irrigation.

2.2. Treatments and Experimental Design

The layout of the experiment was laid out in randomized complete block design (RCBD) with three replicates. The seeds were inoculated by okadin which contains on *Rhizobium leguminosarum* var. phaseolli, bring from Seeds Management of Agricultural Research Center, Giza, Egypt. The plot area was 12 m^2 (4 rows, 5 m length and 0.6 m width). Seeds were sown with 2 seeds per hole and 20 cm between one to another at 20 and 17 September 2021 and 2022, respectively.

- ***The experiment included 10 treatments as follows***

1-T_1 (control).
2- T_2 foliar application with Boron (B) at 25 ppm.
3- T_3 foliar application with Boron (B) at 50 ppm.
4- T_4 foliar application with iron (Fe) at 50 ppm.
5- T_5 foliar application with iron (Fe) at 100 ppm.
6- T_6 Seed inoculation with rhizobium
7- T_7 Rhizobium seed inoculation + foliar application with B at 25 ppm.
8- T_8 Rhizobium seed inoculation + foliar application with B at 50 ppm.
9- T_9 Rhizobium seed inoculation + foliar application with Fe at 50 ppm.
10- T_{10} Rhizobium seed inoculation + foliar application with Fe at 100 ppm.

The sources of Fe and B were $FeSO_4$. 7 H_2O and boric acid which contains 17% boron, sprayed by 3 times during the growing seasons. The first spray was at 25 days after planting and the second spray was 15 days after the first spray, (40 days) and the third spray after 15 days (55 days) at early morning.

2.3. Data recorded

- ***Vegetative growth characters***

At the same time of root determination (60 days after sowing), these plants were taken after removing their roots and vegetative growth recorded as follows:

1- Plant height (cm)
2- Number of branches / plants
3- Number of leaves / plants
4- Plant fresh weight (g)
5- Plant dry weight (g)

- ***Pod yield and its components***

Green pods were picked at the proper maturing stage through the harvesting period for estimation of yield parameters, i.e., pod length (cm), average pod weight (g), number of pods/plant, and total pod yield (ton/feddan).

2.4. Statistical Analysis

All data were statistically analysis according to SAS software program [8]. The least significant difference (LSD) at (0.05) level of probability was used compare the means of treatments values [9].

3. Results and discussion

3.1. Vegetative growth characters

Data presented in Tables (2 and 3) study the effect of Rhizobium inoculation and micro – nutrients of B and Fe on vegetative growth of snap bean. These results indicated that Rhizobium inoculation with B-nutrient at 50 ppm as foliar spray significantly increased vegetative growth characters of snap bean, i.e. plant height, number of leaves and branches, plant fresh weight and plant dry weight. This treatment was followed by the treatments of Rhizobium inoculation with Fe at 50 ppm, and Rhizobium with B at 25 ppm. These results are true in both growing seasons. The lowest values of vegetative growth characters was recorded as a result of control treatment. Regarding the important role of Rhizobium inoculation, boron and iron on legumous plants, [4] stated that Rhizobium spp inoculation increased the photosynthetic rate which promote the vegetative growth of plant. Moreover, [10] concluded that Rhizobia, large number of bacterial species are able to fix atmospheric N due to a symbiotic relationship with legume plants.

In a symbiotic relationship, both the plant and bacteria contribute to each other and benefit as a result of their association, and then increased the plant growth characters. As well as, the important role of micro – nutrients, i.e. B and Fe, [11] confirmed that Boron is one of the micro - elements, it plays an important role in plant growth and activated many enzymes. They added, it is one of the components of the cell membranes, and most plants often fail to produce the normal rate of seeds, in cases of deficiency due to the lake of pollen germination and the fall of buds and flowers, and thus a decrease in fruits and quantity of seeds produced. Moreover, the important role of Fe in increasing plant growth, iron (Fe) plays a crucial role, being a co-factor of enzymes of the reductive assimilatory pathway and then increased plant growth [12]. These results are in close agreement with those reported by [13] and [6-14] and [7], [15] and [5] who used Rhizobium inoculation, B, & Fe on bean plants, respectively.

3.2. Pod yield and its components

Data in Tables (4) explain that Rhizobium inoculation, micro-nutrients of B and Fe with the two concentrations gave the different values on pod yield and its components of snap bean. The treatment of Rhizobium inoculation with Boron at 50 ppm as foliar application gave the highest value of pod yield and its components, i.e. average fresh pod weight, average dry pod weight, number of pods / plant, pod length, and total pod yield / feddan of snap bean. This treatment of Rhizobium and Boron at 50 ppm is the suitable for enhancing the physiological processes in plant and turn on the store parts (pods). This result was followed by the treatments of Rhizobium with Fe at 50 ppm and Rhizobium with B at 25 ppm, respectively. While, the lowest value of pod yield and its components are recorded as a result of the control treatment.

Table (1): The physical and chemical properties of the experimental soil

Physical properties			**Chemical properties**		
	2021/2022	**2022/2023**		**2021/ 2022**	**2022/2023**
Sand (%)	90.5	95.6	Organic matter (%)	0.03	0.08
Silt (%)	4.7	1.6	Available K (ppm)	55	66
Clay	4.8	4.7	Available p (ppm)	5.7	6.8
Field capacity	6.8	7.2	Available N (%)	5.9	6.3
Wilting point	2.5	2.6	Calcium carbonate (%)	0.28	0.26
Available water	4.5	4.5	pH	8.1	8.1
Water holding capacity	13.9	14.6			

Table (2): Effect of Rhizobium, Boron (B) and Iron (Fe) on plant growth characters of snap bean during 2021L 2022 and 2022L2023 seasons

Treatments	Plant height (cm)		Number of leave		Number of branches	
	2021/2022	2022/2023	2021/2022	2022/2023	2021/2022	2022/2023
Control	40.00	33.333	8.33	7.667	2.667	2.666
B at 25 ppm	43.667	47.333	11.00	8.333	4.00	3.00
B at 50 ppm	45.00	48.333	11.00	9.333	4.00	3.00
Fe at 50 ppm	46.667	49.00	11.66	10.333	4.33	4.00
Fe at 100 ppm	42.00	46.333	9.66	8.00	3.33	2.667
Rhizobium inoculation	41.33	41.667	9.66	7.667	3.33	2.667
Rhizobium +B (25 ppm)	48.33	49.667	12.33	11.667	4.33	4.33
Rhizobium +B (50ppm)	51.00	51.00	15.33	17.333	4.667	4.667
Rhizobium +Fe (50ppm)	48.667	50.667	14.66	16.00	4.66	4.333
Rhizobium +Fe (100 ppm)	42.00	46.333	9.66	8.00	3.33	2.667
LSD (0.05)	7.075	7.521	4.69	5.566	1.735	1.657

Table (3): Effect of Rhizobium, Boron (B) and Iron (Fe) on plant fresh and dry weight of snap bean during 2021L 2022 and 2022L2023 seasons

Treatments	Plant fresh weight(g)		Plant dry weight(g)	
	2021/2022	2022/2023	2021/2022	2022/2023
Control	28.33	16.667	3.453	4.583
B at 25 ppm	36.667	30.00	5.876	5.456
B at 50 ppm	45.00	38.333	6.603	6.996
Fe at 50 ppm	45.00	40.00	7.100	7.086
Fe at 100 ppm	33.33	28.333	5.340	5.406
Rhizobium inoculation	30.00	28.333	5.123	4.646
Rhizobium +B (25 ppm)	46.667	43.333	8.116	7.526
Rhizobium +B (50ppm)	61.667	63.333	11.230	9.653
Rhizobium +Fe (50ppm)	51.667	58.333	10.373	7.616
Rhizobium +Fe (100 ppm)	46.667	41.667	7.640	7.173
LSD (0.05)	2.445	6.373	0.6705	1.637

Table (4): Effect of Rhizobium, Boron (B) and Iron (Fe) on pod yield of snap bean during 2021L 2022 and 2022L2023 seasons

Treatments	Average weight of pod(g)		Number of pods/plant		Pod length (cm)		Total pod yield/fedden (ton)	
	2021/2022	2022/2023	2021/2022	2021/2022	2021/2022	2022/2023	2021/2022	2022/2023
Control	3.75	3.25	15.333	15.333	14.166	14.066	1.303	1.119
B at 25 ppm	4.00	4.25	23.667	23.667	14.673	14.866	1.856	1.738
B at 50 ppm	4.00	4.25	25.00	25.00	14.833	15.00	1.909	1.944
Fe at 50 ppm	4.25	4.25	25.00	25.00	15.00	15.166	1.938	2.115
Fe at 100 ppm	4.00	4.00	18.33	18.33	14.33	14.666	1.610	1.574
Rhizobium inoculation	3.75	3.75	18.33	18.33	14.226	14.183	1.488	1.327
Rhizobium +B (25 ppm)	4.75	4.75	27.667	27.667	15.333	15.266	2.362	2.833
Rhizobium +B (50ppm)	5.50	5.5	29.667	29.667	16.00	16.016	2.468	3.009
Rhizobium +Fe (50ppm)	4.75	4.75	28.667	28.667	15.916	15.600	2.422	3.001
Rhizobium +Fe (100 ppm)	4.50	4.50	25.00	25.00	15.00	15.183	2.105	2.706
LSD (0.05)	1.742	1.642	13.556	13.556	1.529	1.577	0.09	0.07

Regarding the vital role of Rhizobium inoculation, B and Fe in increasing bean pod yield, [16] concluded that Rhizobial inoculation increased the total yiel of snap bean due to its greatest N_2 fixation and high pod yield. As well as, the benefits of using rhizobia for N_2 fixation have been realized for grain production in bean [17], and [18]. As well as, [6] illustrated that Boron is important role in translocation of sugars and nucleic acid synthesis that hold a vital role in increasing pod yield of bean. Moreover, [12] demonstrated that Fe plays a vital role in physiological processes and limiting the yield of plant. The obtained results are in harmony with those reported by [19], [7] and [20], and [5], who working with Rhizobium, B and Fe micro nutrients on beans plant.

4. Conclusion

Conclusively: it can be concluded that Rhizobium and Boron at 50 ppm is the suitable for good growth and pod yield of snap bean CV Bolista.

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