Middle East Journal of Agriculture Research
ISSN 2077-4605

Volume : 07 | Issue : 02 | April-June | 2018
Pages:639-649

Growth and Yield of Dry Bean (*Phaseolus vulgaris* L.) as Affected by Zn and B Foliar Application

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Received: 15 Mar. 2018 / Accepted: 14 June 2018 / Publication date: 25 June 2018

ABSTRACT

Two field experiments were carried out in two successive summer seasons of 2015 and 2016 at the Vegetables Research Farm, at Kaha, Qalubia Governorate Egypt. The investigate aims to study the effect of two levels of zinc and boron 250 ppm and 500 ppm foliar spray once (before flowering) or twice (before and after flowering) on growth, nutrient concentrations, yield and yield components of dry bean (*Phaseolus vulgaris* L.). Randomized complete block design with three replicates was used in this study. The obtained results showed that Zn or B sprays had positive significant effects on plant growth traits such as plant length, number of branches per plant, number of leaves, shoot fresh and dry weights, as well as yield components i.e. number of seed per pod, weight of 100 seeds and seed yield per feddan in both seasons as compared with the control treatment. The results also, showed that foliar application of Zn or B led to positive increases of macronutrients (N, K and Ca) and micronutrients (Zn, B and Cu) concentration in bean leaves and seeds. The distribution of nutrients in leaves and seed was differed according to treatment and kind of mineral nutrient.

Key words: Bean, foliar application, zinc, boron, growth, nutrient concentrations, seed yield and germination test.

Introduction

Dry bean (*Phaseolus vulgaris* L.) is a present regarded as one of the most important vegetable legume crops in Egypt on account of its high protein content which very necessary for human nutrition and dietary benefits. Also, dry bean consumption is effective in reducing risk of many diseases, in addition to the potential health benefits of seeds consumption do to the high content of phenolic compounds, which have antioxidant properties. Dry bean is a traditional food in human diet, low in fat and rich in proteins, vitamins, complex carbohydrates and minerals (Abd El-Hakim, 2014)

In Egypt old soil containing relatively moderate amounts of zinc, but the degree of its availability is low due to the different soil physical and chemical characteristics, such as high levels of calcium carbonate and pH as well as low level of organic matter content which leads to zinc deficient in plants (Hafeez *et al*., 2013) and people, (Sadeghzadeh, 2013) .

Zn deficiency in plants results in a severe decline in protein biosynthesis. The amount and activity of various enzymes and DNA-binding proteins are seriously affected under Zn deficient conditions. Zinc deficiency limits photosynthetic CO_2 fixation due to the susceptibility of some photosynthetic enzymes to Zn deficiency and impairments in the utilization of photo assimilates (Marschner and Cakmak, 1989). Improving mineral nutritional status of plants is great importance in alleviating cell damage caused by environmental stress factors. When leaf or shoot zinc concentrations are below 15 mg/kg tissue, plants show very quick reductions in growth and a severe decline in yield and the leaf concentrations of soluble protein and yield of crop plants. Micronutrients deficiency symptoms occur as a result of: a- repeat the crops cultivation in the same soil leads to the depletion of the elements from the soil b- existence of some factors that affect the absorption c- not adding sufficient quantities of Zn and B to the plant d- use method is an effective in the addendum

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especially in the case of dense vegetation, as well as high-yielding varieties also, in addition to the attention that is given to increase the yield and quality and nutritional value of crops.

Soil pH has a strong impact on the availability of most nutrients. This is because pH affects both chemical forms and soluble nutrients. Micronutrients such as Fe, Mn, Zn, Cu and B are less available at higher pH than most nutrients (Aref, 2010). Foliar applications of micronutrient have a significant response in the direction of the reasons, but this method is very expensive to be practiced on a large scale to a lack of resources in some areas, such as the amount of fertilizer and equipment and labor repeated. (Aref, 2012).

Foliar application of zinc sulphate ($ZnSO_4$) and boric acid (H_3BO_3) is a quick and successful simple method to plants deficient in pollen-stigma morphology and fertility, and greatly enhanced seed yield of plants. In addition to, improved zinc and boron deficient plants, seed zinc and boron contents as well as seed yield, which found for maize (Aref, 2012), chickpea (Pathak, *et al*,. 2012), pea plants (Pandey *et al*., 2013), and rice (Boonchuay *et al*,. 2013).

Zinc is a number of basic functions in plant cells which effect on many physiological processes in the plant, as well as plant growth and the crop yield. Zinc is an essential micronutrient and has a number of crucial functions in plant systems.

Foliar application of Zinc increased pigeon pea and soybean seed yield respectively. Moreover, Concentrations of Zn, Fe, P and K increased in the plant leaves with increasing zinc concentration in foliar spray solution, (Osman *et al.*, 2000; Masood & Mishra and 2001; Nasri & Khalatbari, 2011). Zn is essential in the largest number of proteins for their functions (i.e. protein synthesis) and its contribution to the structural integrity of a number of proteins (Hafeez *et al*., 2013 2). Increased food crop content of zinc leads to improving the nutritional status of the plants, as well as human (Hafeez *et al*., 2013).

Many researchers mentioned the effect of boron deficiency on the physiological functions in the plant as well as the growth and yield. Boron (B) is considered as an essential element for plant growth and development. Sexual reproduction in plant is more sensitive to low B content, than vegetative growth (Dell and Huang, 1997). The main functions of boron is that it related to cell wall strength and development, cell division, fruit and seed development, sugar transport and hormone development (Osman, 2012).

Improving pollination, seed setting, low spike sterility and grain formation in rice plants were affected by boron nutrition (Moghadam *et al*,. 2012). Several impairments during many processes such as sugar transport, cell wall synthesis, cell wall structure, carbohydrate metabolism, RNA metabolism and respiration caused under boron deficiency (Kabay *et al*. 2015) . Also, the application of boron along with other nutrients should be completed to maximize plant health and crop yield.

This aims to study the efficiency of zinc or boron spray before and after flowering in improve growth, nutritional status and productivity of dry bean.

Materials and Methods

Two field experiments were carried out on dry beans (*Phaseolus vulgaris* L. cv. Nebraska), under clay soil conditions, in two successive summer seasons of 2015 and 2016 at the Experimental Farm of Vegetables, Horticulture Research institute, Agriculture Research Centre at Kaha, Qalubia Governorate Egypt. The plot area was 10.5 m^2 (3 x 3.5m) with five ridges. Bean seeds were sowing in hills spaced 10 cm on ridge at the 15^{th} of March in the two growing seasons.

The common fertilizer applications were used as following: 15 m^3 fad^{-1} of farmyard manure before sowing. NPK rates were 60 Kg nitrogen (N) as ammonium nitrate (33.5 % N), 30 Kg phosphorus (P_2O_5), as superphosphate (15 % P_2O_5) and 60 Kg potassium (K_2O) as potassium sulfate (48-52%) Kg fad^{-1} was used and divided along the growing season. Other agricultural practices for growing bean were followed as recommended in the region.

The study aims to investigate the efficiency effect of Zn or B foliar spraying at different concentrations (250 ppm and 500 ppm) and at different growth stages (before and after flowering) on growth, nutrient concentrations, yield and yield components of common bean plants.

The experimental treatments were arranged in randomized complete block design with three replicates.

Treatments:

The experiment included eight foliar spray treatments in addition to the control treatment which were as follows:

1- Control (water spraying without Zn or B)
2- Zn (250 ppm) before flowering
3- Zn (250 ppm) before and after flowering
4- Zn (500 ppm) before flowering
5- Zn (500 ppm) before and after flowering
6- B (250 ppm) before flowering
7- B (250 ppm) before and after flowering
8- B (500 ppm) before flowering
9- B (500 ppm) before and after flowering.

Growth measurements, yield and its components:

Ten plants were randomly chosen from central row of each plot and were marked in the field from the flowering to the harvest time. The following characteristics at 75 and 95 days after sowing in both seasons were measured, plant height (cm), number of leaves/ plant, number of branches/ plant, shoots fresh and dry weights (g)/ plant. As well as, number of seeds per pod, 100 seeds weight and seed yield were recorded.

Soil sampling: Soil samples were randomly collected before planting at 30 cm depth.

Leaf sampling: Leaf samples were collected randomly from the fully mature 4^{th} to 5^{th} leaves from the plant top to determine the nutrient contents at 75 days after sowing. Samples were washed with tap water, 0.001 N HCl and distilled water respectively, then dried at 70 °C and ground in a stainless steel mill and stored in plastic bottles.

Pods sampling: At harvest, five plants from each replicate were randomly picked and were used for determination of number of seeds per pod, 100 seeds weight and seed yield/ plant.

Chemical analysis:

Soil chemical analysis: Soil samples were analyzed (Table 1) for texture, pH and electric conductivity (EC) using water extract (1: 2.5) method, total calcium carbonate ($CaCO_3$%) determined with calcimeter method and the organic matter content (O.M %) was determined with using potassium dichromate (Chapman and Pratt, 1978). Phosphorus was extracted using sodium bicarbonate, (Olsen *et al*., 1954). Potassium (K), calcium (Ca), magnesium (Mg) and sodium (Na) were extracted using ammonium acetate (Jackson, 1973). Iron (Fe), manganese (Mn), zinc (Zn) and copper (Cu) were extracted using DTPA, (Lindsay and Norvell, 1978). Soil available boron was extracted by hot water and measured by azomethine-H colorimetric method (Bingham, 1982).

Table 1: Soil physico-chemical properties of the experimental site before sowing

Mechanical analysis (%)			Tex.	Physical properties				Macronutrients (mg/ 100 g)					Micronutrients (mg/ Kg)				
Sand	Silt	Clay	Clay sand	pH	EC (dS/m)	$CaCO_3$ (%)	O.M (%)	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu	B
64.0	8.0	28.0		8.1	0.53	5.63	1.7	1.65	30	270	29.3	6.6	4.6	9.5	1.6	0.7	1.8

Table (1) showed mechanical analysis, the physico- chemical properties of experiment soil used in this study. The physical properties of the soil analysis before sowing refer to a slightly alkaline and salinity soil with calcium carbonate ($CaCO_3$) and organic matter (OM) moderately. The results of soil analysis of the experimental field indicated that P, K, Mg and Zn were normally except Zn which is a slightly moderately meanwhile, Na, Fe, Mn and Cu were less than moderately (Ankerman and Large, 1974).

Leaves and seeds analyses:

The chemical analysis was done in the leaves and seeds to determine the total mineral nutrient contents with using the technique according (Chapman and Pratt, 1978).

Nutrient element compositions in the leaves and seeds were determined with dry ashing method for the macro- and micronutrient contents. Nitrogen was analyzed using the Kjeldahl method (Buresh *et al*., 1982) and P spectrophotometric-ally measured by (Chapman and Pratt, 1978) technique, and K, Ca, Mg, Fe, Mn, Zn and Cu were measured by Perkin-Elmer (1100 B) atomic absorption spectrometer. B concentration in leaf and seeds tissues determined, by the azomethine-H method (Wolf, 1974).

Yield and it's components:

Pods yield (g)/ plant, seed weight (g)/ pod, seed yield (g)/ plant, seed index 100 seed weight (g) and seed yield per feddan were recorded at harvest time.

Seeds Germination test:

Germination Percentage (%): was calculated according to the following equation (Menezes *et al*., 1993).

$$\text{Germination Percentage (\%)} = \frac{\text{Number of germinated seeds x 100}}{\text{Total number of seeds}}$$

Germination rate: Seed germination was counted each day to determine the germination rate and the total index according to the following equation (Menezes *et al*., 1993).

$$\text{Germination rate} = \frac{(G1\ x N1) + (G2\ x\ N2) + \ldots\ldots\ldots\ldots (Gn\ x\ Nn)}{G1 + G2 + \ldots\ldots\ldots\ldots Gn}$$

Where: G = Number of germinated seeds in certain day, N = Number of this certain day.

The seedling growth determination was according to (Nakagawa, 1999).

Statistical analysis:

The results were submitted to analysis of variance according to (Snedecor and Cochran, 1967). Differences among treatment means were determined as using the LSD test at a significance level of 0.05 according to (Waller and Duncan, 1969).

Results and Discussion:

Vegetative Growth Parameters:

The presented data in Table 2 showed that growth parameters of dry bean plants such as plant height, numbers of branches, number of leaves, shoot fresh and dry weights per plant were significantly increased by all foliar application with zinc or boron once: before flowering or twice: before and after flowering during the two seasons.

Foliar application of zinc at 500 ppm twice (before and after flowering) gave the highest values of plant height, number of leaves, shoots fresh and dry weights/ plant as an average of the two seasons as compared with the all foliar application treatments. Foliar application of Zinc at 0.5 and 0.4% increased pigeon pea and soybean seed yield respectively (Osman *et al*., 2000; Masood and Mishra, 2001; Nasri and Khalatbari, 2011).

In addition, the studied growth parameters were differ in their response to Zn or B foliar spray with the same concentration at the same stage, which reflect the important role of each nutrient in plant physiological processes at specific plant growth stages with specific nutrient concentration. In this respect, (Tisdale *et al*., 1984; Marschner, 1995; Brown & Hu, 1997 and Silva *et al*., 2008), mentioned that Zinc plays a very important role in the metabolism of the plant process by influencing the activity of growth enzymes as well as it is involved in carbohydrate metabolism, maintenance of the integrity of cellular membranes, protein synthesis, and regulation of auxin synthesis and pollen formation.

Table 2: Effect of zinc and boron foliar application on vegetative growth of dry common bean at 75 days after sowing (Combined analysis of the two seasons 2015 and 2016).

Treatments	Plant height (cm)	No. of Branches/ plant	No. of Leaves/ plant	Shoot Fresh weight (g/ plant)	Shoot Dry weight (g/ plant)
Control	59.6	4.2	17.0	88.19	22.44
Zn (250 ppm) before flowering	63.0	4.6	22.4	118.28	30.10
Zn (250 ppm) before and after flowering	64.0	4.8	22.6	129.28	32.90
Zn (500 ppm) before flowering	64.8	5.4	24.2	125.80	32.06
Zn (500 ppm) before and after flowering	70.4	5.6	25.8	129.82	34.99
B (250 ppm) before flowering	62.4	4.4	21.0	117.15	29.81
B (250 ppm) before and after flowering	63.2	4.8	22.2	119.98	30.56
B (500 ppm) before flowering	63.2	5.2	22.8	123.62	31.46
B (500 ppm) before and after flowering	66. 0	5.8	26.6	128.55	34.65
LSD 0.05	0.7	0.9	1.1	4.40	0.90

Boron is a required for many physiological processes and plant growth, also adequate nutrition is a critical for increase yields and quality of crops. (Silva, *et al*., 2008 and Ahmed *et al*., 2009), reported that dry weight and seed yield in caster bean plants are adversely affected by boron deficient conditions.

Also, the results showed that there were differences between the same concentrations of zinc or boron at the same application stage. The highest values of plant height, shoots fresh weight and dry weight were obtained with Zn foliar spray at 500 ppm twice (before and after flowering) followed by B treatment at 500 ppm twice (before and after flowering) without significant differences among there except plant height which was higher in case of Zn treatment which were resulted in plant height (66.00 cm), shoots fresh weight (129.82 g/ plant) and dry weight (34.99 g/ plant). On the other hand, control treatment had the lowest values of studied growth parameters, i.e plant height 59.60 cm, shoot fresh 88.19 g/ plant and dry weights 22.44 g/ plant. In addition to, there is was a significant effect between the control and all other treatments.

Meanwhile, foliar application of Zn or B had slightly positive effect on number of branches; however foliar application of Zn and B at 500 ppm once (before flowering) or twice (before and after flowering) gave the highest values of parameters. Boron treatment at 500 ppm twice (before and after flowering) gave the highest value of number branches/ plant followed by Zn at 500 ppm twice without significant differences. As well, the lowest value of number of branches recorded with the control treatment.

Number of leaves per plant had showed strongly positive effects by foliar application of Zn or B treatment. Foliar application of B at 500 ppm twice (before and after flowering) gave the highest value (26.60 leaves/ plant) by increasing (156.5 % than control treatment) followed by Zn at 500 ppm twice (before and after flowering) (25.80 leaves/ plant) by increasing (151.8 % than control treatment), meanwhile, the lowest value of number of leaves/ plant was recorded with the control treatment (17.00 leaves/ plant).

Foliar sprays of zinc or boron can be used to ensure an adequate B supply for optimum growth. Zn or B was gave better result when spraying with 250 ppm at twice before and after flowering or 500 ppm once before flowering and twice before and after flowering.

The best obtained results were found with Zn or B at 250 ppm twice or 500 ppm once or twice. Such enhancement effect of zinc or boron might be attributed to the favorable influence of them on plant metabolism and biological process activity and their stimulating effect on photosynthetic pigments and enzyme activity which in turn encourage vegetative growth of bean plants (Sadeghzadeh, 2013)

In this connection, (Hafeez *et al*., 2013) mentioned that Zinc has a number of fundamental functions in plant cells and therefore many physiological processes as well as the growth and yield are adversely affected when plants are exposed to a Zn deficiency. (Bose and Tripathi, 1996) indicated that boron is needed by the crop plants for cell division, nucleic acid synthesis and uptake of calcium and transport of carbohydrates.

Yield and it's Components:

Data in Table 3 showed that the results of yield and yield components of bean plants such as number of seeds per pod, weight of 100 seeds, and yield per feddan were significantly increased by all foliar application with zinc or boron when compared with their corresponding control treatment.

Foliar application of Zinc and boron whether, once (before flowering) or twice (before and after flowering) at 250 ppm or 500 ppm had significant positive effect on yield and yield components when compared with the control treatment. The best results of seed yield/ plot or feddan were recorded with B treatment at 500 ppm twice (before and after flowering).

The best number of seed per pod resulted from the high concentration of both elements also; the foliar application twice before and after flowering has the best than once spray.

Also, foliar application of B twice at 250 ppm or 500 ppm gave the highest value of 100 seed weight.

Foliar application of Zn and B may be an effective way to correct Zn and B deficiencies, and to increase yield and crop quality. Similar results were obtained by other researchers (Salehin and Rahman, 2012), reported that, using of zinc spray had a significant effect on plant height, number of pods per plant, number of seeds per pod, 100 seed weight and seed yield of *Phaseolus vulgaris*. Meanwhile, the lowest values of seed number per pod, 100 seeds weight and yield per feddan were recorded with the control treatment. Zinc and boron are improves fruit growth by synthesizing tryptophan and auxin (Wojcik and Wojcik, 2003).

Table 3: Effect of zinc and boron foliar application on yield and its components of dry common bean at 95 days after sowing. (Combined analysis of the two seasons 2015 and 2016).

Treatments	No. of seeds/ pod	100 seeds weight (g)	Seed yield (g/ plot)	Seed Yield (kg/ fed)
Control	3.00	27.12	1468.28	587.31
Zn 250 ppm before flowering	4.40	31.16	1800.00	720.00
Zn 250 ppm before and after flowering	4.60	44.75	2499.00	999.60
Zn 500 ppm before flowering	4.40	43.37	1962.15	784.86
Zn 500 ppm before and after flowering	4.60	43.85	2109.75	843.90
B 250 ppm before flowering	4.20	46.70	2682.45	1072.98
B 250 ppm before and after flowering	4.60	49.17	2827.50	1131.00
B 500 ppm before flowering	4.20	47.97	2644.95	1057.98
B 500 ppm before and after flowering	4.60	49.79	2985.00	1194.00
LSD 0.05%	0.50	2.03	2.97	3.73

Feddan (fed) = 0.42 Hectare

In addition, the foliar application of boron twice at 500 ppm surpassed of all treatments in seed yield per feddan. This result agreed with (Ati and Ali, 2011) mentioned that dried bean seeds yield was increased with increasing rate and number of boron as a foliar application.

Thereby, the present study strongly admits the use of foliar application with zinc at 250 ppm twice or boron 500 ppm before and after flowering of dry bean plants for getting the highest number of seed per pod and seed yield per feddan. The results recommended foliar spraying with zinc and boron to increase the final yield and seed quality of kidney bean plants.

Nutrient concentrations

1 -Leaves and seeds macronutrient concentrations

The presented data in Table 4 recorded that macronutrient contents in leaves and seeds of dry bean plants were significantly affected by all foliar application treatments with zinc or boron at before or before and after flowering as an average of the two seasons.

Foliar application of micronutrients such as zinc or boron led to improved absorption of both elements, in addition to an improvement in the absorption of other nutrients which clearly shows the high concentration of elements in the leaves and seeds.

Table 4: Effect of zinc and boron foliar application on macro-nutrient concentrations in Leaves (L) and seeds (S) of dry bean plants (Combined analysis of the two seasons 2015 and 2016).

Treatments	Macro-nutrients (ppm)									
	N		P		K		Ca		Mg	
	L.	S.	L.	S.	L.	S.	L.	S.	L.	S.
Control	2.89	2.95	0.22	0.35	2.21	1.60	1.65	0.07	0.25	0.23
Zn (250 ppm) before flowering	3.42	3.44	0.20	0.28	3.73	2.30	2.45	0.06	0.21	0.18
Zn (250 ppm) before and after flowering	3.68	3.50	0.19	0.21	2.82	1.95	2.65	0.07	0.22	0.20
Zn (500 ppm) before flowering	3.66	3.50	0.20	0.34	3.20	2.23	2.55	0.06	0.21	0.18
Zn (500 ppm) before and after flowering	3.78	3.58	0.18	0.33	2.90	1.73	2.60	0.07	0.23	0.22
B (250 ppm) before flowering	3.29	3.39	0.21	0.31	3.10	1.95	2.40	0.07	0.24	0.19
B (250 ppm) before and after flowering	3.62	3.58	0.20	0.28	2.68	1.85	2.60	0.08	0.24	0.21
B (500 ppm) before flowering	3.42	3.43	0.17	0.32	3.43	1.98	2.25	0.07	0.23	0.18
B (500 ppm) before and after flowering	3.97	3.86	0.16	0.31	2.29	1.90	2.55	0.08	0.20	0.18
LSD 0.05	0.02	0.03	0.02	0.02	0.03	0.02	0.03	0.01	0.01	0.12

Leaves = (L), Seeds = (S)

The results showed that the nitrogen and potassium content of leaves and seeds and calcium in leaves were significantly increased by Zn or B foliar application as compared with the control. The highest values of nitrogen in the leaves and seeds were obtained with boron foliar spraying at 500 ppm twice (before and after flowering) followed by 500 ppm of Zn foliar application twice also, while the highest values of K concentration in leaves and seeds were attained by foliar spraying before flowering with 250 ppm of Zn and 500 ppm of B, respectively. In addition the highest Ca concentration in seeds resulted from B foliar spraying twice at 250 ppm or 500 ppm levels. On the other hand, the lowest values of nitrogen and potassium in leaves and seeds as well as calcium in leaves resulted from the control plants. On the contrary, P and Mg concentration in both leaves and seeds were decreased with Zn or B foliar application treatments.

Some functions of boron interrelate with those of nitrogen, phosphorus, potassium and calcium in plants. These findings were in accordance with (Osman *et al.*, 2000; Masood and Mishra, 2001; Nasri and Khalatbari 2011) mentioned that the concentration of Zn, Fe, P and K increased in the plant leaves with increasing zinc concentration in foliar spray solution. (Krishna, 1995) also found a significant positive effect of zinc treatment on crude protein content in seeds of mungbean. Zinc is required as structural and catalytic components of protein and enzymes for normal growth and development (Broadley *et al.*, 2007). In contrast (Sagardoy *et al.*, 2009) observed the antagonistic effect of Zn along with N in sugar beet (*Beta vulgaris* L.) plants grown in hydroponics. The results of this study are agree with (Aref, 2012) who stated that foliar application of B significantly increased leaf N concentration of maize plants.

2- Leaves and seeds micronutrient concentrations

Data also, indicated that there was a positive effect of foliar application of Zn or B on Zn and Cu contents of leaves and seeds when compared with control treatment. The leaves and seeds concentrations of Zn and Cu concentrate increase with increasing the foliar application of Zn or B.

Foliar application of Zn and B increased nutrient contents of Zn, Cu and B in the leaf and seeds. Despite, soil solution has a high pH and that reduce Zn and B availability to the plant, but the foliar application of Zn and B has improved leaves and seeds contents of Zn and B. Data also showed that presence antagonistic effect of Zn and B with Fe and Mn contents in leaves and seeds. The highest values of Fe and Mn contents of leaves and seeds obtained from the control plants. Similar data were also mentioned by (Asad *et al.*, 2003 and Perveen, 2000) reported that foliar application may be an effective way to correct Zn and B deficiencies, which led to increase in yields and crop quality on sunflower. Also, (Kaur and Nelson, 2015) mentioned that foliar application may be an effective way to correct micronutrient deficiencies, which increase yields and crop quality. While, the foliar applications of Zn or B result in instead of due to reduction of P, Mg, Fe and Mn contents in leaves and seeds as compared control treatment.

The foliar applications of micronutrients is a great importance and positively effect on plant growth, photosynthesis and controlling physiological and biochemical processes of plants, while zinc is essential for plants growth it is vital to the crop nutrition as required in various enzymatic reactions, metabolic processes, and oxidation reduction reactions. In addition, Zn is also essential for many enzymes which are needed for nitrogen metabolism, energy transfer and protein synthesis (Hafeez *et al.,* 2013).

Table 5: Effect of zinc and boron foliar application on micro-nutrient concentrations in leaves (L) and seeds (S) of dry bean (Combined analysis of the two seasons 2015 and 2016).

Treatments	Micro-nutrients (ppm)									
	Fe		Mn		Zn		Cu		B	
	L.	S.	L.	S.	L.	S.	L.	S.	L.	S.
Control	122	78	52	41	51	30	4.5	2.5	25.98	20.24
Zn (250 ppm) before flowering	113	62	33	23	66	37	9.0	5.0	40.86	22.50
Zn (250 ppm) before and after flowering	119	70	38	29	68	47	9.5	8.5	35.76	22.24
Zn (500 ppm) before flowering	117	68	35	25	68	41	8.0	7.5	31.23	21.63
Zn (500 ppm) before and after flowering	121	73	37	28	70	49	9.0	5.5	30.65	21.11
B (250 ppm) before flowering	97	71	40	22	64	38	6.0	3.0	44.31	23.49
B (250 ppm) before and after flowering	102	75	41	23	66	48	7.5	3.5	45.85	24.48
B (500 ppm) before flowering	92	73	42	30	67	37	6.0	4.0	47.33	25.14
B (500 ppm) before and after flowering	95	77	43	31	68	42	8.0	4.5	47.71	25.67
LSD 0.05	1.9	2.5	2.1	1.7	1.8	1.7	0.25	0.17	0.09	0.09

Leaves = (L), Seeds + (S)

Also, boron has crucial role in plant growth, development, nutrition and sexual reproduction (Duddy, 2008 and Ahmed, *et al*,. 2009) The main functions of boron relate to cell wall strength and development, cell division, pollen germination and tube growth, seed setting, seed development and improving yield, sugar transport and hormone development (Blevins and Lukaszewski, 1998). Some functions of boron interrelate with those of nitrogen, phosphorus, potassium and calcium in plant (Salih, 2013).

Seeds Germination Test and Seedlings Growth

The results showed that seeds germination (percent % and rate) in addition to the quality characteristic such as seedling length, fresh and dry weights were significantly increased in the seeds of plants that have been sprayed with zinc and boron as compared with the control as an average of the two seasons (table 6).

Growing plants of vegetables depends on the high quality of the seeds is the basis for increasing agricultural productivity. Germination test and seedling characteristics propagated by the seeds of plants that have been sprayed with zinc and boron were better than that generated by control plants (not sprayed). The seed germination percentage and rate were significantly increased with increasing concentration rate and the number of foliar spraying of Zn or B treatments. In spite of, the application of B at 500 ppm (before and after flowering) gave the highest seeds germination percentage but the highest seeds germination rate value resulted from foliar application of Zn at 500 ppm (before and after flowering) treatment.

The lowest value obtained with the control treatment. The increase of seeds germination rate may be due to increased tryptophan content as a result of adding zinc and directly required for the synthesis of tryptophan.

In addition, seedling characteristics such as length, fresh and dry weights were enhanced by the seeds which produced by foliar application of Zn or B treatments. The highest seedling length, seedling fresh and dry weights values were resulted from foliar application of boron at 250 ppm twice (13.60 cm, 2.68 g and 0.51 g per seedling respectively).

Although the foliar application of boron treatment at a high level twice before and after flowering gave the best seed germination percentage, but the zinc at a high level twice has was the best seed germination rate. This result may be attributed to that zinc and boron are necessary for much function of many enzymes, as well as synthesis for tryptophan, a precursor of indole acetic acid (IAA) (such as, contributes in the biosynthesis of the plant auxin indole-3-acetic acid in addition improves fruit growth by synthesizing tryptophan and auxin (Davis, 1983; Wojcik and Wojcik, 2003 and Gurjar *et al*., 2015).

Table 6: Effect of zinc and boron foliar application on seed germination, seedlings characteristics of common dry bean (Combined analysis of the two seasons 2015 and 2016).

Treatments	Germination		Seedlings	Seedling Weights (g) /	
	Percent (%)	Rate (plant/ day)	Length (cm)	fresh	Dry
Control	76.33	2.82	10.00	2.16	0.41
Zn 250 ppm (before flowering)	80.00	2.68	12.40	2.26	0.43
Zn 250 ppm (before and after flowering)	88.67	2.60	12.80	2.61	0.50
Zn 500 ppm before flowering	80.67	2.49	12.00	2.24	0.43
Zn 500 ppm (before and after flowering)	86.67	2.41	13.00	2.36	0.45
B 250 ppm (before flowering)	87.00	2.61	12.60	2.29	0.44
B 250 ppm (before and after flowering)	90.00	2.57	13.60	2.68	0.51
B 500 ppm (before flowering)	90.33	2.50	11.00	2.20	0.42
B 500 ppm (before and after flowering)	94.00	2.49	12.00	2.40	0.46
LSD 0.05%	2.64	0.05	0.6	0.02	0.01

The germination percentage of onion seed increased as a result of increasing boron concentration to 300 ppm (Abou El-Magd *et al*., 1989). Ismail and Abou Elnour, (2016) mentioned that germination percentage, rate and sprout length were significant increases in seed germination tests with mixing Fe, Mn and Zn when compared with the control treatment.

The improving of seeds germination percentage and rate as well as seedling quality may be due to increasing seed zinc and boron content. Seeds germination percentage and seedlings studied traits were reveled increases in their values with foliar spray of Zn and B twice than foliar spray once.

Conclusion

It could be concluded that two foliar sprays of B before flowering and after flowering at 500 ppm gave the highest seed yield and seed protein and Zn content of dry bean seed (*Phaseolus vulgaris* L.). Foliar application of zinc or boron was strong recommendable when spraying with 250 ppm twice before and after flowering or spraying 500 ppm once before flowering and twice before and after flowering and recorded best results for vegetative growth and seed yield quantity and quality of common dry bean plants. Further increases in the concentrating of Zn or B did not show additional significant increases in plant measurements. It can be concluded that regardless of foliar fertilization technique seems to be more effective for higher yields and increasing the seed content of those elements in the common dry bean plants.

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