Improving seed production of common bean (*Phaseolus vulgaris* L.) plants as a response for Calcium and Boron

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Abstract: Two field experiments were carried out in summer successive seasons of 20115 and 2016 at the Vegetables Research Farm at Kaha, Qalubia Governorate Egypt. Experiment aimed to study the foliar application with calcium (Ca) and boron (B) on growth, nutrient content and yield quantity and quality of dry beans plant (*Phaseolus vulgaris* L.). The experiments were arranged in randomized complete block design. The obtained results showed that vegetative growth and seed yield and its components of dry bean plants were significantly increased by the foliar application with calcium or/and boron before and/or before and after flowering when compared with control treatment during the two seasons. The highest vegetative growth values were recorded by Ca at 2500 ppm or Ca and B foliar spraying ppm before & after flowering, whereas, the seed yield were increased by using 2500 ppm Ca plus 250 ppm B when compared with the other treatments or control plants in both growing seasons. Seed germination and seedling growth of the seeds produced from plants that have been sprayed with Ca and B, which were better than the control seeds. The results also showed that foliar application of Ca or/and B led to positive increases of macro (N, P, K, Ca and Mg) and micronutrients (Fe, Mn, Zn and Cu) concentration in dry bean leaves and seeds. The distribution of nutrients and the kind of mineral nutrient in leaves and seed were different among the treatments.

Keywords: *Phaseolus Vulgaris* L., calcium, boron, foliar application, mineral concentration, vegetative growth, seed yield and quality

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1 Introduction

Dry beans are one of the most important common leguminous crops in the world and Egypt for direct human consumption, and are consumed principally for its dry beans, shell beans (seeds at physiological maturity), and green pods. Common bean seeds contain protein, fat, carbohydrates, as well as adequate levels of many vitamins and minerals. Cultivation of dry beans can be used to improve the soil because of the ability to nitrogen fixation, and also can be used a green fertilizer, which leads to an increase in the soil organic matter.

Calcium and boron are considered as key roles in fruit set stage. When calcium and boron have been applied before flowering, they will cause an increase in flowering and fruit set, which may be due to the strongly need of the plantto these elements at this stage. Calcium plays an important role in many biochemical processes, delay senescence and controlling physiological disorders in fruits and vegetables (Favaro *et al*., 2007). Also, many physiological disorders in the storage of plant organs are connected to the low content of calcium in the plant tissue. Moreover, calcium has been described as an essential element to the maintenance of cell membranes and walls because it is involved in links with pectin substances that help the cell-to-cell adhesion (Hepler & Wayne, 1985). In addition, calcium bridges between free carboxyl groups of adjacent pectin molecules, which led to an increase in tissue firmness of beans (Chang *et al*., 1996).

Crop plants need boron for normal growth because its

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impact on plant physiological processes, such as cell division, calcium uptake, sugar translocation, carbohydrates metabolism, and pollen tube growth. The deficiency or toxicity of boron causes weakness in several metabolic, physiological processes and agricultural production (Goldbach *et al.,* 2001; Camacho-Cristobal, *et al*., 2008; Saleem *et al.*, 2011).Soil reaction is one of the most important factors that affect the availability of boron in the soil. Where, the high degree of soil pH lead to less availability of boron to plants becomes less available to plants (Aref, 2010). Boron can be regenerated through the fertilization of soil with organic matter, or through weathering processes of soil minerals (Peryea *et al*., 1985).

The purpose of this study is to determine the effect of calcium or/and boron spraying on vegetative growth, leaves and seeds protein and nutrient contents, yield and pods quality as well as germination and seedling growth of common bean (*Phaseolus vulgaris* L.).The impact of foliar spray by nutrients on seed germination and seedling growth was also investigated.

2 Material and Methods

Two field experiments were carried out on dry beans *(Phaseolus vulgaris* L. cv. Nebraska), under clay soil conditions, summer seasons of 2015 and 2016 at the Experimental Farm of Vegetables at Kaha, Qalubia Governorate, Horticulture Research Institute, Agriculture Research Centre Giza Egypt. The experiments were arranged in randomized complete block design (R.C.B.D) with three replicates. The plot area was 10.5 m^2 (3×3.5 m) with five rows in 0.6 cm width. Bean seeds were sowed in hills spaced 10 cm on ridge at the 15th of March in the two growing seasons.

The plants seeds were sowed under surface irrigation systems. The common fertilizer applications were used as following: 20 m^3 fed^{-1} of farmyard manure before planting. NPK rates were 60 Kg N as ammonium nitrate (33.5% N), 30 kg P_2O_5 as superphosphate (15% P_2O_5) and 60 kg K_2O as potassium sulfate (48%-52% K_2O) divided along the growing season. Other agricultural practices were done as follows in the region.

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

1. Control
2. Calcium (Ca) 2500 ppm (before flowering)
3. Calcium (Ca) 2500 ppm (before & after flowering)
4. Boron (B) 250 ppm (before flowering)
5. Boron (B) 250 ppm (before & after flowering)
6. Calcium (Ca) 2500 ppm + Boron (B) 250 ppm (before flowering)
7. Calcium (Ca) 2500 ppm + Boron (B) 250 ppm (before & after flowering)

***Foliar application*:** In each season, the foliar spraying treatments were applied at two times, before and after flowering. All treatments were applied as foliar spray at the rate of 10 liters/plot.

***Soil sampling*:** Soil samples were randomly collected before planting at (0-30 cm) depth.

***Leaf sampling*:** Leaf samples were collected randomly from the fully mature leaves of (4 to 5 from the plant top) to determine the nutrient contents.

***Pods sampling*:** At harvest, five plants from each replicate were randomly picked and were used for determination of pod physical, quantitative and qualitative characteristics in the laboratory. Nutrient analysis was done in leaves, shoots and pods to estimate the total mineral nutrient contents in the harvested plants in both seasons.

***Growth parameters*:** Ten plants were randomly chosen from central row of each plot at 75 and 90 days after sowing in both seasons for measurement plant height (cm), number of leaves/plant, number of branches/ plant, shoots fresh and dry weights (g)/plant and nutrients determination were established for the study on growth and quality of dry beans

***Yield and its components*:** Five plants were randomly chosen in each plot and were marked in the field from the start of flowering to harvest time and the following characteristics were studied: no. of seeds/pod, 100 seeds weight (g), seeds yield (g)/plot and seeds yield (kg)/fed.

***Chemical analysis*:**

Soil 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 (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 B was extracted by hot water and measured by azomethine-H colorimetric method (Bingham, 1982). The results of soil analysis of the experimental field indicated that there was a deficient in P, K, Mg, Fe, Mn, Zn, and Cu according to Ankerman and Large (1974).

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

Mechanical analysis, %			Tex.	Physical properties				Macronutrients, mg 100 g^{-1}					Micronutrients, mg kg^{-1}				
Sand	Silt	Clay		pH	EC, mS m^{-1}	$CaCO_3$, %	O.M, %	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu	B
62.8	8.2	29.0	Clay sand	8.9	0.45	3.60	1.35	1.26	28.2	265	25.2	22	3.5	8.7	1.6	0.4	1.8

***Leaves and seeds analysis*:** Nutrient element compositions in the leaves and seeds were analyzed for the macro- and micronutrient contents. Nitrogen was analyzed using the Kjeldahl method AOAC (1990), P was analyzed by using spectrophotometer Chapman and Pratt, (1978), and K, Ca, Mg, Fe, Mn, Zn and Cu were analyzed by Perkin-Elmer (1100 B) atomic absorption spectrometer. Concentrations of B determined in leaf and seeds tissues were estimated by the azomethine-Hmethod Wolf, (1974) by using spectrophotometer (Perkin-Elmer Lambada2).

***Crude Protein (CP %)*:** was determined by estimating the nitrogen content.

Seeds Germination Test:

***Germination Percentage (%)*:** was calculated according to Anjum and Bajwa (2005).

by the flowing formula:

$$= \frac{\text{No. of Germination Seeds} \times 100}{\text{Total No. of Seeds}}$$

***Germination Rate (day)*:** The germinated seeds were counted every day to determine the germination rate and the total index Anjum and Bajwa (2005).

The seedling vigor index (SVI) was determined according to Hosseein and Kasra (2011)

Seedling Vigor Index (SVI) = Germination Percentage (G.P %) × Seedling dry weight (g) (SDW)

***Statistical analysis*:** Randomized Complete Block Design (R.C.B.D) with three replicates was used in this study. The results were submitted to analysis of variance according to Snedecor and Cochran (1980). 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 Discusions:

Vegetative Growth:

Data in Table 2 illustrated that the vegetative growth dry bean plants i.e. number of leaves, plant length, shoot fresh and dry weights per plant were significantly increased with foliar spraying of calcium or / and boron before or before & after flowering when compared with control treatment expect number of branches.

Table 2 Effect of foliar spraying of Ca and B on vegetative growth in dry Bean Plant at 75 days after sowing (Combined analysis of the two seasons 2015 and 2016)

Treatments Characters	Plant Length, cm	No of leaves	No of branches	Shoot FW, g $plant^{-1}$	Shoot DW, g $plant^{-1}$
Control	59.60	17.00	4.20	88.19	22.44
Ca 2500 ppm (before flowering)	62.00	28.00	5.20	176.77	44.42
Ca 2500 ppm (before & after flowering)	62.20	28.00	6.60	179.78	45.22
B 250 ppm (before flowering)	66.00	21.00	4.40	118.15	29.24
B 250 ppm (before & after flowering)	63.40	22.20	4.80	119.98	31.00
Ca 2500 ppm + B 250 ppm (before flowering)	68.80	26.60	5.80	160.55	40.34
Ca 2500ppm + B 250 ppm (before & after flowering)	68.80	27.40	6.00	169.81	42.69
LSD 0.05%		0.9	0.8	6.1	2.7

Number of leaves per plant is significantly affected by each foliar spraying treatment. Foliar spraying of calcium treatments before or before & after flowering were gave the higher value of the number of leaves than the other treatments. In addition, there are no significant differences between calcium before or before & after flowering treatment as well as calcium plus boron before or before & after flowering treatment. Meanwhile, there is a slightly significant difference between boron treatments at before and before & after flowering. There are significant differences between foliar spraying with calcium or boron and calcium plus boron treatments as compared to the control treatment.

However, foliar spraying of Ca at 2500 ppm before flowering or before & after flowering treatments gave the highest values of leaves number followed by Ca 2500 ppm and B 250 ppm before and after flowering. On the other hand, the lowest value of leaves number recorded with the control treatment.

Number of branches were affected by foliar applications of calcium, boron and calcium plus boron treatments. Also, foliar spraying treatments of Ca or/and B had slightly positive effect on the number of branches. The highest value of branches number was appeared with Ca foliar spraying at 2500 ppm before & after flowering when compared with the other treatments. Data in Table 2 also showed that there was a significant increase of plant length with Ca or/and B application when compared with the control treatment. In addition, there are no significant differences for plant length between treatment of Ca or B alone before or before & after flowering. The tallest plants were obtained with Ca 2500 ppm plus B 250 ppm at before flowering or before & after flowering treatments. These results are in agreement with that obtained by Ati and Ali (2011) that vegetative characters of bean plants such as, plant height, numbers of branches per plant increased with the increasing amount of boron applied and number of applications.

Increment of Fresh and dry weights were affected by foliar spraying of calcium or/and boron treatments. Foliar spraying of calcium before flowering or two before & after flowering was the best, followed by spraying calcium and boron as compared with the control treatment. The highest increments in fresh and dry weights were resulted from spraying calcium before & after flowering.

Although there are significant differences between spraying calcium or boron and calcium plus boron treatments, there is no significant effect of calcium or boron and calcium plus boron before &after flowering times. The highest values of fresh and dry weights recorded with foliar application of Ca at 2500 ppm before &after flowering treatment followed by Ca at 2500 ppm before flowering treatment. The previous studies mentioned that foliar spraying bean plants of boron led to the increment of vegetative growth and yield of green pods, seed yield and its components. (Goldbach *et al*., 2001; Camacho-Cristobal *et al*., 2008; Saleem *et al*., 2011; El-Waraky *et al*., 2013) This can be attributed to the effect of boron in improving the qualities of vegetative growth and yield through cell membranes and thus increase vegetative growth, as well as, needed by the crop plants for cell division, nucleic acid synthesis, and the uptake of calcium and transport of carbohydrates which is reflected on the yield.

The result are in agreement with Favaro *et al*. (2007) who mentioned that increasing rates of calcium improved biomass production in dry bean plants where many physiological disorders of storage organs are associated to the low content of calcium in the plant tissues. The results of this study are also in agreement with McKently *et al*. (1982) and Domingues *et al.*(2016) that dry mass of the shoot and root increased linearly in common bean plants which was grown with high calcium concentration.

Yield and its Components:

Data in Table 3 showed yield and its components of bean plants such as number of seeds per pod, 100 seeds weight and seed yield per plot or fed. (Feddan = 0.42 Hectare). According to the table data, seed yield and yield characteristics were positively affected by all foliar application with calcium or/and boron both before and after flowering during the two seasons as compared with the control treatment.

Number of seeds per pod was affected by foliar application of calcium or/and boron either before or before & after flowering treatments. There are significant differences between foliar spraying with calcium or boron and calcium plus boron treatments as compared with the control treatment in the No. of seeds.

The highest number of seeds per pod (4.6 seeds /pod) achieved with foliar spraying of 2500 ppm Ca before &

after flowering or 250 ppm B before flowering, While, the lowest value in number of seeds per pod (3.0 seeds /pod) obtained by control treatment.

Weight of 100 seeds has been positively affected by foliar spraying of Ca or/and B before and before & after flowering treatments.

Table 3 Effect of foliar spraying of Ca and B on seed yield and yield characteristics at 95 days after sowing (Combined analysis of the two seasons 2015 and 2016)

Treatments Characters	No. of seeds/pod	100 seeds weight	Seed yield	
			(g)/Plot	(kg)/fed.
Control	3.00	27.19	1800.0	720.00
Ca 2500 ppm (before flowering)	4.40	35.86	2006.8	802.92
Ca 2500 ppm (before &after flowering)	4.60	39.36	2250.0	900.00
B 250 ppm (before flowering)	4.60	43.90	2682.5	1072.98
B 250 ppm (before &after flowering)	4.40	43.75	2827.5	1084.62
Ca 2500 ppm + B 250 ppm (before flowering)	4.40	42.69	2659.4	1063.96
Ca 2500 ppm + B 250 ppm (before &after flowering)	4.40	43.67	2711.4	1131.00
$LSD_{0.05}$	0.47	0.36	45.2	18.10

Boron had a better impact on100 seed weight than the other treatments. There are significant effects for 100 seeds weight among all foliar spraying treatments when compared to the control treatment. The highest value of 100 seeds weight value (43.85 100 seeds weight) obtained with foliar application of Ca 2500 ppm plus B 250 ppm before & after flowering treatment. Our results are considered in this regard in line with Favaro *et al*. (2007) mentioned that the characteristics of pod i.e. dry matter, number, length and weight, were affected negatively by low calcium concentration in solution. But increasing the rates of calcium improved biomass production in snapbean cultivar. Also, many physiological disorders in storage organs are associated to the low content of calcium in the plant tissues.

Moreover, bean plants grow in the absence of calcium led to a reduction in pod number, which is due to the low calcium mobility in the plant tissues (McKently *et al*., 1982).

Seed yield of bean plant per feddan was affected by the foliar application of Ca or/and B treatments. Data in Table 3 showed that there was a significant increase between foliar spraying of boron and boron plus calcium or boron and calcium at both before or before & after flowering treatments. Also, there are positive effects on seed yield per feddan by foliar spraying before flowering and before &after flowering with calcium or boron solo and calcium plus boron treatments when compared to the control treatment. The highest value of seed yield per feddan (1131.0 kg seeds/fed.) obtained by foliar spraying of Ca 2500 ppm plus B 250 ppm when compared with the other treatments or control plants. The results meet with that achieved by Ati and Ali (2011) reported that green pod and dried bean seeds increased with the increasing amount of boron applied and number of applications. Favaro *et al*. (2007) mentioned that the increasing rates of calcium led to the improvement of biomass production in snap bean cultivar. Also, foliar application of calcium alone improved seed physiological potential in common bean plants when applied at the full bloom stage and had a significant effect on number of seeds per pod (Quintana *et al.*, 1999; Costa *et al.*, 2014).

Nutrient concentration:

- ***Leaf and seed crude protein content (%)***

The application of calcium and boron in a foliar spraying has improved the nutritional status of leaves and seeds, and thus lead to increased seed storage capacity.

The results in Table 4 indicted that the crude protein content of bean leaves and seeds were significantly increased by foliar application of calcium or/and boron when compared with the control treatment.

There are significant differences between foliar spraying with calcium or boron alone and calcium plus boron as compared to the control treatment on crude protein content as well as between foliar spraying with calcium or boron solo treatment before flowering and before & after flowering treatment. However, there are no significant difference between calcium & boron when compared before and before &after flowering treatment.

Table 4 Effect of foliar spraying of Ca and B on leaves and seed crude protein content (%) of (Combined analysis of the two seasons 2015 and 2016)

Treatments Characters	Protein Contents, %	
	Leaf	Seed
Control	13.08	18.63
Ca 2500 ppm (before flowering)	14.39	21.19
Ca 2500 ppm (before &after flowering)	15.84	22.38
B 250 ppm (before flowering)	16.54	23.69
B 250 ppm (before &after flowering)	16.72	23.75
Ca 2500 ppm + B 250 ppm (before flowering)	17.02	24.31
Ca 2500 ppm + B 250 ppm (before &after flowering)	17.07	24.50
$LSD_{0.05}$	0.10	0.08

The highest values of crude protein in leaves and seeds (24.38% and 24.50%, respectively) were recorded with calcium 2500 ppm plus boron 250 ppm before flowering and before & after flowering treatments. On the other hand, the lowest value of crude protein was resulted from the control treatment. The results in same line with Abo-Hamad & El-Feky (2014) mentioned that the increasing concentrations of boron led to increased soluble proteins in plant root and shoots.

- ***Leaves nutrient concentration*:**

The presented data in Table 5 recorded that concentration of macro and micro-nutrient in leaves were significantly different by foliar application of calcium or/and boron when sprayed at before or before &after flowering during the two seasons.

Table 5 Effect of foliar spraying of Ca and B on macro and micro-nutrient concentrations in leaves of dry bean (Combined analysis of the two seasons 2015 and 2016)

Treatments Characters	Macronutrients, %					Micronutrients, ppm				
	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
Control	2.09	0.12	1.21	1.80	0.21	82	32	53	7.0	26.0
Ca 2500 ppm (before flowering)	2.30	0.20	2.01	2.60	0.26	116	41	66	9.0	33.2
Ca 2500 ppm (before & after flowering)	2.53	0.18	1.81	2.75	0.26	92	42	61	9.5	31.7
B 250 ppm (before flowering)	2.65	0.21	2.10	2.40	0.24	97	41	66	7.5	44.3
B 250 ppm (before & after flowering)	2.67	0.20	1.68	2.60	0.24	102	40	68	7.5	45.9
Ca 2500 ppm + B 250 ppm (before flowering)	2.72	0.15	1.60	2.55	0.24	97	50	69	9.0	41.6
Ca 2500 ppm + B 250 ppm (before &after flowering)	2.73	0.14	1.48	2.45	0.24	103	52	69	9.5	43.1
$LSD_{0.05}$	0.04	0.01	0.03	0.03	0.02	1.5	1.6	1.6	0.2	0.04

There are significant differences between all foliar spraying with calcium and boron alone or combination when compared with the control treatment.

Foliar application of calcium had an influence on increasing the level of calcium and magnesium in leaves. The highest values of Ca and Mg in leaves recorded with calcium at 2500 ppm before flowering and before & after flowering treatments. The concentration of N, P, K and B in leaves were increased with boron alone treatment. The highest values of Ca and Mg in leaves resulted from boron spray at 250 ppm before flowering treatment. In this respect, our results are in agreement with Ati and Ali (2011) mentioned that concentration of nitrogen and phosphorus percentage increased with the increasing rate of boron applications in bean plants. Meanwhile, Ca 2500 ppm + B 250 ppm treatment at before & after flowering treatment gave the highest values of Mn, Zn and Cu concentrations of bean leaves. In this respect, the contents of bean pod Ca were increased with calcium fertilizer (Quintana *et al*., 1999).However, the content of K and B were increased in shoot of tomato plants as a response to boron application which was attributed to the activity of glutamate oxaloacetate and glutamate-pyruvate transaminases enzymes (Abo-Hamad & El-Feky, 2014). Also, Ganie *et al*. (2014) mentioned that boron application led to an increase N, P, K and B concentrations in French bean (*Phaseolus vulgaris* L.). Quintana *et al*. (1999) mentioned that calcium fertilizer had a significant effect on pod Ca concentration.

Seeds Nutrient Concentration:

The results in Table 6 indicted that the macro and micronutrient concentrations of the seeds were significantly increased by foliar application of calcium or/and boron when compared with the control in both seasons.

There is a significant effect on P concentration when plants were sprayed with B at before and before & after flowering treatments. Also, there are no significant differences on seed P concentration between treatments of Ca or Ca and B when sprayed before flowering and before

& after flowering. Meanwhile, there is a significant effect on K concentration between all spraying treatments of Ca, B and Ca and B before flowering or before & after flowering in addition control treatment.

Table 6 Effect of foliar spraying of Ca and B on macro and micro-nutrient concentrations in seeds of dry bean (Combined analysis of the two seasons 2015 and 2016)

Treatments Characters	Macronutrients, %					Micronutrients, ppm				
	N	P	K	Ca	Mg	Fe	Mn	Zn	Cu	B
Control	2.98	0.32	1.80	0.06	0.15	54	21	31	3.5	20.2
Ca 2500 ppm (before flowering)	3.39	0.36	1.95	0.07	0.20	95	28	37	4.5	22.4
Ca 2500 ppm (before &after flowering)	3.58	0.34	1.85	0.08	0.21	70	30	33	4.5	21.8
B 250 ppm (before flowering)	3.79	0.38	2.08	0.07	0.18	78	25	38	3.5	23.5
B 250 ppm (before &after flowering)	3.80	0.44	2.18	0.08	0.19	85	23	39	3.5	24.5
Ca 2500 ppm + B 250 ppm (before flowering)	3.89	0.34	1.98	0.08	0.16	57	34	40	6.0	23.0
Ca 2500 ppm + B 250 ppm (before & after flowering)	3.92	0.34	2.00	0.07	0.16	59	38	41	6.0	23.4
$LSD_{0.05}$	0.04	0.02	0.02	0.001	0.001	2.1	1.4	1.6	0.6	0.04

Data showed that the highest values of P, K and B concentrations obtained by foliar spray of B at 250 ppm. On other hand, the highest N concentration founded when sprayed by calcium plus boron before & after flowering treatment. These results are in harmony with Ganie *et al*. (2014) that the application of boron led to an increase in the concentration of N, P, K and B in the seeds of French bean (*Phaseolus vulgaris* L.). Also, calcium and magnesium content were increased by 2500 ppm calcium spraying at before flowering and before & after flowering. In addition, the high concentrations of Fe, Mn, Zn and Cu in seeds obtained by foliar application of calcium or boron and calcium plus boron treatments. The highest values content of Mn, Zn and Cu were obtained with the treatment of Ca 2500 ppm + B 250 ppm (before & after flowering). The Fe concentration in seeds decreased by the increasing of calcium number of times, but increased with increasing number of times application of boron.

From the mentioned data, the foliar spraying treatment of calcium 2500 ppm and boron 250 ppm before flowering and before & after flowering showed the same trend in the increase content of phosphorus and potassium. Meanwhile, the micronutrient contents were also significantly increased by foliar spraying of Ca 2500 ppm + B 250 ppm before & after flowering.

In this connection, our results are in agreement with Yakuba *et al*. (2010) mentioned that boron increased nodulation activity which may have increased the nitrogen content. Moreover, application of boron in soil deficient of boron might have resulted in increasing availability of boron which in turn has influenced DNA and protein synthesis leading to increased nitrogen content and uptake (Debnath & Ghosh, 2011). The increase in the phosphorus content with the increase in boron application could be due to the favorable influence of boron on various metabolic processes like photosynthesis, respiration, enzyme activity (Ganie *et al*., 2014). Also , the increasing the content and uptake of potassium and boron by boron fertilization could be attributed to the better growth of crop resulting in greater absorption of nutrients from soil leading to its higher content and uptake.

Seed Germination Test:

The results in Table 7 showed that germination characteristics of bean seeds produced from treated plants such as germination percentage and rate, seedling length , fresh and dry weights and seed vigor index (SVI) were positively affected by spraying plants with calcium or/and boron in before or before & after flowering when compared with the control treatment.

Seed Germination Percentage and Rate

Seed germination percent induced by Ca or B and their combination, also the seedling length, fresh and dry weights increased significantly with the increased Ca or B at application time. Results showed that there were significant differences among all foliar spraying treatments as compared to the control. Also, there are significant differences between Ca and B treatments before flowering and before & after flowering.

Table 7 Effect of foliar spraying of Ca and B on seeds germination and seedlings growth (Combined analysis of the two seasons 2015 and 2016)

Treatments Characters	Germination		Seedlings length, cm	Seedlings weights, g		SVI
	Percent, %	Rate/day		Fresh	Dry	
Control	76.33	2.71	10.00	2.16	0.41	31.30
Ca 2500 ppm (before flowering)	90.00	2.66	11.80	2.20	0.42	37.80
Ca 2500 ppm (before &after flowering)	91.33	2.52	12.20	2.56	0.49	44.75
B 250 ppm (before flowering)	89.00	2.67	12.80	2.29	0.44	39.16
B 250 ppm (before &after flowering)	90.00	2.61	12.60	2.51	0.48	43.20
Ca 2500 ppm + B 250 ppm (before flowering)	90.67	2.57	13.60	2.49	0.47	42.62
Ca 2500 ppm + B 250 ppm (before & after flowering)	92.67	2.49	13.80	2.68	0.51	47.26
$LSD_{0.05}$	1.9	0.04	0.8	0.07	0.06	1.9

The best value of seed germination percentage and rate recorded with bean seeds resulted from plants which have been sprayed by foliar spraying of Ca 2500 ppm plus B 250 ppm (92.67% and 2.49 rate/day) before and after flowering treatment when compared to the other treatments and control plants. The lowest value of seed germination percent and rate recorded with bean seeds of control treatment. Seed germination percent and rate were enhanced with the increasing foliar spraying concentration rate and the number of times. These results are in agreement with Costa *et al*. (2014) mentioned that foliar application of Ca had a positive effect on seed germination of common bean plants.

Seedling Growth:

Seedling length, fresh and dry weights and seed vigor index were increased by seed produced from the plants which have been sprayed by Ca or/and B as foliar spraying before & after flowering treatment as compared with control plants. There are significant differences in seedling length between the foliar spraying treatments as compared to the control. The foliar application of Ca plus B at before & after flowering treatment gave the tallest seedlings followed by Ca plus B at before flowering treatment. But the shortest seedling produced from control treatment.

Fresh and Dry Weights and Seed Vigor Index:

Also, data indicated that, there are significant differences of seedling fresh and dry weights between all foliar spraying treatments when compared to Ca before flowering and control treatments. The highest value of seedling fresh and dry weights resulted from bean plants which have been sprayed with Ca plus boron at 250 ppm before & after flowering.

Observed data in Table 7 indicated that foliar spray of Ca or/and B had a significant effect on seed germination test (percentage and rate), seedling length, fresh and dry weights and seed vigor index. The increases in concentration of Ca or/ and B lead to increased seed vigor index as compared to control. The result of this finding was in harmony with Ashagre *et al*. (2014) on wheat plant.

3 Conclusion

The study concluded that foliar spray of calcium or/and boron was reasonable when it was foliar spraying both before flowering or before & after flowering on the characteristics of growth and the quantity and quality of seed yield in bean plants. Spraying twice during the growing season (before flowering and before &after flowering) had a positive effect, while spraying once gave unsatisfactory effect. Furthermore, the increase in the concentration of calcium and / or boron did not show additional significant increases in plant measurements. It can be concluded that the foliar application as fertilization technique seems that it is more effective to increase the yield and increase the seed content of elements in the beans.

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