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Evaluation of Calcium Rate and Time Application on Common Bean Nutrient Status, Seeds Yield and Quality

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ABSTRACT

Two field experiments were carried out on common bean (*Phaseolus vulgaris* L. cv. Nebraska), under clay soil conditions, in two successive summer seasons of 2015 and 2016 at the Experimental Farm of Vegetables Research Institute at Kaha, Qalubia Governorate, Egypt. The study aimed to determination the critical growth period of common bean for calcium foliar application once before flowering or twice before and after flowering and its effect on growth, nutrients content and yield as well as seed quality and seed germination. The obtained results showed that foliar application of Ca before flowering period or before and after flowering periods had a positive effects on plant length, number of leaves, fresh and dry weights per plant, as well as number of seed per pod, seed yield and seed quality in both seasons. Results also showed that, calcium foliar application once before flowering or twice before and after flowering increased crude protein content. Also, macro (N, P, K, Ca and Mg) and micro (Fe, Mn, Zn and Cu) nutrients concentration in leaves and seeds. The highest vegetative growth and seed yield were recorded by 5000 ppm calcium as a complete rate once before flowering or half rate twice before and after flowering in both growing seasons. The distribution of nutrients in leaves and seed were differed according to application calcium rate and time. The best result of seed germination percentage obtained with the complete rate once at 5000 ppm before flowering period. But the foliar application of Ca with half rate before and after flowering treatment gave the tallest and the highest fresh and dry weight of seedling.

***Keywords*:** Common bean, calcium foliar application, growth periods, nutrients concentration, seed yield and quality, seed germination.

Introduction

Calcium has been described as mineral for the maintenance of cell membranes and walls because it takes part in links with pectin substances which help to cell adhesion Heppler & Wayne (1985), and as essential for plant nutrition. Calcium is plays an important role for increasing growth, seed quality and period of storage after harvest.

Calcium deficiency is serious for increasing production and quality in several crops. The addition of calcium leads to increase in the plant growth. Also, it is may be believed that the growth increasing is not due to the direct effect of calcium, but also, due to the important role played by calcium in adjusts and balances nutrient solution in the plant and soil.

The growth, yield and its components of snap bean plants were reduced when it's grown under calcium stress condition (Mc Kently *et al*., 1982; Naeem and Khan, 2006 and Naeem *et al*., 2009).

Calcium fertilization leads to enhancing high fertility which increased pollen germination and growth pollen tube (Ge *et al*., 2007).

Foliar spraying is more effective by three or four times than soil application as far as the amount of nutrients necessary to do the same job and there is no contamination of ground water. As well as, it is useful and effective in correcting plant nutrients deficiency. Also, it use primarily to improve growth attributes and increase yield and quality by overcoming the limitations of the soil and its ability to transfer nutrients into the plant.

Foliar application of calcium improved seed physiological potential in common bean plants when applied at the full bloom stage. These results can be interpreted that calcium is low-movement

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nutrients in plants and foliar applications may be useful for correcting the local palaces (Malavolta, 2006). In addition, there was an increase in seeds weight per plant when soybeans plants which were sprayed with calcium application at the full bloom stage (Bevilaqua *et al*., 2002 and Souza *et al*., 2008).

Calcium fertilization of fresh beans planted in the soil was not effective in increasing calcium concentration in immature pods (Quintana *et al*., 1999). These may be related to the water flow in plant during its growing period.

Growing bean plants under high concentrations of calcium in growth medium gave the highest shoot dry weight and the number of pods per plant (Favaro *et al*., 2007 and Silva *et al*., 2011). Also increased root dry weight, grain yield and concentration of calcium in the leaves and grains (Domingues *et al*., 2016).

In indeterminate growth snap bean plants, the leaves and pods grow simultaneously and may compete for water during periods of high transpiration demand by the plants (Domingues *et al*., 2016). At the final developmental stages of determinate growth in plants, nutrients are remobilized from the vegetative organs to the grains, and the nutrient concentration in the grains can increase (Naeem *et al*., 2009).

The results of many studies indicate that calcium addition to bean plants, either through soil or foliar spray, lead to increasing protein and macronutrients contents of leaves and seeds (Naeem & Khan 2006 and Naeem *et al*., 2009).

Common bean plants when grown with high concentrations of calcium in the nutrient solution gave the highest calcium accumulation in the leaves and grains (Cabot, *et al*., 2009; Favaro *et al*., 2007; Schmitt *et al*., 2013 and Domingues, *et al*., 2016).

Some studies had demonstrated an improvement in seed physiological potential after the foliar application of calcium because this element is responsible for the formation of calcium pectate in plant cell walls (Malavolta, 2006). For this reason, plants that are sprayed at an appropriate stage with ideal rates of calcium may have more structured membrane system, reducing the leaching of ions, which results in seeds with more vigor Farinelli, *et al*., (2006) also, Rosolem, *et al*., (1990) observed an improvement in germination speed as a function of the rate of calcium applied to the common bean plant.

This study aims to evaluate the best physiological period to foliar addition of calcium at the complete rate either once before flowering or fragmentation rate on twice before and after flowering. As well as, the effect on growth, yield and nutrient status also, determination seed germination test of common bean plants.

Materials and Methods

Two field experiments were carried out on common bean (*Phaseolus vulgaris* L. cv. Nebraska), under clay soil conditions, in two successive summer seasons of 2015 and 2016 at the Vegetables Institute Experimental Farm at Kaha Qalubia Governorate, Agriculture Research Centre, Egypt.

The common fertilizer applications were used as following: 20 m^3 fed^{-1} of farmyard manure before sowing. NPK rates were 60 Kg N fed^{-1} as ammonium nitrate (33.5 % N), 20 Kg P_2O_5 fed^{-1}, as calcium superphosphate (15 % P_2O_5) and 60 Kg K_2O fed^{-1} as potassium sulfate (48-52%) in both seasons were using divided along the growing season. Other horticultural practices for growing bean were done as follows in the region as recommended.

The experiments were arranged in randomized complete block design with three replicates. The plot area was 10.5 m^2 (3x 3.5 m) with five rows in 0.6 cm width. Bean seeds were sown in hills spaced 30 cm on ridges at the 15th of March in the two seasons. At 20 days after sowing, hills were thinned to one seedling per hill.

Treatments:

In each season, four treatments of calcium foliar application rate as (calcium nitrate) were as follow:

1- Control
2- Ca 2500 ppm once before flowering
3- Ca 5000 ppm divided in two rates (2500 ppm each) at before and after flowering

4- Ca 5000 ppm once before flowering

Soil sampling:

Soil samples at (0 30 cm) depth were randomly collected before planting.

Leaf sampling:

Leaf samples were collected randomly from the fully mature (4 to 5 leaves from the plant top) at 75 days after sowing (DAS) to determine the plant nutrient contents.

Seeds sampling:

Seed samples were collected randomly from the mature pods at 95 days after sowing (DAS) to determine the nutrient contents.

Pods sampling:

At harvest 95 (DAS) five plants from each replicate were randomly picked for determination of dry pods physical, quantitative and qualitative characteristics in the laboratory.

The mineral analysis was done in the leaves and seeds in both seasons according to Chapman and Pratt, (1978).

Vegetative growth, Yield and its component:

Ten plants were randomly chosen from central row of each plot at 75 days after sowing for vegetative growth parameters and 95 days after sowing for yield and its components as follows in both seasons. Plant height (cm), number of leaves/ plant, number of branches/ plant, shoots fresh and dry weights (g)/ plant. As well as, number of pod per plant, seed number of pod, 100 seeds weight and seed yield were determined.

Chemical analysis:

Soil analysis: Soil samples were analyzed (Table 1) for texture, pH and electrical conductivity (EC mS/ m) using water extract (1: 2.5), total calcium carbonate ($CaCO_3$ %) was 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) and 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).

Table 1: Soil physical -chemical properties of the experimental site:

Mechanical analysis %			Tex.	Physical properties				Macronutrients (mg/ 100 g)					Micronutrients (mg/ Kg)			
Sand	Silt	Clay	Sandy clay loam	pH	EC (mS/m)	$CaCO_3$ (%)	O.M (%)	P	K	Ca	Mg	Na	Fe	Mn	Zn	Cu
64.0	8.0	28.0		8.9	0.18	5.36	1.70	0.26	18.2	420	20.2	32	3.5	4.0	1.6	0.4

Soil analysis of the experimental field indicated that, there is a deficiency in P, K, Mg, Fe, Mn, and Cu according to Ankerman and Large, (1974).

Nutrient element analysis in leaves and seeds:

Nutrient in the leaves and seeds were analyzed for the macro- and micronutrient contents as follows, Nitrogen was analyzed using the Kjeldahl method Buresh *et al*., (1982), phosphorus was determined by using vanado-molybdate color reaction and measured by spectrophotometrically according to the method described by Jackson (1973), K, Ca, Mg, Fe, Mn, Zn and Cu were measured by using Perkin-Elmer (1100 B) atomic absorption spectrometer and determined according to Chapman and Pratt, (1978).

Crude Protein (%): was determined by estimating the nitrogen content by the Kjeldahl method (A.O.A.C.1990).

Crude Protein % = N % × 6.25.

Yield characteristics:

Number of seeds per pod, 100 seed weight (g), and seed yield (kg/ fed) were recorded.

Seeds Germination Test:

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

$$Germination\ percentage\ (\%) = \frac{Number\ of\ germinated\ seeds}{Total\ number\ of\ seeds} \times 100$$

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).

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

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

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

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, (1967). Differences among treatment means were compared by using the LSD test at a significance level of 0.05 according to Waller and Duncan, (1969).

Results and Discussion

Vegetative growth:

Data in table (2) showed that all vegetative growth parameters of common bean plants such as plant length, number of leaves and branches as well as shoot fresh and dry weights per plant were positively affected by calcium foliar sprays, either with half of the calcium rate before flowering or the full rate of calcium at one time before flowering or dividing the rate twice before and after flowering as compared to control treatment except number of leaves and number of branches in both seasons.

Table 2: Effect of calcium rate and time on vegetative growth of combined analysis of the two seasons 2015 and 2016).

Treatments	Plant length (cm)	No. of leaves/ plant	No. of branches/ plant	Shoot (g/ plant)	
				(F.W)	(D.W)
Control	62.00	26.00	5.20	135.56	35.29
Ca 2500 ppm at once before flowering	62.00	27.00	5.20	153.34	40.90
Ca 2500 ppm at twice before and after flowering	62.20	28.00	6.60	179.78	44.01
Ca 5000 ppm at once before flowering	67.80	29.80	5.60	176.77	43.75
$LSD_{0.05}$	4.2	NS	NS	13.3	3.4

Plant length was affected by addition of the full dose of calcium once before flowering. Also, the effect was mild slightly when the full dose was added twice (before and after flowering). The full dose of calcium once before flowering treatment gave the longest plant when compared with the other treatments. On the contrary; plant length was not affected by adding half the dose before flowering as compared with the control treatment.

Number of leaves per plant was increased by all calcium spray treatments when compared with the control, although the increases were non-significant. Also, the foliar spray of calcium at complete-rate treatment once before flowering gave the highest number of leaves.

Number of branches per plant was positively affected by calcium spray at full rate, either once before flowering or at dividing the dose twice before and after flowering. While, there were no increases the number of branches per plant by the addition of half the dose of calcium before flowering compared with the control treatment.

The above results indicated that the foliar addition of calcium either before or before and after the flowering period promoted vegetative growth such as plant length, number of leaves and number of branches which agreed with McKently *et al*. (1982), Favaro *et al*. (2007) and Silva *et al*. (2011).

The presented data in Table (2) showed that there was a significant increase in fresh and dry weights of bean plants between calcium foliar spray and control treatment. The highest shoot fresh and dry weights achieved with the foliar addition of the complete rate of calcium with fragmentation on two times before and after flowering followed by treatment with the full rate of calcium once before flowering. The results also, indicated that no significant differences between them. The lowest shoot fresh and dry weights were noticed with control treatment.

The above results of vegetative growth referred the importance of adding calcium at full rate once pre-flowering peroid or splitting the dose twice during pre and after flowering periods. The similar effects of calcium were recorded by Favaro *et al.* (2007) the biomass production in snap bean plant was improved by increasing calcium concentration rates in solution. Also, Naeem and Khan (2009) and Naeem *et al.* (2009) stated that fresh and dry weights were positively increased by calcium application at 60, 90 and 120 day after sowing to Hyacinth bean plant.

Yield and Its Components:

Data presented in table (3) indicated that yield and its components of common bean plants such as number of pod per plant, number of seeds per pod, weight of 100 seeds and seed yield per feddan were significantly increased by all calcium foliar spraying treatments.

The yield and its components were improved by adding calcium full rate one time or twice times when compared to control treatment as an average of the two seasons.

Table 3: Effect of calcium rate and time on yield and its components of combined analysis of the two seasons 2015 and 2016).

Treatments	No. of pods/ plant	No. of seeds/ pod	100 seed Weight	Seed Yield (Kg / fed.)
Control	11.33	3.00	27.12	840.00
Ca 2500 ppm at once before flowering	13.60	4.40	35.86	936.74
Ca 2500 ppm at twice before and after flowering	14.97	4.60	39.28	1050.00
Ca 5000 ppm at once before flowering	17.03	4.80	41.98	1322.86
$LSD_{0.05}$	0.16	0.5	1.6	11.3

The number of pods per plant, seed number of pod, weight of 100 seeds and seed yield in feddan were positively affected by add spraying of calcium. Also, there was significant differences between all spraying and control treatments.

The highest values of yield and its components were obtained by adding full rate of calcium once before flowering, followed by dividing full rate of calcium twice before and after flowering treatments.

Previous results indicated that foliar addition of calcium to bean plants led to increases seed yield and its components, which were accordance with that reported by Quintana, *et al*. (1999) on snap bean plants, Favaro *et al*. (2007), on snap bean Naeem *et al*. (2009) on Hyacinth bean and Domingues, *et al*., (2016) on common bean plants. These results might be due to the effect of calcium on pollen germination and the growth of the pollen tube, as well as high fertility, which leading to an increased number of pods and grains per plant and higher grain yield Ge *et al*. (2007).

The Nutrient Status:

Nutrient status of leaves and seeds were affected by foliar spraying of Ca when applying either a complete rate at one time before flowering period or fragmentation on twice before and after flowering periods as compared to the control treatment as an average of the two seasons.

The addition of all calcium foliar application treatments has improved the nutrient status of leaves and seeds, and thus will lead to improving seeds content and quality. Moreover, there is a certain amount of this naturally occurring calcium that combines with supplemental calcium to stimulate plant growth.

Crude protein (%)

Data in table (4) showed that the crude protein content in common bean leaves and seeds were significantly increased by add the full complete rate of calcium at once or twice periods as compared to the control treatment.

Table 4: Effect of calcium rate and time on leaves and seeds crude protein content (%) of combined analysis of the two seasons 2015 and 2016).

Treatments	Protein Contents (%)	
	Leaf*	**Seed****
Control	18.69	18.50
Ca 2500 ppm (one time)	23.63	23.69
Ca 2500 ppm (before and after flowering)	23.88	23.75
Ca 5000 ppm (one times)	24.19	24.19
LSD $_{0.05}$	1.66	1.78

*Leaves analysis at 75 days after sowing (DAS).
**Seeds analysis at 90 days after sowing (DAS).

There are significant differences in leaves and seeds protein content between the all calcium foliar spraying treatments and the control treatment. But, there are no significant effects between calcium addition when compare between 2500 ppm before and 2500 ppm before and after flowering treatment.

Protein content of leaves ranged from 18.69 – 24.19 and 18.50 – 24.19 (%) for leaves and seeds, respectively. The highest values of crude protein in leaves and seeds (24.19% and 24.19 %, respectively) were recorded with add the complete rate of calcium 5000 ppm simultaneously before flowering followed by fragmentation the full rate of calcium 5000 ppm on twice before and after flowering treatment. On the contrary, the lowest value of crude protein was resulted from the control treatment.

The obtained results are in the same line with those finding by Naeem and Khan (2006) on *Cassia Tora* L. plants, Naeem *et al.* (2009) on hyacinth bean plants and Costa *et al*. (2014) on common bean plants. They reported that calcium element is acts as a co-factor for some proteins, aiding in signaling and the regulation of certain reactions in plants. Moreover, when plants grow in unstable environments, calcium is very important because it plays a role in gene expression, improving certain cellular reactions.

Macro and micronutrient contents:

Leaves:

The presented data in Table (5) represent leaf analysis for macro and micronutrients of common beans plants after 75 days from sowing. It showed that there is a clear significant difference for leaf macro and micro nutrient concentrations as a result of calcium addition when compared with control treatment.

Table 5: Effect of calcium rate and time on leaves nutrient concentration at 75 days after sowing (DAS) of combined analysis of the two seasons 2015 and 2016.

Treatments	Macronutrients (%)					Micronutrients (ppm)				
	N	**P**	**K**	**Ca**	**Mg**	**Fe**	**Mn**	**Zn**	**Cu**	**B**
Control	2.99	0.12	1.21	1.80	0.21	82	41	53	7.0	17.9
Ca 2500 ppm (one time) before	3.78	0.20	2.01	2.25	0.26	116	42	64	9.0	21.1
Ca 2500 ppm (before and after	3.82	0.18	1.81	2.75	0.26	92	47	61	9.0	28.4
Ca 5000 ppm (one times) before	3.87	0.17	1.67	2.60	0.22	95	52	66	9.5	28.8
LSD $_{0.05}$	0.03	0.01	0.02	0.2	0.01	1.0	1.2	1.6	1.6	0.9

Leaves were analysis at 75 days after sowing (DAS).

The addition of calcium either before flowering period or before and after flowering periods significantly increased the most macro and micronutrients content of plant leaves.

In addition, calcium led to improved nitrogen content of plant leaves. Nitrogen content of leaves ranged from 2.99 to 3.87 (%). The highest N content was found with the complete rate of calcium (5000 ppm) which was added once before flowering. Also, the lowest content obtained with control treatment.

Phosphorus and potassium contents of leaves ranged from 0.12 to 0.20 (%) and 1.21 to 2.01(%) respectively. The highest content of P and K were found with the half dose of calcium (2500 ppm) which was add once before flowering. Meanwhile, the lowest content obtained with control treatment. Calcium leaves content were ranged from 1.80 to 2.75 (%). The highest content of calcium resulted from the complete rate of calcium (5000 ppm) which was divided at twice before and after flowering. As well as, the lowest content obtained with control treatment. Calcium concentration in leaves was harmonious with calcium concentration in foliar spraying.

Generally, the highest concentrations of nitrogen, manganese, zinc, copper and boron in the leaves was obtained with add complete rate of the calcium at simultaneously before flowering. Also, the highest concentrations of phosphorus, potassium and iron; were attained with half calcium rate (250 ppm) in the pre-flowering period. The highest calcium concentration obtained with the complete dose of calcium at twice before and after flowering followed by add calcium at one time before flowering. Meanwhile, the lowest nutrient concentrations were obtained without any addition.

These results showed harmony with those of Mc Kently *et al*. (1982) on bean plants, Naeem and khan (2006) on *Cassia tora*, Naeem *et al*. (2009) on Hyacinth bean plants and Domingues *et al*. (2016) on common bean plants they found that calcium addition on plants at growth stages had a positive effect on leaf content from nitrogen, phosphorus, potassium and calcium when compared with the control.

Seeds:

The results of the seed analysis, which was taken after 90 days of planting, indicated that calcium application led to improvement of all seed nutrients content, except Mg when compared with the control treatment. Also, the results referred that there were a differences in some macronutrients such as nitrogen, phosphorus and potassium. As well as some micronutrients such as iron, manganese, zinc, copper and boron as a result of calcium addition by half rate or a complete rate at one time before flowering or complete dose divided at twice before and after flowering.

Table 6: Effect of calcium rate and time on seeds nutrient concentration at 90 days after sowing (DAS) of combined analysis of the two seasons 2015 and 2016.

Treatments	**Macronutrients (%)**						**Micronutrients (ppm)**				
	N	**P**	**K**	**Ca**	**Mg**	**Na**	**Fe**	**Mn**	**Zn**	**Cu**	**B**
Control	2.98	0.34	2.00	0.07	0.17	0.072	54	21	31	3.5	4.7
Ca 2500 ppm (one time) before	3.79	0.44	2.18	0.08	0.16	0.085	95	28	37	4.5	6.2
Ca 2500 ppm (before and after	3.80	0.36	2.08	0.08	0.18	0.084	70	30	33	4.5	5.9
Ca 5000 ppm (one times) before	3.87	0.34	2.15	0.08	0.16	0.078	89	32	42	4.5	7.2
LSD $_{0.05}$	0.05	0.01	0.13	0.01	0.01	0.002	1.0	1.0	1.6	0.17	0.12

Seeds were analysis at 90 days after sowing (DAS).

Seed calcium concentrations was ranged from 0.07 (%) to 0.08 (%) with the all calcium rates at two times and there is no differences among them. The highest values of seed nitrogen, manganese, zinc, copper and boron contents were obtained by add complete rate of calcium at one time before flowering. Also, the highest seed concentration values from phosphorus, potassium and iron resulted from applied half dose of calcium at one time before flowering. Meanwhile, seed concentration value of calcium was not differed among calcium treatments.

Lack of calcium concentration in leaves or seeds is due to the difference in samples times. In addition, to mobility is low in the phloem, which is mainly through the flow of water in the tissues. In this connection, the results accordance with Domingues *et al*. (2014), they referred to add calcium fertilization may be effective and increase the average calcium accumulation in the edible portions of the common bean plant, thus improving the nutritional value of this legume. In addition to, the calcium is transported mainly by the water flux through the xylem and its mobility is low in the phloem. Thus, its lower accumulation in grains than in leaves can be attributed to the low water demand of grains during its growth (Frossard *et al.,* 2000).

Also, the complete rate of calcium at prior to flowering increased the seed concentrations of nitrogen, manganese, zinc, copper and boron. While, there were no clear differences among the different Ca treatments on the calcium content of seeds. These results have been attributed to the fact that calcium is a low-mobility nutrient in plants. Therefore the foliar applications may be useful for correcting local deficiencies. The previously mentioned results agreed with Quintana *et al.* (1999) they reported that the calcium fertilization in the snap bean plants had an effect on pod calcium concentration. Also, Silva *et al.* (2011) noted that soybean plants responded to calcium leaf applications, mainly when the application is combined with other nutrients.

Seed Germination and Seedling growth after 10days

The foliar spraying of calcium during both stages (pre flowering or before and after flowering) was significantly increased the percentage of seed germination, length of seedlings, in addition fresh and dry weights when compared with control treatment.

Table 7: Effect of calcium rate and time on germination and seedling parameters of combined analysis of the two seasons 2015 and 2016**.**

Treatments	Germination		Seedlings	Seedlings Weights (g)	
	Percent (%)	Rate	Length (cm)	Fresh	Dry
Control	76.33	2.49	20.00	2.16	0.41
Ca 2500 ppm	90.00	2.52	24.40	2.20	0.42
Ca 2500 ppm (before and after flowering)	91.33	2.66	27.60	2.56	0.49
Ca 5000 ppm	92.00	2.59	26.40	2.36	0.45
$LSD_{0.05}$	1.5	0.12	1.70	0.12	0.02

Seed germination percentage was increased from the seeds resulting from plants sprayed with all calcium spray treatments. The best result of seed germination percentage recorded with the complete rate5000 ppm Ca once at before flowering period followed by the complete rate divided twice 2500 ppm Ca spraying before and after flowering periods. While, the lowest value recorded with control treatment.

The highest seed germination rate was obtained from control seed (untreated calcium), followed by seed plants resulting from calcium spraying with half a dose at a time before flowering. While, the lowest germination rate was obtained in the seeds of the treated plants by dividing the total rate (before and after flowering). Finding this may be attributed that calcium plays a role in the thickness of the cell walls bean seeds and therefore the germination rate in calcium treatment is less than the control seeds. These results are harmony with Costa *et al.* (2014) who mentioned that Ca foliar application for common bean plants led to improvement seed physiological potential and more over to its other functions. Also it's responsible for the formation of calcium pectate, which is present in plant cell walls (Greene *et al*., 2001).

Seedling growth parameters such as length, fresh and dry weights were significantly increased by seed produced from the plants which received of the calcium as foliar spraying when compared with the control plants.

The foliar spraying of a complete rate of calcium 5000 ppm at fragmentation on twice before and after flowering periods had a significant effect on seed germination percentage, seedling length, fresh and dry weights and seed vigor index and gave the highest values.

The addition complete rate of the calcium at one time before flowering or fragmentation on twice before and after flowering increased seed vigor index as compared to control. The obtained result are in harmony with Paxton *et al.*(2012) reported that spraying plants at a proper stage with ideal rates of calcium may have a more structured membrane system, limiting the leaching of ions, leading to seeds with more activity.

Conclusion

From the previous results we can conclude that the foliar spraying of calcium for common bean plants at 5000 ppm either, once before flowering or fragmentation on twice before and after flowering is a great importance to enhanced growth, nutrient content and yield.

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