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Effect of foliar sprays of boron on growth, yield, nutrient uptake and quality of French bean (*Phaseolus vulgaris* L.) in Entisol: A review

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Abstract
The review of various experiment were conducted on soil and foliar application of boron showed significant increase in growth, yield, nutrient uptake and quality parameters of pulses and legumes.

Keywords: boron, French bean, foliar application

Introduction

Effect of boron on growth parameters of vegetative crops

The field trial conducted in Andhra Pradesh on French bean *cv*. Arka Komal at difference level of boron (2.5 or 5.0 ppm borax) applied individually and in combination as foliar spray at two stages (20 and 40 DAS) and revealed that the greatest plant height (35cm), number of leaves plant^{-1} (14.6), number of branches plant^{-1} (4.3), tap root length (20.4cm), leaf area (941.2 cm^2), leaf area index (0.60) and dry matter production (62.8 g plant^{-1}) were obtained with the 2.5 ppm B treatment [22].

It was observed that application of 10 kg borax ha^{-1} resulted in luxuriant vegetative growth, early flowering, healthy pods and good grain yield setting compared with control in Pea, variety 'Arkcl' [36].

It was reported that the foliar application of boron as boric acid at 200, 300 and 400 ppm significantly increased the plant height, growth rate and leaf area index in pigeon pea [17].

B is required for normal development and function of nodules in case of pea (*Pisum sativum*). In the absence of B, the number, size and weight of nodules decreased and nodule development changed leading to an inhibition of nitrogenase activity [3].

An experiment was conducted on mung bean and observed that application of B (2 kg ha^{-1}) produced 23.37 percent higher 1000 seed weight over control [41].

It was reported that plant height (56.6 cm) with borax @ 10 kg ha^{-1} (basal applied flowering) number of branches plant^{-1} (4.6) and dry matter plant^{-1} (12.82 g) both with borax @ 5 kg ha^{-1} (basal applied at flowering) and number of leaves plant^{-1} (12.0) with borax @ 10 (basal applied) were significantly highest at maturity control [40].

At Raipur it was reported that the application of 20 kg N + 50 kg P + 20 kg K + 20 kg S + 10 kg/ha borax gave the highest dry matter accumulation in urd bean [31].

At Warangal (A.P.) the experiment resulted that soil application of N, P, K, S and seed treatment of boron at 4 g kg^{-1} seed significantly increase the plant height of pigeon pea [29].

It was observed that the application of Zn at 2 mg pot^{-1}, B at 2 mg pot^{-1} and Mo at 2 mg pot^{-1} gives highest total dry matter production in chickpea crop [39].

At IARI Delhi conducted experiment and concluded that the application of sulphur at 50 kg ha^{-} and boron at 1.50 kg ha^{-1} significantly increase the plant height and number of branches plant^{-1} in mung bean [35].

It was reported that treatment combination involving three irrigations at branching, pre-flowering and pod filling stages along with foliar application of 0.2% borax at flowering stage recorded maximum mung bean seed yield (898 kg ha^{-1}) which was comparatively higher over other treatment combinations [20].

At Lucknow observed that the foliar application of borax 0.05%, 0.1% and 0.2% at different stages increased the total dry matter production in black gram [23]. A field experiment was conducted during rabi 2009-10 and 2010-11 with sixteen treatment combinations consisting four levels of sulphur(0, 15, 30 and 45 kg S ha^{-1}) and boron (0, 1, 2 and 3 kg B ha^{-1}).

Application of 30 kg S ha^{-1} showed marked improvement in growth and nodulation parameters in pea. Increasing dose of boron in the absence of sulphur up to 3 kg ha $^{-1}$ resulted marked improvement in growth and nodulation in garden pea. Higher values of plant height, number of branches $plant^{-1}$, fresh weight $plant^{-1}$, dry weight $plant^{-1}$, number of nodules $plant^{-1}$, fresh weight of nodules $plant^{-1}$ and dry weight of nodules plant $^{-1}$ were noticed with combined application of 30 kg S + 2 kg B ha^{-1} [25].

The study reported that there was no significant variation observed in all the characters of French bean. But the highest plant height, days to 50% flowering showed in control and the lowest in the Boron level of 1.0 kg ha^{-1}. The highest pod length, pod width and number of green pods per plant was found in Boron level of 1.0 kg ha^{-1}. The maximum individual pod weight, pod yield, 1000 dry seed weight and seed yield was found in Boron level of 0.5 kg ha^{-1} and the minimum pod weight in control [15].

Effect of boron on yield parameter of vegetative crops

A field trials carried out at 7 sites in North Bihar, India. They observed that the seed yield of chickpea increased from 1.4 t ha $^{-1}$ with no B to 1.79 t ha $^{-1}$ with 3 kg B ha $^{-1}$. The yield response to B application was greater on low B soils. It was concluded that on soils <0.35 ppm B, 3 kg B ha^{-1} was optimum and on soils >0.35 ppm B, 2 kg B ha^{-1} was optimum [30].

It was found that pod length and number in *Phaseolus vulgaris* increased with increasing B concentration upto 0.5 mg dm^{-3} in soil [6].

The effect of increasing rates of boron fertilizers and dolomite lime stone on B nutrition of peas and maize growth in sequential cropping on acid alfisol at Barapani was studied and the highest yield of peas with 1.5 kg boron and 3.0 t dolomitic lime stone per ha was obtained. Higher rates of boron fertilizer resulted boron toxicity in peas.[9]

Beneficial effect of the application of boron upto 0.6 mg kg^{-1} soil on grain yield of pea was reported. Toxicity of boron was observed at 1.2 mg kg^{-1} soil. Boron influenced markedly the mineral composition of the plant particu1arly the percentage of boron in straw [18].

A pot experiment carried out with *cv*. PDM 54, boron was applied by seed treatment, soil application or foliar spraying. Boron increased yield and growth parameters, with the best results in terms of seed yiel $plant^{-1}$ when the equivalent of 5 kg borax ha^{-1} was applied at flowering [40].

It was observed that foliar application of boron (0.33mg lit^{-1}), resulted in significantly higher dry matter yield per plant (18.96 g) and pod weight (7.23 g) per plant over 0.011, 0.033, 0.165, 1.65 and 3.3 mg per litre boron in pea [37].

It was noticed that foliar application of boron @ 1 kg per ha had a positive effect on number of pods per plant (50.66), seed weight per plant (8.68 g), seed yield (12.39 q ha^{-1}) over control (28.83, 4.11 g and 8.99 q ha^{-1} respectively) in chickpea [19].

A field experiment carried out in Bihar, India during the winter of 1997-98 to observed the effects of B (0, 1.5 and 2.5 kg ha^{-1}) application on the yield and nutrition of chickpea (cv. BG256). They reported that the mean seed yield, and seed and stover N and B content increased, whereas stover yield decreased with the increasing B rate [2].

It was observed that in absence of applied B, there was no yield as no pods were formed, in comparison to a yield of 300 kg ha^{-1} in the full nutrient treatment. There was yellowing of younger leaves and typical little leaf symptoms when B was omitted. A critical concentration range of 15-20 ppm B was found for the shoot tips of chickpeas [38].

The experiment was conducted to investigate the effects of four boron (B) doses (control, 0 kg B ha^{-1}. 1 kg B ha^{-1}, 3 kg B ha^{-1} and 6 kg B ha^{-1}) in soils deficient soil on yield and some yield components of chickpea (*Cicer arietinum* L.) like Plant height, pods per plant, grain yield, protein content, protein yield, thousand seed weight and leaf B concentration were measured. Grain yields were significantly increased by 1 kg ha^{-1} B application and increased the yield by an average of 5% [5].

The study showed that the effect of two per cent DAP, NAA 40 ppm, boron @ 0.2 per cent and molybdenum 0.05 per cent as foliar spray on green gram. The results revealed that foliar spray of DAP two per cent + NAA 40 ppm + B 0.2 per cent + Mo 0.05 percent at 30 DAS resulted in higher benefit cost ratio (1.97) over control (1.45) on sandy loam soil during rainy season at the Allahabad Agricultural Institute, Allahabad [8].

The experiment was carried out to study the residual effect of zinc and boron applied for transplanted rice on french bean, during rabi 2007-08 at Sagara taluk, Shimoga district, Karnataka state. This study included seven treatments with three replications. Application of RDF + Zinc (Zinc sulphate) at 18 Kg ha^{-1}+ boron (boric acid) at 4 Kg ha^{-1} brought about significantly the highest residual impact on yield (number of pods per plant, pod length, pod yield per plant, pod yield ha^{-1}) of French bean and on par with application of RDF + Zinc (Zinc sulphate) at 12 kg ha^{-1} + boron (boric acid) at 4 kg ha $^{-1}$ as compared to other treatments [11].

It was resulted that the response of common bean cultivars to foliar and soil applied boron in boron deficient soil resulted that application of both soil and foliar B increased yield 10 and 20%, respectively. Genotype has the highest seed yield when B was foliar applied that soil factors affected available B [12].

At Jhargram (West bengal) reported that the effect of four levels of boron significantly improved yield attributing character and yield of mung bean [26].

At Madaripur (Bangaladesh) reported that the application of Zn at 1.5 kg ha^{-1} and boron application at 1.0 kg ha^{-1} significantly increased the seed yield over control in mung bean [26].

At Lucknow workers reported that foliar application of boron at 0.1% increase the yield attributing parameter like number of pods, pod size, number of seed pod^{-1} and yield in black gram [23].

The experiment was conducted on boron deficient soil to study the influence of soil and foliar application of boron on green gram, showed that soil applied boron has more influenced on mean dry matter yield while foliar applied boron has on mean grain yield. Among all soil applied boron 0.5 mg kg^{-1} is best treatment while 0.1% is best foliar treatment [21].

An experiment was conducted on French bean with three levels of boron (0.0, 2.0 and 3.0 mg kg^{-1} soil) and recorded improvement in different yield attributes resulted that the lower B concentration, i.e. @ 2.0 mg kg^{-1} soil was found to be most suitable combination for this particular crop in the present agro-climatic conditions [14].

Effect of boron on nutrient uptake of vegetative crops

It was reported that application of boron increased the contents of P, K, Na, Ca, Fe, Mn, Zn, Cu and B in cowpea

seeds. Boron content in different parts of pea plants increased with increasing boron concentration [13].

It was observed that application of boron increased seed germination, root elongation, plant development and mineral composition of pea in saline soils [4].

The experiment was conducted to study the effect of sulphur and boron application on nutrient content and uptake pattern of N, P, K, S and B in French bean. Owing to boron application observed increased N, P, K, S and B content and uptake of French bean at pod picking stage as well as harvesting stage. However, it was found that higher levels of sulphur and boron showed antagonistic effect on nutrient content and uptake of French bean at pod picking stage as well as harvesting stage. The study suggested that soil application of sulphur and boron in inceptisols of Kashmir valley increased the availability of primary nutrients in addition to sulphur and boron causing their absorption by French bean plant [10].

The experiment was conducted in 20 acidic Alfisols of East Sikkim (India) to estimate the critical limit of soil boron (B) and pea plant for predicting the response of pea (*Pisum sativum*) to B application. The hot water-soluble B in these soils was found to be positively and significantly correlated B uptake by shoots. The critical concentration of soil available B and plant tissues B was worked out to 0.55 and 24.5 mg kg^{-1} respectively. Soil containing available negative response to B application was also observed at its higher level. The average dry matter yield increased with increasing level of B application [7].

An experiment was conducted to study the, jointly effects of three potassium (K) levels (0, 200, and 400 mg kg^{-1} as K_2SO_4) and four boron (B) levels (0, 5, 10, and 20 mg kg^{-1} as H_3BO_3) on shoot and root dry weights and some macro and micronutrient contents of bean (*Phaseolus vulgaris* L.) were investigated. According to the results, the interactions of K and B on shoot and root dry weights, macro and micronutrient contents of shoots, and B and K uptakes were found statistically significant. In all treatments, shoot and root dry weights were negatively affected by increasing B levels [33].

Effect of boron on quality parameter of vegetative crops

Pratima *et al.*, (1999) reported that the lower levels of boron application increased the concentration of sugars, starch, and proteins in pea seeds [27].

A field experiment conducted during the two winter seasons of 2000-01 and 2001-02 with faba bean (*Vicia faba* L.). Plants grown on sandy soil to determine the response of faba bean plants to different nitrogen level applied to soil in the presence or absence of different doses of boron foliar treatments. Results showed that boron/nitrogen synergetic effect additively increased nutrient content within faba bean plant tissue. Boron foliar fertilization in a concentration of 25-50 ppm in the spray solution, in combination with 40 kg nitrogen ha^{-1} fed as soil treatment has significantly increased plant height, leaf area, total dry weight, number of pods, number of pods, number of seeds per pod, seed yield. However, seed protein and carbohydrate proper accumulation required higher doses [34].

An experiment conducted to investigate the growth, yield and certain metabolic activities of both broad bean and lupin plants in response to foliar treatment with either Boron (75ppm) or Zinc (100ppm). Plants were grown in natural loamy soil conditions and treated twice with each of the applied micronutrients. The treated plants showed significant stimulation in most of the growth and yield characteristics (lengths of shoots and roots, number of leaves $plant^{-1}$, plant biomass, number of pods $plant^{-1}$, number of seeds $plant^{-1}$ and weight of 100 seeds). Also, treatment with either B or Zn caused significant increase in the contents of photosynthetic pigments, soluble carbohydrates and soluble proteins in the two tested plants [1].

It was examined that boron had significant influence on the protein content of mungbean seeds. The highest protein content was found with 5 kg B ha-1 while the lowest with control which was identical to 10 kg B ha-1 [16].

At Lucknow it was reported that the foliar application of boron at 0.05%, 0.1%, 0.2% improve the seed quality in terms and storage, seed protein and carbohydrate in black gram [23].

A pot experiment was carried out under greenhouse conditions during 2011 and 2012 growth season to investigate Fe, B and Zn foliar application effects on nutrient concentration and seed protein of cowpea (*Vigna unguiculata*). Three concentrations (0, 1 and 2 ppm) of micro-nutrient solutions were applied. Fe, B and Zn were sprayed every 15 days. Parameters measured were values of each nutrients and protein%, also, P, K, Ca, Mg, Na and Cl. The results showed that the effect of different treatments on nutrient concentration and seed protein were significant [32].

Conclusion

Thus, from reviewing the above literatures, importance of soil and foliar application of boron observed in respect of growth, yield, nutrient uptake and quality of different crop found to be significant. Hence for the fulfillment of growing population it is necessary to study more on micronutrient application of boron

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