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The Micronutrients Boron Its Influence On Growth and Development of Plants and Factors Affecting Availabilty: A Review

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Abstract: *Boron (B) is an essential nutrient for normal growth of plants, and B availability in soil is an important determinant of agricultural production. To date, the function of B is undoubtedly its structural role in the cell wall; however, there is increasing evidence for a possible role of B in other processes such as the maintenance of plasma membrane function and several metabolic pathways. The aim of this review is to provide an update on recent findings related to these topics, which can contribute to a better understanding of the role of B in plants.*

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I. Introduction

Boron (B) is an essential nutrient for normal growth of higher plants; it is one of the important plant micronutrient elements and plays a significant role in physiological and biochemical processes. The primary function of B is in plant cell wall structural integrity. Boron is needed by the crop plants for cell division, nucleic acid synthesis, and uptake of calcium and transport of carbohydrates (Bose and Tripathi, 1996). Boron also plays an important role in flowering and fruit formation (Nonnecke, 1989). In several plant functions, B is implicated directly and indirectly as it involves in growth of cells in newly emerging shoot and root while in some plants it is crucial for boll formation, flowering, pollination, and seed development(Hu and Brown, 1997; Brown et al., 2002; Dordas et al., 2007). Boron plays supportive role in cell wall synthesis and lignifications (Loomis and Durst, 1991), cell wall structure, carbohydrate and RNA metabolism, respiration, indole acetic acid and phenol metabolism as well as membrane transportation (Shelp, 1993; Brown *et al.*, 2002).

Boron deficiency affects the growing points of roots and youngest leaves. The leaves become wrinkled and curled with light green colour. Its deficiency affects translocation of sugar, starches, nitrogen and phosphorus, synthesis of amino acids and proteins (Stanley et al., 1995). Under B deficiency, normal cell wall expansion is disrupted (Havlin et al., 2006).

Boron availability to plants is influenced by many soil factors such as: soil organic matter, content, texture/clay content, intensive cultivation, drought, and microbial activity (Mengel and Kirkby, 2001). Soil pH and moisture conditions directly affect the population of soil microbes that help decompose soil organic matter for onward mineralization of several essential macro and micro elements including boron.

Boron on growth, yield and quality attributes of crops

Application of boron to tomato was found to be significant on most of the parameters observed as reported by many researchers (Jyolsna and Usher,2008; Dipti *et al.*,2008 and Kumuthini, 2015)

Gazala *et al.*, (2016) carried out an experiment on boron its importance in crop production status in Indian soils and crop responses to its application and summarizes their result by saying that "application of boron at different rates in different crop have shown a positive influence on yield and other agronomic parameters of different crops reflecting the significant of boron in enhancing the yield of different crops".

Naz *et al.*, (2012) conducted an experiment to study the effect of Boron (B) on the growth and yield of Rio Grand and Rio Figue cultivar of tomato. Different doses of B (0, 0.5, 1.0, 2.0, 3.0 and 5.0kg ha^{-1}) with constant doses of nitrogen, phosphorus and potash was incorporated at the rate of 150, 100, 60 kg $ha^{-}1$ .The outcome of the experiment was positive with Rio Grand cultivar of tomato showing significant respond on all parameters.They concluded that 2 kg B ha^{-1} significantly affected flowering and fruiting of Rio Grand cultivar (Tables 1 and 2.)

Maria and Ladislav (2014) performed an experiment at the Research – Breeding Station at Vígľaš – Pstruša to investigate the effect of increasing doses of boron on oil production of oilseed rape. Doses of nitrogen and sulfur (183 kg $N.ha^{-1}$, 46.5 kg $S.ha^{-1}$) and different doses of boron (200 g $B.ha^{-1}$, 400 g $B.ha^{-1}$, 800 g $B.ha^{-1}$

) were applied.The result shows that the boron nutrition positively influences the oil content in seeds of oilseed rape (*Brassica napus*L.).

Moura *et al.,*(2013) conducted an experiment with the objective to evaluate the effect of boron on the nutritional status of the cocoanut palm trees and its productivity when artificially applied to the culture soil. The treatments consisted of five levels of boron dosages: zero, 1, 2, 4, and 6 kg ha^{-1}. Boron (borax) dosages were applied in equal halves directly into the soil. The outcome of the research shows that ninety five percent of palm trees maximum production was obtained with the use of boron dosage at 2.1kg $ha^{-1.}$

Syed *et al.,*(2012) carried out an experiment to investigate the effect of different levels of boron (0.5, 1.0, 1.5 and 2.0 kg ha^{-1}) on growth, yield and ionic concentration of rice directly sown on raised beds under saline sodic soils. The crop was harvested at maturity. Data on tillering, plant height, spike length, number of grains $spike^{-1}$, 1000-grain weight, straw and paddy yields were recorded. Na, K, Ca and B concentration in grain and straw were estimated. The result obtained was significant; it shows that B concentration in grain increased with boron application. Positive correlation was found between B contents in grain and paddy grain yield. Hellal *et al.,* (2009) investigated the application of nitrogen and boron rates on root yield and nutrient contents of sugar beet (*Beta vulgaris* L.) *cv.* pamela grown in calcareous soil conditions.. The obtained results showed that increasing N level up to 80 mg N kg^{-1} significantly increased root and shoot yield and P, K and Fe. Application of 50 ppm Boron significantly improved the parameters of the yield of roots and above ground growth and nutrient contents and balance ratio of sugar beet. The combined application of N-B treatments at the rate of 100 mg N kg-1 + 50 ppm B gave the maximum shoot and root yield and nutrient balance whereas increasing the B application until 100 ppm appeared to have a toxic effect on plant growth. The results concluded that B found also to interact positively with nitrogen to affect yield components of sugar beet. The interaction from the applied N and B increased N, K and Fe distribution between root and shoot. The yield of sugar beet was highly and positively correlated with N, K and B content in root and shoot. (Table 3)

Hossain *et al.,*(2011) carried out a reasearch to find out the optimum rate of B application for maximizing nutrient uptake and yield of mustard in calcareous soil, boron was applied at 0, 1, and 2 kg/ha. Effect of B was evaluated in terms of yield and mineral nutrients (N, P, K, S, Zn, and B) uptake. The mustard crop responded significantly to B application. Boron and N concentrations of grain and stover were significantly increased with increased rate of B application indicating that B had positive role on protein synthesis. In case of P, S, and Zn, the concentrations were significantly increased but in case of K, it remained unchanged in stover. The grain B concentration increased from 19.96 μg/g in B control to 45.99 μg/g and 51.29 μg/g due to application of 1 kg and 2 kg B/ha, respectively. Concerning the effect of B on the nutrient uptake, six elements followed the order K> N> S> P> B> Zn and these were significantly influenced by B application.(Tables 4-7)

Soomro et al., (2011) conducted a field experiment to compare the effect of foliar and soil applied boron on the different growth stages and fodder yield of maize (*Zea mays* L.) variety Akbar. Experimental results revealed that the foliar application of 0.5% boron as a boric acid at early, mid and late whorl stages resulted in significant increase in all parameters recorded. Soil and applied boron at 2 kg ha^{-1} did not remain effective for growth and yield of maize crop as compared to foliarly applied boron. There was significant effect of boron on its concentration in straw and its uptake when applied on foliage. It can be concluded from the study that application of B (0.5%) as foliar spray at early, mid and late whorl stage along with recommended dose of NPK fertilizers may be considered for getting higher fodder yield of maize. Riaz and Muhammad (2011) conducted an experiment to evaluate the response of wheat, rice and cotton to B application. Boron was applied at 1 kg ha^{-1} as Borax decahydrate (11.3% B) at different times along with recommended doses of N, P and K. The results revealed that B application at sowing time to wheat increased significantly the number of tillers plant (15%), number of grains spike (11%), 1000-grain weight (7%) and grain yield (10%) over control. Among the treatments, B application at sowing time showed best results followed by B application at 1st irrigation and at booting stage. In rice (coarse), B application before transplanting substantially increased number of tillers hill-1 (21%), plant height (3%), panicle length (10%), and number of paddy grains $panicle^{-1}$ (17%), 1000-grain weight (11%) and paddy yield (31%) over control. Response of fine rice to the B application was similar for all yield parameters as in coarse rice. In cotton, B application considerably increased plant height (3%), number of mature bolls $plan^{t-1}$ (12%), seed weight $boll^{-1}$ (8%) and seed cotton yield (9%) over control..

In a trial conducted by Mubshar *et al.*, (2012) they reported that application of boron at different stages in rice field significantly improved the growth and yield of the crop. They recommended soil application of boron to rice field for maximum yield production

II. Conclusion

The outcome of this review clearly demonstrated that boron being a micronutrients contributes immensely to the growth and productivity of agricultural crops, hence the need to encourage the local farmers to imbibe the habit of applying the fertilizer to the field crop so as to obtain maximum economic yield return.

Table 1 Effect of different concentration of boron on number of flower clusters per plant of Rio Grand and Rio fique cultivar of Tomato

	CULTIVER		
B Kgha^{-} 1	Rio Grand	Rio Fique	Mean
Control	17.13	16.37	16.75c
0.5	23.69	22.24	22.97b
1.0	25.83	23.16	24.50b
2.0	30.70	24.77	27.73c
3.0	24.17	26.43	27.73ab
5.0	25.35	23.16	24.25b
Mean	24.48	22.69	

(Adapted from Naz *et al.*, 2012) Means wit different letter(s) in columns are significantly different at p < 0.005.

Table 2 Effect of different concentration of boron on number of fruit set percentage of Rio Grand and Rio Fique cultivars of Tomato

	CULTIVER		
B Kgha^{-1}	Rio Grand	Rio Fique	Mean
Control	41.64d	37.91e	39.77c
0.5	54.11b	51.18bg	52.b64a
1.0	49.63c	52.14bc	50.88b
2.0	59.34a	52.32bc	55.83a
3.0	51.52c	49.57c	50.54b
5.0	50.54c	50.01c	50.27b
Mean	51.13	488.85	

(Adapted from Naz *et al.*, 2012) Means with different letter(s) in columns are significantly different at p <0.005.

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