BORON NUTRITION OF CROPS IN RELATION TO YIELD AND QUALITY- A REVIEW

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ABSTRACT

Boron nutrition of soil and crops has assumed greater importance with the introduction of high yielding crop varieties under intensive cultivation with high use of chemical fertilizers. The availability and transformation of B in soil, yield and quality of crops have a significant bearing in relation to B nutrition. The literature pertaining to the effect of B on yield and quality of crops are reviewed and presented below.

Key words: Boron, Nutrition, Crop, Yield, Quality, Cereals, Legums, oilseeds.

Increased yield through intensive cultivation with high yielding crop varieties, use of chemically pure NPK fertilizers, and limited use of organic manures and restricted recycling of crop residues are some important factors which have to accelerate exhaustion of micronutrients from soil. In several places, normal yield of crops could not be achieved despite balanced use of NPK due to micronutrient deficiency in soils. The incessant efforts for enhancing food grain production from shrinking land resources will further magnify the depletion of limited micronutrient reserves and would cause the deficiency of other micronutrients besides accentuating the existing ones.

Present review paper indicates that among micronutrients, B stands next to Zn with its growing deficiency in the soils of our country. Because of its role in fertilization and flowering processes of crops, B is being given special importance. If it is deficient, one of the first adverse effects is on flowering and fruiting and therefore, on the yield and quality of the crops. Adverse effects on the yield can occur even though no deficiency symptoms are evident on the foliage and it is known as hidden hunger. Boron deficiency is often an unsuspected enemy of crop production. Depletion of B from soils is mainly through leaching to the lower layers and through the uptake by crops, which removes a significant amount of B from the nutrient reserve each season. These two factors together deplete the B supply in the top soil or bring the B to the levels that are not accessible by the crops. Yield increase due to B application in almost all crops has been reported by several workers. Spectacular responses of cereals, pulses, oil seeds and cash crops to B application have largely been observed on B deficient soils.

Importance of B in crop production

B is one of the essential micronutrient required for normal growth of most of the plants. The essentiality of B as it affected the growth of maize was first reported by Maze (1914) in France. However, it was the work of Warrington (1923) in England that provided firm knowledge of B requirement for a variety of crops.
The role of B in plant nutrition is the least understood of all the mineral nutrients. On molar basis, the requirement of B for dicotyledons is higher than any other micronutrient. Various authors have proposed different views on the possible role of this element in plant growth. According to Kolesnik (1962) B fertilization improves photosynthetic activity, enhances activity of enzymes and plays a significant role in protein and nucleic acid metabolism.

Boron deficiency severely inhibits pollen germination and pollen tube growth as well as the viability of pollen grains (Dugger, 1973). Boron is unique among the essential mineral nutrients. It is the only element that is normally present in soil solution as non-ionized molecule over the pH range suitable for the plant growth (Oertli and Grgurevic, 1975). According to them boric acid as source of B is effectively absorbed by plant roots than other sources.

Boron seems to be a crucial element for the maintenance of structural integrity and protect plasma membranes against peroxidative damage (Ismail and Volkar, 1997). Parr and Loughmann (1983) reported that B is involved in sugar transport, cell wall synthesis, lignifications and IAA synthesis and phenol metabolism. Sharma and Tanuja (1991) have suggested the involvement of B in stomatal regulation.

Boron is essential micronutrients for plants, but at the same time, its range between deficiency and toxicity is narrower than that of any other element (Goldberg, 1997).

**Effect of B on growth and yield attributes of crops**

Singh and Verma (1991) from their study reported that application of borax @ 2 kg ha-1 increased the plant height and number of branches per plant of tomato.

Kalyani et al. (1993) observed that B applied as boric acid increased the plant height, relative growth rate, net assimilation rate and leaf area index in pigeon pea. Salam et al. (2004) reported that B increased the plant growth, leaf area index, and root length and root nodule of bean. Foliar application of 100 ppm of boric acid three times viz., 40, 50, 60 days after sowing produced significant improvement in growth parameters of tomato which might be due to the enhanced photosynthetic activity and metabolic activity with the application of B (Lalit Bhatt et al., 2004).

Asokan and Raj (1974) studied the response of groundnut grown in pot culture to various forms and levels of B and reported that application of 15 kg of boric acid/borax ha-1 increased the yield of crop appreciably and it also improved the formation of pods in plants. Jarmillo et al. (1978) reported that tomato fruit yield was higher with the application of 75 kg N, 50 kg P2O5, 50 kg K2O and 15 kg borax ha-1 compared to NPK alone. Gulati et al. (1980) studied the effect of different levels of B on the yield of tomato and revealed that highest yield of tomato was obtained in the treatment receiving 1.5 ppm of B.

The yield of marketable fruits of tomato was increased with B application at 2 kg ha-1 (Verma et al., 1995). Castellance et al. (1982) also reported that the highest yield of marketable fruits of tomato (28 t ha-1) was obtained in the treatment of 20 kg borax ha-1. Ahmed et al. (1988) reported that tomato fruit yield was enhanced by the addition of 6 ppm B to the soil. Das and Patro (1989) observed that the highest yield of tomato (298 q ha-1) was obtained with urea followed by 0.25 per cent B as foliar spray.

Incorporation of 0.52 or 0.80 mg boric acid kg-1 in the greenhouse soil increased the yield of cucumber and tomato from 1723 and
Combined application of micronutrients like Zn, Mn, Fe and B produced highest fruit yield with reduced cracking of fruits of tomato. This might be due to increasing RNA and DNA contents in reproductive tissues in the presence of Zn and B which may enhance the flower bud initiation and fruit setting (Bose and Tripathi, 1996).

Singh and Verma (1991) observed that application of B at 2 kg ha⁻¹ either alone or in combination with potassium and zinc resulted in optimum plant growth and highest fruit yield of tomato. Oyewole and Aduayi (1992) noted that application of B at 2 ppm to tomato plants increased the leaf number, stem diameter, number of flowers, fruit yield, and reduced percentage of flower abortion. Boric acid spray had favorable effect on vegetative growth, retention of flowers and fruits. It also increased the number of fruits per plant besides improving the fruit size which leads to highest yield of tomato (Lalit Bhatt et al., 2004).

Sathya (2006) conducted an experiment to evaluate the various levels of B on yield of PKM1 tomato. The results revealed that the highest fruit yield of 33 t ha⁻¹ was recorded in treatment that received borax @ 20 kg ha⁻¹ and was found to be significantly superior to rest of the treatments (0, 5, 10, 15 and 25 kg ha⁻¹). The yield increase was about 33.6 per cent over control.

Application of 0.25 to 0.50 kg B ha⁻¹ significantly increased pod yield of groundnut (Maheshkumar and Sen, 2004). B deficiency had largely been reported in high calcareous soils of Bihar, Orissa, West Bengal and Assam as well as some coarse textured soils of Punjab and significant response to B application had been reported by Arrora et al. (1985) and Sakal and Singh (1995). Pulses and oilseeds gave higher economic response as compared to cereals. The response of chickpea to B application varied from 167 to 182 kg ha⁻¹ with 2 kg B ha⁻¹ except in severely deficient sites where it was 3 kg ha⁻¹ (Sakal et al., 1990).

Reskasem et al. (1993) observed “hallow heart” symptoms on groundnut without the addition of B. Boron increased seed yield of sesamum and mustard varieties at application rate of 1.5 and 2.5 kg B ha⁻¹.

In a field experiments conducted in coarse textured soils of Ludhiana, the optimum yield of groundnut was recorded at 0.5 kg B ha⁻¹ (Arrora et al., 1983).

In vertisols, application of nitrogen and phosphorus each at 150 kg ha⁻¹ along with sulphur and B at 10 and 2.5 kg ha⁻¹, respectively improved safflower yield and oil yield besides protein content (Purvimath et al., 1993). Spectacular response of cereals, pulses, oilseeds and cash crops to B application (0.5 to 2.5 kg ha⁻¹) had largely been observed on B deficient soils of Bihar, Orissa, West Bengal, Punjab and Assam (Sakal and Singh, 1995).

Average yield response of groundnut, sesamum, mustard and sunflower to 1 to 2 kg B ha⁻¹ was 370, 70, 210 and 320 kg ha⁻¹ respectively (Sakal et al., 1996). In acid soils of Orissa, application of B at 2 kg ha⁻¹ to groundnut gave yield response of 29.9 per cent. In B deficient acid sedentary soils having 0.3 kg ha⁻¹ of hot water soluble B at Ranchi, groundnut responded significantly to boron application and pod yield increased remarkably from 1140 kg ha⁻¹ in control to 1530 kg ha⁻¹ with 3 kg B ha⁻¹. However 4.5 kg ha⁻¹ reduced pod yield in groundnut (Kumar et al., 1996).

The magnitude of yield response to soil applied B ranged from 0.10 to 11.9 q ha⁻¹ in cereals, 1.2 to 15.5 q ha⁻¹ in pulses, 0.14 to 5.0 q ha⁻¹ in oil seeds, 28.3 to 79.5 q ha⁻¹ in onion and 105 q ha⁻¹ in sugarcane (Sakal et al., 1996).
Effect of B on quality of crops

Govindan (1952) observed the influence of B on the carbohydrate balance in tomato crop and reported that increasing levels of B increased the reducing and non-reducing sugar content of tomato. Zubanova et al. (1975) observed that addition of B increased the ascorbic acid content and protein N contents of the tomato plants.

The significant increase in nodule number in groundnut was observed due to application of graded levels of boron. The maximum number of nodule was recorded at 2 ppm B level (Patil and Golakiya, 1986 and Bhuiyan et al., 1997). Though B is not required by rhizobia like other free living organisms, it is also considered essential element for N fixation (Lewis, 1980 and Parr and Loughmann, 1983). The reduction of nitrogenase activity in B deficient soil was also reported by Garcia Gonzales et al. (1991).

Irrespective of the soils, increasing levels of B increased the filling and shelling percentage of groundnut which might be due to the role of B in sugar transport and utilization by developing pollen and embryos, fruit and seeds and its unique role in cell wall structure and function (Slavko Perica et al., 2001).

Protein content of groundnut pod was significantly influenced by B application. Maximization of protein in pods of groundnut through combined application of super and B was reported by many workers (Bhuiyan et al., 1997 and Murthy, 2006). Application of B stimulated nitrogen content of potato tubers and might have increased protein synthesis and subsequent storage of protein as suggested by Yadav and Manchanda (1979). Boron fertilization improves photosynthetic activity, enhances activity of enzymes and plays a significant role in protein and nucleic acid metabolism (Kolesnik, 1962).

Boron and Zinc when applied to tomato and capsicum crops significantly increased the total fruit sugar content (Rawat and Mathpal, 1984). While Reddy et al. (1985) observed that foliar application of Zn and B improved the crop quality in tomato. Reddy and Reddy (1986) reported that application of Zn and B at 500 ppm each, improved the quality indices in brinjal.

Lopez Andreu et al. (1988) reported that the titratable acidity was lower in tomatoes grown under B deficient conditions. Ryabykh and Chuprikova (1989) observed that foliar sprays with boric acid increased the fruit vitamin C and total sugars in tomatoes. Ascorbic acid content of fruits was enhanced by the addition of 6 ppm B to the soil (Ahmed and Hargitai, 1989).

Application of 2 kg B ha-1 significantly increased the quality of tomato viz., ascorbic acid content and titratable acidity at all stages of picking (Verma et al., 1995). Application of 0.3 per cent borax as foliar spray improved the fruit size, ascorbic acid content, TSS and also reduced the fruit cracking (Paithankar et al., 2004).

The highest groundnut pod protein content was recorded at 1.0 ppm and further increase in B levels the protein content get decreased correspondingly (Muthukrishnan, 2007).

REFERENCES


