SOIL–PLANT–WATER RELATIONSHIP OF BORON AND FACTORS AFFECTING ITS AVAILABILITY A REVIEW (PART–II)

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Functions of boron in plants

The exact and specific function of boron in plant vegetative life is not understood as yet. However, investigations have shown that it causes death of the terminal growing point, breakdown of the conducting tissues and results in the brittleness of stem and petiole which finally causes brown coloration and cessation of roots and height-growth (Bangash & Gardiner, 1985). Boron deficiency causes increase in total sugar and starch in leaves and stems of boron deficient plant (Oram, 1961); while a greater amount of benzene insoluble matter is also found in the leaves of normal plants and in the stem of boron deficient plants. Certain parts of plants die because of lack of sugar of inadequate presence of boron. Thus boron deficiency symptoms may be an expression of sugar deficiency. Boron is essential to cell division (Haas and Klotz, 1931) in the meristematic tissue and in the cambium and is a necessary component of cell wall (Berger, 1949). It prevents excessive swellings & Plays some part in the formation of pectin. Its deficiency results in cellular swellings of the middle lemella followed by the discoloration & breakdown of cell wall as a result of boron starvation strongly indicates that boron plays definite role in the formation of pectin substances and in cell rigidity (Oram, 1961).

Boron also plays an important role in the nitrogen metabolism and consequently in the synthesis of protein in the plant tissues because nitrogen compounds and sugar accumulate while meristematic tissues dies in absence of boron (Berger, 1949). There may also be an accumulation of soluble nitrogen and carbohydrates in plants and a reduction of amount of protein formed. Its deficiency results in higher NO_3-N, whereas its sufficiency decreases NO_3-N in plants (Oram, 1961). Boron has an effect on pollen germination and prevents bursting of Pollen Tube, hastens flowering and fruiting process and increases seed & fruit formation, activities salt absorption, Increases seed & Fruit formation, hormone movement, metabolism of pecitc sustances, water metabolism and the water relations in plants and respiratory activities. Boron is said to be a constituent of membranes and serve in precipitating excess cations. This acts as a buffer necessary in the

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maintenance of conducting tissues and thus exerts a regulatory effect on other elements.

Boron is necessary for carbohydrate metabolism and transportation of sugars in plants (Hass and Klotz, 1931, Berger, 1949 and Oram, 1961). In order for highly Polar compounds such as sugars to move through cell walls and other membrances, energy must be expended. Boron may lower Polarity of the sugar, thus reduces the energy required for translocation by either or both of two modes of action. Boron may combine directly with sugar and thus move with it. B-deficient leaves have, therefore, comparatively high concentration of sugar & starch, & thus keeps the sugar-starch balance in plant (Oram, 1961). Boron controls the activity of oxidative enzymes, reduces adsorption of water in plants (Moldovan *et al.*, 1969). Further, B deficiency enhances the development of "Root diseases such as Fusarium Wilt and Root Rot". Whereas the excess amount of B destroys Chlorophyl content. Boron sufficient Plant can "better stands against drought and Frost".

Boron deficiency symptoms in plants

Visual symptoms of boron deficiency have been the subject of much investigations. They vary with type and age of the plant, prevailing soil and climatic conditions under which it is growing and the severity of the deficiency (Bangash and Gardiner, 1985, and Bangash, 2000). However, all crops have more or less characteristic growth abnormalities associated with deficiency of boron but these symptoms are manifestations of general boron deficiency symptoms found in crops.

The first and the most general specific visual symptom is the death of the terminal growing tip of the meristematic tissue. This indicates that boron is not translocated in the plant but is fixed in insoluble compounds and that it is needed for cell division. The lateral buds produces side shoots but the terminal buds in the shoot dies also. Due to the repeated death of apical bud, flowers may not form; if they do, fruits and seeds frequently fail to form. Further rebranching may occur, the internodes and stem become shortened bringing the upper branches closer together. This multibranched plant, in many cases, gives a "Rosetted appearance". The plant root are generally stunted thus the plant growth and yield start to decline before further boron deficiency symptoms becoms apparent (Bangash and Gardiner 1985).

Further symptoms are slight thickening of leaves leading to Curling and Chlorosis. The petiole and even the leaves become brittle. This is always accompanied to a varying degree by yellowing of upper leaves, occasionally reddening is observed instead of yellowing, while the lower leaves remain green. The older leaves and the stem are usually malformed, dark brown spots appear and tip of the leaves become bronzed. Marginal growth is suspended resulting in folding back of the leaf tips. This results in the destruction of meristematic tissue and consequently death of the whole plant. Thus there is a whole series of boron deficiency symptoms with the mildest manifested only by a reduced growth and certain chemical changes leading to premature death of the entire plant.

Boron requirements of plants

Plants species exhibit wide differences both for boron requirements and in tolerance to excess boron so the concentrations necessary for the growth of plants having high boron requirements may be verging on the toxic levels for plants sensitive to boron. With some plants, injuries result when the concentrations of boron best suited to growth are only slightly exceeded; whereas with others there is a rather broad range in which plant growth is slightly affected. Shieve (1941) has likewise observed that boron requirement of monocotyledon is commonly about 1/10th of that of dicotyledon, although the optimum concentration even for dicotyledon varies considerably. Bradford (1966) has therefore, rightly said that grasses and other monocots grow well at lower concentration of B than dicots and most Conifers.

Scofield and Wilcox (1931) found that 0.5 p.p.m. B in irrigation water injured some crops, while boron content of 1.0 p.p.m. caused injury to most crops, even those with high boron requirements. Majistad and Christian (1944) studied the qualities of irrigation water in California and found that water having more than 2.0 p.p.m. B was unsuitable for irrigation. Similarly Wilcox (1948) observed that irrigation water containing more than 2.0. p.p.m. B creates a problem, while levels below 0.3-0.6 p.p.m. B are excellent for safe irrigation purposes. Woodbridge (1937) concluded from a large number of analysis that soil concentration of water soluble B above 0.5 p.p.m. (dry weight basis) were associated with general freedom from "drought spot and corky core of Apple". Eaton and Wilcox (1939) reported that B content as low as 0.5-5.0 p.p.m. in saturation extract may cause injury to many agricultural crops. Eaton (1944) noted that plants made normal growth in sand culture with traces of B (0.03-0.04 p.p.m.) and injury often occurred in culture containing 1.0 p.p.m. B. Likewise observations have been made by Bangash and Gardiner (1985) in green-house pot expt. using Hoaglands Nutrient Solution in Australia. Berger (1949) found that most of problems of B availability and its fixation were associated in the humid region where the amount of available boron in soils was of the order of 0.1 to 2.5 p.p.m. However, this range varies from area to area, soil to soil and Climatic variation. Atkinson *et al.* (1953) found that soil containing approximately 0.4-0.6 p.p.m. water soluble boron is a satisfactory level. From laboratory & green-house experiments, Bear (1935) reported that soil should not contain less than 0.3 p.p.m. hot-water soluble boron and according to Richards (1954) boron concentrations below 0.7 p.p.m. are safe for sensitive crops, from 0.7-1.5 p.p.m. is marginal and more than 1.5 p.p.m. B appears to be unsafe. These values were for the soil saturation extracts. Wild and Iyer (1962) reported that 0.6 p.p.m. available B content is maximum for Pinus resionsa. Lanuza (1966) studied the various levels of boron in nutrient solution in a green-house experiment with Pinus radiata seedlings and reported that these seedlings were incapable of tolerating more than 5.0 p.p.m. B and showed severe boron toxicity symptoms within 21 days when supplied with higher boron concentrations. Plants showed substantial improvement in height growth when treated with solutions as low as 0.005 p.p.m. B. likewise observations have been reported by Bangash and Gardiner (1985) from a green-house pot expt. using Hoaglands nutrient solution for different Forest Tree Species in Australia. Bradford (1966) recommended 0.15-0.50 p.p.m. water soluble B as deficient range depending upon crops and soils. Heese (1971) reported that less than 1.0 p.p.m. available B is deficient, whereas 3.0 p.p.m. B is toxic. Soil of arid region falls in the same range but occasionally contain 10.0-40.0 p.p.m. B.

Conclusions

In the last few decades, the role played by number of trace elements in the development of plant has been universally recognized. Prominent among these is Boron, being essential and indispensable to the life and growth of the Chlorophillous plants.

Boron deficiency may causes "DIEBACK DISEASE" in agricultural, forests and horticultural crops in many countries of Arid and Tropical Zones. Its deficiency causes severe damage to rooting system resulting in Root diseases such as Fusarium Wilt & Root Rot, affects growth increment and yield of straight poles of the forest tree species and thus ultimately affects the quality and quantity of sustained timber yield which could otherwise be obtained from normal healthy trees. Dieback symptoms begin to appear on the onset of dry season and becomes more and more marked from time to time until the rain breakes.

Its starvation results an increased cell division in the cambium, disintegration of the Cambium and phloem and gum formation accompanied by less cell differentiation. The cell walls remain thin and the parenchyma tissues increase at the expense of conducting tissues. The reduction in the normal development of conducting tissues leads indirectly to many of the internal and external characteristics Such as "leaf distortion" and the increased "anthocyanin contents". Internal discoloration appears first in a relatively fewer cells but necrosis gradually expends untill large areas of dead or dying cells results. The by-products of the dead cells also may become factors that influence the growth of the surrounding cells. Besides its effect on the cell structure, boron also interfers with translocation of material in the plants. An accumulation of carbohydrates in leaves and destruction of phloem in boron deficient plants point out to the effect of lack of this element. Because of the relatively immobility in plants, a sharp reduction of boron supply would bring about an uneven distribution in the plant tissue. This explains that why there must be constant source of supplying of available boron to the plants. It is therefore, suggested that the analysis of the apical growing part of the plant, rather than analysing of total shoot would serve as a better criterian of boron status of the plant. Thus the foliar content of boron represent the net accumulation of boron during the period of the organ sample. Thus the assessment of visual symptoms, plant tissue and soil analysis involves a host of considerations and precautions.

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