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IMPACT OF HIGH BORON CONCENTRATION ON PLANTS

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ABSTRACT

Micronutrients are essential elements utilized by plants for a healthy growth. Each of these elements has a significant role in plant nutrition. Boron is an essential element for plants' development. Adequate B nutrition is critical for quality of crops and high yields. In small concentrations boron compounds are used as micronutrients in fertilizers, in large concentrations it adversely affects the plant growth and can be used as. But there is a narrow range in boron deficiency and toxicity. Present review work focused on the toxic concentration level of boron and its effects on plant growth as well as the methods to overcome the boron toxicity.

Key words : Micro nutrient, Boron, Toxicity, Plant nutrition. .

INTRODUCTION

Boron is one of the essential micronutrient for plants. It is unique among the essential elements in that a narrow range in concentration can mean the difference between plant deficiency and plant toxicity. Whereas a fraction of one part per million may be required, a few parts per million may be toxic to plants (Muntean, 2009). All nutrient elements are required in adequate amount for better growth of plants. But when the amount exceed adequacy it become harmful to plants and known as toxicity. Mineral toxicity is an excess level of any of the minerals essential to plant health. An abnormally high mineral concentration is usually defined as a level that may impair a function on that mineral (Fig-1).

Reduced crop productivity due to soils containing toxic level of Boron is a worldwide problem that can limit plant growth (Nable *et. al.*, 1997). Boron toxicity leads to decreases in crop yields grown in different regions of the world (Cartwright *et. al.*, 1986). However, despite the importance of this nutritional disorder, it is not understood why B is toxic to plants, or how tolerant plants avoid toxicity (Reid *et. al.*, 2004). It has long been known that the optimum B level for one species could be either toxic or insufficient for other species (Blevins and Lukaszewski, 1998).

Conditions which lead to toxicity:

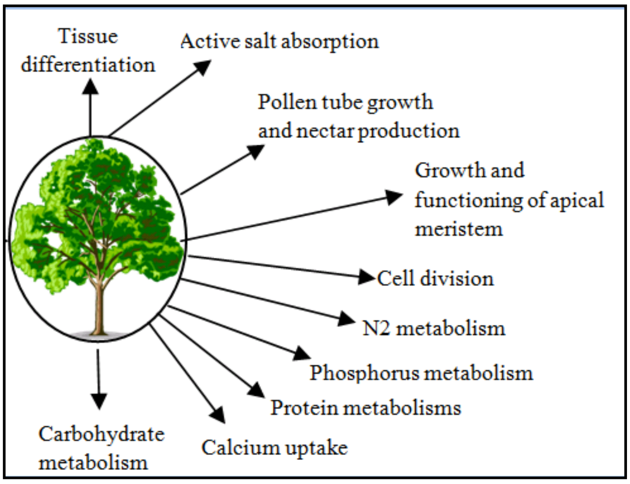
There are several natural as well as anthropogenic sources which are responsible for boron toxicity. Much of the earlier literature in regard to the toxic effects of boron is reviewed by Brenchley and Winifred in 1927.

The major sources of high B concentration are boron rich soils and ground water or soils exposed to B-rich irrigation water. Irrigation water is the most important contributor to high levels of soil B (Eaton and Frank, 1935; Scofield

Fig: Role of Boron in Plant Metabolism

et. al., 1931; Nable et.al., 1997; Chauhan and Power, 1978). B level in soils can also be increased by fertilizers (Schreiner *et. al.*, 1920; Nable *et. al.*, 1997), Nutrient solutions used experimentally (Mchargue and Calfee, 1933; Warington, 1923), Sewage sludge or by fly ash (Nable *et. al.*, 1997). Although of considerable agronomic importance, our understanding of B toxicity is rather fragmented and limited (Nable *et. al.*, 1997).

Figure-1: Role of Boron in Plant Metabolism



Boron toxicity, on the other hand, has also been observed, notably in plants growing in arid and semi-arid regions of the world and desert areas where native soil high in boron and low rainfall co-exist. (Marschner, 1995; Muntean, 2009) The highest concentrations of soil B are often concentrated in marine evaporites and in marine argillaceous sediment. (Erd, 1980; Muntean, 2009) Boron is often found in high concentrations in association with saline soils and saline well water (Dhankhar and Dahiya, 1980).

Furthermore, in recent years, B toxicity has attracted increasing interest owing to the greater demand for desalinated water, in which the B concentration may be too high for healthy irrigation (Parks and Edwards, 2005).

Toxicity Symptoms:
Because B accumulates in the leaf margins, an early symptom of excess B is discoloration and eventual death of the leaf margins. It is the typical visible symptom of B toxicity amongst a wide variety of plant species. Generally it appears on older leaves than younger leaves. Leaf burn – chlorotic and/or necrotic patches at the margins and tips of older leaves occur. Some plants may also develop black spots on older foliage. Normally, discoloration along the whole length of the leaf distinguishes B excess from Ca deficiency, where just the leaf tip and margin at the tip turn brown and die. Due to this crop yield adversely affected. (Paull *et. al.*,1992; Nable *et. al.*, 1997; Bennett, 1993; Bergmann, 1992; Eaton, 1944; Muntean, 2009; Benton, 1997; Punchana *et. al.*, 2004).

Boron toxicity negatively affects plant growth, which results in reduced vigour, stunted plant growth, delayed development, decreases number, size and weight of fruits and discoloration of leaves. (Paull *et. al.*, 1992; Nable *et. al.*, 1997; Muntean, 2009; Punchana *et. al.*, 2004). Visible symptoms of B toxicity do not appear to develop in roots. As B concentrations in the roots remain relatively low compared to those in leaves, even at very high levels of B supply (Nable, 1988; Oertli and Roth, 1969), perhaps toxic concentrations do not occur in root tissues.

The physiological effects of boron toxicity include reduced root cell division, decreased shoot and root growth (Lovatt and Bates 1984: Nable *et. al.* 1997), decrease in leaf chlorophyll, inhibition of photosynthesis, lower stomatal conductance (Lovatt and Bates 1984), deposition of lignin and suberin (Ajay Singh et al,2013 and Ghanati *et. al.*, 2002), reduced proton extrusion from roots (Roldan *et. al.*, 1992), increased membrane leakiness, peroxidation of lipids and altered activities of antioxidation pathways (Karabal *et. al.*, 2003). These toxicity symptoms are slow to develop, or are only observed with extreme B treatments.

Method to overcome Boron toxicity:
There is a narrow margin between boron deficiency and toxicity in some plants; however, the risk of inducing toxicity should not be ignored. There are several ways by which B toxicity can be reduced.

As boron is easily leached from soil it can be removed from soils through the leaching action of water passing through and below the active plant root zone. It is at times necessary to treat high boron soils that are alkaline with soil acidifying amendments like elemental sulfur prior to the leaching process. (Muntean, 2009).

It has been suggested that an antioxidant response may reduce B-toxicity damage in some plants (Gunes *et. al.*, 2006). This antioxidant response is considered to be a critical process for protecting plants against oxidative damage in combination with a wide range of environmental factors (Inze´ and Montagu, 1995), including UV-light excess, salinity, drought, heavy metals, chilling, oxygen shortage and nutritional deprivation (Mittler, 2002).

Allelopathic interaction between nutrients elements can also be very useful in reducing toxic level of B. Boron toxicity can be decreased with P x B interaction (Gunes *et. al.*, 1999), also high level of N decreases the B concentration (Alpaslan *et. al.*, 1996). Under some circumstances it may be possible to alleviate B toxicity in plants by applying Zn to soils or as a foliar spray to affected plants (Graham *et. al.*, 1986 and Swietlik, 1995).

The toxic effect of boron was observed to be alleviated by calcium application, particularly at 10 and 20 mg B kg-1 levels, suggesting the negative impact of Ca on B availability, in agreement of the statement of by Gupta (1972) and Taban *et. al.* (1995). Ca counteracted the toxic effect of B, and result in higher dry weight of B treated plants. These results agreed with Chatterjee *et. al.* (1987), Taban *et. al.* (1995) and Turan *et. al.* (2009). One of structural element in plant cell wall is Ca. Calcium bounded with pectin molecules and localized in the cell wall as Ca-pectate complexes which may act to stabilize boron in cell wall (Yamaouchi *et. al.*, 1986, Cleland *et. al.*, 1990).

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