AgriCos e-Newsletter
ISSN: 2582-7049
AgriCos e-Newsletter
Open Access Multidisciplinary Monthly Online Magazine
Volume: 03 Issue:06 June2022 Article No: 27

Role of Boron in Crop Productivity and Plant Growth

Narendra Kumar Bharati[1], Anwesha Samanta[1] and Sourav Hazari[2]
[1]Ph.D. Scholar, Department of Soil Science, Bidhan Chandra Krishi Viswavidyalaya West Bengal
[2]Ph.D. Scholar, Department Genetics and Plant Breeding, Bidhan Chandra Krishi Viswavidyalaya West Bengal

SUMMARY

Boron is a non-metal micronutrient with unique physiological and metabolic activities, making it a vital component for optimum crop growth and development. Boron deficiency is the second most common trace element deficiency in the world, after zinc deficiency. Due to the little gap between boron shortage and toxicity, boron deficit management in agriculture is a big concern. As a result, boron nutrition for crop shortage should be addressed by providing boron fertilisers at the right rate, period, source, technique, and balancing with other nutrients in the soil. To avoid boron toxicity in crops, foliar administration of boron at the optimum stage of crop growth outperforms soil application, especially in zinc-deficient soil. In alkaline and calcareous soils, boron interacts with other nutrients and adsorbs in the soil, reducing boron availability for crop growth. Therefore, foliar boron delivery is preferable to soil application in these soils.

INTRODUCTION

Boron (B) is a topic that comes up when micronutrients are examined in terms of deficiency or toxicity. Boron, according to many soil scientists, may be more significant than any other micronutrient in achieving high-quality crop yields. Boron is taken up by plants in two forms: H3BO3 and H2BO3-. Due to its deficit in most types of Indian soils, boron deficiency is more common in crops than zinc deficiency. Boron deficiency first manifests itself in the growth stage of plants. When there isn't enough boron in the soil, growing tips die and plant growth slows. It increases cell division, cell elongation, cell wall strength, flowering, pollination, seed set, and sugar translocation and plays a significant role in crop growth and nutrition. Boron's roles in plants are intertwined with those of nitrogen, phosphorus, potassium, and calcium. The structural role of boron in cell wall growth, as well as the stimulation or inhibition of certain metabolic pathways, are regarded to be the most essential roles of boron in plants. Soil texture, moisture, pH, EC, CEC, CaCO3, OC, and inter-relationships with other elements all affect the availability of boron in soil. In India, boron nutrition is inadequate in 33% of the soils. Maze was the first to recognize that boron is an essential nutrient for crop growth. Boron shortage primarily causes sterility in plants, which reduces production. As a result, proper boron fertiliser treatment in crops is required to overcome the shortage and produce optimal development and production.

Function of Boron in growth and development

Boron is involved in a variety of structural, physiological, and biochemical functions in plants, including cell wall formation and stability, plasma membrane electron transport reactions, carbohydrate metabolism and sugar transport, phenol and auxin metabolism, root elongation and nucleic acid metabolism, nitrogen fixation and nitrate assimilation, water relations stimulation, and sugar movement.

Critical level and availability of boron in soil

Boron is found in fundamental minerals like tourmaline and boron-rich micas in the soil. Adsorbed on clays, hydrous oxide surfaces, and organic matter; in solution as boric acid and borate anions, in organic matter, and in microbial biomass as secondary minerals within the clay mineral lattice. The amount of boron in soil parent materials varies greatly. The total quantity of boron in the soil can range from 2 to 200 mg kg-1, but only approximately 3 to 5% of that is available to the crop. Tourmaline, a very insoluble mineral, contains a significant amount of the total boron in the soil. Boron is available to plants in a variety of forms, including inorganic borate complexes of Ca, Mg, and Na, as well as numerous organic compounds. Most crops become hazardous above 20 mg kg-1 or more.

Deficiency symptoms of boron

Boron insufficiency has been recorded in over 100 crops from all over the world. Many structural, physiological, and metabolic changes occur as a result of it. Boron cannot be mobilised from vegetative portions to actively growing plant tissues like shoots, root tips, flowers, anthers, pollen, seeds, or fruits in most crops. Boron is transported largely through the xylem channel as a result of transpiration. Deficiency symptoms appear initially in newly produced plant tissue such as young leaves and reproductive structures as a result of this. Chlorosis and mortality of the developing points are common B deficient signs, as are stem distortion, thickness, and cracking, creation of rosettes, growth of auxiliary buds, bushy growth, and repeated branching. Roots become twisted and thick, roots exhibit excessive branching, root crops frequently fail to grow edible portions, dark coloured corky patches appear, buds or blossoms drop, fruits and seed are also harmed. Water soluble boron concentration in soil is classified according to its adequacy, shortage, and toxicity to crop plants.

Factors affecting boron availability in soils

Boron concentration and availability in soils are influenced by a variety of characteristics such as parent material, texture, clay mineral nature, pH, liming, organic matter content, and interrelationships with other elements. As a result, understanding the components that influence boron intake is critical for determining boron insufficiency and toxicity under various circumstances.

Parent material

Parent material is thought to be a major determinant of boron availability from the soil. In general, volcanic rock-derived soils in tropical and temperate regions of the world have substantially lower boron concentrations than sedimentary rock-derived soils in dry or semi-arid areas. High boron concentrations are commonly seen in soils derived from marine shale-enriched source material. Lacking boron concentrations have been seen in soils originating from acid granite, other igneous rocks, fresh-water sedimentary deposits, and coarse textured soils low in organic matter.

Soil texture and clay minerals

Boron availability is often lower in coarse-textured soils than in fine-textured soils. It's possible that this is one of the reasons why boron deficiency in agricultural plants is so common on sandy soils. Because boron leaching losses from sandy soils are so significant, these soils are typically deficient in accessible boron. Boron deficiency is less common in silty and clay soils than in sandy soils. At the same equilibrium concentration, boron adsorption is higher in fine-textured soils than in coarse- and medium-textured soils. The amount of native boron in the soil is also influenced by its clay concentration. At the same time, plants grown in coarse-textured soils had increased water soluble boron concentrations and boron uptake. Illite clay types generally have more boron adsorption than kaolinite or montmorillonite clay types. Sims & Bingham discovered that iron (Fe) and aluminium (Al) coated kaolinite or montmorillonite adsorbed more boron than uncoated clays.

Soil reaction (pH) and liming

Plant availability of boron diminishes when soil pH rises, especially at pH 6.5. However, due of boron sorption to the iron and aluminium oxide surfaces of soil minerals, extremely acid soils (pH less than 5.0) tend to be poor in accessible boron. Some crops with a high boron demand, such as alfalfa, also require a soil pH of greater than 6.5 for optimal growth, hence liming may be required. Overliming acid soils, on the other hand, has frequently resulted in temporary boron deficiency, particularly when liming to pH levels above 7.0.

Soil organic matter

The majority of the boron in soils is found in organic materials. Soils with little organic matter content have a lesser capacity to supply boron and will require more frequent boron fertiliser at lower rates. Because soil organic matter must degrade to release complexed boron, conditions that restrict organic matter breakdown, such as chilly, rainy weather or hot, dry weather, can lower accessible boron in soils.

Soil Moisture

Even if boron levels in the soil are higher than optimal, low soil moisture content reduces boron uptake. Because soil drying reduces water uptake, boron transport to plant roots via mass flow is reduced. Microorganisms mineralize boron from organic matter at a slower rate when soil moisture is low. B insufficiency can also be caused by low plant transpiration.

Soil microbial activity and Soil fertility

Plant-available boron is liberated from organic complexes as microorganisms break down soil organic materials. Warm, moist soils with proper aeration are ideal for increased microbial activity. Drought conditions, cold and wet soils, poor soil tilth (poor aeration), and balanced soil fertility often result in better boron uptake by plants. The improved plant vigour and root growth that results allows for more boron and other nutrient uptake. As a result, soil test findings should be scrutinised carefully, and nutrients that are marginal or deficient should be provided at suggested rates.

Liming

Because pH has a negative relationship with boron availability, soil amelioration using lime raises the pH, resulting in boron deficit. Soluble boron reacts with calcium ions in acid soils to generate the very insoluble Ca-metaborate, which lowers boron availability to crops. Overliming acid soils, on the other hand, has frequently resulted in temporary boron deficiency, particularly when liming to pH levels above 7.0.

Interactions of boron with other nutrients

Boron's (B) roles in plants are intertwined with those of nitrogen (N), phosphorus (P), potassium (K), and calcium (Ca). Its interactions (synergistic or antagonistic) with the majority of nutrients (N, P, K, Ca, Mg [magnesium], Al [aluminium], and Zn [Zinc]) may have a role in regulating B availability to plants in the soil. The availability of native and applied boron is influenced by the presence of other elements in the soil, which can be beneficial or harmful. For example, a low level of B in the soil aided in the increase of Zn content in plants, but a high level of B in the soil inhibited the increase of Zn content in plants (antagonism). The presence of a low level of Zn in soil aided the increase of B content in plants, whereas the presence of a high level of Zn in soil inhibited the increase of B content in plants (antagonism). Increased boron treatment has a synergetic effect on Ca content in plant leaves and stems. Increasing the amount of boron applied has an antagonistic effect on the concentration of Zn in the leaf and stem. In terms of crop assimilation/uptake as well as crop produce, a substantial association has been discovered between K and B fertilisers.

Amelioration of boron deficiency

The agriculture sector's boron nutrient study has greatly benefited in a better understanding of the role of boron in crop plants. The amount of boron that should be included in fertiliser recommendations is determined by crop requirements and soil boron test levels. A high boron rate may be required for sandy-type soils, soils with acidic and basic pH, high calcium concentration, and low organic matter content. For optimal development and production, knowing the application rate, method, and time of application, the source of nutrients to use, and how the components are influenced by soil and climatic conditions are all important. Because boron is non-mobile in plants, it requires a consistent supply from the soil, fertigation, or foliar spray to ensure maximum plant growth. The only method to deal with boron scarcity is to use it outside.

Boron Fertilizer

Boron can be given to the soil as a pure boron ingredient, such as borax, or it can be purchased in a fertiliser mix. It can also be dissolved in water and sprayed on the crop or soil as a foliar application. It can also be used to irrigate crops (fertigation). In India, there are several boron fertiliser sources to choose from. Borax, granubor, boric acid, and solubor, among other boron fertilisers, are suited for soil and foliar application.

Method of Application, dose and precautions

Instead of row/banded approaches, broadcast is the preferred application method. Broadcast applications should be made 1 to 2 weeks before seeding or planting. To avoid boron toxicity problems, typical boron application rates are 0.5 to 2.0 kg ha-1 for soils with a pH less than 6.5, but 2 kg ha-1 for calcareous soil. Foliar sprays with boric acid, solubor, and sodium borate are effective. Foliar applications of 0.2 to 1.0 percent boric acid or borax at the preflowering, pollination, and head formation stages increase crop production, but not to the point of toxicity. Boron-containing fertilisers should be used with caution because if it comes into touch with the seed at planting time, it will limit germination and should not be coupled with ammonium sulphate to avoid ammonia liberation (NH3).

CONCLUSION

Boron shortage reduces crop growth and production significantly, thus boron nutrition is critical for optimum development and yield. On boron-deficient soils, crop output is affected by the source, rate, time, and technique of boron fertiliser application, as well as the right balancing of boron with other nutrients in the soil. Foliar boron application at the correct time of crop growth outperforms soil application, particularly in zinc-deficient soil to avoid boron toxicity in crops and in alkaline, calcareous soil to avoid contact and adsorption in soil, which impacts crop growth and yield.

REFERENCES

Argust P. Distribution of boron in the environment. Biol. Trace Element Res. 1998; 66:153-166.

Benton JJ. Agronomic handbook; management of crops, soils and their fertility. CRC press LLC. USA, 2003.

Carlos B, Effects of Boron on Plants. Nevada's Horticulture Connection. Univ. Nevada Cooperative Extension. 2000, 1(1).

Dell B, Huang L. Physiological response of plants to low boron. Plant Soil. 1997; 193:103-120.

Elarashidi MA, O'Connar GA. Boron sorption and desorption in soils. Soil Sci. Soc. America J. 1982; 46:27-31.

Evans CM, Sparks DL. On the chemistry and mineralogy of boron in pure and mixed systems: A Review. Comm. Soil Sci. Plant Anal. 1983; 14:827-846.

Fleming GA. Essential micronutrients. New York. 1980, 155-195.

Goldberg S, Chuming S. New advances in boron soil chemistry. Springer Sci. 2007; 313-330.

Gupta UC, Jame YW, Campbell CA, Leyshon AJ, Nicholaichuk W. Boron toxicity and deficiency: A review. Canadian J Soil Sci. 1985; 65:381-409.

Gupta UC. Relationship of total and hot-water soluble boron and fixation of added boron, to properties of Podzol soils. Soil Sci. Soc. America Proceedings. 1968; 32:45-48.

Gupta UC. Sources of boron. In: Gupta UC, (Ed.) Boron and its role in crop production. CRP Press, Florida, USA.1993; 87-104.

Hill WE, Morrill LG. Boron, calcium and potassium interactions in Spanish peanuts. Soil Sci. Soc. America Proceedings. 1975; 39:80-83.

Hou LJ, Evans LJ, Spiers GA. Boron fractionation in soils. Comm. Soil Sci. Plant Anal., 1994; 25: 1841–1853.

Kalmet R. Boon content of soils of the Estonian SSR. Inst. Zemled. Melior. 1963; 2:60-74.

Liu Z, Zhu QQ, Tong LH. Microelements in the main soils of China. Soil Sci. 1983; 135:40-46.

Maze P. Influences respective des elements de la solution minerale sar le developpement du maiz. Ann. Inst. Pasteur. 1915; 28:21-68.

Shorrocks VM. The occurrence and correction of boron deficiency. Plant Soil. 1997; 193:121-148.

Sillanpaa M. Micronutrients and nutrient status of soils: A Global Study. FAO Soil Bulletin No. 48, FAO, Rome, 1982.

Sims JR, Bingham FT. Retention of boron by layer silicates, sesquioxides and soil materials: I. Layer silicates. Soil Sci Soc. America Proceedings. 1967; 31:728-732.

Takkar PN, Chibba IM, Mehta SK. Twenty years of coordinated research on micronutrient in soils and plants. Indian Inst. Soil Sci. Bhopal, India Bull. 1989, 314.

Zhu D, Shi L, Liu W. Study on the properties of different chemical boron pools in soil – Investigation on plant availability of soil boron. J Huazhong Agric. Univ. 1999; 28:159-165.