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REVIEW ARTICLE

THE AVAILABILITY STATUS OF BORON IN THE CULTIVATED SOIL OF NEPAL

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ABSTRACT

Boron is available in nature in rocks and deposits and the availability is influenced by soil organic matter, soil pH, soil texture, and temperature and is taken up by plants in non-ionic form H_3BO_3 (boric acid) but this concentration account for only about 10% of total soil boron leading to boron deficiency. Also, boron toxicity may occur in low rainfall, extremely alkaline, and saline soils harming plants' growth and development. Boron shortage and toxicity in plants have a fairly narrow range, and both are detrimental. Hence, it is needed to critically balance boron homeostasis in cropping soil. The concentration of boron in cultivated soil in different agroecological regions was found to be low to very low (1mg/kg of soil) in this review study, which was undertaken to familiarize the status of boron in Nepalese cultivated land. In separate micronutrient investigations, a few additional micronutrients were shown to be medium albeit, boron was found to be low even in the valley (>0.01ppm) including all three ecological regions. This shows boron deficiency is a universal problem in Nepal affecting 80-90% of agricultural soil. And this problem can be corrected by both foliar applications and by soil application of boron sources such as borate as per the recommended dose.

KEYWORDS

Boron, Deficiency, Homeostasis, Role, Toxicity.

1. INTRODUCTION

Boron (B) is a micronutrient that plants require to thrive (Tripathi, 1999). Warrington was the first to identify boron as a critical plant nutrient in 1923, and to show that deficient symptoms were present (Takano et al., 2008). The cell wall integrity of plants required boron. It is involved in the deposition of cell wall material as well as the flexibility of plasma membrane and the preservation of cell integrity (Fleischer et al., 1999). It is important for tissue development and differentiation and glucose transport and sugar translocation in plants. The elemental form of boron is never seen in nature. Borates (oxygen-bound sodium, calcium, magnesium, or silicon) are found in rocks and deposits, and they are frequently hydrated (Argust, 1998). Plants take up boron from the soil in the form of uncharged boric acid either passively through diffusion or actively (under B-deficient soil conditions), However, this pool accounts for only about 10% of total soil boron (Power and Woods, 1997). Several soil variables influence boron availability, including organic matter (OM), pH, texture, and temperature (Goldberg, 1997). Low soil B concentration is the leading cause of B insufficiency in plants (Shorrocks, 1997).

Boron plays an important function in plant development tissue, and a lack of it inhibits both vegetative and reproductive growth (Dell and Huang, 1997). Due to the boron deficit in cell division, disorganization of the root apical meristem occurs, resulting in a balanced loss of the shoot-to-root biomass (Poza-Viejo, 2018). According to Rerkasem and his co-workers, boron shortage causes fertilization failure in wheat due to decreased anther development and poor pollen germination. Rice output and genetic makeup are also controlled by soil B treatment in rainfed settings (Shrestha et al., 2018). Plants' genetic makeup has an impact on their ability to respond to low B concentrations. Inefficient genotypes reveal the negative effects of boron deprivation while efficient genotypes grow in boron-deficient soil (Rerkasem and Jamjod, 2004). Boron insufficiency and toxicity have a relatively narrow range, thus maintaining correct boron homeostasis is essential (Shorrocks, 1997). When the soil is salty and inadequately drained, boron levels can be poisonous. Alpaslan and Gunes reported that salinity increased leaf injury and membrane permeability in boron-toxic circumstances in cucumber and tomato, as well as an osmotic imbalance (Alpaslan and Gunes, 2001). Boron toxicity, which is more difficult to manage than boron shortage, affects crop output in low rainfall, extremely alkaline, and saline soils (Roessner, 2006). However, fertilizing with boron to prevent deficiency can cause poisoning (Shrestha et al., 2020).

2. DISCUSSION

2.1 Status of Boron in Cultivated Soil of Nepal

Boron insufficiency causes sterility in grains and legumes, however, it is rarely recognized in Nepal, and the symptoms of deficiency are mostly disguised in plants rather than in grains (Bhatta, 2001). The majority of investigations have found similar levels of deficiency in the country. Boron (B) deficiency has been found in 80 to 90 percent of soil samples. This is a critical micronutrient deficiency because it limits agricultural production and also affects human nutrition directly or indirectly (Andersen, 2007). Micronutrient studies are rare, but those that have been conducted reveal that boron levels are lower in all three ecological areas of Nepal (Terai, hill, and mountain) and practically all farmed land (Bajracharya and Sherchan, 2009). Soil fertility in Nepal's Bari land is dwindling due to excessive erosion and leaching losses, as well as a lack of farmyard manure application. As a result, increased soil conservation is critical in the most severely affected locations (Acharya et al., 2005).

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A group researchers investigated the availability of micronutrients for plant growth in several agro-ecological zones of Nepal, finding that boron availability was low in the high Himalayas, mid-hills, and central hills (Karki et al., 2005). Boron along with molybdenum is discovered to be low even in valley soils, while other elements like Zn, Cu, Fe, and Mn were found to be medium, and crops reacted well to its application. In the western hills of Nepal, discovered that 87 percent of samples were insufficient in boron (i.e. 1 mg/kg of soil), as described in an article (Tariq and Mott, 2007). Khatri-Chhetri and Ghimire found boron deficiency in 100 percent of 70 soil samples in the Chitwan district (Khatri-Chhetri and Ghimire, 1992).

Two field experiments conducted at Khairanitar farm with different wheat genotypes (41 in one and 6 in the other) demonstrate significant differences in sterility (5.5 percent to 97.5 percent). One-third of the genotypes showed 25% sterility, 16 showed >75% sterility, and only a few (ten percent) were tolerant to boron deficiency. As a result, a substantial response to the application of boron was seen (Budhathoki et al., 1997). A field experiment in the Rupandehi district in cauliflower crop indicates a quadratic response of curd production, harvest index, and plant boron uptake to applied boron, with the best output at 1.3 kg boron and 60kg P2O5 (Dhakal et al., 2009).

Boron shortage becomes more prevalent in a more diverse system. There is a higher need for boron during the dry season due to the shift of vegetables over wheat (Shrestha et al., 2020). The boron level in dry biomass was also examined in various crops, with concentrations falling below critical limits in wheat, cauliflower, and tomato, with 10mg B/kg, 21mg B/kg, and 23mg B/kg, respectively. In 2016, a study was carried out in which 25 soil samples were collected and examined to assess the fertility status of the agriculture research station in Belachapi, Dhanusha, with the result revealing a low boron concentration of 0.560 (Khadka et al., 2016). Khadka and his co-workers collected 81 soil samples at a depth of 0-20cm based on land variability and analysed them for various soil properties in the regional agricultural research station, Tarahumara, Sunsari, the result showed 0.08ppm available boron, which is very low (Khadka et al., 2017).

A comparable investigation was carried out in the regional agriculture station of Parwanipur, Bara, and the available boron concentration was reported to be 0.590ppm, which was very low (Khadka, 2018). Another study for soil fertility evaluation was carried out in Chungbung Farm, Pakhribas, Dhankuta Nepal, utilizing a GPS device to find the location for soil sampling. A total of 27 soil samples were collected and analyzed, with the result revealing a very low boron concentration which was 0.210.05ppm (Khadka, 2018). The findings of a report by Sippola and Lindstedt based on 150 soil samples collected from cultivated fields in Nepal's central middle hills revealed a major deficiency of boron among other micronutrients, with very low levels in 58 percent of samples and low levels in 36 percent (Andersen, 2007).

It also demonstrates that the paddy-paddy cycle had the lowest content of all nutrients. FAO soils bulletin no. 48 is the most authoritative source for micronutrient concentrations in Nepalese soil, and it provides a global overview of soil micronutrients by measuring plant-accessible micronutrients in soil samples collected from various countries. Its research revealed that Nepal had the lowest average B content in soil samples of all the nations studied, and it was also stated that widespread boron shortage (acute or hidden) is likely to occur in Nepal, restricting yields, particularly for crops that require a high Boron concentration (Andersen, 2007). The concentration of boron in different districts of Nepal is shown in the table below.

Table 1: Status of Boron (Ppm) in The Soil of Different Districts in Eastern, Central, and Western Nepal (Bajracharya and Sherchan, 2009).

District	Boron Availability (ppm)
Chitwan	0.30
Gorkha	0.23
Kaski	0.61
Kathmandu	0.01
Myagdi	0.72
Palpa	0.93
Parbat	0.46
Tanahu	0.65
Mean	2.52

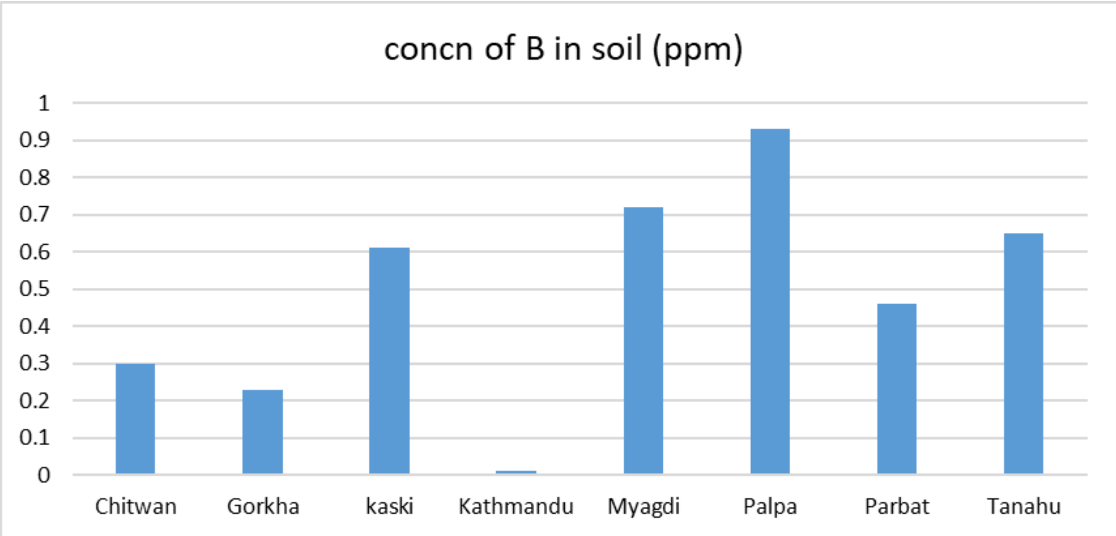

Figure 1: Status of Boron in Different Cultivated Regions **o**f Nepal

Table 2: Status of Boron in Various Districts of Three Physiographic Regions of Nepal (Bajracharya and Sherchan, 2009).

Region of Nepal	Boron Availability
Terai	Low
Middle mountain	Low
High mountain	Low
In Overall Nepal	Low

2.2 Causes of Boron Deficiency

Micronutrient deficiencies are common in Himalayan food systems due to high erosion rates, poverty, subsistence agriculture, low-nutrient bedrock, and rising cropping intensity (Andersen, 2007). Many natural factors such as high soil erosion rates, leaching in the Himalayan region resulting in low concentrations of some elements in the soil, and soil formed from sandstone, granite, and quartzite in hilly regions result in infertile sandy soil contributing to micronutrient deficiencies. Basalt, shale, and limestone, which are nutrient-rich bedrocks, are less common. Boron insufficiency is widespread, however, it is limited to specific crops and soil types in some areas. Boron-deficient crops are produced by the acrisols and podzols soil groups. Boron shortage has also been linked to soil parent materials and texture, as well as climate conditions such as low temperatures and strong light intensity (Shorrocks, 1997). Subedi and his colleagues discovered genetic differences in boron demand and responsiveness to boron in wheat during their research at Khairanitar Farm in 1993 (Subedi et al., 1997).

2.3 Correction of Boron Deficiency in the Context of Nepal

Agriculture-based strategies for reducing micronutrient deficiency will necessitate understanding soil deficits or excesses of certain elements. Boron insufficiency is a widespread problem in Nepal, impacting 80 to 90 percent of agricultural soils and resulting in lower crop yields; yet the pattern of this deficit suggests that blanket recommendations and the use of B-added fertilizers may be achievable (Andersen, 2007). Boron is applied to over 15 million hectares of cropland each year. Boron shortage can be easily avoided and addressed by applying it to the soil and the leaves (foliar application). Boron is applied using sodium borates, boron-containing fertilizers, or crushed ores (Shorrocks, 1997).

3. Conclusion

According to this review study, the agricultural area of Nepal, which includes all three ecological regions (Himalayan, hills, and terai even valley), is deficient in the micronutrient boron. To begin with, only a few research studies have been conducted, and all of the results show low to very low concentrations of boron in the soil of farmers throughout Nepal, from the eastern to western parts, and farmers are unaware of this situation which can be corrected by applying boron-based fertilizers, carefully following the recommended dose as there is a very narrow range between boron deficiency and toxicity, and by increasing extension workers the situation can be handled by making farmers aware of the prevailing situation. And the concentration of boron can be maintained to sufficient through both soil and foliar applications.

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