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Critical limit of boron in acid laterite soil for cultivation of sunflower *(Helianthus annus* L.)

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Abstract
The present investigation was carried out to study the critical limit of boron and its response to Sunflower *(Helianthus annus* L.) in acid laterite soils of Odisha. This work will be of immense importance of recommending appropriate doses for soil boron application. The critical limit of boron in soil and plant is the level below which there is appreciable response to boron application. The concept of critical limit distinguishes deficiency from sufficiency, which could be employed to advice on need for nutrient fertilization. It has been realized as the second most important micronutrient constraint in crops after that of zinc (Zn) on global scale. Deficiency of B mainly occurs in acidic and lateritic soils. Its application only slightly above the optimum level proves to be toxic to plants. Therefore the study was taken up emphasizing the need for a careful appraisal of available B status in soils for judicious use of boron fertilizers and establishing the critical concentration of boron in Sunflower. The experiment was laid out in factorial completely randomised block design in laterite Soil during *Zadi*, in 2018 at AICRP on Micronutrients, department Soil science and Agricultural chemistry, OUAT, Bhubaneswar, with two factors (5 Soil types and 5 boron doses of 0kg boron/ha, 0.5kg boron/ha, 1.0kg boron/ha, 1.5kg boron/ha and 2kg boron/ha.) with 25 treatments replicated twice. The plant height, seed dry weight and number of seeds per head showed positive and significant correlation with the soil boron application in all soil type except in soil type 2 and soil type 3 where the growth declined after kg/ha and kg/ha respectively. The critical limit of boron was found to be 0.58ppm in soil and 23.4 ppm in plants.

Keywords: critical limit, boron, sunflower

Introduction
The critical limit of boron in soil and plant is the level below which there is appreciable response to boron application. Boron deficiency is one of the major constraints to crop production Boron particularly in sunflower is very essential for seed setting development of head (Krudnak, 2013) [4]. It is very essential to know the critical limit of boron since there is a very narrow range between boron toxicity and boron deficiency (Reid *et al.,* 2013) [8]. The critical limit of soil available boron would be essential to delineate boron deficiency in soil. Plant analysis is useful in determining the availability of elements, nutrient deficiencies, toxicities or imbalances, identifying hidden hunger, evaluating fertilizer programme Sometimes adequate nutrients may be present in the soil, but because of other problems like soil moisture and inadequate amounts of some other nutrients, the plant availability of the nutrient in question may be constrained.

Developed critical limits can be used in calibration and interpretation of soil testing and finding the toxic concentrations in plants. In an experiment of boron application in rice grown in alluvial soils of west Bengal (Debnath and Ghosh, 2011) [2] the critical concentration of soil available B and plant tissues B was 0.35 and 12.0 mg kg^{-1} respectively below which there was an appreciable responses to boron application. A similar study was taken up to analyse the critical limit of boron in sunflower crop cultivated in acid laterite soils of Odisha. Boron is a key micronutrient in sunflower economic yield Reddy S, 2003. Since Different soil characteristics like pH, EC and Organic matter effect boron status in soils (Mengel, K. and Kirkby, 2001) [6] these soil parameters were also evaluated. However in the current experiment the focus is on establishing the response of sunflower to the soil boron application and its critical limit in soil and the critical limit of seed boron concentration in plant.

Material and Methods

Factorial completely randomized block design was adopted for this experiment with 25 treatments with 2 replications each. Black polybags were used for the experiment having an approximate 5 kg soil (Table 1). Boron was applied in form of borate to soil in 5 doses of 0kg boron/ha, 0.5kg boron/ha, 1.0kg boron/ha, 1.5kg boron/ha and 2kg boron/ha (Table 2). The pH was recorded using a pH meter (ELICO LI 617 Model). The E.C. was measured from the supernatant solution (Model: Digital conductivity Meter 611(B). The OC was determined following Walkly and Black 1934 [11]. The plant height was measured and total number of seeds per head were counted at harvest. The head dry weight seed dry weight and head diameter was also estimated. Dry weight was measured by oven drying till a constant eight was obtained. Available boron was determined by using *Azomethine - H* colorimetric method (Jakson, 1973) [3]. The critical level of nutrient in soil was derived by plotting the nutrient on 'X' axis and Bray's percent yield on 'Y' axis. A cross is placed over the data and moved to the upper left and lower right to have a minimum number of points (Cate and Nelson, 1965) [1]. The critical limit of boron in plant tissue was found by taking Bray % over seed yield against seed boron concentration.

Table 1: Preparation of pots and fertilization schedule

Fertilizer	Rate (kg/ha)	Amount of fertilizer applied per pot (5kg soil)
Nitrogen	60	69.58mg urea basal and again at 35DAS
Phosphorous(P_2O_5)	80	380.42mg DAP basal only
Potash (K_2O)	80	110.4mg MOP basal and again at 35DAS

Table 2: Factorial completely randomized block design with 25 treatment

Serial No.	Treatments
1	S1B0-Soil type1 with a boron dose of 0kg boron/ha (control)
2	S1B0.5- Soil type1 with a boron dose of 0.5kg boron/ha
3	S1B1.0- Soil type1 with a boron dose of 1.0kg boron/ha
4	S1B1.5- Soil type1 with a boron dose of 1.5kg boron/ha
5	S1B2.0- Soil type1 with a boron dose of 2.0kg boron/ha
6	S2B0 -Soil type2 with a boron dose of 0kg boron/ha (control)
7	S2B0.5- Soil type2 with a boron dose of 0.5kg boron/ha
8	S2B1.0- Soil type2 with a boron dose of 1.0kg boron/ha
9	S2B1.5- Soil type2 with a boron dose of 1.5kg boron/ha
10	S3B0- Soil type3 with a boron dose of 0kg boron/ha (control)
11	S3B0.5- Soil type3 with a boron dose of 0.5kg boron/ha
12	S3B1.0- Soil type3 with a boron dose of 1.0kg boron/ha
13	S31.5- Soil type3 with a boron dose of 1.5kg boron/ha
14	S32.0- Soil type3 with a boron dose of 2.0kg boron/ha
15	S4B0- Soil type4 with a boron dose of 0kg boron/ha (control)
16	S4B0.5- Soil type4 with a boron dose of 0.5kg boron/ha
17	S4B1.0- Soil type4 with a boron dose of 1.0 kg boron/ha
18	S4B1.5- Soil type4 with a boron dose of 1.5kg boron/ha
19	S4B2.0- Soil type4 with a boron dose of 2.0kg boron/ha
20	S5B0- Soil type5 with a boron dose of 0kg boron/ha (control)
21	S5B0.5- Soil type5 with a boron dose of 0.5 kg boron/ha
22	S5B1.0- Soil type5with a boron dose of 1.0kg boron/ha
23	S5B1.5- Soil type5 with a boron dose of 1.5kg boron/ha
24	S5B2.0- Soil type5 with a boron dose of 2.0kg boron/ha
25	S2B2.0- Soil type2 with a boron dose of 2.0kg boron/ha

NB: Soil types-laterite soil having different pH and organic carbon

Results and Discussion

The critical limit of boron in soil and plant was established by taking Bray's percentage over seed yield against the boron concentration in soil. It was found that the critical limit of boron in soil is 0.58 ppm (Figure 1). This is supported by the findings of Yadav, 2016 who reported that the critical limits of extractable B in soil as determined by the graphical procedure were between 0.45ppm to 0.60 ppm. The critical limit of boron in seed was found to be 23.4ppm. This was near to the findings of Wani, 2007 [12] who reported the critical concentration of soil available boron and plant tissues was 23.0 ppm (Figure 2).

Soil type 1 and Soil type 5 had boron concentration of 0.08ppm and 0.16ppm respectively, and hence showed enhanced response to fertilizer application over other soil types. It suggests the rapid response of plants to soil boron application which is supported by findings of Sathya *et al*., 2013 [10] that boron application help in uptake of other nutrients in boron deficient soil. Soil type 4 also had boron concentration (0.21ppm) below the critical limit but could not show better performance due to low organic matter content (0.362). It is in line with study of (Sarwar & Mubeen, 2015) [9] on the impact of soil organic matter on boron availability.

Soil type 3 having the highest initial soil boron content of 3.2 ppm showed good response at lower dose but the growth sharply declined beyond a boron dose 1kg/ha. Soil type 3 there was a decrease in plant height beyond boron dose 1 kg B/ha. There was similar decline in growth in soil type 2 (initial soil boron 0.620ppm) beyond a boron dose of 1.5 kg/ha. Boron had a marked effect on number of seeds and a plant showed a significant response to boron. Soil type 1 having lowest initial boron content (0.08ppm) much below the critical limit of boron in soil showed the maximum number of filled seeds as well as seed weight. Toxic concentration of boron in plant was found to 81.1 ppm in seeds.

At this concentration the plant response to boron application declined. There was a decline in seed weight and no of filled seed per head in Soil type 2 and Soil type 3 beyond boron dose 1.5kg B/ha and 1 kg/ha respectively. It can be suggested that soil application of 1.5 kg boron is sufficient for optimum yield. Higher doses of boron can be detrimental to growth (Luis *et al*., 2013) [5]. The critical limit of boron was determined in both soil and plant which is indispensable for the judicious application boron fertilizer considering the initial soil boron content and organic matter status

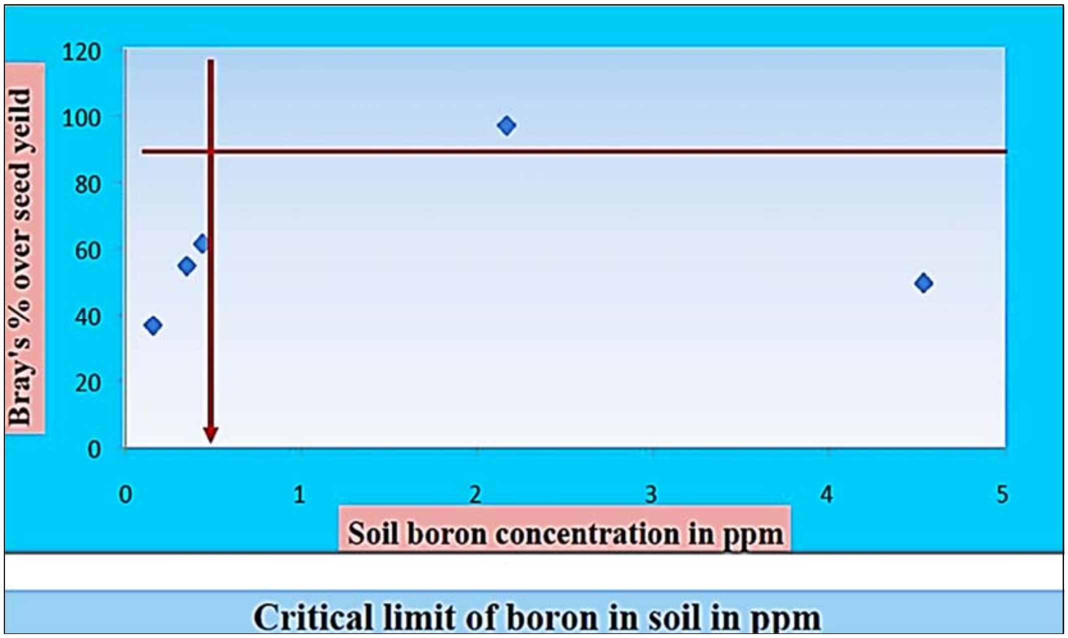

Fig 1: Observation of critical limit of boron in soil

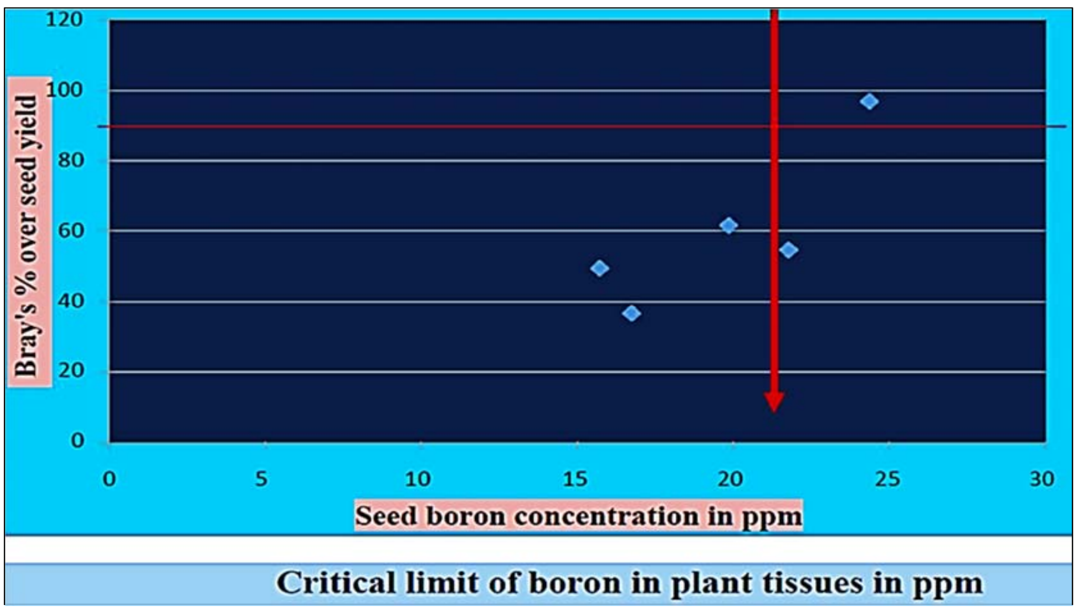

Fig 2: Observation of critical limit of boron in sunflower tissue

Conclusion

From these observations in the present investigation Yield attributes such as number of filled seeds per head, seed weight, and oil content increased significantly over all treatments except Soil type 3 there was a decrease in plant height beyond boron dose 1 kg B/ha and soil type 2 beyond a boron dose of 1.5 kg/ha. There as significant growth below 0.58ppm boron concentration in soil. The overall best performance was observed in S1B2 treatment. Toxic concentration of boron in plant was found to be 3.5 ppm in seeds. At this concentration the plant response to boron application declined for all the parameters. It can be concluded that critical limit of boron was found to be 0.58ppm in soil and 23.4 ppm in plants. This critical limits must be defined and refined with reference to growing environment, certain soil characteristics like pH, EC organic matter. The critical limits generated plays an important role in decision making at farm level planning particularly for the application of balanced nutrient to ensure the yield potential of sunflower crop in Odisha.

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