Plant Archives Vol. 18, Special Issue (ICAAAS-2018), 2018 pp. 31-35 ***ISSN 0972-5210***

RELEASE BEHAVIOUR OF BORON IN LOW AND HIGH BORON STATUS SOILS VIS-A-VIS ZINC AND PHOSPHORUS APPLICATION

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Abstract

A laboratory experiment was conducted to determine the effect of zinc and phosphorus application on release behaviour of boron under high and low B status soils. The incubation was done at an interval of 0, 4, 7, 15, 30, 45 and 60th day after the application of zinc and phosphorus. The levels of P 0, 25, 50, 75 and 100 mg P_2O_5 kg^{-1} soil and Zn 0, 5, 10 and 20 mg Zn kg^{-1} soil were applied in triplicate and the soils were kept at field capacity under room temperature in the laboratory for incubation up to 60 days. The results revealed that the release of hot water soluble boron (HWS-B) of high B and low B soils showed a different trend among themselves *i.e.* High B soil released more B continuously up to 60 days compared to low B soil being higher content of native B content. The maximum HWS-B released at 4th day of incubation in high B and low B soil and, thereafter, a continuous decrease in release of HWS-B was noticed up to 60th day of their incubation. Whereas, combined application of graded doses of P and Zn had no significant effect on desorption/release of HWS-B. However, individual application of P showed an improvement in the release of available B.

Key words : Boron, phosphorus, zinc, release behaviour, incubation.

Introduction

Among all the micronutrient Boron (B) is only a unique non-metal essential for plant growth. The boron containing mineral is Tourmaline in which B is present in insoluble form while hydrated B minerals contain soluble form of B minerals. The boron toxicity and deficiency range is very narrow. Boron deficiency is the second most widespread micronutrient problem (Alloway, 2008). In India, boron deficiency was initially reported 2% in the year 1980 (Katyal and Vlek, 1985), which has now increased to 52% (Singh, 2012). Its deficiency has been widely found in highly calcareous soils of Bihar, Tamil Nadu, eastern Uttar Pradesh and Saurashtra, sandy soils of Haryana and Rajasthan, hill and sub mountaneous soils of north Himalayan and NEH States and in red and lateritic soils of Orissa, Karnataka, Andhra Pradesh and Kokan region.

Several soil factors and conditions responsible for B deficiency as sandy texture, highly leached, calcareous (>15% calcium carbonate) soil having high pH (> 7) and recently limed soils (Borkakati and Takkar, 2000; Alloway, 2008). Since, adsorption and desorption reactions are likely to be major factors in regulating boron concentration in solution, an understanding of the mechanism of boron adsorption on soil constituents is important (Elrashidi and O'Connor, 1982). The absorption and utilization of one element is influenced by the concentration of other elements present both in soil and plant system. Therefore, the concentration of B affects or be affected by other elements present or applied in the soil. The magnitude of release of inherent B is governed by many factors, *viz.* type and amount of clay, B status, alternate wetting and drying, type and doses of fertilizer application, pH, moisture content, temperature, carbon and $CaCO_3$ content as well as status of other nutrients. The soils release more HWS-B is considered good for crop production up to some extent. Therefore, knowledge of these factors affecting B uptake is essential for the assessment of B deficiency and toxicity under different conditions.

Materials and Methods

For native soil B release behaviour with graded doses of P and Zn application, 200 g soil each of low and high B status were taken in wide mouth plastic bottle. The levels of P and Zn were applied in triplicate and the soils were kept under room temperature in the lab at field capacity for incubation up to 60 days. Under incubation period Hot Water Soluble - Boron were recorded at an interval of - 0, 4, 7, 15, 30, 45 and 60 days. Boron was extracted from the soil with hot water and was subjected to colorimetric estimation, following reaction with Azomethine- H reagent. Intensity of the colour was measured on spectrophotometer at 420 nm.

Results

In the present study, it was found that both the soils released HWS- B up to 60 days of their incubation.

On 1st day

The total HWS-B concentration with the application of P significantly increased B concentration from 1.3 mg B kg^{-1} under control to 1.71 mg B kg^{-1} at 100 mg P kg^{-1} in soil I (Ambala soil). Similarly, in soil II (Balsamand) a significant increase in HWS-B concentration was observed from 0.74 mg B kg^{-1} in control to 0.90 mg B kg^{-1} at 100 mg P kg^{-1} application. In the absence of added P, the application of zinc decrease the concentration of HWS-B up to 1.12 mg kg^{-1} at 20 mg Zn kg^{-1} level over control (1.0 mg B kg^{-1}) in soil I, whereas in soil II with increased zinc application there was a significant decrease in HWS-B concentration as shown in fig. 1(i).

On 4th day

Similarly, on 4th day also the increase in HWS-B release from 2.33 mg B kg^{-1} under control treatment to 3.05 mg B kg^{-1} where 100 mg P kg^{-1} was applied in soil I was noticed. This increase in soil II ranged from 0.69 mg B kg^{-1} in control to 0.95 mg B kg^{-1} at 100 mg P kg^{-1} application. In the absence of P, the application of Zn fertilizer significantly decreased the concentration of HWS – B up to 20 mg Zn kg^{-1} *i.e.* 1.16 mg B kg^{-1} over control (2.33 mg B kg^{-1}) in soil I and in soil II (Balsamand) this decrease ranged from 0.69 in control to 0.56 at 20 mg Zn kg^{-1}. Highly significant HWS-B concentration was found at treatment $P_{100}Zn_0$ in both soils [fig. 1(ii)].

On 7th day

On 7th day also the same trend of increasing HWS-B concentration with P application in the absence of zinc takes place. The concentration of HWS-B increased from 1.92 mg B kg^{-1} in control to 2.46 mg B kg^{-1} at 100 mg P kg^{-1} in soil I and 0.58 mg B kg^{-1} in control to 0.89 mg B kg^{-1} at 100 mg P kg^{-1} in soil II. Also, in the absence of P, with added zinc the concentration of HWS-B decreased with increasing level of zinc in both soil I and soil II. Higher HWS-B concentration in soil I was 1.92 mg B kg^{-1} under control treatment which decreased up to 1.22 mg B kg^{-1} in soil I and up to 0.42 mg B kg^{-1} in soil II at 20 mg Zn kg^{-1} in the absence of added P [fig. 1(iii)].

On 15th day

Increase in the release of HWS-B concentration occur in similar manner and it ranged from 1.00 mg B kg^{-1} in control to 1.90 mg B kg^{-1} at highest level of applied P *i.e.* 100 mg P kg^{-1} in Ambala soil (soil I) and in Balsamand soil (soil II) this increase in HWS-B ranged from 0.52 mg kg^{-1} in control to 0.87 mg kg^{-1} at 100 mg P kg^{-1} application rate. Addition of zinc when P was not added, there was a decrease in the concentration of HWS-B in Ambala soil (soil I) and varied from 1.00 mg B kg^{-1} in control to 0.87 mg B kg^{-1} at 20 mg Zn kg^{-1} whereas in soil II with addition of zinc in the absence of P decreased in HWS-B was observed from 0.52 mg B kg^{-1} to 0.43 mg B kg^{-1} at 20 mg Zn kg^{-1} [fig. 1(iv)].

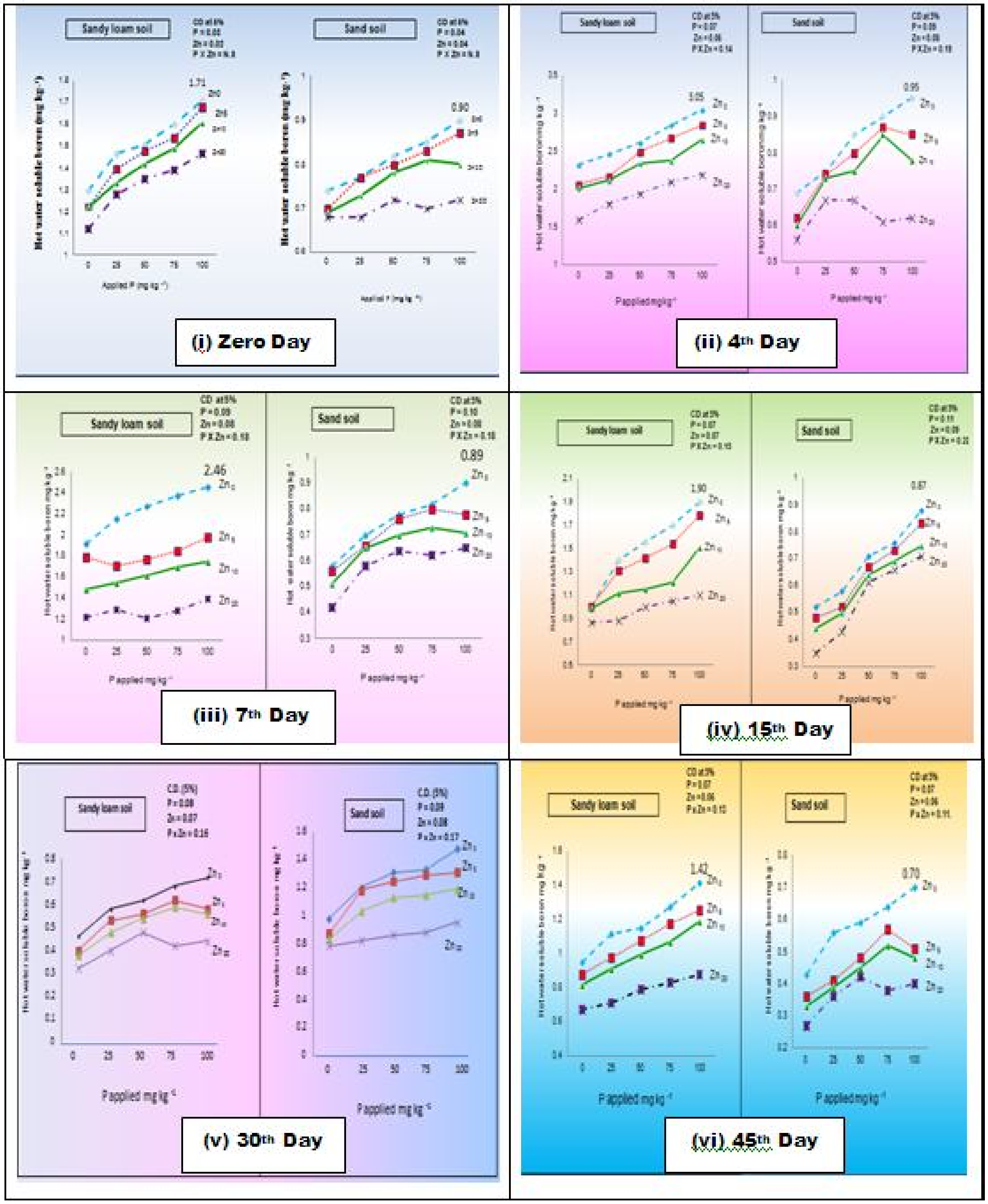
On 30th day

Again the same trend of significant increase in HWS-B concentration with increase in level of P application in the absence of applied zinc was found in both soils. Highly significant HWS-B concentration at 100 mg P kg^{-1} *i.e.* 1.47 mg B kg^{-1} over control (0.98 mg B kg^{-1}) in soil I and 0.72 mg B kg^{-1} over control (0.46 mg B kg^{-1}) in soil II. In soil I, when zinc was applied in the absence of phosphorus it decreased HWS–B concentration with each increased level of applied zinc and lowest HWS-B concentration was noticed at 20 mg Zn kg^{-1} *i.e.* 0.78 mg B kg^{-1} over control (0.98 mg B kg^{-1}) whereas in soil II it ranged from 0.46 mg B kg^{-1} under control to 0.32 mg B kg^{-1} at 20 mg Zn kg^{-1}. The interaction among the different level of applied P and Zn fertilizer on release of HWS-B was found significant in both the soils. However, in soil I, the highly significant HWS-B concentration was observed to the time of 1.47 mg B kg^{-1} and in soil II 0.78 mg B kg^{-1} at same treatment combination *i.e.* $P_{100}Zn_0$ [fig. 1(v)].

On 45th day

There was a significant increase in the concentration of HWS – B, which increased with increasing level of phosphorus content in the absence of zinc from 0.95 mg B kg^{-1} in control to 1.42 mg B kg^{-1} in soil I and from 0.43 mg B kg^{-1} in control to 0.70 mg B kg^{-1} in soil II at 100 mg P kg^{-1}. When compared with previous day desorption of HWS-B *i.e.* 30th day this release of HWS-B increased in soil I and decreases in soil II [fig. (vi)].

On 45th day of incubation without any addition of P, HWS-B concentration decreased significantly with increase in each level of zinc from 0.95 mg B kg^{-1} in control to 0.67 mg B kg^{-1} at 20 mg Zn kg^{-1} in soil I and from 0.43 mg B kg^{-1} in control to 0.27 mg B kg^{-1} at 20 mg Zn kg^{-1} in Balsamand soil (soil II). This value of HWS-B



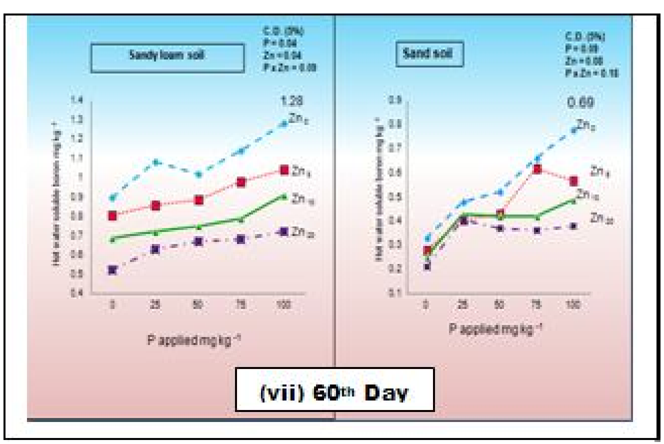


Fig. 1 : Effect of P and Zn on release behavior of HWS-B from soils at different intervals of incubation period (0, 4, 7, 15, 30, 45 and 60 days).

in both the soils decreased when compared to 30th day of incubation. The interactive effect of P and Zn on HWS-B concentration was found significant in both soils. Highly significant HWS-B concentration was obtained at a level of P_{100} Zn_0 level *i.e.* 1.42 mg B kg^{-1} in soil I and 0.70 mg B kg^{-1} in soil II [fig. (vi)].

On 60th day

Consequent after 60th day of incubation HWS-B content found in increasing order with increased level of added P in Ambala soil from 0.90 in control to 1.28 and in soil II from 0.33 mg B kg^{-1} in control to 0.69 mg B kg^{-1} at 100 mg P kg^{-1} application. However, the release of HWS-B decreased in both the soil as compare 45th day of incubation [fig. (vii)].

In the absence of phosphorus, addition of Zn decreased the concentration of HWS-B from 0.90 mg B kg^{-1} under control to 0.52 mg B kg^{-1} where 20 mg Zn kg^{-1} was applied in soil I and also in soil II with addition of Zn in the absence of P the concentration of HWS-B was found to decrease from 0.33 mg B kg^{-1} under control to 0.21 mg B kg^{-1} and it was less as compare to 45th day of incubation. The interaction effect among different treatments of P and Zn was found significant in both soils. Highly significant HWS-B *i.e.* 1.28 mg B kg^{-1} and 0.69 mg B kg^{-1} was found at $P_{100}Zn_0$ level in soil I and II, respectively [fig. (vii)].

Discussion

The soils releasing more HWS-B are considered good for crop production up to some extent. The release pattern of hot water soluble boron (HWS-B) of Balsamand and Ambala soils showed a different trend among themselves. The magnitude of release of inherent B is governed by many factors *viz.* type and amount of clay, B status, alternate wetting and drying, type and doses of fertilizer application, pH, moisture content, temperature, carbon and $CaCO_3$ content as well as status of other nutrients (Moraghan and Mascagni, 1991). A very limited work has been done to study the release behaviour of native boron in relation to phosphorus and zinc application. In the present study the major differences were noticed in their textural class, $CaCO_3$, organic matter and inherent B content. Both the soils release HWS- B up to 60 days of their incubation. However, Ambala soil release more B continuously up to their 60 days of incubation compared to Balsamand soil being higher content of native B content. Combined application of graded doses of P and Zn was found no significant effect on desorption/release of HWS-B. However, individual application of P was found an improvement in the release of available B.

Table 1 : Details of experiment with treatments level and design used.

Treatments	
Soil	2 (low and high B status Soil)
Level of zinc	0, 5, 10 and 20 mg Zn kg^{-1} soil
Level of phosphorus	0, 25, 50, 75 and 100 mg P_2O_5 kg^{-1} soil
Replication	Three
Design	Complete Randomised Design

Table 2 : Details of soils used in experiment.

Soils and their properties	
Soil 1	Soil 2
Sandy loam in texture	Sand in texture
Marginal in organic carbon (0.42%)	Low in organic carbon (0.07%)
Calcium carbonate (%) - Nil	Calcium carbonate (%) - 2
The DTPA extractable Zn was high 2.38 mg kg^{-1}	The DTPA extractable Zn was low 0.25 mg kg^{-1}
Available P was high 34 kg ha^{-1}	Available P was medium 14.5 kg ha^{-1}
Hot water soluble Boron was high 1.25 mg kg^{-1}	Hot water soluble Boron was marginal 0.5 mg kg^{-1}

The study indicated that the Ambala soils require higher rate of B application due more adsorption and less release/desorption. While Balsamand soils which are coarse textured and low in its native B status need lower rate of B application but at more frequent application as these soils release most of their available B in the initial days of their incubation. Mathew *et al.* (2013) in a laboratory experiment for incubation study of sulphur and boron also found that the available boron status of the soil was significantly influenced by the application of different levels of sulphur and boron individually and in combination. Also, Reisenauer *et al.* (1973) reported the Boron deficiency in coarse-textured soils in humid regions. Calcium carbonate also acts as an important B adsorbing surface in calcareous soils (Goldberg and Forster, 1991). Balsamand soil having 2% calcium carbonate adsorbed more boron and release less as compare to Ambala soil in which no calcium carbonate was found. Boron adsorption was greater on soils having higher calcium carbonate content (Saha and Singh, 1998).

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