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Boron Translocation Study in Terms of its Content at Different Growth Stages in Rice

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Abstract A field study was conducted to evaluate boron concentration and its translocation in rice at different growth stages in various plant parts during *kharif* of 2012 and 2013. The recommended dose of N, P and K (80 : 40 : 30 kg ha^{-1}) was applied in combination with four levels of boron (0, 1, 1.5 and 1 kg B ha^{-1} + 2 foliar sprays of 0.2% Borax at tillering and before flowering). The highest B concentration was observed under the treatment 1 kg B ha^{-1} + 2 foliar spray of 0.2% borax at tillering and pre flowering stages in all the plant parts at all the stages. The magnitude of B concentration (mg kg^{-1}) in different plant parts was found in order of upper leaf < lower leaf < stem at pre flowering stage whereas at panicle initiation stage the highest B concentration was recorded in lower leaf in an order of lower leaf > stem > middle leaf > upper leaf > panicle. At maturity the highest B concentration was recorded in straw followed by husk and brown rice. From the observed trend, it is inferred that the translocation of B remains maximum towards the lower most part of the plant and in a decreasing manner towards the sink (panicle / grain).

Keywords Boron, Content, Grain, Rice, Stage.

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Introduction

About 2.6 billion people in the world take rice as staple food which provides dietary energy and protein. The main reason behind depletion of soil micronutrients was due to adoption of intensive cropping systems and the use of high yielding hybrids [1]. At the same time, imbalance use of macro as well as micronutrients has resulted in an imbalanced situation which is limiting the yield maximization efforts. Globally, B deficiency has been the most wide spread after Zn [2]. Boron is very helpful in reducing disease severity [3] and at reproductive stage generally the requirement of boron is high. Foliar application of B enhances the crop yield and crop quality [4]. Boron transport and transfer in plant is relatively low and thus its concentration in lower parts of the plant is found higher. The main objective of the study was to understand the effect of application of various concentrations of boron on its uptake by roots, B translocation within the plant, and B loading into grains.

Materials and Methods

The field study was conducted at Ranchi, during 2012 and 2013. Experiment was laid out in randomized complete block design. The soil texture was sandy loam with an average pH of 4.7, organic matter 0.31%, 1.08 ppm Zn and 0.31 ppm B.

During *kharif* season rice crop (var Sahbhagi)

Table 1. B content (mg kg^{-1}) in rice plant at tillering and pre flowering stages.

Level of B application	Tillering stage			Pre flowering								
	Tillers			Upper Leaf			Lower Leaf			Stem		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
T_1	2.6	2.8	2.7	2.8	2.8	2.8	3.3	3.3	3.3	3.7	3.7	3.7
T_2	2.9	3.1	3.0	2.9	2.9	2.9	3.4	3.5	3.4	4.3	4.3	4.3
T_3	3.5	3.7	3.6	3.2	3.1	3.2	4.2	4.3	4.2	4.8	5.1	4.9
T_4	3.7	3.8	3.8	3.2	3.2	3.2	4.9	4.9	4.9	5.9	6.2	6.0
CD at 5%	0.36	0.27	0.08	0.14	0.19	0.13	0.28	0.17	0.19	0.26	0.38	0.25
CV	13.4	9.7	8.22	5.42	7.43	5.20	8.60	5.05	5.65	6.82	9.32	6.40

was grown with the recommended dose of N, P and K (80 N : 40 P_2O_5 : 30 K_2O kg ha^{-1}) having four levels of B : T_1 (control), T_2 (1 kg B ha^{-1}), T_3 (1.5 kg B ha^{-1}) and T_4 (1 kg B ha^{-1} + 2 foliar sprays of 0.2% borax at tillering and before flowering) and the experiment was laid down in randomized block design having 4 treatments of B applications under 3 replications.

The samples of various plant parts like stem, leaves and panicles were collected at different successive growth stages (tillering, pre-flowering, panicle initiation and maturity stages) of rice. At the tillering stage, concentration of B was determined considering whole plant. Thereafter, at the pre flowering stage, plant was divided into lower leaf, upper leaf and stem, at panicle initiation stage, plant was divided into lower leaf, middle leaf, upper leaf, panicle and stem for translocation study whereas straw, brown rice and husk were considered for translocation study at maturity stage.

Table 2. B content (mg kg^{-1}) in rice plant at panicle initiation stage.

Level of B application	Panicle initiation								
	Upper Leaf			Middle Leaf			Lower Leaf		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
T_1	2.2	2.2	2.2	2.3	2.2	2.3	4.0	3.9	4.0
T_2	2.3	2.3	2.3	2.6	2.3	2.5	4.1	4.0	4.1
T_3	2.5	2.4	2.5	2.7	2.5	2.6	4.3	4.3	4.3
T_4	3.0	2.9	3.0	3.1	3.1	3.1	4.7	4.5	4.6
CD at 5%	0.22	0.18	0.20	0.22	0.25	0.17	0.62	0.43	0.41
CV	10.6	8.45	9.72	9.94	11.8	7.84	17.2	12.2	11.6

Table 2. Continued.

Level of B application	Panicle initiation					
	Panicle			Stem		
	2012	2013	Pooled	2012	2013	Pooled
T_1	2.1	2.1	2.1	2.7	2.8	2.7
T_2	2.2	2.2	2.2	3.0	3.1	3.1
T_3	2.2	2.3	2.2	3.0	3.1	3.1
T_4	2.3	2.3	2.3	3.6	3.7	3.6
CD at 5%	NS	NS	NS	0.28	0.33	0.23
CV	10.7	6.38	6.57	10.9	12.4	8.74

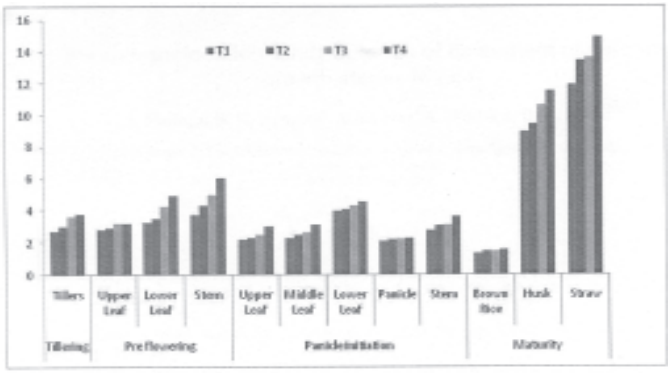

Fig. 1. Accumulation of boron in different plant parts at different crop growth stages.

Results and Discussion

B concentration, in plant, ranged from 2.71 to 3.77 mg kg^{-1} at tillering stage, from 2.84 to 6.01 mg kg^{-1} at pre flowering stage, from 2.18 to 4.56 mg kg^{-1} at panicle initiation stage and from 1.35 to 14.9 mg kg^{-1} at maturity stage.

Boron application levels under T_2, T_3 and T_4 were found to increase the B concentration of tillers at tillering stage with corresponding values of 2.71, 3.03, 3.62 and 3.77 mg kg^{-1}, all the three levels of B application being found significantly superior over the control. At pre flowering stage, B concentrations of 2.84, 2.93, 3.21 and 3.22 mg kg^{-1} in upper leaves, 3.71, 4.28, 4.95 and 6.01 mg kg^{-1} in stem and 3.28, 3.43, 4.22 and 4.91 mg kg^{-1} in lower leaves, were observed under T_1, T_2, T_3 and T_4 respectively. All the levels of B application were found significantly superior over control in lower leaf and stem. However, in upper leaf the level T_3 and T_4 were found at par with each other. Furlani [5] has also reported significant increase in B contents of different plant parts with additional doses of B application. At panicle initiation stage, B concentration of 2.18, 2.31, 2.74 and 2.99 mg kg^{-1} in upper leaves, 2.27, 2.47, 2.61 and 3.09 mg kg^{-1} in middle leaves, 3.97, 4.06, 4.31 and 4.56 mg kg^{-1} in lower leaves, 2.75, 3.07, 3.09 and 3.65 mg kg^{-1} in stem and2.11, 2.21, 2.25 and 2.28 in panicle were observed under T_1, T_2, T_3 and T_4 respectively. B concentration in plant parts were found in a decreasing way as it moved to upper parts. Boron transport in plant is relatively low and thus its concentration in lower part is higher [6]. The least amount of B concentration was found in panicle which was directly reflected at maturity. Slower B transport towards the inflorescence at the shoot apices is probably due to sink activity. Boron concentrations at maturity were recorded to be 1.35, 1.47, 1.49 and 1.57 mg kg^{-1} in brown rice 11.9, 13.4, 13.6 and 14.9 mg kg^{-1} in straw and 8.91, 9.41, 10.60 and 11.51 mg kg^{-1} in husk under T_1, T_2, T_3 and T_4 respectively.

Table 3. B content (mg kg^{-1}) in rice plant at maturity.

Level of B application	Brown rice			Husk			Straw		
	2012	2013	Pooled	2012	2013	Pooled	2012	2013	Pooled
T_1	1.4	1.3	1.3	8.9	8.8	8.9	11.9	11.9	11.9
T_2	1.5	1.5	1.5	9.5	9.3	9.4	13.4	13.5	13.4
T_3	1.5	1.5	1.5	10.6	10.5	10.6	13.4	13.8	13.6
T_4	1.6	1.6	1.6	11.5	11.4	11.5	14.8	15.0	14.9
CD at 5%	NS	0.16	0.04	0.80	0.86	0.51	1.15	1.28	1.13
CV	19.4	13.1	8.75	9.45	10.2	6.09	10.3	11.3	10.0

The accumulation of B in different plant parts at different crop growth stages has been depicted in Figure 1. The maximum amount of B was accumulated in stem which was gradually translocated to different plant parts. Among the plant parts (other than stem) the accumulation of B, in terms of its content, was in an order of lower leaf > middle leaf > upper leaf > panicle. The accumulation of B remains maximum towards the lower most part and it seems that its accumulation was gradually lowered down as it moved to upper parts of the plant. This can also be ascertained by looking at the plant B contents in different plant parts at maturity, when the translocation of other metabolites are supposed to have ceased almost. As far as the effect of different levels of B application on B translocation / accumulation pattern is concerned the preference of translocation was same in all the treatments but extent differed, higher dose levels showing higher extent of it. The treatment T4 could contribute towards highest B accumulation in different plant parts, very similar to the result obtained and reported by Khan [7].

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