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Effect of soil application of boron on growth, yield and soil properties of lowland paddy

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Abstract
Boron (B) is an essential micro nutrient and its deficiency caused a reduction in final crop harvest and yield. A field experiment was conducted during 2010-11 to 2014-15 at Zonal Agricultural Research Station, Igatpuri, Dist. Nasik (Maharashtra) to study the effect of soil application of boron on growth, yield and soil properties of lowland paddy. The experiment was laid out in randomized block design with five treatment replicated four times. The doses of borax were 0 kg, 2.5 kg, 5.0 kg, 7.5 kg and 10 kg per hectare respectively. The soils of the site were shallow laterite having pH 6.7, low in soil available N and K_2O and moderate in available P_2O_5. The soil available B (hot water soluble) was ranges between 0.292 to 0.412 ppm. The pooled data revealed that treatment T5 (Soil application of borax @10 kgha^{-1}) produced significantly higher grain (43.45 q ha^{-1}) and straw yield (51.91 q ha^{-1}), however it was at par with treatment T3 (Soil application of borax @ 5 kg ha^{-1}) and T4 (Soil application of borax @ 7.5 kg ha^{-1}). It was recommended to apply 5 kg borax ha^{-1} in boron deficient soils at the time of transplanting for higher yield and returns of paddy.

Keywords: Boron, rice, yield

Introduction
The functions of B in rice plants are to promote cell growth and development of the panicle [17]. Boron (B) is responsible for better pollination, seed setting and grain formation in different rice varieties [7, 1], making it more important during the reproductive stage as compared to the vegetative stage of the crop [14] found that 90% of the boron in plants is localized in the cell walls. B deficiency symptoms in rice begin with a whitish discoloration and twisting of new leaves [18, 11]. Severe deficiency symptoms from rice include thinner stems, shorter and fewer tillers, and failure to produce viable seeds. Boron deficient stems and leaves were found to be brittle while boron sufficient leaves and stems are flaccid. Several factors including drought, low soil pH, calcareous nature of soil, and B leaching and fixation have been considered as the possible reasons of B deficiency [12]. Declining productivity trends in rice growing countries are due to the micronutrient deficiencies [10]. Boron (B) deficiency is of particular importance since it affects the flowering and plant reproductive process and therefore directly affects harvested yield [4]. The amount of protein and soluble nitrogenous compounds are lower in B deficient plants [13]. Rice is a major staple food of Asia, and to keep pace with population growth, rice yields should be increased. Boron can be satisfactorily applied to the soil to provide season long elevation of the B status of a crop. In high rainfall areas with soils derived from igneous rocks, B deficiency occur due to heavy leaching. The present study was therefore conducted to evaluate the effect of soil applied B on the grain yield, soil properties and economic returns of paddy crop.

Material and methods
A field experiment was conducted at Zonal Agricultural Research Station, Western Ghat Zone, Igatpuri, Dist. Nasik during 2010-11 to 2014-152010-11 to 2014-15. It is situated between 15^0 -17$^{'}$ and 19^0-35$^{'}$ N latitude and 73^0-15$^{'}$ and 75^0-58$^{'}$ E longitude. It is unevenly narrow strip extending from North to South along the crest of the *Sahyadri* ranges with an altitude about 500 m. towards the eastern slopes of the ranges and up to 2000 m. Western Sea ward side. The Western Ghat Zone extends over a total geographical area of 4.51 lakhs ha. covering about 1.46 percent of the total state geographical area. The annual average rainfall of the zone ranges between 2000 mm. to 6050 mm. mostly through south west monsoon.

The no of rainy days ranges from 99 to 120 days. The maximum & minimum temperature ranges from 31.1 to39.9^0 c. & 9.8 to 12.5^0 c. respectively. The soils of the zone are mostly forest lands and "*workas*". The soils are light lateritic, laterites and redish brown in nature, major proportion of which are shallow (23 cm) to medium (23 cm to 45 cm) in depth. The soils are distinctly acidic in nature and poor in fertility (low in available nitrogen, low to medium in available phosphorus and potash content).

The soil of the experimental field was shallow laterite having pH 6.72, electrical conductivity (EC) 0.13 dS/m, low in organic carbon content (0.28 %), low in available nitrogen (174 kg/ ha), moderate in available phosphorus (17.5 kg/ha) and moderate in available potassium (178 kg/ha).

The paddy crop (*Indrayani* variety) was transplanted in *kharif* season in randomized block design with five treatments and four replications. The plant spacing was 15-25 x 15-25 cm. plot size was 4.80 m x 2.40 m.

Treatment Details

T1:- Control
T2:- Soil application of borax @ 2.5 kg ha^{-1}
T3:- Soil application of borax @ 5.0 kg ha^{-1}
T4:- Soil application of borax @ 7.5 kg ha^{-1}
T5:- Soil application of borax @ 10.0 kg ha^{-1}

(Uniform dose of 56 kg N, 30 kg P_2O_5 through Urea-DAP briquettes and 50 kg K_2O through MOP and borax was applied at the time of transplanting)

Soil samples were collected initially and after harvest of crop. Dry and processed soil samples were used to determine chemical properties using standard procedures. Soil samples were analysed for pH and EC in 1:2.5 soil suspension ratio, organic carbon by [16] Available B by hot water soluble given by [21], Available N by alkaline potassium permanganate method [20], available P as per method given by [19] and available K determined by flame photo metrically as described by Knudsen *et al*.(1982) [15].

Results and Discussion

Pooled Mean (2010-2014)

Growth and yield parameters

In pooled data the grain and straw yield of paddy influenced significantly due to different levels of soil application of borax (Table no.1). The treatment T5 (Soil application of borax @10 kg ha^{-1}) produced significantly higher grain (43.45 q ha^{-1}) and straw yield (51.91 q ha^{-1}), however it was at par with treatment T3 (Soil application of borax @ 5 kg ha^{-1}) grain (41.44 q ha^{-1}) and straw yield (49.98 q ha^{-1}), and T4 (Soil application of borax @7.5 kg ha^{-1}) grain (42.84 q ha^{-1}) and straw yield (50.89 q ha^{-1}) respectively.

Similarly, all the growth and yield parameters of paddy were found to be significant. Highest test weight (22.38 g), plant height (96.40 cm) and number of tillers per hill (15.73) were recorded in the treatment T5 (Soil application of borax @10 kg ha^{-1}), followed by the treatment T4 (Soil application of borax @ 7.5 kg ha^{-1}) and T3 (Soil application of borax @ 5 kg ha^{-1}) respectively. However the treatment T5, T4 and T3 were found at par with each other.

Table 1: Pooled data of grain and straw yield of paddy as influenced by different levels of soil application of borax 2010-2014

Tr. No.	Treatment	Grain yield (q ha^{-1})						Straw yield (q ha^{-1})					
		2010	2011	2012	2013	2014	Pooled Mean	2010	2011	2012	2013	2014	Pooled Mean
T1	Control	25.66	32.13	42.34	48.66	28.54	35.46	30.53	43.04	53.62	54.37	30.46	42.40
T2	Soil application of borax @ 2.5 kg ha^{-1}	28.83	34.92	45.16	51.20	29.40	37.90	34.34	45.04	64.39	57.97	31.80	46.71
T3	Soil application of borax @ 5.0 kg ha^{-1}	31.91	38.05	48.99	55.45	32.80	41.44	38.15	47.98	67.22	61.45	35.11	49.98
T4	Soil application of borax @ 7.5 kg ha^{-1}	33.67	39.06	50.60	56.74	34.13	42.84	39.36	48.33	67.48	63.37	35.92	50.89
T5	Soil application of borax @ 10.0 kg ha^{-1}	32.84	39.94	51.07	58.50	34.90	43.45	39.47	50.10	68.43	64.20	37.35	51.91
	SE ±	1.58	1.49	1.80	1.94	1.94	0.75	1.66	1.51	2.11	1.85	1.85	0.78
	CD at 5 %	4.87	4.59	5.55	5.97	4.45	2.11	5.11	4.65	6.51	5.70	4.42	2.19
	CV %	10.34	8.09	7.56	7.16	9.05	8.26	9.12	6.43	6.57	6.13	8.39	7.15

Table 2: Pooled mean of growth and yield attributing characters of paddy as influenced by different levels of soil application of borax 2010-2014

Tr. No.	Treatment	1000 grain wt. (g)	Plant height (cm)	No. of tillers per hill
T1	Control	20.41	87.03	10.62
T2	Soil application of borax @ 2.5 kg ha^{-1}	21.27	89.80	12.85
T3	Soil application of borax @ 5.0 kg ha^{-1}	22.06	94.70	14.68
T4	Soil application of borax @ 7.5 kg ha^{-1}	22.13	96.00	15.30
T5	Soil application of borax @ 10.0 kg ha^{-1}	22.38	96.40	15.73
	SE ±	0.19	1.66	0.83
	CD at 5 %	0.54	5.12	1.66
	CV %	3.93	3.58	7.77

Soil chemical properties

The soil properties showed non significant results; however there is significant increase in available B content in soil. Significantly highest soil available B was recorded in the treatment T5 (0.471 mg kg $^{-1}$) followed by treatment T4 (0.450 mg kg $^{-1}$) and treatment T3 (0.424 mg kg $^{-1}$) respectively over the initial status (0.292 mg kg $^{-1}$).

Uptake of the nutrients

The uptake of the N, P and K nutrients was found non significant, however significant uptake of B was noticed with increase in level of borax. The highest uptake of B was noticed in the treatment T5 (64.1 g ha^{-1}) followed by T4 (60.1 g ha^{-1}) and T3 (56.7 g ha^{-1}).

Economics

The highest B: C ratio was noticed in the treatment T5 (1.34) followed by T4 (1.32) and T3 (1.29) respectively. The treatment T5, T4 and T3 were found at par with each other.

Table 3: Pooled mean of soil properties and nutrient uptake by paddy crop after harvest 2010-2014

Sr. No	Treatments	pH	EC (dSm^{-1})	Available nutrients (kg ha $^{-1}$)				Nutrient Uptake (kg ha $^{-1}$)			
				N	P	K	B (mg kg^{-1})	N	P	K	B (g ha $^{-1}$)
1	Control	6.70	0.13	180.2	16.75	169.3	0.267	76.7	18.3	78.0	39.7
2	Soil application of borax @ 2.5 kg ha^{-1}	6.69	0.14	172.8	16.62	147.3	0.335	80.3	20.8	81.0	46.4
3	Soil application of borax @ 5.0 kg ha^{-1}	6.77	0.13	170.3	14.90	154.3	0.424	82.0	22.0	85.0	56.7
4	Soil application of borax @ 7.5 kg ha^{-1}	6.59	0.14	171.5	15.02	146.5	0.450	85.7	23.5	86.8	60.1
5	Soil application of borax @ 10.0 kg ha^{-}	6.71	0.15	169.3	14.82	150.8	0.471	86.0	24.0	90.3	64.1
	SE ±	0.14	0.005	2.97	0.66	5.83	0.012	2.8	1.4	3.2	2.35
	CD at 5 %	NS	NS	NS	NS	NS	0.037	NS	NS	NS	7.66

Table 4: Economics

Sr. No.	Treatments	Gross monetary returns (Rs.)	Cost of cultivation (Rs.)	Net Monetary returns (Rs.)	B:C ratio
1	Control	67476	48951	18525	1.38
2	Soil application of borax @ 2.5 kg ha^{-1}	71970	49313	22657	1.46
3	Soil application of borax @ 5.0 kg ha^{-1}	78584	49676	28908	1.58
4	Soil application of borax @ 7.5 kg ha^{-1}	81137	50038	31099	1.62
5	Soil application of borax @ 10.0 kg ha^{-}	82432	50401	32031	1.64

Market Rates:- Paddy grains @ Rs. 1800 / q., paddy straw @ Rs.1080 /t, borax@150/kg

Discussion

This study revealed that B application substantially improve the grain yield and straw yield and as a result, the net economic returns. Higher grain weight by B application might be due to involvement of B in reproductive growth as B improves the panicle fertility in rice [1]. [6], observed that there was a substantial increase in grain yield of rice varieties due to reduced panicle sterility after B application. Maximum grain yield against control plots might be due to the reduction in pollen sterility of rice and proper grain filling (Rashid *et al*, 2004) [6]. Maximum grain yield by soil application of B at the flowering stage might be the direct effect of higher number of grains per panicle and 1000-grain weight. Many reports indicate that B applied at the heading or flowering stage in rice resulted in increased rice grain yield and number of grains per panicle [9, 8]. Similarly, [3, 2], reported enhanced paddy yield due to reduced panicle sterility by B application appreciably. The reason for the lowest grain yield in B deprived plots might be the higher pollen infertility and lower grain filling as it plays very active role in both processes [3]. Similarly [5], also concluded that, soil application of B at the flowering stage improved the number of grains per panicle, 1000-grain weight, grain yield, harvest index, LAI, CGR, net income and RCB compared with other treatments.

Conclusion

It is concluded that soil application of borax @ 5 kg ha^{-1} produced significantly higher grain and straw yield of paddy and consequently higher monetary returns. It is recommended to apply soil application of borax @ 5 kg ha^{-1} for higher yield and returns of paddy in boron deficient soils of Western Ghat Zone of Maharashtra.

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