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BORON ON PRODUCTIVITY AND NUTRIENT STATUS OF RICE (*ORYZA SATIVA* L.) IN KOLE LANDS , KERALA, INDIA

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ABSTRACT

An experiment was conducted in farmer's field at different locations of kole lands to study the effect of micro nutrient Boron on yield and soil nutrient status of rice during 2012-2014. The treatments comprised of different levels of B viz; 2.5 kg Borax/ha, 5 kg Borax/ha, 10 kg Borax/ha, 12.5 kg Borax/ha, 15 kg Borax/ha and untreated control. Observations on growth characters, yield attributes, yield and soil and plant nutrient status were recorded. The application of 15 kg borax /ha recorded the maximum number of panicles/m^2, number of grains /panicles, thousand grain weight, grain and straw yield of rice. The results of pooled data on plant and soil nutrient status revealed that application of boron had a positive effect on uptake and availability of nutrients in soil. The study concluded that the soil application of borax @ 15 kg /ha was found to be good for correcting the deficiency in B deficient areas of Kole lands.

Keywords: Micronutrients, rice growth, productivity, kole wet lands

INTRODUCTION

Rice (*Oryza sativa* L.) is one of the most important staple food crops of India particularly in Kerala. It is grown in Kerala in an estimate area of 1.98 lakh ha with a production of 5.78 lakh tonnes with an average productivity of 2.92 t ha^{-1} (Eco. Review 2019). Among the food grains, the demand for rice continues to grow and is projected to increase by more than 50 per cent over the next few decades. Rice provides 21 % of energy and 15 % of protein requirements of human populations. The yield of rice has stagnated due to the deficiency of micronutrients primarily the soil deficient in zinc and boron.

The deficiency of boron is spreading and it is most common in rice growing soils of Kerala. Boron is associated with one or more process of calcium utilization, cell division, flowering/fruiting, disease resistance, water relations and act as catalyst for several reactions (Spraque, 1951). It is also very much essential for the metabolism of carbohydrate, transport of sugars, synthesis of nucleotide, respiration and pollen viability (Dell and Huang, 1997). Deficiency of boron affects the cell wall biosynthesis, phenol metabolism, structure and plasma membrane integrity. The factors contribute to B deficiency in rice are drought, low pH, leaching and fixation (Mengel and Kirby, 2001; Niaz *et al*., 2002 and Rashid *et al.*, 2004). Boron can influence photosynthesis and respiration and activate number of enzymatic systems of protein and nucleic acid metabolism in plants (Chowdhury *et al*., 2010). Boron is the essential micronutrient for proper growth and development of crop plants and also to improve the economic yield and quality of several crops (Pratima Sinha *et al*., 2000). The deficiency symptoms of B in rice include thinner stems, shorter and fewer tillers, and failure to produce viable seeds and brittle stems and leaves (Dunn *et al.*, 2005). Abbas *et al*., (2013) reported that fertilizers, particularly zinc and boron in addition to recommended dose of major nutrients is needed to increase yield, uptake and total content of essential nutrients in rice.

Kole wetlands are low lying tracts located 0.5 to 1m below Mean Sea Level (MSL) and remain submerged for about six months in a year. It forms one of the rice granaries of Kerala, comprising of a unique rice eco system, meeting forty per cent of the rice requirement of Kerala. The data on soil analysis of kole lands for a decade revealed that there is wide spread deficiency of secondary and micro nutrients especially boron, zinc and copper. With this background the present investigation was undertaken to study effect of different levels of boron on growth and yield enhancement in rice in kole lands.

MATERIALS AND METHODS

The experiment was conducted in kole lands of Thrissur district to study the effect of boron on yield, plant and soil nutrient status of rice crop during 2012-2014 and to determine optimum dose of boron for maximum yield in rice.

The experiment was laid out in randomized block design and replicated thrice with six treatments of different levels of Borax viz.,

Table :1 Effect of levels of Boron on growth of rice

Treatments	Height (cm) 2012-13	Height (cm) 2013-14	Pooled (cm)	No. of tillers 2012-13	No. of tillers 2012-13	Pooled
2.5kg Borax/ha	89.80	98.80	94.30	5.16	5.92	5.54
5kg Borax/ha	89.22	95.20	92.21	5.66	5.98	5.82
10kg Borax/ha	90.85	96.32	93.58	5.33	6.32	5.82
12.5 kg Borax/ha	89.98	100.25	95.11	5.33	6.54	5.93
15kg Borax/ha	94.66	102.65	98.65	5.83	6.25	6.04
Control	86.00	89.65	87.825	5.00	5.32	5.16
CD(0.05)	1.32			0.26		

Table :2 Effect of levels of Boron on yield attributes of rice

Treatments	No of panicles/m^2 2012-13	No of panicles/m^2 2013-14	Pooled	No of grains/ Panicle 2012-13	No of grains/ Panicle 2013-14	Pooled	1000grain wt (g) (2012-13)	1000grain wt (g) (2013-14)	Pooled
2.5kg Borax/ha	548.2	562.3	555.25	75.00	78.62	76.81	29.75	25.64	27.69
5kg Borax/ha	581.66	572.3	576.98	76.68	75.62	76.15	29.25	26.58	27.91
10kg Borax/ha	530.33	587.30	558.81	78.68	79.32	79.00	29.75	29.57	29.46
12.5 kg Borax/ha	684.83	592.3	638.56	94.13	85.32	89.72	29.50	28.25	29.08
15kg Borax/ha	703.33	601.36	652.34	94.75	92.36	93.55	28.83	30.25	29.54
Control	425.3	402.35	413.82	70.21	72.36	71.28	25.83	24.65	25.24
CD(0.05)	1.32	1.58	1.42	26	28	25	0.06	0.04	0.05

Table :3 Effect of levels of Boron on grain and straw yield of rice (t/ha)

Treatments	Grain yield (t/ha) 2012-13	Grain yield (t/ha) 2013-14	Pooled	Straw yield (t/ha) 2012-13	Straw yield (t/ha) 2013-14	Pooled
2.5kg Borax/ha	8.23	8.4	8.29	9.32	8.65	8.98
5kg Borax/ha	8.65	8.6	8.60	9.54	8.47	9.00
10kg Borax/ha	8.67	8.8	8.71	9.58	8.97	9.27
12.5 kg Borax/ha	8.67	9.00	8.81	9.65	9.25	9.45
15kg Borax/ha	9.95	9.80	9.85	9.98	9.58	9.78
Control	7.32	7	7.17	7.58	7.23	7.40
CD(0.05)	0.98	0.87	0.89	0.98	0.54	0.08

Table :4 Effect of levels of Boron on plant nutrient Content (Macro nutrients)

Treatments	N content (%)			P content (%)			K content (%)			Ca content (mg/kg)			Mg content (mg/kg)		
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
2.5kg Borax/ha	2.53	2.59	2.56	0.190	0.180	0.185	0.59	0.63	0.61	810	816	813	81.0	82.0	81.5
5kg Borax/ha	2.70	2.84	2.77	0.19	0.21	0.20	0.64	0.72	0.68	911	913	912	81	83	82
10kg Borax/ha	2.95	2.99	2.97	0.20	0.26	0.23	0.90	0.96	0.93	965	969	967	83	88	85
12.5 kg Borax/ha	3.30	3.42	3.36	0.215	0.235	0.250	1.00	1.06	1.03	1014	1022	1018	96.0	97.0	96.5
15kg Borax/ha	3.40	3.58	3.49	0.250	0.254	0.252	1.13	1.17	1.15	1120	1128	1124	103	101	102
Control	2.40	2.54	2.47	0.170	0.180	0.175	0.80	0.94	0.87	710	712	711	58.3	58.7	58.5
CD(0.05)	0.29	0.31	0.30	0.04	0.06	0.05	0.66	0.72	0.69	176	180	178	27	29	28

Table :5 Effect of levels of Boron on plant nutrient Content (Micro nutrients) (mg/kg)

Treatments	S content			Fe content			Mn content			Zn content			B content		
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
2.5kg Borax/ha	1060	1072	1066	1134	1140	1137	500	510	505	54.52	54.92	54.72	9.79	9.81	9.80
5kg Borax/ha	1130	1134	1132	1022	1021	1023	428	432	430	55.00	55.22	55.11	9.80	9.82	9.81
10kg Borax/ha	1520	1522	1521	1003	1007	1005	339	341	340	58.69	58.71	58.70	9.93	9.97	9.95
12.5 kg Borax/ha	1655	1675	1660	1000	1002	1001	307	313	310	59.24	59.32	59.28	10.21	10.23	10.22
15kg Borax/ha	1805	1795	1800	830	832	831	270	278	274	75.64	75.72	75.68	11.97	11.99	11.98
Control	928	932	930	1220	1222	1221	598	600	599	53.00	53.08	53.04	3.97	3.99	3.98
CD(0.05)	96	98	97	76	80	78	55	59	57	7.20	7.22	7.21	1.00	1.04	1.02

Table :6 Effect of levels of Boron on available soil nutrient status (Macro nutrients)

Treatments	Organic carbon (%)			Available P (%)			Available K (%)			Available Ca (mg/kg)			Available Mg (mg/kg)			Available S Content (mg/kg)		
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled
2.5kg Borax/ha	2.60	2.64	2.62	21.60	21.74	21.67	282.40	282.46	282.43	580	590	585	66.40	66.52	66.46	53.00	53.22	53.11
5kg Borax/ha	2.90	2.98	2.94	24.00	26.00	25.00	323.35	327.30	325.32	914	920	917	77.20	77.24	77.22	46.0	47.06	46.8
10kg Borax/ha	3.24	3.32	3.28	26.0	27.00	26.50	356.10	356.36	356.23	940	948	944	82.32	82.48	82.80	33.60	33.68	33.64
12.5 kg Borax/ha	3.69	3.73	3.71	33.70	33.80	33.75	432.74	432.82	432.78	971	975	973	87.60	87.68	87.64	31.90	32.04	31.97
15kg Borax/ha	4.26	4.30	4.28	37.71	38.01	37.91	476.92	478.94	477.93	1030	1032	1031	90.00	90.06	90.03	29.40	29.50	29.45
Control	1.40	1.50	1.45	13.42	13.66	13.54	214.50	214.62	214.56	445	449	447	25.18	25.10	25.14	19.10	19.18	19.14
CD(0.05)	0.85	0.89	0.87	1.97	1.99	1.98	48.60	48.66	48.63	78.60	78.70	78.65	14.60	14.70	14.65	7.00	7.04	7.02

Table :7 Effect of levels of Boron on available soil nutrient status (Micro nutrients) (mg/kg)

Treatments	Available Fe Content			Available Mn Content			Available Zn Content			Available Boron Content		
	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013-14	Pooled	2012-13	2013 -14	Pooled
2.5kg Borax/ha	1020	1022	1021	132.52	132.92	132.72	12.08	12.12	12.10	0.48	0.52	0.50
5kg Borax/ha	1023	1027	1025	115.00	115.12	115.06	16.10	16.24	16.17	1.15	1.17	1.16
10kg Borax/ha	1150	1158	1154	96.10	96.20	96.15	17.52	17.56	17.54	1.80	1.90	1.85
12.5 kg Borax/ha	1114	1116	1110	84.04	84.16	84.10	17.80	17.96	17.88	2.15	2.19	2.17
15kg Borax/ha	980	986	983	47.00	47.18	47.09	21.99	22.01	22.00	3.24	3.40	3.32
Control	1290	1298	1294	101.50	101.60	101.55	12.0	13.0	12.5	1.10	1.22	1.16
CD(0.05)	78.94	78.98	78.96	51.28	51.32	51.30	2.97	2.99	2.98	0.67	0.69	0.68

T_1 - 2.5 kg Borax/ha

T_2 – 5 kg Borax/ha

T_3 – 10 kg Borax/ha

T_4 – 12.5 kg Borax/ha

T_5 – 15 kg Borax/ha

T_6 – control

The experiment was conducted in farmer's field of kole lands. Initial N, P, K and micro nutrients except B were applied as per soil test-based recommendation along with all other operations as per Package of Practices (POP) of Kerala Agricultural University. Soil nutrient status was analyzed and experiment was conducted in that field which showed the deficiency of B in both the years. The experiment was repeated in the same season of next year.

RESULTS AND DISCUSSION

The data of boron nutrition had significant effect on yield and yield attributes of rice. The pooled data on yield and yield contributing factors due to boron application revealed that the plot receiving borax at the rate of 15 kg/ha (T_5) exhibited significantly higher number of tillers/hill (6.04), number of panicles/m^2 (652.34) and number of grains/panicle (93.55) (Table 1&2). The application of 15 kg borax/ha also recorded significantly higher values compared to all other treatments with respect to thousand grain weight (29.54 g) and grain yield (9.85 t/ha). The application of borax was positively influenced in number of tillers/hills, no. of grains/panicle and grain yield. Studies showed that the panicle number per square meter is the most important factor in increasing the grain yield of rice (Miller *et al*., 1991). More number of grains per panicle and higher grain weight and grain yield by boron application might be due to involvement of boron in reproductive growth as boron improves the panicle fertility in rice. The results are in conformity with the work by Rehman *et al*., (2012).

The pooled data on the plant nutrient status after the harvest of the crop furnished that the application of borax had a positive relationship with the uptake of N, P, K, Ca, Mg, S, B and Zn by plant (Table 4 & 5). The uptake of major and micro nutrients was enhanced with the application of borax @ 15 kg/ha. Application of boron was positively affected with the uptake of micro nutrients by plant, which implies the importance of boron nutrition for rice crop grown in kole lands. Grain yield also showed a positive relationship with nutrient uptake by plants at maturity. The increases in N uptake by plants due to B application may be attributed to the enhancing N mineralization in soil. The increase in nutrient uptake by plants with increase in B application which indicates that boron takes part in the mechanisms of nutrient absorption and transport of other nutrient minerals. The results are in agreement with findings of Patel and Golakia (1986).

The effect of different levels of boron on soil nutrient status inferred that the highest available nutrient content was observed with application of 15 kg borax/ha (T_5). Availability of nutrients in the soil increased with increase in boron application which may be due to the synergistic relationship of B with all other nutrients. The results are in conformity with the work by Mahendra kumar (2017). The application of B @ 15 kg/ha showed low available Fe and Mn content in soil. This may be due to the antagonistic interaction of boron with Fe and Mn. Tisdale *et al.,* (1985) reported that decreased availability of Fe and Mn in soils may be due to antagonistic interaction between boron and iron and manganese in soil.

CONCLUSION

The micro nutrient (boron) with recommended dose of N, P and K showed positive response to yield components, yield and the availability of nutrient contents of plant and soil in rice. The plant nutrient status after the harvest of the crop furnished that the application of borax had a positive relationship with the uptake of nutrients by plant. The content of major and micro nutrients was maximum with the application of borax @ 15 kg/ha, resulting in higher number of tillers per hill, number of panicles per meter square, number of grains per panicle and grain yield. The study revealed that in boron deficient areas of kole lands, application of 15 Kg borax/ha was found to be optimum for correcting the deficiency in rice.

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