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Effect of different levels of borax application on growth and yield of rice (*Oryza sativa* L) at Bhadra command, Karnataka

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Abstract
A field experiment was conducted on boron deficient soil of Bhadra command area, Karnataka to evaluate the effect of borax levels on growth and yield of rice and the experiment was laid out in a randomized complete block design with seven treatments and replicated thrice. Application of recommended FYM+NPK+8 kg Borax per ha recorded significantly higher plant height (76.90 cm), number of leaves (89.43 plant^{-1}), number of tillers (17.70 plant^{-1}), dry matter accumulation (55.78 g hill^{-1}), grain yield (5135.64 kg ha^{-1}) and straw yield (5845.39 kg ha^{-1}). Lowest plant height (65.00 cm), number of leaves (76.50 plant^{-1}), number of tillers (15.73 plant^{-1}), dry matter accumulation (47.42 g hill^{-1}), grain yield (3904.26 kg ha^{-1}) and straw yield (4733.48 kg ha^{-1}) was recorded treatment that received recommended FYM+NPK+20 kg Borax per ha.

Keywords: borax, rice, yield

Introduction
Bhadra command in Karnataka is the area commanded by Bhadra Reservoir covering an area of 1.21 lakh hectares that comprises a part of Shivamogga, Davanagere and also a part of Chikkamagalure districts. Major crops that are being cultivated in the Bhadra command are paddy (*Oryza sativa* L.), Sugarcane (*Saccharum Officinarum* L.) and areca nut (*Areca catechu* L.) and major areas coming under paddy cultivation.

Rice (*Oryza sativa* L.), is the most important staple food for more than half of the planet's population. Rice provides 30 to 75 per cent of the total calories to more than 3 billion Asians (Khush, 2004) [9]. Worldwide, rice is grown in an area of 258.8 m ha with an average productivity of 4660 kg per ha, out of which 90 per cent of world's rice is produced in Asian region including China, India, Bangladesh, Indonesia and Japan (Anon., 2016) [3]. India being the second largest producer of the world (106.57 m t), covers an area of 43.97 m ha with the productivity of 2424 kg per ha (Anon., 2016a) [4]. In Karnataka, rice occupies 1.33 m ha producing 3.52 m t with the productivity of 2649 kg per ha (Anon., 2016b) [5]. The crop is again one of the important staple food of the Southern Transitional Zone and grown both under irrigated and rainfed situations to the tune of three lakh hectares with the productivity of 2990 kg per ha.

Rice is an exhaustive nutrient crop and nutrient removal from the soil is much higher than fertilizer input. As a result, wide spread micronutrient deficiencies occurred in rice. Soils under rice cultivation are generally alkaline and calcareous in nature and deficient in micronutrient especially zinc and boron (Rashid and Ryan, 2004) [14]. Boron (B) an important mineral nutrient stimulate a number of physiological processes in vascular plants, it is important for carbohydrates metabolism, translocation, development of cell wall and RNA metabolism (Herrera-Rodriguez *et al.*, 2010; Siddiky *et al.*, 2007) [7, 17]. Deficiency of B causes a reduction in leaf photosynthetic rate, total dry matter production, plant height and a number of productive tillers during vegetative and grain filling stage (Zhao and Oosterhuis, 2003) [18].

Farmers in Bhadra command are cultivating the paddy with intensive agricultural practices with imbalanced fertilizers application particularly micronutrients (zinc and boron) without soil test results and as such no information is available with respect nutrition and micronutrient status in soils of Bhadra command in Karnataka.

Keeping in view the important role of boron in increasing grain yield of rice present study was conducted to investigate the effects of the direct effect of boron application on rice.

Materials and Methods

The field experiment was conducted at Agricultural and Horticultural Research Station, Kathalagere, Davanagere district coming under Bhadra command area of Karnataka during *Kharif* season 2016-17, to investigate the "Effect of different levels of borax application on growth and yield of rice (*Oryza sativa* L) at Bhadra command, Karnataka". The experiment was conducted under protective irrigation to maintain soil under saturation condition. The initial soils have sandy clay loam in texture with pH of 7.04, electrical conductivity (0.53 dSm^{-1}), organic carbon content (8.56 g kg^{-1}), available nitrogen, phosphorus, potassium (257.81, 28.62 and 219.81 kg ha^{-1} respectively), available sulphur (21.25 mg kg^{-1}), exchangeable calcium and magnesium (2.78 and 1.63 cmol [p^+] kg^{-1} respectively) and hot water extractable boron (0.41 mg kg^{-1}) were observed. The experiment consists of seven treatments with replicated three times and was laid out in a Randomized complete block design with different levels of boron. The treatments include *viz.* T_1: Control, T_2: 2 kg Borax ha^{-1}, T_3: 4 kg Borax ha^{-1}, T_4: 8 kg Borax ha^{-1}, T_5: 12 kg Borax ha^{-1}, T_6: 16 kg Borax ha^{-1}, T_7: 20 kg Borax ha^{-1} and Recommended dose of N: P: K and 10 tons FYM was common for all the treatments including control. Plant height was recorded at 30, 60, 90 DAT from the base of the plant up to the last sheath of the main shoot and expressed in centimeter. A total number of fully opened leaves from five tagged plants were counted and mean per plant was computed. Five plants were uprooted at randomly from the adjacent to net plot area excluding two border rows each plot and were dried in hot air oven at 65^{O}C for 72 hours until the constant weight. Then dry matter per plant was calculated. The crop was harvested, threshed and dried in the sun. The grains were cleaned and weight was recorded and straw after threshing was dried in the sun, weighed and expressed in kg per hectare.

Results and Discussion

Highest plant height was recorded in treatment that received borax @ 8 kg ha^{-1} at 30, 60and 90 DAT (30.53, 57.03 and 76.90 cm, respectively) and on par with treatment which received borax @ 4 kg ha^{-1}(29.67, 57.43and 73.47 cm, respectively) followed by the treatment receiving borax @2 kg ha^{-1}over control (Table 1). Lowest plant height was recorded in T_7 treatment which received borax @ 20 kg ha^{-1} (27.07, 50.77and 65.00 cm, respectively). The maximum number of leaves per plant was recorded in treatment received borax @ 8 kg ha^{-1}at all crop growth stages (36.90, 81.43 and 89.43 at 30, 60 and 90 DAT respectively) and on par with treatment received borax @ 4 kg ha^{-1}at 30, 60 and 90 DAT (35.63, 78.27and 84.90, respectively). A minimum number of leaves per plant (Table 1) was recorded in T_7 treatment which received borax @ 20 kg ha^{-1}at 30, 60, 90 and at harvest (30.13, 71.23and 76.50, respectively). A maximum number of tillers per plant were recorded in the treatment that received borax @ 8 kg ha^{-1} at all crop growth stages (10.80, 14.60 and 17.70 at 30, 60 and 90 DAT, respectively) and on par with treatment which received borax @ 4kg ha^{-1}(10.30, 14.27 and 17.20, respectively). A minimum number of tillers per plant (Table 2) was recorded in the T_7 treatment which received borax @ 8 kg ha^{-1} at 30, 60, and 90 DAT (8.87, 12.40and 15.73, respectively). Significantly higher total dry matter per plant was recorded in treatment that received borax @ 8 kg ha^{-1}at all crop growth stages (4.56, 13.55 and 55.78 g per hill at 30, 60 and 90 DAT, respectively) and on par with treatment received borax @ 4 kg ha^{-1}(4.16, 12.29 and 54.68 g per hill, respectively). However, significantly lower amount of dry matter per plant (Table 2) was recorded in T_7 treatment which received borax @ 20 kg ha^{-1} (3.16, 9.86 and 47.42 g per hill, respectively). An increase in plant height, number of leaves, number of tillers and dry matter accumulation was recorded due to the efficient photosynthetic system, use of NPK and borax along with organic matter (FYM) application might have helped in inducing better vegetative growth. Addition of FYM might have regulated the supply of the added nutrients in tune with the crop requirements in addition to encouraging soil micro-biota to induce some hormonal influence on stem and leaf elongation hence plant growth enhanced (Chandan Kumar *et al.*, 2013) [6]. An increase in growth components could be ascribed due to the effect of boron for proper development and differentiation of tissues, particularly growing tips, phloem and xylem. These results are in conformity with the findings of Mehmood *et al.* (2009) [10] and Ahmad *et al*. (2009) [2]. Similarly, Ahmad and Irshad, (2011) [1] reported that a positive effect on growth components may be attributed to proper development and differentiation of tissue as boron affects the deposition of cell wall material by altering membrane properties. The results of the present investigation also confirmed the findings of Rahamthullah *et al.* (2006) [13] and Muhammad *et al.* (2011) [11].

The treatment which received borax @ 8 kg ha^{-1} had resulted in higher grain yield (5135.64 kg ha^{-1}) and straw yield (5845.39 kg ha^{-1}) with higher harvest index of 0.47 (Table 3 and Fig. 1) and was found on par with treatment receiving borax @ 4 kg $ha^{-1}$and significantly lower grain yield (3904.26 kg ha^{-1}) and straw yield (4733.48 kg ha^{-1}) with a harvest index (0.45) was noticed in treatment which received borax @ 20 kg ha^{-1}. The applied nutrients by their effect on the metabolism of the cell, promoted the meristematic activity of the crop and its better uptake by plants for favorable metabolic processes such as nucleic acid, carbohydrate, protein, auxins and pollen development. Efficient metabolism and translocation of carbohydrate from the source to sink might have increased the grain yield. Khan *et al.* (2006) [8], observed in field experiments that paddy yield was significantly increased by the B application, which ranged from 3.51 to 6.00 t per ha while maximum yield was observed with application of 2 kg B per ha in rice and wheat. Rashid *et al.* (2007) [15] reported that 14 to 23 per cent increase in paddy yield was achieved with the B application. Muhammad *et al.* (2011) [11] also reported the application of borax improved all plant growth parameters, B concentration in plant and rice yield. These results are in accordance with the findings of Murthy (2006) [12] and Shinde *et al*. (1990) [16].

Table 1: Influence of different levels of borax on plant height and number of leaves of paddy of Bhadra command, Karnataka

Treatments	Plant height (cm)			Number of leaves per plant		
	30 Dat	60 Dat	90 Dat	30 Dat	60 Dat	90 Dat
T_1: Control	28.73	56.13	72.37	34.43	77.33	84.23
T_2: 2.0 kg Borax ha^{-1}	29.33	56.77	72.53	34.53	77.73	83.77
T_3: 4.0 kg Borax ha^{-1}	29.67	57.43	73.47	35.63	78.27	84.90

T_4: 8.0 kg Borax ha^{-1}	30.53	57.03	76.90	36.90	81.43	89.43
T_5: 12.0 kg Borax ha^{-1}	28.10	56.03	71.50	33.27	74.93	83.07
T_6: 16.0 kg Borax ha^{-1}	27.87	54.27	69.23	31.87	73.50	80.23
T_7: 20.0 kg Borax ha^{-1}	27.07	50.77	65.00	30.13	71.23	76.50
S.Em. ±	0.68	1.58	1.89	1.28	1.48	1.48
C.D. at 5%	NS	NS	5.83	3.95	4.56	4.55

NS: Non significant, **DAT:** Days after transplanting

Table 2: Influence of different levels of borax on number of tillers and dry matter accumulation of paddy of Bhadra command, Karnataka

Treatments	Number of tillers per plant			Dry matter accumulation (g hill^{1})		
	30 Dat	60 Dat	90 Dat	30 Dat	60 Dat	90 Dat
T_1: Control	10.00	13.87	16.83	3.97	12.25	53.52
T_2: 2.0 kg Borax ha^{-1}	10.13	14.13	17.03	4.07	12.28	53.85
T_3: 4.0 kg Borax ha^{-1}	10.30	14.27	17.20	4.16	12.29	54.68
T_4: 8.0 kg Borax ha^{-1}	10.80	14.60	17.70	4.56	13.55	55.78
T_5: 12.0 kg Borax ha^{-1}	9.47	13.63	16.50	3.92	11.61	49.38
T_6: 16.0 kg Borax ha^{-1}	9.17	13.23	16.13	3.64	10.68	49.31
T_7: 20.0 kg Borax ha^{-1}	8.87	12.40	15.73	3.16	9.86	47.42
S.Em. ±	0.35	0.24	0.35	0.15	0.33	1.19
C.D. at 5%	1.08	0.73	1.09	0.45	1.00	3.67

DAT: Days after transplanting,

Table 3: Influence of different levels of borax on grain, straw and harvest index of paddy of Bhadra command, Karnataka

Treatments	Grain yield	Straw yield	Harvest index
	kg ha^{-1}		
T_1: Control	4855.47	5633.33	0.46
T_2: 2.0 kg Borax ha^{-1}	4892.33	5689.63	0.46
T_3: 4.0 kg Borax ha^{-1}	4997.86	5782.18	0.46
T_4: 8.0 kg Borax ha^{-1}	5135.64	5845.39	0.47
T_5: 12.0 kg Borax ha^{-1}	4490.56	5499.67	0.45
T_6: 16.0 kg Borax ha^{-1}	4211.39	5185.16	0.45
T_7: 20.0 kg Borax ha^{-1}	3904.26	4733.48	0.45
S.Em. ±	251.05	256.63	0.007
C.D. at 5%	773.57	NS	NS

NS: Non significant

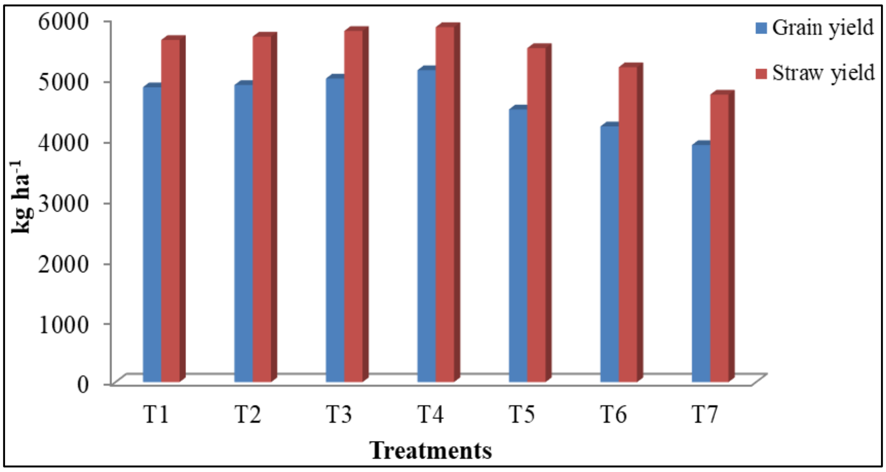

Fig 1: Different levels of borax application on grain and straw yield of paddy at Bhadra command, Karnataka
T_1: Control, T_2: 2.0 kg Borax ha^{-1}, T_3: 4.0 kg Borax ha^{-1}, T_4: 8.0 kg Borax ha^{-1}, T_5: 12.0 kg Borax ha^{-1}, T_6: 16.0 kg Borax ha^{-1}, T_7: 20.0 kg Borax ha^{-1}

Conclusion

The application of borax to the soil increased the yield and yield attributes of paddy over control, which showed a positive response of rice to borax (boron) application. However, soil application of 8 kg borax ha^{-1} + a Recommended dose of NPK recorded significantly higher growth and yield of paddy compare to a higher dose of borax in Bhadra command area of Karnataka.

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