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Research Article

EFFECT OF BORON ON GROWTH, YIELD AND ECONOMICS OF RICE UNDER EASTERN GHAT HIGH LAND ZONE OF ODISHA

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Abstract- Present investigation was conducted to assess the effect of boron on growth, yield and economics of rice (*cv.* Mandakini) on Alfisol under Eastern Ghat High Land Zone of the Odhisa during *kharif* -2015 at Regional Research and Technology Transfer Sub-Station (OUAT) Umerkote, Nabarangpur district of Odisha. The experiment was laid out in Randomized Block Design with 8 treatments and 3 replications. The details treatments were T_1= Soil Test Based NPK (75:38:30 kg ha^{-1}) + 0 kg B ha^{-1}; T_2= Soil Test Based NPK + 0.5 kg B ha^{-1}; T_3= Soil Test Based NPK + 1 kg B ha^{-1}; T_4= Soil Test Based NPK + 1.5 kg B ha^{-1}; T_5= Soil Test Based NPK + 0.2 % borax foliar spray at 21 DAT and 45 DAT; T_6= Soil Test Based NPK + 0.3 % borax foliar spray at DAT and 45 DAT; T_7= Soil Test Based NPK + 0.5 kg B ha^{-1} + 0.2 % borax foliar spray at 45 DAT; T_8= Soil Test Based NPK + 0.5 kg B ha^{-1} + 0.3 % borax foliar spray at 45 DAT. The results revealed that growth parameters like plant height (88.17 cm) & number of tillers per m^2 (304) and yield attributes like panicle length (21.98 cm), number of grains per panicle (101.92), 1000 grain weight (28.16 g), straw yield (6.66 t ha^{-1}), grain yield (4.30 t ha^{-1}) and B:C ratio (1.89) were recorded maximum in treatment T_7 followed by T_4 over T_1 (control). It can be concluded that application of Soil Test Based NPK (75:38:30 kg ha^{-1}) + 0.5 kg B ha^{-1} as basal + 0.2 % borax as foliar spray at 45 DAT has better impact as compared to other treatments on the yield and economics of rice.

Key words- Rice, Boron, Growth, Yield, Economics.

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Introduction

Rice (*Oryza sativa* L.) is one of the most important food crop and a primary food source for more than one third of world's population [1]. India has the largest area under rice cultivation (44.3 million ha) accounting for 29.4 per cent of the global rice area. The productivity level in India is low (2.04 t ha^{-1}) as compared to Japan (6.25 t ha^{-1}), China (6.24 t ha^{-1}) and Indonesia (4.25 t ha^{-1}) [2]. Rice covers about 69% of the cultivated area and is the major crop covering about 63% of the total area under food grains. It is the staple food of almost the entire population of Odisha and its economy is linked with production and productivity of rice (Das, 2012) [3]. Rice is the principal food grain of the state and occupies about 0.40 m ha during *kharif* and 0.03 m ha during *rabi* season in irrigated command areas covering Alfisols and Inceptisols [4]. The state of Odisha covering geographical area of 15.57 m ha lies in the tropical belt in the eastern regions of India between 17^0.47' to 22^0 33' N latitude and 81^0 31' to 87^{0}30' E longitudes. The climate is characterized by high temperature and medium rainfall. The average annual rainfall of the state is 1500 mm and the mean annual temperature is 26.2^{0}C. The soils are deficient in nitrogen, phosphorus and micronutrients like boron and molybdenum are highly deficient in these soils [5]. About 44 percent of soils of Odisha are deficient in B [4]. Micronutrient deficiency is one of the major causes of the declining crop productivity trends because of the escalated nutrient demand from the more intensive and exploitative agriculture [6]. Declining productivity trends in rice growing countries are due to the micronutrient deficiencies [7]. Boron deficiencies occur over a much wider range of soils and crops in comparison to any other micronutrient deficiency. Boron deficiency has been reported in 80 countries and for 132 crops around the world. Soil orders with prevalent B deficiency are ultisols, lithic entisols, alfisols, psamments, oxisols, spodosols and andepts [8]. Boron (B) deficiency is of particular importance since it affects the flowering and plant reproductive process and therefore directly affects harvested yield [9]. Boron (B) is responsible for better pollination, seed setting and grain formation in different rice varieties [10,11], making it more important during reproductive stage as compared to the vegetative stage of the crop. The deficiency symptoms of B in rice include thinner stems, shorter and fewer tillers and failure to produce viable seeds. Boron deficient stems and leaves are brittle whereas B sufficient stems and leaves are flaccid [12]. Boron carries out certain important functions in plants like it helps in cell wall formation, stabilization and lignifications; encourage pollen tube growth and pollen germination in grain crops like cereals and oilseeds. The functions of B in rice plants are to promote cell growth and development of the panicle [13]. Boron deficiency symptoms in rice begin with a whitish discoloration and twisting of new leaves [14]. With this information, the present investigation has been undertaken to determine the effect of boron on growth and yield of rice (*cv. Mandakini*) on *Alfisol* under Eastern Ghat High Land zone (EGHZ) of the Odisha.

Materials and Method

Characterization of experimental site: The field experiment was conducted during *Kharif*-2015 at Regional Research and Technology Transfer Sub-Station, Umerkote under Nabarangpur district of Odisha, India. The field is situated at19°39'12.35''N latitude, 82°11'54.06''E longitude, experiencing warm and humid climate with mean annual rainfall of 1204 mm, minimum and maximum temperature of 12 ºC and 40 ºC, respectively. The soil was *Typic Haplustalfs* with loamy sand texture, strongly acidic in reaction. The experimental soils were non-saline (EC 0.278 dSm^{-1}), loamy sand in texture, acidic in reaction (pH 5.3), medium in organic carbon (6.0 g kg^{-1}), low in available N (161 kg ha^{-1}), available P (10 kg ha^{-1}), medium in available K (121 kg ha^{-1}) and low in available B (0.40 mg kg^{-1}) respectively.

Experimental details

The experiment was laid out in Randomized Block Design with eight treatments being replicated thrice taking rice (*cv. Mandakini*) as the test crop. The details of eight treatments were as follows:T_1= Soil Test Based NPK+ 0 kg B ha^{-1}; T_2= Soil Test Based NPK + 0.5 kg B ha^{-1}; T_3= Soil Test Based NPK + 1 kg B ha^{-1}; T_4= Soil Test Based NPK + 1.5 kg B ha^{-1}; T_5= Soil Test Based NPK + 0.2 % borax as foliar spray at 21 DAT and 45 DAT; T_6= Soil Test Based NPK + 0.3 % borax as foliar spray at DAT and 45 DAT; T_7= Soil Test Based NPK + 0.5 kg B ha^{-1}+ 0.2 % borax as foliar spray at 45 DAT; T_8= Soil Test Based NPK + 0.5 kg B ha^{-1} + 0.3 % borax as foliar spray at 45 DAT. The recommended dose of soil test based NPK @ 75:38:30 kg ha^{-1} were applied in the experimental plots. The entire amount of P and 25% of N& K were applied at final land preparation and 50% of N & K at tillering (3 weeks after transplanting) and rest 25% of N & K at panicle initiation (PI) stage. Borax fertilizer was applied as basal soil application during transplanting mixed with FYM @ 5 t ha^{-1} in each respective treatment except control and foliar spray of B as borax was applied at 21 and 45 days after transplanting. The rice was planted during last week of July. All the other cultural practices were followed uniformly throughout the growing period of crop.

Analytical methodologies

Before initiating the experiment, a composite soil sample was analyzed for physico-chemical properties. The method involved in analyses of initial soil samples is depicted [Table-1].

Table-1 *Analytical methodologies for different soil parameters.*

Parameter	Methodology	Citation	Equipment used
Soil analyses			
Sand-Silt-Clay	Hydrometer method	Bouyoucos (1962) [16]	Hydrometer
pH	(in 1:2.5:: Soil : Water)	Jackson (1967) [17]	m-processor based pH-EC-Ion meter
EC	(in 1:2.5:: Soil : Water)	Jackson (1967) [17]	
Organic carbon	Wet oxidation method	Jackson (1973) [18]	
Available N	Hot alkaline $KMnO_4$ Method	Subbiah and Asija (1956) [19]	Kjeldahl apparatus
Available P	Bray's No. 1 extractant	Bray and Kurtz [20]	Spectrophotometer
Available K	Neutral N NH_4OAc extraction	Brown and Warncke (1988) [21]	Flame photometer
Available B	Hot water extraction	Berger and Truog (1939) [22]	Spectrophotometer

Statistical interpretation

The data were analyzed statistically by the analysis of variance technique using SPSS (version 18.0, Chicago, USA). The Duncan's multiple range test (DMRT) was applied to determine the least significant difference (LSD) at $P < 0.05$unless otherwise mentioned [15].

Results and Discussion

Growth, yield attributes and yield: Effect of different doses of boron on growth, yield attributes and yield of rice was significant [Table-2]. Boron application either as soil @ 1.5 kg B ha^{-1} and (or) as soil @ 0.5 kg B ha^{-1} + 0.2 % B (borax) foliar spray at 45 DAT were statistically at par with respect to the plant height, number of tiller per m^2, panicle length, number of grain per panicle, 1000 grain weight, straw yield and grain yield. With application of different doses of boron an increase in grain yield were recorded by 62.04% and 64.75% over control (T_1) at boron@ 1.5 kg ha^{-1} (T_4) and boron @ 0.5 kg ha^{-1}soil application as basal + 0.2% borax foliar spray at 45 DAT(T_7), respectively. Increase in paddy yield has been observed in all the treatments where B was applied as compared to control. Yield data of paddy presented [Table-2] revealed that maximum yield of 4.30 t ha^{-1} was obtained where B was applied before transplanting indicating 64.75 % increase over control.

Table-2 *Effect of application of boron on growth parameters and yield attributes of rice (var. Mandakini)*

B application	Plant height (cm)	No. of tillers/ m^2	Panicle length (cm)	No. of grains $panicle^{-1}$	1000 grain weight (g)	Straw yield (t ha^{-1})	Grain yield (t ha^{-1})
T_1	81.33^{a}	210^{a}	18.25^{a}	75.08^{a}	25.46^{a}	4.32^{a}	2.61^{a}
T_2	83.55^{ab}	225^{a}	19.40^{abc}	87.08^{b}	26.47^{ab}	5.35^{a}	3.57^{b}
T_3	85.22^{abc}	237^{a}	20.76^{cde}	94.50^{d}	26.89^{abc}	5.72^{b}	3.89^{c}
T_4	87.52^{b}	298^{b}	21.54^{de}	101.33^{f}	28.03^{bc}	6.54^{b}	4.23_{d}
T_5	85.86^{bc}	242^{a}	19.07^{ab}	99.67^{e}	27.10^{bc}	5.65^{b}	3.97^{cd}
T_6	86.55^{bc}	234^{a}	20.20^{bcd}	92.50^{c}	27.27^{bc}	5.94^{b}	4.11^{cd}
T_7	88.17^{c}	304^{b}	21.98^{e}	101.92^{f}	28.16^{c}	6.66^{b}	4.30^{d}
T_8	84.55^{abc}	227^{a}	20.46^{bcde}	98.67^{e}	27.89^{bc}	6.17^{b}	4.17^{cd}
LSD (0.05)	**3.623**	**30.310**	**1.449**	**1.655**	**1.504**	**1.215**	**0.306**

Means followed by a different letter are significantly different (otherwise statistically at par) at P < 0.05 by Duncan's multiple range tests.T_1= Soil Test Based NPK+ 0 kg B ha^{-1}; T_2= Soil Test Based NPK + 0.5 kg B ha^{-1}; T_3= Soil Test Based NPK + 1 kg B ha^{-1}; T_4= Soil Test Based NPK + 1.5 kg B ha^{-1}; T_5= Soil Test Based NPK + 0.2 % B as foliar spray at 21 DAT and 45 DAT; T_6= Soil Test Based NPK + 0.3 % B as foliar spray at DAT and 45 DAT; T_7= Soil Test Based NPK + 0.5 kg B ha^{-1}+ 0.2 % B as foliar spray at 45 DAT; T_8= Soil Test Based NPK + 0.5 kg B ha^{-1} + 0.3 % B as foliar spray at 45 DAT.

Economics of rice cultivation

Result revealed that the production cost of high yielding rice [Table-3] varied between Rs.31329 ha^{-1} to Rs.38974 ha^{-1}. Highest income (Rs.68800) and profit (Rs.32471) per ha was obtained in the T_7 (Soil Test Based NPK+ 0.5 kg B ha^{-1} + 0.2 % borax as foliar spray at 45 DAT). The return per rupee invested varied from 1.33 to 1.89 and highest return was in the soil test based NPK + 0.5 kg B ha^{-1}+ 0.2 % B (borax) foliar sprays at 45 DAT. There was no extra economic advantage of boron application of 0.3% B (borax) as foliar spray at 21 DAT and 45 DAT.

Table-3 *Economics of rice cultivation under boron fertilization.*

Treatments	Production cost, INR ha^{-1}	Income, INR ha^{-1}	Benefit, INR ha^{-1}	Income per INR investment
Soil Test Based NPK+ 0 kg B ha^{-1}	31329	41760	10431	1 : 1.33
Soil Test Based NPK + 0.5 kg B ha^{-1}	34329	57120	22791	1 : 1.66
Soil Test Based NPK + 1 kg B ha^{-1}	35329	62240	26911	1 : 1.76
Soil Test Based NPK + 1.5 kg B ha^{-1}	36129	67680	31551	1 : 1.87
Soil Test Based NPK + 0.2 % B (Borax) foliar spray at 21 DAT and 45 DAT	37329	63520	26191	1 : 1.70
Soil Test Based NPK + 0.3 % B (Borax) foliar spray at 21 DAT and 45 DAT	38974	65760	26786	1 : 1.69
Soil Test Based NPK + 0.5 kg B ha^{-1}+ 0.2 % B (Borax) foliar spray at 45 DAT	36329	68800	32471	1 : 1.89
Soil Test Based NPK + 0.5 B kg B ha^{-1}+ 0.3 % B (Borax) foliar spray at 45 DAT.	37152	66720	29568	1 : 1.80

Costs/prices used are: Cost of seed: INR 2506 q^{-1}, N: INR 6.6 kg^{-1}, P_2O_5: INR 24.9 kg^{-1}, K_2O: INR 17.2 kg^{-1}, Borax: INR 200 kg^{-1}, Labour wages: INR 200 M. U^{-1} Selling price: INR 16 kg^{-1}

Conclusion

It can be concluded that soil test based NPK @ 75:38:30 kg ha^{-1} + boron as soil application @ 0.5 kg B ha^{-1} as basal along with foliar application @ 0.2% borax at 45 DAT recorded highest grain yield (4.30 t ha^{-1}) and benefit (Rs.32471) among all the treatments.

Application of research: The study showed that the application of boron in rice is profitable and it improves rice productivity.

Research Category: Crop production and soil fertility.

Abbreviations: B- Boron; DAT- Days after transplanting; NPK- Nitrogen, phosphorus and potassium; INR- Indian rupee; SPSS – Statistical package for the social sciences ; DMRT- Duncan's multiple range test.

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