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RESEARCH NOTE :

Effect of boron application through soil and foliar methods on the yield attributes and nutrient uptake of wet land rice

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SUMMARY : A field experiment was conducted to evaluate the effect of boron (B) application through soil and foliar methods on the yield attributes and nutrient uptake of wet land rice, at Cropping Systems Research Centre, Karamana, during *Rabi* season (September to January), 2016. Both soil application (T_1- 0.25 kg ha^{-1}, T_2- 0.5 kg ha^{-1}, T_3- 0.75 kg ha^{-1}and T_4-1.0 kg ha^{-1}) and foliar application (T_5- 250 mg lit^{-1}, T_6-500 mg L^{-1}, T_7- 750 mg L^{-1} and T_8- 1000 mg L^{-1}) of B were given at active tillering and flowering stages in equal splits along with a no B control. Boron application through both methods substantially improved the yield and yield attributes of rice as well as the nutrient uptake as compared to control treatment receiving only NPK fertilizers. However, soil application was better in improving the thousand grain weight, grain yield and harvest index as compared to foliar treatments and control. Foliar application improved the weight per panicle, straw yield and uptake of N, P, K and B. Soil application of B at levels 0.75 kg ha^{-1} or above was better than all the foliar levels in producing higher grain yields with significant increase at 1.0 kg ha^{-1} B. No significant difference was obtained in straw yields between any of the foliar treatments and the soil treatments from 0.5 to 1.0 kg ha^{-1} B. Application of B @ 1.0 kg ha^{-1} to the soil gave the highest B:C ratio (1.52) which was on par with 0.75 kg ha^{-1} B (1.48) and with foliar application of 250 mg L^{-1} B (1.45). A further increase in B:C ratio was not noticed at higher foliar application levels which had an inhibitory effect on yield, yield attributes and nutrient uptake of rice. Hence, B may be applied as soil application @ 0.75 kg ha^{-1} in two equal splits to get better yields and higher benefit cost ratio.

KEY WORDS :
Boron, Soil application, Foliar application, Rice, Yield

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Rice is one of the most important food crops of the world and is one of the staple foods of the people of India. The population of India is estimated to reach around 1.4 and 1.6 billion by 2025 and 2050, with the respective requirement of 380 and 450 mt of food grains annually (Yadav *et al*., 2010). At present, rice productivity is declining due to imbalanced fertilizer use combined with inefficient management of other inputs. With no scope for increase in net cultivated area, much of the increase in rice production has to be attained through productivity enhancement. Farmers are normally following the NPK

based fertilizer management practice ignoring the application of other essential nutrients. Micronutrient deficiency especially that of B is one of the major causes of declining crop productivity through inhibition of pollen tube elongation, stunted growth and failure of rice plant to produce panicles and to set seeds (Dobermann and Fairhurst, 2000). Soil application of B, in some cases, becomes ineffective due to leaching losses and B fixation. Under such situations, foliar application becomes an alternative to satisfy the requirements. So the rate and method of boron application to plants is to be validated. Hence a study was conducted to determine the effect of various levels and methods of B nutrition on the growth and yield parameters of wet land rice.

The experiment was conducted at Cropping Systems Research Centre, Karamana, under Kerala Agricultural University. The soil of the experiment site was deep riverine alluvium, belonging to acidic Typic tropofluent, medium in available N (376 kg ha^{-1}), P (48 kg ha^{-1}) and K (179 kg ha^{-1}), and marginal in available B contents (0.5 mg kg^{-1}). Rice (*Oryza sativa* L.) variety Uma, (medium duration) was raised under wetland conditions during *Rabi* season (September to January). The treatments consisted of four levels of B (T_1 to T_4) as soil application (0.25, 0.5, 0.75 and 1.0 kg $ha^{-1,}$ respectively) and four levels of B (T_5 to T_8) as foliar spray (250, 500, 750 and 1000 mg L^{-1}, respectively), along with a control (only NPK), arranged in a Randomized Block Design with three replications. Fertilizer application was given as per the recommendations of package of practices of KAU (KAU, 2011), *viz*: 90:45:45 kg NPK per ha. Boron treatments were given in two equal splits at active tillering and flowering stages. The NPK fertilizer requirements were supplied through urea (46 % N), rajphos (20 % P_2O_5) and muriate of potash (60 % K_2O), respectively and B through borax (11.3 % B). Lime was applied at the rate of 350 kg ha^{-1}.

Panicles from five hills from each plot were collected separately and their lengths and weights were recorded. Thousand grain weight was also estimated. The grain and straw yields recorded per plot were expressed in kg ha^{-1}. Grain and straw samples were collected after harvesting and oven dried at 70°C were analysed using standard procedures for N (Modified kjeldahl method), P (Vanado molybdate yellow colour method), K (Flame photometry) and B (Azomethine-H colorimetric method) contents and the respective nutrient uptakes were determined. The data obtained were statistically analyzed using analysis of variance (ANOVA) technique given by Steel and Torrie (1980).

Panicle length and number of grains per panicle were not markedly affected by B application (Table 1). The weight per panicle was significantly increased at the highest soil application level of 1 kg B ha^{-1} and at the lowest foliar application level of 250 mg L^{-1}. Though all the soil treatments increased the thousand grain weight significantly, none of the foliar treatments could brought a significant increase in the parameter. As a result of B nutrition, the yield attributes such as weight per panicle and thousand grain weight showed an improved response probably due to the role of B in better pollination, seed setting, lowering spikelet sterility and increasing grain number (Aslam *et al.*, 2002).

A significant increase in straw yield was noticed at the highest level of soil treatment and for all the levels of foliar treatments except T_8 (Table 2). Though the foliar treatments were found significant, it showed a slight decreasing trend with increase in concentration of B. All the soil treatments showed a significant increase in grain yield with a highest value for T_4 (5502.85 kg ha^{-1}) which was on par with T_3 (5443.93 kg ha^{-1}). For foliar application, though grain yield was increased significantly for all the levels compared to control, a slight decreasing trend was noticed for the levels above 250 mg L^{-1}. The higher levels of soil treatment (T_3 and T_4) and the lowest level of foliar treatment produced better grain yield. The increase in grain yield may be attributed to increased panicle weight and thousand grain weight (Table 2). Reports indicate that B applied at the heading or flowering stage in rice resulted in increased grain yield and number of grains per panicle (Ramanthan *et al.*, 2002).

Harvest index and cost of cultivation showed a non-significant variation in all the levels of soil and foliar application. An increment in B:C ratio was noticed for all soil treatments with significant increase from T_2 to T_4 (0.5 to 1 kg B ha^{-1}) compared to control (Table 2). B:C ratio was highest (1.52) for T_4 which was at par with T_3 (1.48). Foliar application also showed significant increase in B:C ratio at all levels compared to the control with a maximum value of 1.45 (250 mg L^{-1} B).

Soil B application at the rate of 0.75 and 1.0 kg ha^{-1} resulted in significant increase in total nitrogen uptake (258.50 and 241.25 kg ha^{-1}, respectively) by the plant. Foliar application also remarkably increased the nitrogen

Table 1 : Effect of boron fertilization on yield attributes of rice

Treatments	Panicle length (cm)	Weight per panicle (g)	Number of grains/panicle	Thousand grain weight (g)
T_1	19.89	1.64	118.43	24.43
T_2	20.09	1.89	124.02	25.16
T_3	20.32	2.24	126.94	24.53
T_4	20.59	2.71	130.42	24.48
T_5	20.30	2.51	129.71	23.46
T_6	19.99	2.26	122.09	23.46
T_7	20.03	2.27	117.63	23.43
T_8	19.93	2.18	119.27	23.37
T_9	19.86	1.98	116.82	22.78
C.D. (P=0.05)	NS	0.511	NS	1.138

NS=Non-significant

Table 2 : Effect of boron fertilization on yield and economics of rice

Treatments	Straw yield (kg ha^{-1})	Grain yield (kg ha^{-1})	Harvest Index	Cost of cultivation (Rs.)	Gross returns/ha (Rs.)	Benefit-cost ratio
T_1	5210.16	5074.45	0.98	102367	137689	1.35
T_2	6221.76	5199.26	0.86	102481	145493	1.42
T_3	6359.44	5443.93	0.86	102594	151564	1.48
T_4	7014.52	5502.85	0.81	102708	156135	1.52
T_5	6853.65	5195.20	0.76	102310	148563	1.45
T_6	6713.06	5176.12	0.78	102367	147440	1.44
T_7	6731.91	5104.94	0.76	102424	145968	1.43
T_8	6386.98	5124.27	0.80	102480	144669	1.41
T_9	5513.06	4667.60	0.85	100949	130252	1.29
C.D. (P=0.05)	1085.851	291.283	NS	NS	9155.787	0.090

NS=Non-significant

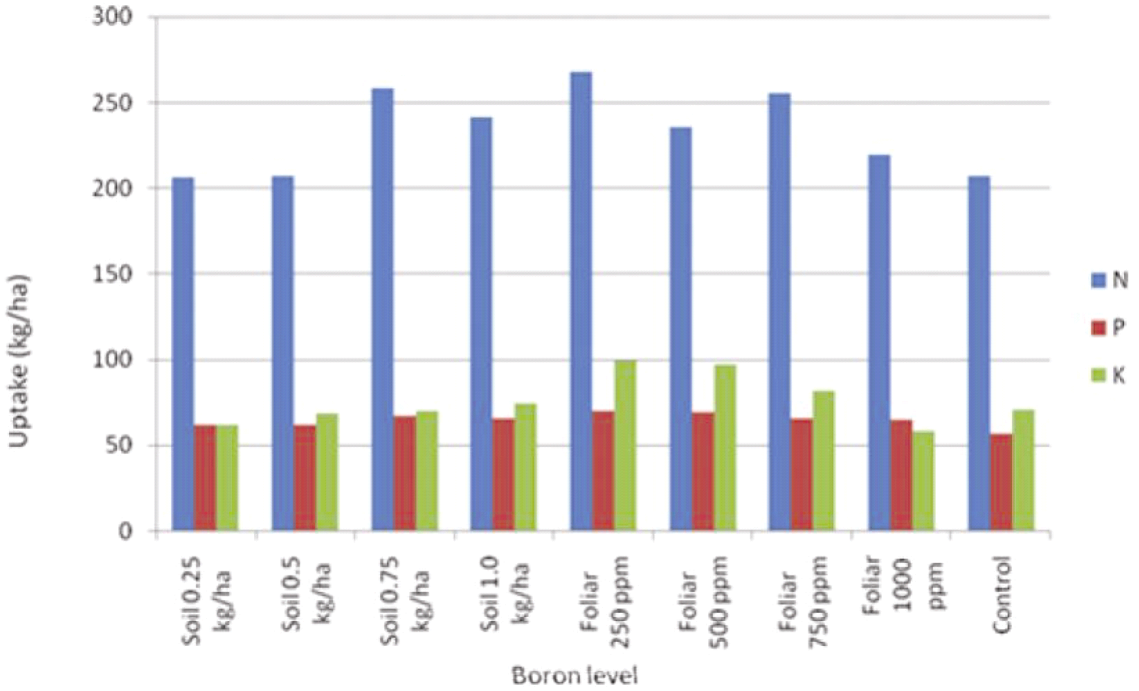

Fig. 1 : Effect of boron fertilization on total nutrient uptake by the plant

uptake with the maximum value for the lowest level of 250 mg L^{-1}. An increase in B concentration of spray fluid up to 1000 mg L^{-1} did not produce further beneficial results (Fig. 1). Soil B treatments T_3 (67.02 kg ha^{-1}) and T_4 (65.59 kg ha^{-1}) increased the phosphorus uptake markedly compared to the control. Though all foliar treatments showed significant increase in phosphorus uptake, the increase in B concentration in spray fluid above 250 mg L^{-1} did not give additional response. Soil application of B did not affect potassium uptake significantly but foliar application up to 500 mg L^{-1} increased the uptake of K significantly and further increase in concentration of spray fluid resulted in an abrupt reduction in uptake values.

Soil treatment was found to be a better method of B application in increasing the thousand grain weight and weight per panicle. Soil treatments gave significantly higher grain yields compared to foliar treatments. Economic analysis revealed the superiority of B treatments over control. The highest gross returns and B:C ratios were recorded for the soil treatment T_4 (1.52) which was at par with T_3 (1.48). Since the yield and B:C ratios for T_4 and T_3 were on par, in the case of micronutrient recommendations, it is mandatory to recommend the lower dose *i.e.*, 0.75 kg B ha^{-1} as soil application in two splits at active tillering and flowering stages to meet the B requirement of wet land rice in the acid soils of Kerala to increase the grain yield.

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