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RESPONSE OF BORON NUTRITION ON GROWTH AND YIELD OF RICE GROWN UNDER TEMPERATE CONDITIONS OF KASHMIR VALLEY

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AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration among all authors. Author KAS collected all the data and managed the literature searches. Author AG drafted the manuscript. Author TI designed and analyzed the final manuscript. Author RG edited the manuscript. All the authors read and approved the final manuscript.

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ABSTRACT

A field experiment was conducted at Krishi Vigyan Kendra- Bandipora, SKUAST-Kashmir to study Response of Boron nutrition on growth & yield of Rice grown under temperate conditions of Kashmir valley with four treatments of *Boron* @ 0 Kg/ha (farmers practice), T1: No Boron (control) recommended dose fertilizer of SKUAST-K, T2: 1 Kg borax/ha + recommended dose fertilizer of SKUAST-K, T3: 2 Kg borax/ha + recommended dose fertilizer of SKUAST-K. The significant results were obtained with Application of borax at 1 Kgs/ha resulted in Panicle sterility of 3.28% & the maximum Grain yield 68.25 Qtls/ha was recorded as compared to the Farmers Practice where Panicle sterility of 12.25% and grain yield of 61.05 Qtls/ha was recorded as farmers do not use boron fertilizers in their fields. Farmer was satisfied so far as Subsequent panicle initiation & grain yield obtained were redressed during the conduct of on farm trial. The farmers were suggested for applications of Soil application of Boron during seed bed preparation on the farmer's field. As far as Economics is concerned, the farmers practice obtained the Net Return of (Profit) in Rs. 73000 Rs / ha as compared with Application of borax @ 1Kg Borax/ha + Recommended dose fertilizer of SKUAST-K obtained the Net Return of (Profit) I 87560 Rs/ha with B:C ratio of 2.08.

Keywords: Boron; rice; grain filling; yield; fertilizers.

1. INTRODUCTION

Micronutrient deficiencies are prominent in South Asian regions of World where the rice-wheat system have contributed to diminish the productivity level. Major micronutrients such as zinc (Zn), boron (B), iron (Fe), molybdenum (Mo), and manganese (Mn) are found to be insufficient in the soil. Panicle sterility is one of major threat to global rice production [1, 2]. The decrease in soil water status is typically associated with an increase in rice panicle sterility. Ekanayake et al. [3], Kato et al. [4] During reproductive development, soil water deficiency is disrupted the meiosis in the pollen mother cells [5, 4]. Factors suggested to be responsible for sterility include boron deficiency, low radiation cloudy dull

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weather, morning fogs, low temperature, mists during development of reproduction; water logging at flowering stage. Other factors include low soil nitrogen and dry high temperatures, high humidity low humidity drought or water shortage and high pH. Of all these factors, boron deficiency and cold temperatures are the only causes that have been conclusively proven: sterility was effectively reduced by boron application in one study. A soil boron concentration of <1 ppm is considered deficient. In some cases, however, notably at higher altitudes, low temperature stress was suspected as a contributing factor because boron application did not cure sterility.

In addition to sterile young terminal florets, soil boron deficiency often results in sterility of older florets found at the base of a spikelet. Boron is essential for cell wall development of the generative organs, germination and growth. Boron deficiency results in the failure of pollen tube growth due to a reduction in development of the pollen tube cell wall leading to failure in fertilization or sterility. Therefore, a crop of a wheat variety susceptible to sterility may have luxurious vegetative growth, but boron deficiency at the critical stage of an thesis would result in sterile spikes with low yield. Climatic conditions (such as cloudy days and low or high temperature), very high soil pH, water logging, and so on influence the degree of crop response to boron application in wheat Boron is readily leached. After 25 mm of rainfall, it is estimated that there is a 30 percent reduction in soil boron concentration. Boron deficiency is also likely to be caused by the incidence of such a fall during the reproductive stages. Boron (B) deficiency has been described as one of the most significant sterility inducing factors since it causes low anther and pollen growth and pollen germination failure [6]. It is found that a short-term B deficiency hinders anther production during micro-sporogenesis and also has adverse effects on pollen viability, which are primary reasons for panicle sterility. Rashid et al. [7] compared the status of soil water with the availability of B for plants They found that the key explanation for panicle sterility and low grain quality in rice is B deficiency. Some other studies say that the low water capacity in the panicle also leads to the sterility of the panicle [8]. For example, Kato [4] stated that even a mild decrease in the status of plant water at the meiosis stage triggered high rates of secondary branch pre-flowering abortion, causing a 40-45% decrease in the number of spike lets per panicle. A drop in the status of plant water under drought was due to this pre-flowering spikelet abortion.

The reproductive stage of plants is more vulnerable than the vegetative one to B deficiency [9]. Limited soil water also restricts the supply of B because there is limited release of B from organic complexes; this often impairs plants' ability to extract B from soil [10]. Gupta et al. [11], for example, stated that soil water drives the B dynamics in the soil and its absorption after adding B to the soil. The availability of boron under aerobic conditions in alkaline soils is reduced as its availability to plants decreases as soil pH increases, especially above pH 6.5. Under such circumstances, the application of supplemental B is essential for adequate supply to the plants. Boron use at a rate of 1 kg/ha has been shown to be very effective in mitigating sterility, significantly improving germination, early seedling growth, tillering, and leaf expansion to a great extent [8]. Improving the tillering and leaf area results in an increase in the size of the source, which is hypothesized to increase the supply of assimilates and decrease the sterility of the panicle. This study was conducted to evaluate the impact of B on grain yield, with particular focus on the sterility of panicles in rice.

2. MATERIALS AND METHODS

Extensive field experiment were carried during the year 2015-2016 at Krishi Vigyan Kendra- Bandipora, SKUAST-Kashmir to research the Response of Boron nutrition on growth & yield of rice under temperate conditions of Kashmir. Rice variety Jehlum was transplanted after 25 DAS. The experimental soil was Clay loam with (pH) 6.2, (EC) 0.13, (OC) 0.71%, (N) 345 kg/ha, (P) 22.5 kg/ha, (K) 265 kg/ha. Fertilizers NPK and Zn were applied according to soil analysis report using urea (46% N), single superphosphate (18% P2O5), sulfate of potash [50% potassium oxide (K2O)] and zinc sulfate (ZnSO4; 35% Zn), respectively as fertilizer sources. The whole quantity of P, K and Zn was applied as basal dose while half quantity of nitrogen was applied as basal and other half in two splits at tillering and panicle initiation stage was applied. Boron, taking borax (10.5% B) as a source, was applied as basal dose **T0**: Farmers practice.**T1**: No Boron (control) recommended dose fertilizer of SKUAST-K, **T2**: 1kg borax/ha + recommended dose fertilizer of SKUAST-K, **T3**: 2kg borax/ha + recommended dose fertilizer of SKUAST-K kg ha−1. Irrigation was applied every third day or according to crop requirements. However, there was never standing water in an experimental pot, and soil conditions were aerobic. Grain yield and panicle sterility was calculated after harvesting.

3. RESULTS AND DISCUSSION

Boron application significantly improved the agronomic and yield related traits. Paddy yield was significantly increased by the B application over control (Table I). The highest paddy yield (68.25 Q ha-1) was recorded with the application of 1 Kg Borax/ha + Recommended dose fertilizer of SKUAST-K followed by 67.15 Q ha-1 which was obtained with the application of 2Kg Borax/ha + Recommended dose fertilizer of SKUAST-K which were significantly different from one another. Application of B applied to rice at 1 kg ha-1 (T2) gave an increase of 11.79 % yield over control followed by 10 % yield obtained from the B applied at 2 kg ha-1 (T3) respectively (Khan et al. 2006). Rashid et al. [7] Data showed that 1000-grain weight was significantly affected with the cumulative application of 1 and 2 kg B ha-1 over control. Highest 1000 grain weight was recorded with the application of B applied to rice at 1 kg/ha (T2) followed by the application of B applied to rice at 2 kg ha-1 (T23) while lowest from the control treatment. The number of panicle per plant was significantly affected with the B application.

The range of panicle per plants was 18.0 to 28.87. The highest numbers of panicles per plant were recorded with the application of the B applied rice at 1 kg ha-1 (T2). The cumulative application of B significantly increased the panicle length over control and ranged from 16.98 to 20.89 cm. The ample amount panicle length was achieved with the application of the B applied to rice at 1 kg ha-1 (T2) being significantly different from the other ways. The size of panicles m-2 was significantly increased with the cumulative, effect of the B application. Though, the rising size of panicle m- 2 was recorded in (T2) followed by (T3) and (T1) which were statistically at par with one another. Plant height of rice was significantly increased with the application of B applied both to rice at 1 (T2) and 2 kg ha-1 (T3) in rice Plant height increased due to the application of B at 1 kg ha-1 as direct (T3) and (T1) were statistically similar but significantly different from control. Maximum plant height was recorded with the application of the B applied to rice at 1 kg ha-1 (T2) while the lowest with the control as shown in (Table 1).

Application of B applied to rice at 1 kg ha^{-1} (T2) showed the lowest panicle sterility percent (3.28%) followed by B applied to rice at 2 kg ha^{-1} (T3) showed the panicle sterility percent (3.86%) and the highest panicle sterility percent was observed in control. All the yield parameters significantly increased in the rice crop with the B applied to rice at 1 kg ha^{-1} but was statistically at par with the B applied to rice at 2 kg ha^{-1} in rice. This all reflects that the direct application of 1kg B ha^{-1} gave the highest yield in rice. This research hints that the B application is important for leaf development, tillering, panicle fertility, Grain yield. Not only adequate B supply boost rice growth, but even the grain yield decreased panicle sterility, but an adverse effect of B application was observed beyond the optimum level of 1 kg ha^{-1}. This reveals a small spectrum between B's deficiency and toxicity. With an optimum rate of B, leaves appeared earlier and developed faster. Similarly, the optimum rate of B

Table 1. Response to boron application on yield and yield components of rice

Treatment	Paddy Yield (Q ha-1)	Increase in Paddy yield over control (%)	1000 grain weight (g)	Panicle/ plant	Panicle length (cm)	No. of panicles m-2	Plant height (cm)	Panicle Sterlity%
T_0:Farmers practice	61.05	--	18.0	14.56	16.98	276	97.97	12.25
T_1: No Boron (Recommended dose fertilizer of SKUAST-K)	65.10	6.63	21.07	16.43	17.88	317	108.98	6.62
T2: 1 kg Borax/ha + Recommended dose fertilizer of SKUAST-K	68.25	11.79	28.87	19.87	20.89	365	145.90	3.28
T3: 2 kg Borax/ha + Recommended dose fertilizer of SKUAST-K	67.15	10.00	27.35	17.80	19.65	345	128.90	3.86

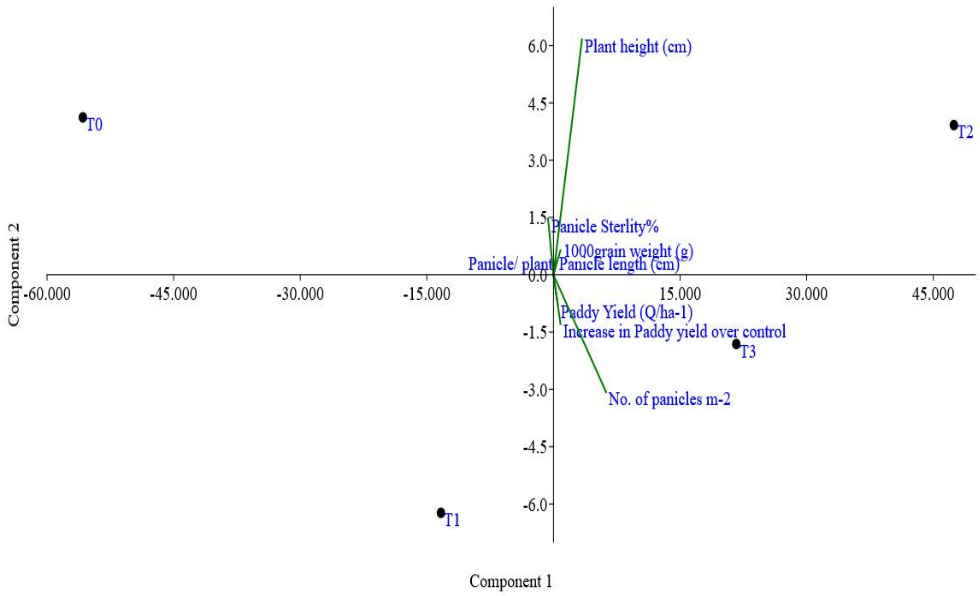

Fig. 1. Principle Component Analysis (PCA) showing relationship between treatments and attributes of rice plant

application increased the number and rate of leaves and tiller appearance as well. In this analysis, the extreme and regulated growth of both rice cultivars with optimum B could be explained by the key role of B in the foundation of primary cell walls [12,13] and the regulation of structure and function of membranes [14,15]. B's role in cell division and synthesis of the cell wall and general metabolism [14] also describes the increase in the growth of leaves and the application of B tillering. Substantial reduction in panicle sterility by B application confirms its role during anthesis and fertilization in the production of anthers and pollen and pollen germination [6,9]. There also tends to be a decline in panicle sterility due to some indirect influence of Boron. We used Past software (Version 4.03/64 bits) to do multivariate Principle Component Analysis (PCA) and plot Radar chart as shown in Figs. 1 and 2 respectively.

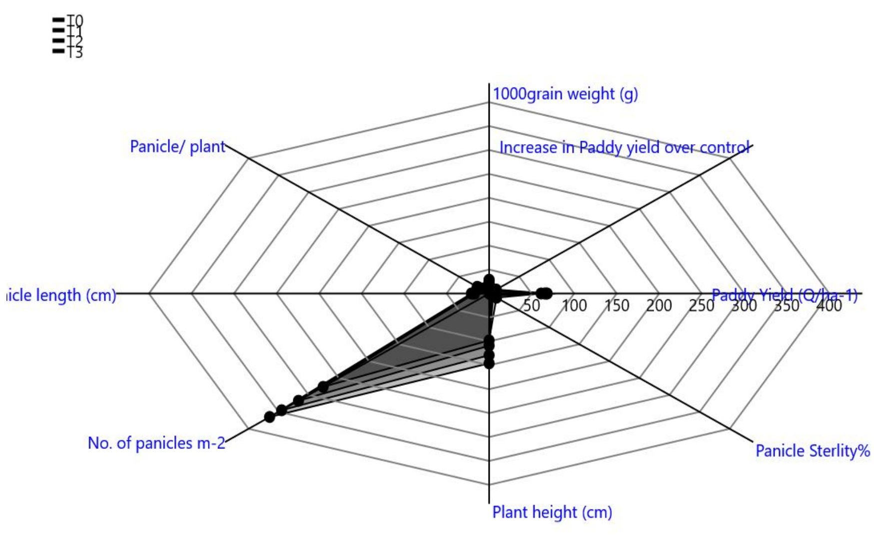

Fig. 2. Radar chart showing relationship between treatments and attributes of rice plant

4. CONCLUSION

Farmers are satisfied so far as Subsequent panicle initiation & grain yield obtained were redressed during the conduct of on farm trial. The Farmers were suggested for applications of Soil application of Boron during seed bed preparation in the farmer's field. As far as Economics is concerned, the farmers practice obtained the Net Return of (Profit) in Rs. 73000 Rs / ha as compared with Application of borax @ 1 Kg Borax/ha + Recommended dose fertilizer of SKUAST-K obtained the Net Return of (Profit) I 87560 Rs/ha with B:C ratio of 2.08. In nut shell, soil application of the B at 1.0 kg ha−1 improved the growth, yield, and B grain enrichment in rice through improvement in leaf development and tillering and reduction in panicle sterility.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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