Influence of Boron on Productivity, Profitability and Quality of Processing-Grade Potato

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Productivity of potato in India is currently low due to multi-nutrient deficiencies and other allied problems (Banerjee et al., 2016). Potato farmers of India largely apply only N, P, and K in potato. As a consequence, deficiencies of S, Fe, Mn, Zn, and B are increasing. Attainable yields of potato are often not achieved despite balanced use of NPK due to micronutrient deficiencies (Banerjee et al., 2016). Widespread B deficiency is one of the major emerging constraints to crop production next to Zn. About one-third of cultivated soils in India are deficient in B and the number is increasing due to lack of effective management strategies. Boron plays a significant role in improving tuber yield and quality of potato. Adverse effects of B omission on the yield can occur even though no deficiency symptoms are evident on the foliage. The 4R nutrient management guidelines (IPNI, 2015) for B fertilization in potato (i.e., B fertilization using the right source at the right rate, time, and place) is not yet standardized for the alluvial plains of West Bengal.

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Potato tubers displaying boron deficiency symptoms.

An on-station experiment was carried out at Bidhan Chandra Krishi Viswavidyalaya, West Bengal (**Figure 1**) during the winter seasons (November to March) of 2014-15 and 2015-16 to determine the right rate of B application for improving yield and quality of processing grade potato in the sub-tropical agro-ecology of eastern India. The experiment was laid out in a randomized block design (RBD) with five treatments, four replications and an individual plot size of 5 m x 4 m. The experimental treatments were comprised of five fertilizer treatments:

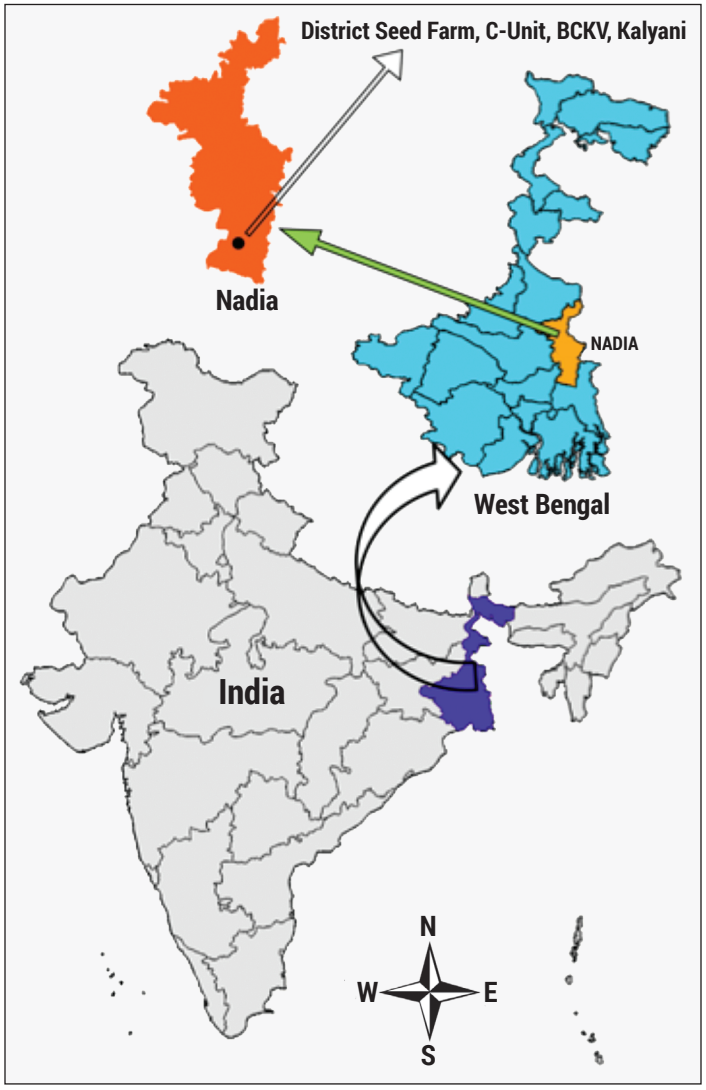

Figure 1. Location of the experimental site (22°58' N latitude, 88°25' E longitude, 9 m above mean sea level). (Map not in Scale.)

SUMMARY

Boron fertilization has a significant impact on tuber yield and quality of potato. Foliar spray of 0.1% Boric acid at 40, 50, and 60 days after planting, along with recommended doses of NPK, improved yield and processing quality of tubers.

KEYWORDS:

crop quality; foliar B; micronutrients

ABBREVIATIONS AND NOTES:

N = nitrogen; P = phosphorus; K = potassium; S = sulphur; Fe = iron; Mn = manganese; Zn = zinc; B = boron.

T_1: Recommended Doses (RD) of NPK (i.e., 200 kg N, 150 kg P_2O_5 and 150 kg K_2O/ha applied through urea, single super phosphate and muriate of potash) (Control);
T_2: RD of NPK + 2.0 kg B/ha as soil application as Granubor (containing 15% B);
T_3: RD of NPK + 0.1% boric acid as foliar application at 40 days after planting (DAP);
T_4: RD of NPK + 0.1% boric acid as foliar application at 40 and 60 DAP; and
T_5: RD of NPK + 0.1% boric acid as foliar application at 40, 50, and 60 DAP.

The test crop was a processing grade potato cultivar. The seed pieces of 30 to 40 g were planted at 20 cm distance at a depth of 15 cm in rows 60 cm apart. The crop was planted on November 20 and harvested on March 10 in both years. Boron uptake in tuber was estimated by dry-ashing following the azomethine-H colorimetric method. Quality parameters of potato tuber were determined following standard protocols (AOAC, 1995).

Impact of B Application on Yield and Economic Return

Boron fertilization had a significant positive impact on tuber number, yield of potato, net return, and Benefit:Cost (B:C) ratio (**Table 1**). Treatment T_5 produced a significantly ($p \leq 0.05$) higher number of total tubers and improved processing grade tuber compared to the other B treatments (foliar and soil). The same treatment resulted in the highest yield of processing grade tuber (33.5 t/ha) as well as total tuber (35.1 t/ha) accounting for 35.5 and 34.7% increases over the control (RD of NPK only), respectively. Application of 0.1% boric acid spray (thrice at 40, 50, and 60 DAP) in combination with RD of NPK has been most effective, with the highest net return (US$ 2,383/ha) and best B:C ratio (2.40).

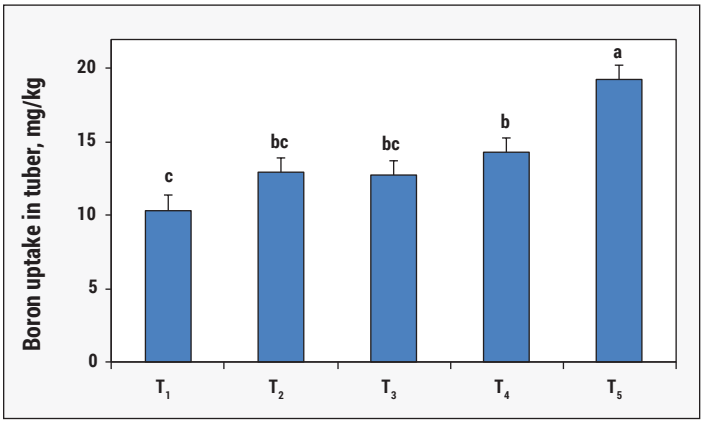

Figure 2. Effect of boron fertilization on tuber uptake in potato. (Bars indicates standard error.)

Uptake and B Application

Boron concentration in potato tuber increased significantly ($p \leq 0.05$) as B application increased (**Figure 2**). Tuber B content was highest (85.8% higher than control) with T_5, which was significantly ($p \leq 0.05$) higher than the other treatments. The same treatment recorded the highest N concentration (75% more than control), highlighting the importance of B in protein and other quality parameters of tuber potato.

Tuber Quality and B Application

The quality parameters namely specific gravity, total soluble solids (TSS), tuber hardness, total acidity, and vitamin C content of potato tubers were significantly influenced by B application (**Table 2**). The tubers from the plants treated with foliar B had higher quality attributes than those harvested from the plants treated

Table 1. Effect of boron fertilization on tuber number, yield, net return, and B:C ratio. (Pooled data of two years.)

Fertilizer treatment	Tuber number, x10,000/ha		- - - - Tuber yield, t/ha - - - -		Net return, US$/ha	B:C ratio
	Processing grade	Total	Processing grade	Total		
T_1	2.71 d	3.33 b	24.72 d	26.02 d	1,353 d	1.80 d
T_2	3.23 bc	4.04 a	28.57 bc	30.24 bc	1,817 bc	2.06 bc
T_3	2.93 cd	3.61 b	26.88 cd	28.04 cd	1,580 cd	1.93 cd
T_4	3.44 ab	4.15 a	29.59 b	30.91 b	1,907 b	2.12 b
T_5	3.70 a	4.44 a	33.49 a	35.05 a	2,383 a	2.40 a

Numbers followed by different letters within columns indicate significant difference at $p \leq 0.05$.

Table 2. Quality parameters of potato cv. Kufri Chipsona-3 as influenced by boron fertilization. (Pooled data of two years.)

Fertilizer treatment	Specific gravity	Tuber dry matter content, %	TSS, °Brix	Tuber hardness, kg/cm	Total acidity, %	Vitamin C, mg/100 g of dry weight	Protein, %	Total starch, mg/100 g of dry weight	Total sugar, mg 100/g of dry weight	Total phenols, mg/100 g of fresh weight	Chip colour†
T_1	1.070 c	21.51 a	3.50 d	7.09 d	7.34 c	12.84 b	1.54 b	53.09 d	0.81 a	25.93 a	3.36 a
T_2	1.074 bc	21.83 a	4.08 cd	7.61 cd	7.42 c	13.31 b	2.08 a	55.14 c	0.77 ab	21.58 b	3.09 ab
T_3	1.078 b	21.06 a	4.40 bc	8.46 bc	7.99 b	13.23 b	2.01 a	55.98 c	0.78 ab	20.42 bc	2.74 b
T_4	1.080 b	22.37 a	4.84 ab	9.16 ab	8.64 a	13.70 b	2.17 a	61.10 b	0.73 b	17.14 dc	2.25 c
T_5	1.090 a	23.59 a	5.30 a	9.49 a	8.95 a	15.43 a	2.63 a	65.43 a	0.72 b	16.21 d	1.94 c

†On a 1-10 scale, where 1 is the lightest and 10 is the darkest chip colour; chip colour score up to 3 is acceptable, where Low score = Preferred colour; TSS, Total soluble solids.
Numbers followed by different letters indicate significant difference at $p \leq 0.05$.

with soil applied B. Tubers harvested from the T_5 treatment plots exhibited significantly higher specific gravity, TSS, tuber hardness, total acidity, and vitamin C content that were 1.87, 51.4, 33.9, 21.9 and 20.2% higher in potatoes harvested from control plots (only NPK, without B), respectively. Statistical analysis in the present study did not show any significant variation in total dry matter content in tubers with B fertilization. The protein and total starch content in tubers in T_5 were 70.8 and 23.2% higher than the control (without B). Boron application reduced the phenolic concentration in tubers. Significantly low total phenol content (60% less than control) was recorded in potatoes harvested from the T_5 plot, as compared to other treatments. Potatoes harvested from the T_5 treatment plots recorded lighter chip colour (73.2% lighter than control) than those in the control plots. However, reduction of B application of up to two foliar sprays resulted in a non-significant ($p \geq 0.05$) decrease in chip colour of potato. Soil application of B was less effective in producing lighter chip colour than foliar sprays, and it was statistically at par with B omission treatment (Control).

Conclusion

Potato responded positively to foliar applied B, along with the recommended doses of NPK. Considering the yield, economics, tuber quality, and nutrient uptake it may be concluded that a B application of 0.1% boric acid at 40, 50, and 60 DAP, in combination with recommended doses of NPK (200 kg N, 150 K_2O, and 150 kg P_2O_5/ha) is beneficial to the development of processing grade potato in the alluvial Gangetic plains of West Bengal. **BCSA**

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