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Differential response of vegetable crops to boron application

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ABSTRACT

A field experiment was conducted on an alluvial soil at research farm, Raja Balwant Singh College Bichpuri Agra (U.P.) to study the effect of boron on yield, quality and uptake of nutrients in vegetable crop (carrot, onion and cauliflower), The experiment was laid out in randomized block design with five levels of B (0, 0.5, 1.0, 1.5, 2.0 kg ha^{-1}) and four replications. The results revealed that the application of boron up to 1 kg B ha^{-1} significantly increased the yields and dry matter production of vegetable crops, whereas at higher boron level (2 kg B ha^{-1}) the yields tended to decrease. The magnitude of response differed from crop to crop and arranged in descending order as carrot > cauliflower > onion. Boron application also improved the content and yield of protein of vegetable crops over control. Boron addition progressively increased its concentration and uptake in vegetable crops over control. The maximum boron removal was recorded in cauliflower curd and minimum in carrot roots. The carrot and onion crops gave maximum net profits and B/C ratios with 1.0 kg B ha^{-1}, whereas cauliflower gave maximum values of net returns and B:C ratio with 1.5 kg B ha^{-1}. The per cent apparent recovery of boron was influenced by its levels with maximum at 1 kg B ha^{-1}. The boron use efficiency decreased with its increasing levels and minimum use efficiency was recorded at 1.5 kg B ha^{-1} application. The maximum values of PAR and BUE were recorded in cauliflower at all the levels of boron.

Keywords: Response, vegetable crops, boron

INTRODUCTION

Carrot (*Daucus carota*), onion (*Allium cepa*) and cauliflower (*Brassica oleracea Botryts*) are the most popular vegetable crops grown in Uttar Pradesh. Boron deficiency, in varying degrees of intensity has been noted on vegetable crops being grown in Uttar Pradesh. The vegetable crops require substantial amounts of plant nutrients and responds very well to the added nutrients. Boron deficiency and neglect to give equal importance to boron in fertilization program me has resulted in low productivity of these vegetable crops. Boron plays a vital role in transport of carbohydrates as well as in cell wall metabolism, permeability and stability of cell membranes, phenol metabolism with primary role in lignin synthesis. Deficiency of boron restricts stomata opening and transpiratory water loss and also leads enhanced leakage of solutes across the plasma membrane. The information regarding the differential behavior of vegetable crops to boron application under identical soil and weather conditions was considered to be of interest. The present investigation was, therefore, undertaken to study the variability in the response of vegetable crops to boron application in alluvial soil of Agra region.

MATERIALS AND METHODS

A field experiment was initiated on a sandy loam soil at Raja Balwant Singh College, Research Farm, Bichpuri, Agra (U.P.). The climate of the study area is semi-arid with an average rainfall of about 650 mm per annum, about 80% of which is received during June to September. The pH, EC, organic carbon and HWS-B of the soil at the initial stage (before sowing / transplanting) were 8.0, 0.20 dSm^{-1}, 3.2 g kg^{-1}, 0.5 mg kg^{-1}, respectively. The pH, EC, organic carbon was estimated by standard methods and boron in hot water extract was estimated colorimetrically by carmine method (Hatcher and Wilcox, 1950). Boron was applied to soil at the rate of 0, 0.5, 1.0, 1.5 and 2.0 kg B ha^{-1} as borax. Randomized block design was followed with four replications. Three vegetable crops namely carrot (var. Pusa Kesar), cauliflower (var. Puse Snowball-16) and onion (var. Nasik Red) were sown / transplanted on November 20 and December 3 during both the experimental years, respectively. A basal application of 60 kg N, 60 kg P_2O_2 and 100 kg K_2O ha^{-1} was given to carrot, 200-100-100 for onion and 120-80-60 for cauliflower through urea, diammonium phosphate and muriate of

potash, respectively. The vegetable crops were harvested at maturity and yields were recorded. Plant samples were drawn and processed for chemical analysis taking special care against boron concentration. The samples were digested in diacid mixture and boron concentration was determined by Carmine method (Hatcher and Wilcox, 1950). Nitrogen content in crops was determined following micro Kjeldahl method (Jackson 1973). The protein content was computed from the nitrogen content multiplied by a factor 6.25. The uptake of boron was calculated by multiplying the concentration value with respective yield data. The following formulae were used to calculate boron use efficiency and apparent B recovery.

Boron use efficiency (kg produce / kg B applied) = yield (F) – yield (C) / fertilizer boron applied.

Apparent B recovery (%) = [uptake of B in treated plot – uptake of B in control plot / applied B dose] x 100

Where F and C are fertilizer treated and control plot, respectively.

Data obtained from consecutive two years were statistically analysed as per procedure given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Yield

The data on yields of vegetable crops are presented in Table 1. The results indicated that the increases in yields of carrot roots and onion bulb were significant for each level of boron up to 1 kg B ha^{-1} as compared to control, but in cauliflower significant increase was noted up to 1.5 kg B ha^{-1}. There was a reduction in yields of all the vegetable crops due to 2.0 kg B ha^{-1} over lower levels. Thus, a level of 1.0 kg B ha^{-1} appeared to be the optimum dose for carrot and onion and 1.5 kg B ha^{-1} for cauliflower under the experimental condition. This may be because boron takes part in active photosynthesis, which ultimately helps towards increase in quality and yields of vegetable crops. Singh (2003) and Chander *et al.* (2010) also reported that boron improved the yield of cauliflower curd over control. It was also apparent from the data (Table 1) that the vegetable crops differed significantly amongst themselves in their magnitude of response to boron.

Table 1: Effect of B on yield (t ha^{-1}), dry matter yield (t ha^{-1}), content (%) and yield (q ha^{-1}) of protein of vegetable crops

Vegetable crops	Boron levels (kg ha^{-1})						
	0	0.5	1.0	1.5	2.0	SEm±	CD (P = 0.05)
	Yield (t ha^{-1})						
Carrot root	31.33 (4.17)	34.10 (4.54)	35.51 (4.73)	35.09 (4.67)	34.74 (4.62)	0.35 (0.04)	0.76 (0.10)
Onion bulb	25.62 (4.07)	29.10 (4.63)	30.11 (4.79)	29.42 (4.69)	28.57 (4.55)	0.40 (0.06)	0.87 (0.13)
Cauliflower curd	28.33 (12.14)	32.22 (13.81)	35.06 (15.02)	35.28 (15.12)	37.30 (14.69)	0.28 (0.12)	0.61 (0.26)
	Protein yield (q ha^{-1})						
Carrot root	1.60 (3.78)	1.80 (3.97)	1.90 (4.12)	2.00 (4.31)	1.95 (4.35)	0.06 (0.12)	0.13 (0.27)
Onion bulb	2.45 (6.11)	3.50 (6.62)	35.51 (7.05)	3.35 (7.17)	3.30 (7.40)	0.13 (0.25)	0.29 (0.54)
Cauliflower curd	7.25 (5.97)	8.55 (6.22)	9.95 (6.62)	10.25 (7.15)	10.05 (6.85)	0.16 (0.09)	0.35 (0.19)

Data in parenthesis indicate mean dry matter yield and protein content

The maximum yield responses of cauliflower, carrot and onion were 35.28, 35.51 and 30.11 t ha^{-1}, respectively. As far as yields are concerned, the vegetable crops responded in the following order: carrot > cauliflower > onion. Boron levels had significantly beneficial effect on the dry matter yields of the vegetable crops. The maximum dry matter yields of carrot (4.73 t ha^{-1}) and onion (4.79 t ha^{-1}) crops were recorded under 1.0 kg B ha^{-1} while increase in cauliflower curd was noted up to 1.5 kg B ha^{-1}. The promotive effect of B may be interpreted in

terms of manufacturing more carbohydrates and protein along with its role in enhancing the translocation from the site of synthesis to the storage organs (Sharma 2002, Chander *et al.* 2010 and Solanki *et al.* 2018). The dry matter yields of these vegetable crops were reduced at 2.0 kg B ha^{-1} over 1.5 kg B ha^{-1}. The variable magnitude of response to boron application has also been reported by several workers like Gupta *et al.* (2002).

Quality

The highest average values of protein content were recorded in onion bulbs and lowest in carrot roots. The maximum value of protein content in carrot (4.35%) and onion (7.40%) were recorded at 2.0 kg B ha^{-1}. In cauliflower crop, the maximum protein content (7.15%) was noted under1.5 kg B ha^{-1}. The protein content of vegetable crops increased with increasing levels of B up to 2 kg B ha^{-1}. The maximum value of protein yield was recorded in cauliflower (10.25 q ha^{-1}, followed by onion (3.35 q ha^{-1}) and carrot (2.00 q ha^{-1}) at 2 kg B ha^{-1}. The highest level of B (2.0 kg B ha^{-1}) could not improve significantly the protein yield in all the vegetable crops over 1.5 kg B ha^{-1}. The increases in protein yield with boron application have been reported by Solanki *et al.* (2018).

Table 2: Effect of B on its content (mg kg^{-1}) and uptake of vegetable crops

Vegetable crops	Boron levels (kg ha^{-1})						
	0	0.5	1.0	1.5	2.0	SEm±	CD (P = 0.05)
	Boron uptake (g ha^{-1})						
Carrot root	145.0 (34.2)	185.0 (40.9)	230.0 (49.5)	270.0 (57.7)	280.0 (61.0)	0.005 (0.60)	0.010 (1.31)
Onion bulb	250.0 (61.0)	315.0 (70.5)	400.0 (83.2)	420.0 (89.3)	420.0 (93.2)	0.012 (0.51)	0.020 (1.11)
Cauliflower curd	620.0 (51.0)	810.0 (58.7)	1050.0 (70.1)	1210.0 (81.0)	1245.0 (84.7)	0.015 (0.45)	0.035 (0.98)

Data in parenthesis indicate mean B concentration

Content and uptake of boron

Application of B significantly increased boron content in all vegetable crops (Table 2). The boron content increased from 34.2 to 61.0, 61.0 to 93.2 and 51.0 to 84.7 mg kg^{-1} in carrot, onion and cauliflower crops with the addition of 2 kg B ha^{-1}. This increase in boron content in vegetable crops may be ascribed to increased availability of boron in soil solution due to boron application to the soil. The higher amounts of boron were utilized by cauliflower than those of other vegetable crops. Boron uptake by vegetable crops increased with boron application. The boron uptake increased from 145.0 to 280.0, 250.0 to 420.0 and 620.0 to 1245.0 g ha^{-1} by carrot roots, onion bulbs and cauliflower curds, respectively with 2 kg B ha^{-1}. Singh and Singh (2003), Dixit and Singh (1997) and Chander *et al.* (2007) also reported an increase in boron uptake by cauliflower curd and cabbage head, respectively with boron application.

Economics

All the vegetable crops gave higher benefit with boron application (Table 3). The maximum net return of Rs. 143636 ha^{-1} was obtained from 1.5 kg B ha^{-1} in cauliflower. In carrot and onion the maximum net return of Rs. 105588 and 122064 ha^{-1} were obtained with 1.0 kg B ha^{-1}. Similarly, the maximum value of B / C ratio in carrot (1.85), onion (2.04) and cauliflower (2.35) were obtained with 1.0 and 1.5 kg B ha^{-1}, respectively. Singh (2003) also reported that the B / C ratio was significantly superior with the application of boron in cauliflower.

Efficiency indices

The minimum mean values of apparent recovery of boron in carrot, onion and cauliflower were 0.91, 1.46 and 4.34 per cent, respectively at 1 kg B ha^{-1}. The minimum values of apparent recovery of boron in all the three vegetable crops were recorded at 2 kg B ha^{-1}.

Table 3: Effect of B on net return (Rs ha^{-1}), B:C ratio, apparent recovery (%) and boron use efficiency (kg produce/ kg boron) by vegetable crops

Vegetable crops		Boron levels (kg ha^{-1})				
		0	0.5	1.0	1.5	2.0
Carrot	Net return	88322	99941	105588	103251	101218
	B;C ratio	1.61	1.76	1.85	1.79	1.74
	PAR	-	0.86	0.91	0.84	0.69
	BUE	-	554.0	417.0	250.3	170.2
Onion	Net return	92234	115794	122064	116434	109684
	B;C ratio	1.64	1.96	2.04	1.94	1.84
	PAR	-	1.24	1.46	1.10	0.85
	BUE	-	696.0	449.0	253.3	147.5
Cauliflower	Net return	106035	127431	142891	143656	137616
	B;C ratio	1.86	2.15	2.32	2.35	2.24
	PAR	-	3.85	4.34	3.95	3.13
	BUE	-	772.0	673.0	463.6	298.5

The boron use efficiency in various vegetable crops was affected by B levels (Table 3). The increasing levels of boron tended to decrease the boron use efficiency (kg produce / kg borax) over 0.5 kg B ha^{-1} (Solanki *et al.* 2018). Cauliflower responded more to boron with 772.0 kg fresh curd / kg boron applied than those of other vegetable crops. Better boron use efficiency was obtained with boron addition up to 0.5 kg B ha^{-1} recoding 554.0 kg in carrot root, 696.0 kg in onion bulb and 772.0 kg in cauliflower curd per kg boron application.

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