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Boron Uptake, Yield and Quality of Carrot (*Daucus carota* L.) In Response to Boron Application

Sadia Sultana[1], Atif Muhmood[1*], Syed Shahid Hussain Shah[1], Ifra Saleem[1], Abid Niaz[1], Zahid Ashfaq Ahmed[1] and Abdul Wakeel[1]

[1]Soil Chemistry Section, Institute of Soil Chemistry and Environmental Sciences (ISCES), Ayub Agricultural Research Institute (AARI), Faisalabad, Pakistan.

Authors' contributions

This work was carried out in collaboration between all authors. Author SS designed the study, performed the statistical analysis. Author AM wrote the protocol and wrote the first draft of the manuscript. Authors SSHS, IS and AN managed the analyses of the study. Authors ZAA and AW managed the literature searches. All authors read and approved the final manuscript.

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Short Communication

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ABSTRACT

Boron is directly or indirectly involved in the enhancement of quality and quantity of crops especially vegetables and fruits so this study was planned to assess the boron uptake, yield and quality of carrot in response to boron application at Institute of Soil Chemistry and Environmental Science, Ayub Agricultural Research Institute Faisalabad. The study was set up as randomized complete block design with three replications. Six treatments viz. Control (No fertilizer), recommended dose (RD) of Chemical fertilizers (CF), RD of CF + 0.5 kg B ha^{-1}, RD of CF + 0.75 kg B ha^{-1}, RD of CF + 1.0 kg B ha^{-1}, RD of CF + 1.25 kg B ha^{-1} were tested. The results depicted that the higher levels of boron i.e 1.0 and 1.25 kg ha^{-1} along with RD of CF resulted in higher yield (14 and 18% respectively), higher uptake (47.8 and 93.1 g ha^{-1} respectively) and caused reduction in carrot damage (42 and 39% respectively) in comparison with recommended dose of chemical fertilizers. The highest level of boron (1.25 kg B ha^{-1}) responded highest boron concentration (47.6 ppm) in

*Corresponding author: E-mail: atif_1534@yahoo.com;

carrot fruit and vice versa in control (19.1 ppm) where no boron application was practiced. The boron application is essential and crucial need of the hour along with chemical fertilizers for enhancing the quality and quantity of carrot and avoiding the soils to become boron deficient. In this perspective future research should be inclined on role of B in vegetable production with levels > 1.0 kg ha^{-1} under boron deficient soils.

Keywords: Boron; carrot; yield; chemical fertilizers; uptake.

1. INTRODUCTION

Vegetables are important source of minerals, vitamins and plant proteins in human diet. Carrot (*Daucus carota* L.) is the most economically important vegetable crop in the world, among the top-ten vegetables in terms of both area of production and market value [1]. Carrot is an essential root vegetable and best source of carotene; a precursor of vitamin A [2]. Minerals and nutrients are present in sufficient quantities in carrot [3]. Carrot is consumed uncooked in salads, steamed or boiled in vegetables, and may also be used in the preparation of soups and stews [4].

Macronutrients as well micronutrients are of primary importance in our agriculture system but due to illiteracy and unawareness of our farmers, they usually overlook the importance of applying micronutrients which are becoming deficient in our soils. Boron is one of those micronutrients which are rapidly becoming deficient in soils [5]. Boron (B) an important mineral nutrient because of the important role that it plays in physiological processes like carbohydrates metabolism, translocation and development of cell wall and RNA metabolism [6,7]. Boron has been found to play a vital role in pollen tube growth, pollen germination, plasma membrane stimulation, floret fertility, anther development and development of seed [8,9]. Reduction in leaf photosynthetic rate, plant height, number of reproductive structures during squaring and fruiting stage and dry matter production is caused by boron deficiency [10]. This study was planned to investigate the role of boron application in increasing boron uptake, carrot yield and quality.

2. MATERIALS AND METHODS

This study was conducted to investigate the effect of boron on yield and quality of carrot from 2012 to 2013 at Institute of Soil Chemistry and Environmental Sciences, Ayub Agriculture Research Institute, Faisalabad. The field where this trial was undertaken was low in available phosphorus, organic matter and boron contents while potassium was sufficient (Table 1). The texture of the field was sandy clay loam. The study was set up as randomized complete block design (RCBD) with three replications. Recommended dose of nitrogen, phosphorus and potassium (100 kg N + 65 kg P_2O_5 + 65 kg K_2O) were applied in all experimental units. Six treatments were used in the experiment viz: No fertilizer, Recommended dose (RD) of Chemical fertilizers (CF), RD of CF + 0.5 kg B ha^{-1}, RD of CF + 0.75 kg B ha^{-1}, RD of CF + 1.0 kg B ha^{-1}, RD of CF + 1.25 kg B ha^{-1}. Urea, Single Super Phosphate, Sulphate of Potash and H_3BO_3 were used as the sources of N, P, K and B. Full P, K and B were applied at the time of sowing where N was applied in two splits (half at sowing and half with first irrigation). Carrot seeds (cv. T-29) were sown on ridges in winter 2011. Row to row distance was maintained at 75 cm while plant to plant distance was 8 cm. All the recommended management practices were performed throughout the growth period of tested vegetables in the permanent layout. The carrot yield data of whole experimental plot (3.0 m × 7.5 m) was recorded and converted into standard unit i.e. t ha^{-1}.

2.1 Soil Sampling and Analysis

Five representative soil samples from the site were taken following diagonal technique from two depths (0-15 and 15-30 cm) before the start of experiment. The samples of each depth were mixed separately to form composite samples in order to investigate the initial fertility status of the soil. The collected soil samples were air dried, crushed and sieved through a 2 mm stainless steel sieve for physicochemical characteristics. Hydrometer method [11] was used for the measurement of soil particle distribution. For the determination of soil pH 250 g soil was saturated with distilled water and paste was allowed to stand for one hour. After that pH was recorded by pH meter (Jenway- 3510) with glass electrodes using buffer of pH 4.0 and 9.0 as standard [12]. Vacuum pump was used for the extraction of soil paste extract and ECe was measured with conductivity meter (Jenway-4510). Method described by Ryan et al. [13] was used for the estimation of soil organic carbon (SOC) content. Olsen's method [14] was used for available phosphorus determination and ammonium acetate (1 N of pH 7.0) extractable potassium [15] was estimated by flame photometer (PFP-7 Jenway. Soil Boron was analyzed by Dilute Hydrochloric Acid method [16]. 20 g soil, 0.2 g activated charcoal (B-free) and 20 ml 0.05 N HCl solution were taken in polypropylene tube, shake for five minutes and filter. Then boron was measured by colorimetry using Azomethine-H [17].

2.2 Plant Sampling and Analysis

The carrot root samples were taken at the time of harvesting. In laboratory the samples were washed to remove soil particles. Samples were washed, cut into small pieces, air dried, placed in oven at 70ºC for 24 hrs and then ground. Boron in carrot root samples was measured by dry ashing and subsequent measurement of B by colorimetry using Azomethine-H [17]. The uptake of boron by carrot was determined on dry weight basis using the relationship given in Majeed et al. [18]:

Boron uptake kg ha^{-1}

$$= \frac{\text{Boron contents (\%) in plant part}}{\text{yield}} \times 100$$

Yield data of whole plot (3.0 m × 7.5 m) was taken and the damage carrots (due to boron deficiency) were weighed separately to find the damage percentage. The data collected from the experiments regarding different parameters was subjected to analysis of variance to test the significance of treatments and treatment means were compared using least significant difference (LSD) [19].

3. RESULTS AND DISCUSSION

Results showed that carrot yield was greater in boron applied plot than non boron applied plot. Results further indicated that carrot yield increased with increasing boron dose though there had no significant differences among the boron doses. This treatment also improved the quality of carrot by lowering the damage percentage (10%) and enhancing 36.1 g ha^{-1} more extraction of boron from the soil compared with no fertilizer (0 NPK) treatment (Tables 3 and 4). This situation suggested that sole application of chemical fertilizers resulted in boron mining that ultimately caused boron deficiency in our soils which is increasing with the passage of time. This is the alarming situation from agricultural sustainability point of view. Along with chemical fertilizers four doses of boron (0.5, 0.75, 1.0 and 1.25 kg ha^{-1}) were tested to check the quality and quantity of carrot. It was indicated from the results that B @ 0.50 and 0.75 kg ha^{-1} had no significant role in yield and B uptake, however enhanced 7.10 and 14.6 g ha^{-1} more B uptake compared with recommended dose of chemical fertilizers. The higher levels of boron i.e 1.0 and 1.25 kg ha^{-1} resulted in higher yield (14 and 18% respectively), higher uptake (47.8 and 93.1 g ha^{-1} respectively) and caused reduction in carrot damage (42 and 39% respectively) in comparison with recommended dose of chemical fertilizers (Tables 2, 4 and 3).

Table 1. Basic soil analysis

Soil depth	pHs	EC_e	Av. P	Ext. K	B	OM	Textural class
Cm		dS m^{-1}		mg kg^{-1}		%	
0 - 15	7.20	2.10	7.50	240	0.21	0.69	Sandy clay loam
15 - 30	7.22	1.79	6.90	200	0.16	0.61	

Table 2. Effect of boron application on carrot yield (t ha^{-1})

Treatment	Carrot yield	Increase over control
	t ha^{-1}	%
No fertilizer	25.75 c	-
RD of chemical fertilizers (CF)	36.17 b	40
RD of CF + 0.50 kg B/ha	37.89 ab	47
RD of CF + 0.75 kg B/ha	38.46 ab	49
RD of CF + 1.0 kg B/ha	41.33 ab	61
RD of CF + 1.25 kg B/ha	42.62 a	66
LSD	5.35	

Table 3. Effect of boron application on carrot damage

Treatment	Damage carrot yield	Damage
	t ha^{-1}	%
No fertilizer	0.42 a	1.63
RD of chemical fertilizers (CF)	0.38 a	1.48
RD of CF + 0.50 kg B/ha	0.32 b	1.24
RD of CF + 0.75 kg B/ha	0.25 bc	0.97
RD of CF + 1.0 kg B/ha	0.22 c	0.82
RD of CF + 1.25 kg B/ha	0.21 c	0.85
LSD	0.06	

Table 4. Effect of boron application on boron concentration and uptake

Treatment	B concentration	B uptake
	ppm	g ha^{-1}
No fertilizer	19.1 e	48.9 e
RD of chemical fertilizers (CF)	26.1 d	85.0 d
RD of CF + 0.50 kg B/ha	27.0 cd	92.0 cd
RD of CF + 0.75 kg B/ha	28.7 c	99.6 c
RD of CF + 1.0 kg B/ha	35.7 b	132.8 b
RD of CF + 1.25 kg B/ha	47.6 a	178.1 a
LSD	2.41	11.4

This study suggested that 1.0 kg ha^{-1} is best for having optimum quality but the higher level (1.25 kg ha^{-1}) of boron showed tendency towards poor quality of carrot with non-significant increase in yield compared with B @ 1.0 kg ha^{-1}. Many scientists supported our findings by reporting that boron concentration in edible parts increased with the increase in boron application [20,21,22]. Similarly the other scientists working on boron reported increase in yield with B application [23,24], improvement in quality [24,25] and decrease in carrot damage [26,27].

4. CONCLUSION

The boron application is essential and crucial need of the hour along with chemical fertilizers for enhancing the quality and quantity of carrot and avoiding the soils to become boron deficient. In this perspective future research should be inclined on role of B in vegetable production with levels > 1.0 kg ha^{-1} under boron deficient soils.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Simon PW, Freeman RE, Vieira JV, Boiteux LS, Briard M, Nothnagel T, Michalik B, Kwon Y. Carrot. In: Handbook of plant breeding, (Eds) Prohens J, Nuez F. New York, NY: Springer. 2008;2: 327-357.
2. Zeb A, Mahmood S. Carotenoids contents from various sources and their potential health applications. Pak. J. Nutri. 2004; 3(3):199-204.
3. Nicolle C, Simon G, Rock E, Amouroux P, Remesy C. Genetic variability influences carotenoids, vitamin, phenolic and mineral content in white, yellow, purple, orange and dark orange cultivars. J. Am. Soc. Hort. Sci. 2004;129(4):523-529.
4. Anjum MA, Amjad M. Influence of mother root size and plant spacing on carrot seed production. J. Resou. Sci. 2002;13(2): 105- 112.
5. Tahir M, Tanveer A, Shah TH, Fiaz N, Wasaya A. Yield response of wheat (*Triticum aestivum* L.) to boron application at different growth stages. Pakistan Journal o Life and Social Sciences. 2009; 7(1):39–42.
6. Siddiky MA, Halder NK, Ahammad KU, Anam K, Rafiuddin M. Response of brinjal to zinc and boron fertilization. Int. J. Sustain. Agric. Technol. 2007;3:40–45.
7. Herrera-Rodriguez MB, Gonzalez-Fontes A, Rexach J, Camacho- Cristobal JJ, Maldonado JM, Navarro-Gochicao MT. Role of boron in vascular plants and response mechanism to boron stresses. Plant Stress. 2010;4:115–122.

8. Oosterhuis DM. Physiology and Nutrition of High Yielding Cotton in the USA. In Informacoes Agronomicas N-Setembro. 2001;18–24.
9. Wang Q, Longdou LU, Xiaoqin WU, Yiqin LI, Jinxing LIN. Boron influences pollen germination and pollen tube growth in *Picea meyeri*. Tree Physiol. 2003;23: 345-351.
10. Zhao D, Oosterhuis DM. Cotton growth and physiological responses to boron deficiency. J. Plant Nutr. 2003;26:855-867.
11. Blake GR, Hartge KH. Bulk density. In. Methods of Soil Analysis, Part 1: Physical and Mineralogical Methods. (Ed) Klute A. American Society of Agronomy, Madison, WI, USA; 1986.
12. Mclean EO. Soil pH and lime requirement. In: Methods of Soil Analysis and Part 2: Chemical and microbiological properties. (Eds) Page AL, Miller RH, Keeney DR. American Society of Agronomy. 9. Madison, WI, USA. 1982;199-209.
13. Ryan J, Estefan G, Rashid A. Soil and plant analysis laboratory manual. 2nd Ed. International Center for Agricultural Research in Dry Areas, Alleppo, Syria; 2001.
14. Jackson ML. Chemical composition of soil. In: Chemistry of Soil. (Ed). Bean EF. Van Notstrand Co., New York. 1962;71-144.
15. Rowell DL. Soil Science. Methods and Application. Longman Scientific & Technical, UK; 1994.
16. Rashid A, Rafique E, Bughio N. Micronutrient deficiencies in calcareous soils of Pakistan. III. Boron nutrition of sorghum. Commun. Soil Sci. Plant Anal. 1997;28:441–454.
17. Bingham FT. Boron. In Methods of soil analysis, Part 2: Chemical and mineralogical properties. (Ed) Page AL. Amer. Soc. Agron., Madison, WI, USA. 1982;431-448.
18. Majeed A, Muhmood A, Niaz A, Javid S, Ahmad ZA, Shah SSH, Shah AH. Bed planting of wheat (*Triticum aestivum* L.) improves nitrogen use efficiency and grain yield compared to flat planting. The Crop Journal. 2015;3:118-124.
19. Steel RGD, Torrie JH, Dickey DA. Principles and procedures of statistics. A biometrical approach. 3rd ed. McGraw Hill Book Co. New York, USA; 1997.
20. Furlani AMC, Carvalho CP, Freitas JG, Verdial MF. Wheat cultivar tolerance to boron deficiency and toxicity in nutrient solution. Scientia Agricola. 2003;60(2): 359–370.
21. Johnson SE, Lauren JG, Welch RM, Duxbury JM. A comparison of the effects of micronutrient, seed priming and soil fertilization on the mineral nutrition of chickpea (*Cicer arietinum* L.), lentil (*Lens culinaris*), rice (*Oryza sativa* L.) and wheat (*Triticum aestivum* L.) in Nepal. Experimental-Agriculture. 2005;41(4): 427–448.
22. Muhmood A, Javid S, Niaz A, Majeed A, Majeed T, Anwar M. Effect of boron on seed germination, seedling vigor and wheat yield. Soil Environ. 2014;33(1): 17–22.
23. Davies JM, Douglas CS, Nelson PV, Lengnick L, Sperry WI. Boron improves growth, quality and nutrient content of tomato. J. Amer. Sco. Hort. Sci. 2003; 128 (3):441-446.
24. Naz RMM, Muhammad S, Hamid A, Bibi F. Effect of boron on the flowering and fruiting of tomato. Sarhad Journal of Agriculture. 2012;28(1):32-45.
25. Downes GM, Ward JV, Turvey ND. Lignin distribution across tracheid cell walls of poorly lignified wood from deformed copper deficient *Pinus radiata* (D. Don). Wood Science Technology.1991;25:7–14.
26. Pilbeam DJ, Kirkby EA. The physiological role of boron in plants. J. Plant Nutr. 1983; 6:563-583.
27. Loomis WD, Durst RW. Chemistry, Biology of boron. Biofactors. 1992;3:229-239.

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