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EFFECT OF ZINC AND BORON FOLIAR SPRAY ON GROWTH, YIELD, QUALITY AND NUTRITIONAL VALUE OF BROCCOLI HEADS

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Abstract

The present study was carried out to compare different concentrations of zinc and boron foliar spary on broccoli in sandy soil opene field. Seven different treatments including control were used in Randomized Block design (RBD). In a field experiment, two concentrations of zinc and boron (100 and 200 ppm from each), mixture of zinc and boron and control were applied as foliar spary to test its effect on different parameters of broccoli plants cv. Centauro. Foliar spray of Mix_2 (mixzed zinc+ boron at 200 ppm from each) increased vegetative growth, physical quality and nutritional value of broccoli heads. This treatment achieved the highest primary, secondary and total head yields when compared to all other treatments. However, there were no significant differences between it and Mix_1 (mixed Zn+ B at 100 ppm from each).

Key words : Broccoli, zinc, boron, vegetative growth, physical quality, yield, nutritional value.

Introduction

Broccoli (*Brassica oleracea* var. *italic* plenck), crucifereae, is a widespread international vegetable crop. Its heads are rich with mineral sespecially K, S, P, Mg (Aboul-Nasr and Ragab, 2000), vitamin A, vitamin C, vitamin B_2, calcium and proteins (Decoteau, 2000; Aires, 2015). Also, it has been appointed as an anti-cancer source by American Cancer Society (Yoldas *et al*., 2008). Nutritional value, quality and yield of any crop are affected by many factors such as genotype (species, cultivar), soil fertility, soil structure and environmental conditions (Cartea *et al*., 2008). Plant fertilization is one of the most important factor affecting plant quality (Savci, 2012). The Agricultural practices such as fertilization can highly impact the levels of bioactive components in brassica (Samec *et al*., 2011 and Aires *et al*., 2015).

Low soil organic matter contents, nutrients deficiency and unreliable rainfall are problems threaten transplanting in sandy soils (Arisha and Bardisi, 1999; Stewart *et al*., 2005). Zinc and boron are microelements which required with small quantities play a vital role in plant growth and development (Mohsen *et al*., 2016). Zinc participates in IAA, chlorophyll, carbohydrate, protein and some enzyemes synthesis (Tisdale *et al*., 1985). Boron plays a vital role in cell division,sugar translocation, movement of growth regulators within the plant and lignin synthesis (Aparna and Puttaiah, 2012).

This work aims to study the effect of zinc and boron foliar with different concentrations on growth, yield, quality and nutritional value of broccoli heads.

Material and Methods

This study was carried out at the experimental station of the National Research Centre, Beheira Governorate (north of Egypt), during the two winter season of 2016/2017 and 2017/2018 to investigate the response of broccoli to defferent concentrations of foliar application of zinc and boron. Physical and chemical analysis of soil samples were executed according to Chapman and Pratt (1978) (table 1).

Transplanting

Seeds of broccoli (*Brassica oleracea* L. *varitalica* Plenk) hybrid Centauro (Takii Co., Japan) were sown in the nursery in foam trays on 5^{th} of October. Forty day-old seedlings were field transplanted, then healthy transplants 40 days age were selected. The area of the experimental plot was 16.8 m2 consisted of three rows; each row was 8 m length and 0.7 m width. Broccoli

Table 1 : Physical and chemical properties of the experimental soil.

Physical properties							
Sand		Clay	Silt	Texture	Field capacity %	Wilting point %	
90.08		9.26	0.66	Sandy	16.57	5.25	
Chemical analysis							
E.C.M/m	pH	Meq/L					
		Ca	Mg	Na	K	Hco_2	Cl
1.7	8.2	7.02	0.527	0.982	0.31	1.3	0.566

Table 2 : Effect of different zinc and boron concentrations on vegetative growth of broccoli plants during 2016/2017 and 2017/2018 seasons.

Treatment	Plant length(cm)		Leaves number/plant		Total plant F.w(g/ plant)		Total plant dry matter (%)	
	1st season	2nd Season	1st season	2nd Season	1st season	2nd Season	1st season	2nd Season
Control	48.33^{e}	46.67^{f}	13.33^{e}	13.67^{d}	674.27^{f}	775.00^{g}	15.12^{e}	13.49^{d}
Zn_1	57.67^{c}	60.00^{cd}	17.67^{b-d}	18.00^{b}	823.26^{de}	832.12^{e}	17.99^{cd}	18.88^{b}
Zn_2	61.00^{b}	61.33^{bc}	19.33^{ab}	19.00^{b}	952.83^{c}	937.85^{c}	19.72^{bc}	19.21^{b}
B_1	51.33^{d}	53.67^{e}	16.00^{d}	15.33^{c}	811.93^{e}	801.47^{f}	16.54^{de}	15.80^{c}
B_2	56.33^{c}	57.33^{d}	18.00^{bc}	18.33^{b}	873.90^{d}	902.01^{d}	18.76^{cd}	19.26^{b}
Mix_1	62.33^{b}	64.00^{b}	17.00^{cd}	19.33^{b}	1029.48^{b}	1015.25^{b}	21.64^{ab}	20.23^{b}
Mix_2	67.00^{a}	67.33^{a}	20.67^{a}	20.67^{a}	1173.28^{a}	1125.02^{a}	22.60^{a}	23.18^{a}

Values followed by the same letter (s) are not significantly different at 5%. Control, without micronutrients spary; Zn_1, Zn at 100 ppm; Zn_2, Zn at 200ppm; B_1, B at 100 ppm; B_2, B at 200 ppm; Mix1, Zn+ B at 100 ppm from each; Mix_2, Zn + B at 200 ppm from each.

transplants were sown 0.5 m apart on one side of the irrigation line, one seedling beside every irrigation eye. Ditches of 20 cm width and 20 cm depth were prepared besides every irrigation line. Organic fertilizers (compost was used as a nitrogen source), calcium super phosphate and agricultural sulphur at a rate of 100 Kg per fed were spread through the ditches and covered by sand. Drip irrigation lines were established over the ditches and soil was irrigated continuously three days before transplanting. Needed horticultural practices of growing broccoli were followed. Nitrogen source of mineral fertilizer (ammonium sulfate 21.5% N) at arate of 100 N units/fed. and potassium sulfate (48% K_2O) at a rate of 60 K_2O units/fed were applied through irrigation system allover the growing season and stopped two weeks before harvesting.

Ttreatments

Experimental plots were formulated in Randomized Block design (RBD) system with three replications. Zinc sulphate was used as a source for zinc, while boric acid was used as source for boron.

1. Control: Without micronutrients spary
2. Zn_1: Zinc at 100 ppm
3. Zn_2: Zinc at 200 ppm
4. B_1: Boron at 100 ppm
5. B_2: Boron at 200 ppm6- Mix_1: Zinc+ Boron at 100 ppm from each7- Mix_2: Zinc+ Boron at 200 ppm from each.

Foliar application was applied two times, first was one month after transplanting and the second application was 10-days later.

Measured parameters

Vegetative plant growth : A random sample of three plants were taken at 45 days after planting to measure plant length, number of leaves / plant, total plant fresh weight and dry matter.

Physical quality : Head height, head diameter, number of stalks /head, head fresh and dry weights were recorded.

Total heads yield : All broccoli heads of each plot were harvested at the green mature stage. Primary head yield (main yield of the apical heads), secondary heads yield (side heads yield), the sum was the total heads yield.

Chemical contents

Total nitrogen content was estimated by modified Kjeldahl's methods (Motsara and Roy, 2008). The percentages of phosphorus and potassium in the acid digested samples of broccoli dry heads were determined. Phosphorus was determined colorimetrically by NH4-

Metavanidate method (Motsara and Roy, 2008). Potassium was flame-photometrically estimated (Motsara and Roy, 2008). As well as the zinc was analyzed by atomic absorption according to the method described in the A.O.A.C. (2000).

Vitamin C contents: Vitamin C contents (mg/100 gmF.w) were determined in heads (fresh weigh basis) according to A.O.A.C. (1990). The content of total phenoles was determined using the Folin-Ciocalteau modified method (Chaovanalikit and Wrolstad, 2004). Total flavonoids content (TFC) of methanolic extracts of broccoli head samples was measured by aluminum chloride colorimetric assay according to Zhishen *et al.* (1999). Total pigments content of primary heads: The total chlorophyll and total carotenoids contents of the apical head tissues were determined in representative fresh heads samples according to Moran (1982). The obtained extracts were measured by spectrophotometer at the wave length of 663, 647 and 470 nm, using N,N-Dimethylformamide as a blank.

Statistical analysis

All data were subjected to statistical analysis using Mstatic (M.S.) software. The comparison among means of the different treatments was determined, as illustrated by Snedecor and Cochran (1982). Means of the treatments were compared by the Least Significant Differences Test at (0.05) level of significance.

Results and Disscussion

Effect of micronutrients

A) Vegetative growth : Data in table 2 indicte that all recorded vegetative growth parameters positively responded to micronutrients foliar spary in both seasons. The highest values of vegetative growth expressed as plant length, leaves number, total plant fresh weight and total plant dry matter were recorded by plants when supplied with Mix_2 (zinc+ boronat 200 ppm from each). However, the lowest values were recorded by control.

Vegetative growth enhancement may be due to dual effect of Zinc and boron which are essential for plant growth and have a well known effect on physiological activities. Zinc assist in formation of carbohydrate and chlorophyll. Additionally it helps in tryptophan synthesis which finally produce IAA (Zhi, *et al.*, 2005). Boron plays a role in carbohydrates translocation in plant and also stimulates the activation of certain hormones. These results come along with results obtained by Moniruzzaman *et al.* (2008) and Ain *et al.* (2016) on broccoli.

B) Physical quality and head yield : Data reported in table 3 indicate that plants supplied with Mix_2 (200

Table 3 : Effect of different zinc and boron concentrations on physical quality and yield of broccoli heads during 2016/2017 and 2017/2018 seasons.

Treatment	Head height (cm)		Head diameter (cm)		Number of stalks per head		Head fresh weight(g)		Head dry weight (g/100gm F.w)		Head yields (ton/feddan) Primary		Secondary		Total yields	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd Season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	15.33^{c}	15.67^{d}	13.33^{d}	14.67^{e}	12.67^{d}	11.67^{e}	389.70^{f}	238.90^{f}	10.45^{e}	10.17^{d}	2.23^{d}	2.57^{d}	0.32^{d}	0.41^{d}	2.55^{e}	2.98^{e}
Zn_1	16.67^{bc}	17.00^{cd}	16.67^{c}	17.33^{cd}	14.33^{c}	14.00^{bc}	580.48^{e}	408.01^{de}	14.65^{d}	14.08^{c}	3.30^{c}	4.07^{c}	1.31^{b}	1.53^{b}	4.61^{c}	5.60^{c}
Zn_2	19.00^{a}	19.33^{ab}	19.33^{b}	18.67^{bc}	15.33^{b}	15.67^{a}	715.77^{c}	528.72^{c}	15.93^{bc}	16.18^{b}	3.95^{b}	4.39^{bc}	1.38^{ab}	1.57^{ab}	5.33^{b}	5.96^{bc}
B_1	18.00^{ab}	18.33^{bc}	15.67^{c}	16.33^{de}	11.67^{e}	12.33^{de}	533.33^{e}	379.43^{e}	13.88^{d}	14.34^{c}	2.96^{c}	2.63^{d}	0.48^{cd}	0.93^{c}	3.45^{d}	3.55^{d}
B_2	19.33^{a}	19.33^{ab}	17.67^{bc}	18.00^{cd}	12.67^{d}	13.00^{cd}	642.39^{d}	488.14^{cd}	14.97^{cd}	15.94^{b}	3.05^{c}	2.96^{d}	0.68^{c}	1.07^{c}	3.73^{d}	4.03^{d}
Mix_1	16.00^{c}	17.67^{bc}	19.67^{ab}	20.33^{ab}	15.00^{bc}	15.00^{ab}	835.69^{b}	697.83^{b}	16.96^{b}	16.43^{b}	4.08^{ab}	4.80^{ab}	1.47^{ab}	1.62^{ab}	5.55^{ab}	6.43^{ab}
Mix_2	19.33^{a}	21.00^{a}	21.67^{a}	20.67^{a}	16.33^{a}	16.00^{a}	941.61^{a}	953.55^{a}	20.69^{a}	19.90^{a}	4.43^{a}	5.03^{a}	1.55^{a}	1.78^{a}	5.99^{a}	6.81^{a}

Values followed by the same letter (s) are not significantly different at 5%. Control, without micronutrients spary; Zn_1, Zn at 100 ppm; Zn_2, Zn at 200ppm; B_1, B at 100 ppm; B_2, B at 200 ppm; Mix_1, Zn+ B at 100 ppm from each; Mix_2, Zn + B at 200 ppm from each.

Table 4 : Effect of different zinc and boron concentrations on nutritional value of broccoli heads during 2016/2017 and 2017/2018 seasons.

Treatment	N (%)		P (%)		K (%)		Zn (ppm)		Vitamin C (mg/100gm F.w)		Total phenol (mg/gmD.w)		Total flavonoides (mg/gmD.w)		Total chlorophyll (mg/100gm F.w)		Total carote-noids (mg/ 100gm F.w.)	
	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season	1st season	2nd season
Control	1.97^{d}	2.25^{f}	1.32^{g}	1.32^{e}	2.39^{e}	2.25^{f}	21.13^{d}	21.30^{e}	56.87^{e}	58.27^{e}	7.34^{d}	7.55^{d}	5.25^{d}	5.27^{e}	4.17^{g}	5.64^{g}	3.64^{e}	3.69^{c}
Zn_1	3.74^{bc}	3.70^{cd}	2.65^{e}	2.40^{d}	3.19^{b}	3.50^{c}	28.67^{b}	27.83^{c}	69.13^{cd}	70.13^{cd}	9.53^{c}	9.57^{c}	7.18^{b}	6.90^{b}	6.05^{d}	7.57^{d}	4.00^{c}	3.97^{b}
Zn_2	3.77^{b}	3.80^{c}	3.59^{c}	3.46^{c}	2.74^{c}	3.73^{b}	30.07^{ab}	28.97^{bc}	75.45^{a-c}	75.20^{bc}	10.15^{c}	11.13^{a-c}	8.23^{a}	8.12^{a}	6.72^{c}	8.20^{c}	4.10^{b}	4.02^{b}
B_1	3.56^{c}	3.54^{e}	1.94^{f}	2.36^{d}	2.50^{de}	3.35^{e}	23.13^{c}	22.73^{de}	64.65^{d}	64.31^{d}	9.56^{c}	9.65^{c}	6.29^{c}	6.96^{b}	5.56^{f}	6.98^{f}	3.90^{d}	3.94^{b}
B_2	3.62^{bc}	3.63^{de}	3.37^{d}	3.42^{c}	2.53^{d}	3.39^{d}	23.47^{c}	23.30^{d}	73.65^{bc}	71.38^{bc}	10.49^{bc}	10.29^{bc}	7.17^{b}	7.80^{ab}	5.86^{e}	7.27^{e}	4.08^{bc}	4.01^{b}
Mix_1	4.27^{a}	4.24^{b}	4.15^{b}	3.95^{b}	3.28^{b}	3.73^{b}	31.40^{a}	29.97^{ab}	78.10^{ab}	76.81^{ab}	11.56^{ab}	11.74^{ab}	8.25^{a}	8.24^{a}	7.04^{b}	8.51^{b}	4.13^{ab}	4.02^{b}
Mix_2	4.39^{a}	4.39^{a}	4.47^{a}	4.58^{a}	3.53^{a}	3.81^{a}	31.70^{a}	31.33^{a}	82.64^{a}	81.95^{a}	12.36^{a}	11.94^{a}	8.37^{a}	8.45^{a}	7.22^{a}	8.70^{a}	4.20^{a}	4.15^{a}

Values followed by the same letter (s) are not significantly different at 5%. Control, without micronutrients spary; Zn_1, Zn at 100 ppm; Zn_2, Zn at 200ppm; B_1, B at 100 ppm; B_2, B at 200 ppm; Mix_1, Zn+ B at 100 ppm from each; Mix_2, Zn + B at 200 ppm from each.

ppm zinc plus 200 ppm boron) gave the highest head height, head diameter, number of stalks per head and head fresh and dry weights. In addition, primary, secondary and total yields in this treatment were not significantly different from the plants which treated with Mix_1(100 ppm Zn + 100 ppm B). However, the lowest values were recorded by control in both seasons.

The increase in quality and head yields by the application of Mix_2(200 ppm zinc+ 200 ppm boron) or Mix_1 (100 ppm zinc+ 100 ppm boron) may be attributed to the dual effect of zinc and boron on plant metabolism. Consequently, the plants were received the benefit of both elements at the same time. These results are in close conformity with the findings of Varghese and Duraisami (2005) and Zhao (2006).

C) Nutritional value of broccoli heads : It is clear from table 4 that nutritional value of broccoli heads *i.e.* nitrogen, phosphorus, potassium, zinc, vitamin C, phenol, flavonoid, total chlorophyll and total carotenoids content were significantly enhanced by zinc and boron application in both seasons. The highest values of the above mentioned parameters were obtained by plants that treated with Mix_2. There are no significant differences detected in zinc, vitamin C, phenol and flavonoid content in broccoli heads between the plants treated with Mix_2 or Mix_1.

The increase in mineral content (N, P K, Zn), vitamin C, phenol, flavonoid, total chlorophyll and total carotenoids content in broccoli heads by zinc+ boron application may be due to the effect of beneficial micronutrients that increased plant growth by improving plant metabolic activities. These results are in accordance with those obtained from Basavaraj (2013) on cauliflower.

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