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EFFECT OF ZINC AND BORON ON YIELD AND NUTRIENT CONTENT OF CORIANDER

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Abstract

Micronutrient deficiency, especially zinc and boron deficiency, commonly occurs in Bangladesh soils. Nevertheless, common diets of this country's people are often deficient in zinc. Thus, application of zinc and boron has significant value in enhancing crop yield as well as zinc and boron content in crop. With this understanding, field experiments were conducted in two consecutive seasons of 2018-19 and 2019-20 at Bangladesh Agricultural Research Institute (BARI) farm, Gazipur under the agroecological zone 28 (Madhupur Tract). Texturally the soil was sandy clay loam with 6.2 pH, 1.26% organic matter, 0.99 mg kg^{-1} zinc and 0.13 mg kg^{-1} boron content. Treatments consisted of a factorial arrangement of three levels of zinc (0, 2, 4 kg ha^{-1}) and three levels of boron (0, 1, 2 kg ha^{-1}) in a randomized complete block design (RCBD) with three replications. Combined application of Zn and B significantly increased the foliage and seed yield as well as their (zinc and boron) contents. On an average, among the treatment combinations, Zn_4B_1 produced the highest foliage yield (4.55 t ha^{-1}) and Zn_2B_2 gave the highest seed yield (1.99t ha^{-1}). The highest zinc and boron contents were found in Zn_4B_2 treatment for both foliage and seeds. Agronomic biofortification of zinc in coriander could be possible without reducing yield through the use of Zn_4B_1 treatment for foliage purpose and Zn_2B_2 for seed purpose.

Keywords: Biofortification, Zinc, Boron, Coriander, Capital foliage and Capital foliage yield.

Introduction

Coriander (*Coriandrum sativum* L.; Bengali Dhonia) is a popular spice, which belongs to the family Apiaceae and usually cultivated in winter (*rabi*) season in Bangladesh. This spice is mainly used as culinary and medicinal purposes. It is a multifunctional herb grown mainly for its foliage and seeds, but all parts of the plant such as leaves, flower, fruit and seed can be used as medicinal purpose. Coriander seed is useful in flatulence, indigestion, vomiting and other intestinal disorders and both leaves and seeds are greatly valued as food mainly for its high Vit. A and Vit. C contents (Nadeem *et al*., 2013).

Among the micronutrients, the zinc and boron deficiency has arisen in Bangladesh mainly due to continuous mining of soil nutrients for increased

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cropping intensity (198% at present) (BBS, 2020). Zinc deficiency not only causes lower yield, the dietary Zn deficiency in cereals and vegetables may lead to malnutrition and chronic health problems in human. Increasing nutrient content of vegetable tissues during their growth period is known as biofortification. Biofortification is a good mechanism for human nutrition (Marschner, 2011; and Jahiruddin, 2020). Exogenous application of Zn might be a useful option to recover Zn deficiency in coriander. On the other hand, boron is essential for seed production of crops as it plays a vital role in the physiological processes of plants, such as cell elongation, cell maturation, meristematic tissue development and protein synthesis (Mengel and Kirkby, 1982). It influences absorption of N, P, and K. Boron deficiency causes poor seed quality (Jahiruddin, 2011).

Coriander growing areas in Bangladesh covers 7377 acres with a total yield of 5487 M. ton (leaves) and in case of seed production the area covers 50049 acres with a total production of 19295 M. ton (BBS., 2019Both Zn and B have vital role on the yield and quality of coriander. In such situation bio-fortification is a good solution to meet the demand. However, information on the response of coriander to application of Zn and B fertilizers is lacking. Therefore, the present study was undertaken to see the response of coriander crops to Zn and B application.

Materials and Methods

Experimental site and soil

The experiment was set up at the experimental field of Bangladesh Agricultural Research Institute (BARI), Gazipur during *rabi* season of 2018-19 and 2019-20. The site belongs to AEZ 28 (Madhuput Tract). Initial soil properties were: texture – sandy clay loam, pH – 6.2, OM – 1.26%, total N – 0.07%, exchangeable K – 0.18 me%, available S – 20.6 mg kg^{-1}, available P – 4.65 mg kg^{-1}, available zinc – 0.99 mg kg^{-1} and available boron – 0.13 mg kg^{-1}.

Treatments

The experiment was laid out in randomized complete block design (RCBD) with five treatment combinations having three replications, the unit plot size being 1.5 m × 2 m. Treatment combinations were made with three levels of zinc: 0, 2, 4 kg ha^{-1} and three levels of boron: 0, 1, 2 kg ha^{-1}. A basal application was made with 5 t ha^{-1} cowdung, 83 kg ha^{-1} N, 26 kg ha^{-1} P, 55 kg ha^{-1} K and 13 kg ha^{-1} S to all plots to support normal plant growth. Zinc as zinc sulphate heptahydrate (ZnSo4. 7H2o) and boron as boric acid H_3Bo_3 were added to soil during final land preparation. The full amount of cowdung, P from TSP, K from MOP, S from gypsum and half of N from urea were applied during final land preparation. Rest of the N from urea was top dressed after 35 days of sowing.

Set up of experiment

The seeds of coriander (var. BARI Dhonia-1) were rubbed and soaked in water for 24 hours to enhance germination. Before sowing the seeds were treated with Bavistin at 2 g kg^{-1} and sown it at 30 cm apart rows continuously by hand at 25 kg ha^{-1}. Seeds were sown on 28 November in both years of 2018 and 2019. The soils of all plots were kept moist with light irrigation for quick germination. Necessary intercultural operations viz. irrigation, weeding etc. were done throughout the cropping period. For foliage record, green plants were harvested before bolting. Ten plants were selected randomly in each plot for recording data on plant height, number of leaves $plant^{-1}$, foliage yield etc. On the other hand, plants cultivated for seed yield were harvested when 50% seeds turned brown color. Five plants were selected randomly from each plot for recording data on plant height, number of umbells $plant^{-1}$, number of umbellates $plant^{-1}$ etc. Seeds were dried in an oven at 70°C for 72 hours and the dry samples were analyzed for chemical analysis.

Chemical analysis

For initial soil analysis, pH was measured by a combined glass calomel electrode (Jackson, 1962). Organic carbon determination was done by wet oxidation method (Walkley and Black, 1934) and Total N by modified Kjeldahl method. Element P was determined by $NaHCO_3$ extraction (Olsen method), K by NH_4OAc extraction method, S and B (boron) by $CaCl_2$ extraction method, and Zn and B were determined by DTPA extraction method. Vitamin C was determined by classical titration method using 2, 6- dichlorophenol indophenols solution and expressed as 100 mg g^{-1} of fresh weight (Miller, 1998). Total carotenoids (µg 100 g^{-1}) were measured by spectrophotometer (T-40, PG Instrument Ltd.UK) at 451ɳm (Alasalvar *et al.*, 2005).

Statistical analysis

All field and lab. data were statistically analyzed by statistical package STATISTIX-10 to examine the treatment effects and mean comparisons were done by Tukey HSD test at 5% level of significence.

Results and Discussion

Effect of zinc and boron on foliage yield of coriander

Different parameters were significantly influenced by the combined effects of different levels of zinc and boron (Table 1). The highest plant height (15.9 cm) was found in T_4 treatment which was significantly higher except T_3 treatment (15.4 cm). The highest single plant weight (2.60 g) was also recorded in T_4 treatment. The maximum number of leaves plant^{-1} (6.50) was noted in T_4 treatment which was statistically identical to T_3 (6.30) and T_5 (5.70 g). Significant variation was also noticed in foliage yield of coriander. The T_4 treatment recorded the highest foliage yield (455 g m^{-2} fresh yield and 74.3 g m^{-2} dry yield). The application of 1 kg B ha^{-1} coupled with 5 kg Zn ha^{-1} gave higher foliage yield in coriander (Tania *et al*., 2018).

Table 1. Foliage yield and yield attributes of coriander as influenced by the different zinc and boron levels (Pooled) years)

Treatments	Plant height (cm)	Single plant weight (g)	No. of leaves plant^{-1}	Foliage fresh yield (g m$^{-2)}$	Foliage dry yield (g m$^{-2)}$	Foliage yield (t ha$^{-1)}$
T_1 (Zn_0B_0)	12.7 b	1.4 c	4.8 b	236 c	38.9 d	2.36 c
T_2 (Zn_2B_1)	13.4 b	2.0 b	5.0 b	330 bc	54.0 c	3.30 bc
T_3 (Zn_2B_2)	15.4 a	2.5 a	6.3 a	369 ab	60.4 bc	3.69 ab
T_4 (Zn_4B_1)	15.9 a	2.6 a	6.5 a	455 a	74.3 a	4.55 a
T_5 (Zn_4B_2)	13.7 b	2.1 b	5.7 ab	392 ab	69.7 ab	3.92 ab
CV (%)	3.47	6.72	7.71	10.62	6.31	10.62

Means followed by same letter (s) in a column do not differ significantly at 5% level of significance by Tukey HSD test.

Effects of zinc and boron on seed yield of coriander

The combined effect of Zn and B had significant influence on the seed yield of coriander (Tables 2a and 2b). The highest plant height (82.2 cm),t number of primary and secondary branches plant^{-1} (4.2 and 10.7, respectively) were recorded in T_3 (Zn_2B_2) treatment. Similar trend was followed in case of umbels plant^{-1} (31.0).The maximum number of umbellates plant^{-1} (103) was in T_3 treatment which was statistically identical to T_4 (99.4) and T_2 (98.6) treatments. The T_2 (Zn_2B_1) treatment showed statistically the highest number of umbellates umbel^{-1} (3.59). Significant variation was recorded in seed yield and 1000-seed weight of coriander. Treatment T_3 exhibited the highest 1000- seed weight (5.25 g) and seed yield (1.70 t ha^{-1}). Kamrozzaman *et al*. (2016) also .recorded the maximum seed yield of coriander due to combined application of 2.2 kg Zn and 0.8 kg B ha^{-1}. Bepari *et al*. (2018) reported that application of 45 kg S ha^{-1} combined with 6 kg Zn ha^{-1} gave the maximum growth, seed yield and quality of coriander.

The results revealed that application of boron and zinc in all combinations positively influenced every plant parameter as compared with the control (No Zn or B applied). The result suggests that application of 4 kg Zn ha^{-1} + 1kg B ha^{-1} and 2 kg Zn ha^{-1} + 2 kg B ha^{-1} performed better in producing foliage and seed yields, respectively.

Table 2a. Plant height and yield attributes of coriander as influenced by zinc and boron levels (Pooled)

Treatments	Plant height (cm)	No. of primary branches plant^{-1}	No. of secondary branches plant^{-1}	No of umbels plant^{-1}	No. of umbellates plant^{-1}
T_1 (Zn_0B_0)	70.9 b	3.1 b	7.45 c	27.0 b	85.2 c
T_2 (Zn_2B_1)	73.9 b	3.8 ab	7.83 c	27.5 b	98.6 ab
T_3 (Zn_2B_2)	82.2 a	4.2 a	10.7 a	31 a	103 a
T_4 (Zn_4B_1)	81.3 a	4.0 a	9.8 ab	30.4 a	99.4 ab
T_5 (Zn_4B_2)	80.6 a	3.5 ab	8.57 bc	28.2 b	94.9 b
CV (%)	2.95	7.36	7.86	2.43	2.47

Means followed by same letter (s) in a column do not differ significantly at 5% level of significance by Turkey LSD test.

Table 2b. Seed yield and yield attributes of coriander (seed purpose) as influenced by zinc and boron levels (Pooled)

Treatments	No of umbellates umbel^{-1}	Seed yield (g m^{-2})	Seed yield (t ha^{-1})	1000- seed weight (g)
T_1 (Zn_0B_0)	3.16 c	129 d	1.29 d	3.99 c
T_2 (Zn_2B_1)	3.59 a	153 c	1.53 c	4.21 c
T_3 (Zn_2B_2)	3.33 b	199 a	1.99 a	5.25 a
T_4 (Zn_4B_1)	3.27 bc	170 b	1.70 b	5.03 ab
T_5 (Zn_4B_2)	3.37 b	185 a	1.85 a	4.40 bc
CV (%)	2	3.09	3.09	5.63

Means followed by same letter (s) in a column do not differ significantly at 5% level of significance by Turkey LSD test.

Vitamin C and β -Carotene content

Like many green leafy vegetables, coriander leaves are a rich source of vitamins (e.g. Vit. A and C) and minerals (e.g. iron). The highest Vit. C (121 mg 100 g^{-1}) and β -Carotene (5.2 mg 100 g^{-1}) were found in T_4 treatment (Table 3). β -carotene is a precursor of Vit. A. Chizoba (2015) reported that the green herbs contain vitamin C up to 160 mg100 g^{-1} and vitamin A up to 12 mg 100 g^{-1}.

Table 3. Quality character of coriander foliage as influenced by zinc and boron levels (Pooled)

Treatment	Vit. C (mg/100g)	β -Carotene (mg/100g)
T_1 (Zn_0B_0)	96	4.4
T_2 (Zn_2B_1)	108	4.8
T_3 (Zn_2B_2)	112	5.0
T_4 (Zn_4B_1)	121	5.2
T_5 (Zn_4B_2)	116	4.9

Table 4. Nutrient content of coriander leaves and seeds as influenced by the zinc and boron levels (Pooled)

Treatment	Coriander leaves			Coriander seeds		
	Zn conc. (ppm)	B conc. (ppm)	Increase in Zn concentration (%)	Zn conc. (ppm)	B conc. (ppm)	Increase in Zn concentration (%)
T_1 (Zn_0B_0)	61.4	22.5	-	69.4	27.3	-
T_2 (Zn_2B_1)	63.6	24.3	3.58	70.4	28.5	1.44
T_3 (Zn_2B_2)	64.8	25.5	5.54	70.7	30.8	1.87
T_4 (Zn_4B_1)	65.9	27.5	7.33	71.3	31.2	2.74
T_5 (Zn_4B_2)	66.4	30.2	8.14	71.6	31.8	3.17

Zinc and boron content of coriander leaves and seeds

Zinc and boron concentrations of coriander leaves ranged from 61.4 to 66.4 ppm and 22.5 to 30.2 ppm, respectively (Table 4). Treatment T_5 (Zn_4B_2) had the highest Zn and B concentrations and the T_1 (Zn_0B_0) control treatment lowest value. Similarly, treatment T_5 (Zn_4B_2) exhibited the highest Zn (71.6 ppm) and B (31.8 ppm) concentrations in coriander seeds, whereas control (Zn_0B_0) displayed the lowest values (69.4 ppm and 27.3 ppm, respectively). Zn concentration increased progressively with increasing rates of zinc application showing a range of 3.58% - 8.14% in case of coriander leaves and 1.44% - 3.17% in case of coriander seeds (Table 4). B concentration had increased up to 34.2% for coriander leaves and up to 16.5% for coriander seeds.

Conclusion

Application of zinc and boron enhanced the foliage and seed yields of coriander and positively influenced Zn and B enrichment and also Vit. C and β-carotene (precursor of Vit. A) contents. The results reveal that application of 4 kg Zn ha^{-1} + 1 kg B ha^{-1} significantly improved foliage yield whereas 2 kg Zn ha^{-1} + and 2 kg B ha^{-1} markedly increased seed yield of coriander. For Zn enrichment, coriander leaves and seeds Zn could be applied at 4 kg ha^{-1} along with boron at 2 kg ha^{-1}.

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