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Effect of foliar application of zinc and boron on growth and yield of Chilli (*Capsicum frutescens* L.)

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Abstract

The experimental trial was carried out to find the impact of foliar feeding of Zinc and Boron on flourishment and production of green chilli (*Capsicum frutescens* L.). Experiment was designed according to Randomized Complete Block Design (RCBD). Moreover, ten treatments and four replications were considered. Each treatment contained ten plants. Vegetative and reproductive of chilli hybrid cultivar BSS-410 were observed for data collection. Results revealed that maximum plant height (76.18cm), stem thickness (1.78cm), highest fruit weight (5.39g), maximum number of seeds per fruit (158.25), highest TSS value (10.63 Brix°) and highest pH value (5.68) was observed in T_9 while T_8 had maximum number of branches (36), maximum fruit pedicel length (3.17cm), highest value of fruit length (12.49cm), maximum fruit yield per plant (1113g), maximum fruit yield per hectare (51.15tons), highest value of 100 seeds weight (0.3250g), Hence, it was concluded that foliar application of Zinc and Boron @ $ZnSO_4$ + B_2O_3 (0.75 + 0.6g) per liter of water increased yield characters up to maximum and this dose can be recommended to farmers to get more yield and ultimately increase their profit.

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Introduction

Chilli (*Capsicum frutescens* L.) locally known as "Mirch" is a member of family Solanaceae, also known as nightshade family. Chilli has been originated in Mexico and is considered to be naturalized more than five times by ancient peoples in various regions of Southern, Central and Northern America (Kraft *et al.*, 2013). Species name "annuum" is a Latin word which means annual. Chilli plant is not annual but it is very sensitive to frost. It can live in multiple seasons and can grow up into a large perennial herb in the absence of winter frost (Katzer and Gernot, 2008). Hotness and pungency in chilli is because of different biochemical and antioxidant compounds found in it. The most prominent of these compounds is capsaicin which varies in quantity variety by variety. Chilli plants which face water stress produce very strong pods and concentration of capsaicin increases in these pods (Nancy *et al.*, 2008). Capsaicin produced in chilli fruit is actually a defensive weapon against mammals and microbial organism particularly fusarium fungus that attack on some species of peppers. Chilli enhances concentration of capsaicin to compensate the damage caused by fungus. However, birds cannot feel this pungency character of chilli (Tewksbury *et al.*, 2008). Capsaicin also protects chilli fruit from insect pests and molds. Moreover, man has been using this character for the treatment of different infectious disease as well as for preservation of food (Ziglio and D. Goncalyes, 2014).

Pakistan stands in top twenty countries of the world in term of green chilli production. While Pakistan holds 4th position in dry pepper production cultivated on an area of 65.1 thousand hectares with annual production of 148.13 thousand tons among pepper producing countries (Pakistan Economic Survey 2017-18).

Chilli fruit yield is not satisfactory in our homeland as in other chilli growing areas of the world. Irregular nutrients management is mainly responsible for low production because application of different nutrients in required amount is given no attention. Many production problems in chilli (*Capsicum frutescens* L.) are related to micronutrients deficiency (Bose and Tripathi, 1996). Micronutrients are needed in very little quantity but are very important for proper growth of plants (Mousavi, 2009). Less production of chilli (*Capsicum frutescens* L.) might also be because of insufficient amount of Zinc and Boron present in soil of chilli producing regions. It has been reported that yield of chilli (*Capsicum annuum* L.) is affected because of unavailability of required micronutrients in soil (Abdou *et al.*, 2011).

Like many other micronutrients Zinc and Boron are very important elements although required in very small quantity by plants for some specific and physiological functions performed by plants. Zinc is responsible for many enzymatic activities i.e. aldolase, peptidase, isomerase and phosphohydrolase etc. (Rawat and Mathpal, 1984). Zinc is involved in formation of protein. Zinc availability to plants is dependent upon weather conditions i.e. Zinc is more easily available to plants in less cold and release of Zinc decreases in cold weather (Mallick and Muthukrishnan, 1979). Zinc is very important immobile micronutrient for development and growth of plants. Most of the time calcareous, eroded and highly alkaline soils are deficient in Zinc. Zinc and Boron are responsible for enhancement of photosynthesis (Gupta, 1993). Zinc is also responsible for the synthesis of tryptophan which is involved in the formation of Indole Acetic Acid (Marschner, H. 1995).

Boron is also one of the important and sensitive micronutrients which is needed for proper growth and better development of plants. Requirement of different plant species and different soils for Boron is different. Boron management is very difficult as compared to other micronutrients because the optimum Boron addition range is very limited (Shol'nik, 1965; Haque *et al.*, 2011). Boron empowers pollen viability, absorption of ions and affects the metabolic process of different nutrients (Davis *et al.*, 2003). However, Boron is involved in water absorption and metabolism of carbohydrates (Steel *et al.*, 1997). Boron is also involved indirectly in the metabolism of nitrogen and phosphorus. Boron deficiency can cause small fruit size and sterility in plants. Degeneration of tissues and disintegration of cambium cells may also be due to deficiency of Boron (Agarwal, 2018).

In Pakistan, yield and quality of chilli is very low as compared to developed countries. Unbalanced nutrients application and unfair nutrient's application methods are mainly responsible for low production. Through foliar application, uptake of nutrients occurs rapidly and accurately. Keeping in view the needs of chilli producers and exporters this study was planned to provide some of the necessary information related to micronutrients requirement of chilli crop in order to maximize their production and profitability. By keeping this view present study was carried to find out the combined effect of Zinc and Boron on chilli plant applied through foliar spray.

Materials and methods

Research trial was conducted at Vegetable Research Area, Institute of Horticultural Sciences, University of Agriculture Faisalabad. Nursery of hybrid chilli cultivar BSS-410 was collected from Chuadhry Hakim Vegetable Nursery Farm, Sheikhupura. It was transplanted on 20th of November, 2017 on both sides of the beds. This is covered under low tunnel under harsh climate (Dec-Feb). Ten treatments with different doses of Zinc and Boron with four replications were implicated. Treatments were applied at the concentration of T_0 (control), T_1 ($ZnSO_4$, 0.5g/L of water), T_2 ($ZnSO_4$, 0.75g/L of water), T_3 ($ZnSO_4$, 1.0g/L of water), T_4 (B_2O_3, 0.4g/L of water), T_5 (B_2O_3, 0.6g/L of water), (T_6 B_2O_3, 0.8g/L of water), T_7, ($ZnSO_4$ + B_2O_3, 0.5 + 0.4g/L of water), T_8 ($ZnSO_4$ + B_2O_3, 0.75 + 0.6g/L of water) and T_9, ($ZnSO_4$ + B_2O_3, 1.0 + 0.8g/L of water). Three foliar sprays were done. Micronutrients were applied as foliar after 20 days' interval starting from 45 days after transplanting. Recommended doses of irrigations and fertilizers were given to the crop when required. Moreover, according to requirement standard plant protection measures were employed to keep insects and diseases controlled. When fruit got ready to harvest, they were picked with the interval of 3-4 days and other quality parameters were analyzed and recorded.

Experimental Design and Statistics

Research trial was accompanied by using Randomized Complete Block Design (RCBD) with four replications and each replication contains hundred plants while each treatment contains ten plants. Data was analyzed statistically using LSD test at 5% probability level (Steel *et al.,* 1997).

Results and discussion

Growth contributing traits of chilli

Plant height

Plant height (cm) represents the growth rate of hot pepper as it is one of the main growth contributing factors. The characteristic affiliated with this trait (plant height) are presented in given table 1 which denoted significant difference among plant height of all treatments. It was observed that treatment T_9 ($ZnSO_4$ + B_2O_3 @1.0 + 0.8g/L of water respectively) increased plant height up to 76.183cm which was maximum while control treatment T_0 produced plants with plant height of 57.847cm. Therefore, it was observed that there was a great variation among most of the treatments in term of plant height (cm) which would be very beneficial for vegetable growers. Hot pepper plants with more plant height (cm) produces more flowers; thus ultimately producing more yield per plant. Therefore, peasants growing pepper crop would apply dose of Zinc and Boron (T_9) which would increase plant height (cm) up to maximum. El-Mohsen *et al.* (2007) applied Zinc and Boron @ 1g/L on chilli crop in foliar form and found the increase in plant height and number of leaves per plant. Moreover, research findings of Baloch *et al.* (2008) in case of plant height supported to my results.

Number of branches per plant

The characteristic affiliated with this trait (branches per plant) are offered in given table 1. This denoted significant difference among number of branches per plant of all treatments. It was observed that treatment T_8 ($ZnSO_4$ + B_2O_3 @ 0.75 + 0.6g/L of water respectively) increased number of branches up to 36 branches per plant which was maximum while control treatment T_0 produced 19 branches per plant which was less than all treatments. Hence, it was observed that there was a great variation among most of the treatments in term of number of branches per plant which would be very beneficial for vegetable growers. Hot pepper plants with more branches produces more flowers; thus ultimately producing more yield per plant. It is remarkable to pronounce that obtained results are according to the findings of El-Mohsen *et al.* (2007) and Baloch *et al.* (2008).

Stem thickness (cm)

Plant stem one inch above soil surface was focused for calculation of stem thickness. Significant difference was observed in case of mean stem thickness of different treatments (Table 1). However, it was clearly revealed from the existing results that most of the treatments were found with more than 1.5cm stem thickness except one treatment was found with stem thickness less than 1.5cm. According to results, treatment T_9 produced plants with highest stem thickness of 1.78cm. Moreover, treatment T_0 produced plants with minimum stem thickness of 1.34cm in given experimental conditions. Furthermore, it was observed that there was a great variation among most of the treatments in term of stem thickness (cm) which would be very beneficial for vegetable growers. Hot pepper plants with more stem thickness (cm) carries more branches absorbing more nutrients; thus ultimately producing more yield per plant. Therefore, peasants growing pepper crop would apply dose of Zinc and Boron (T_9) which would increase stem thickness (cm) up to maximum. Jeyakumar and Balamohan (2007) applied Zinc in Zinc deficient soil and observed that Zinc deficiency in soil is responsible for plant stunted growth with less stem thickness and less number of leaves per plant. Moreover, it is interesting to describe that obtained results are according to research findings of Baloch *et al.* (2008).

Fruit length (cm)

Fruit length (cm) expresses marketability rate of hot pepper fruit as it is a main yield contributing factor. The consequences related to this trait (fruit length) are offered in given (Table 1) which described significant difference among fruit length of all treatments. It was observed that treatment T_8 produced pepper fruits with maximum fruit length of 12.49cm while treatment T_0 produced fruits with minimum fruit length of 7.82cm. Generally, it was found that three treatments produced fruits having length less than 10cm fruit length while remaining treatments produced fruits with fruit length greater than 10cm and less than 12.50cm. Shil *et al.* (2013) applied Zinc and Boron on chilli crop in addition to NPK application and observed increase in fruit length which interestingly supported to my results.

Fruit diameter (cm)

Center of fruit was focused for calculation of chilli fruit diameter. Significant difference was observed in case of mean fruit diameter (center) of different treatments (Table 1). However, it was clearly revealed from the existing results that most of the treatments were found with more than 1.2cm fruit diameter (center) except two treatments (T_4 & T_0) was found with fruit diameter less than 1.2cm. According to results, treatment T_3 produced the fruits with highest fruit diameter of 1.45cm. Moreover, treatment T_0 produced fruits with minimum fruit diameter of 1.03cm in given experimental conditions. Hot pepper plants with more fruit diameter (cm) produces more weighed fruits; thus ultimately producing more yield per plant. Shil *et al.* (2013) applied Zinc and Boron on chilli crop in addition to NPK application and observed increase in fruit length which interestingly supported to my findings.

Fruit firmness (lb)

Results showed that maximum value of fruit firmness obtained was 8.12 lb while minimum value obtained was 6.17 lb while treatment T_3 gave minimum fruit firmness value of 6.17 lb under given climatic conditions (Table 1). Hot pepper plants with high fruit firmness (lb) produces fruits which can afford more injury stress during transportation and storage; thus ultimately reducing transportation and storage losses. Research findings of Agarwal (2018) are similar to my findings in term of fruit firmness.

Fruit pedicel length (cm)

Results showed that maximum pedicel length was recorded 3.17cm in treatment T_8 while minimum level of pedicel length was observed 2.83cm in control treatment (Table 1). On general basis it was estimated that seven treatments showed pedicel length more than 3.0cm while remaining treatments had pedicel length less than 3.0cm.

However, treatment T_8 exhibited highest value 3.17cm of pedicel length and control treatment T_0 was recorded to have minimum pedicel length (2.83cm). However, it is concluded that our results for fruit pedicel length resembles with the results of El-Awad *et al.* (2010).

Yield contributing traits of chilli

Fruit weight (g)

Results showed that maximum fruit weight was recorded 5.39g while minimum fruit weight was observed 3.24g (Table 2). Generally, it was estimated that fruit weight of only two treatments (T_0 & T_1) was found less than 4g while remaining cultivars produced fruits with fruit weight more than 4g. However, treatment T_9 produced fruits with highest fruit weight of 5.39g while treatment T_0 produced fruits with minimum fruit weight of 3.24g under the climatic conditions of Faisalabad, Punjab. Hot pepper plants with more fruit weight (cm) produces more yield per plant; thus ultimately producing more yield per hectare. Our findings are in accordance with the findings of Shil *et al.* (2013).

Fruit yield per plant (g)

Average fruit yield (g) data were significantly analyzed. Significant variability was observed for this trait (fruit yield) among all the treatments. Results showed that maximum fruit yield obtained was 1113g while minimum fruit yield obtained was 826.25g (Table 2). However, treatment T_8 gave maximum fruit yield of 1113g while treatment T_0 gave minimum fruit yield of 826.25g under these climatic conditions. Therefore, peasants growing pepper crop would apply dose of Zinc and Boron (T_8) which would increase fruit yield (g) up to maximum. Shil *et al.* (2013); Naga-Sivaiah *et al.* (2013); Manna (2013) and Ali *et al.* (2015) observed increase in fruit yield per plant with the application of Zinc and Boron on chilli crop. Hence, their findings added a support in my results obtained for this trait.

Fruit Yield/ Hectare (tons)

Results showed that maximum fruit yield per hectare obtained were 51.15 tons while minimum fruit yield obtained was 36.52 tons (Table 2). Hence, it was estimated that fruit yield of seven treatments was found more than 40 tons per hectare while remaining treatments produced fruits with fruit yield less than 40 tons per hectare. However, treatment T_8 gave maximum fruit yield of 51.15 tons per hectare while treatment T_0 gave minimum fruit yield of 36.52 tons per hectare under given climatic conditions. It is interesting to add that obtained results are according to the findings of Shil *et al.* (2013); Naga-Sivaiah *et al.* (2013); Manna (2013) and Ali *et al.* (2015).

Number of Seeds per Fruit

Average number of seeds per fruit data was significantly analyzed. Significant variability was observed for this trait (number of seeds) among all the treatments Results showed that maximum number of seeds per fruit obtained were 158.25 while minimum number of seeds per fruit obtained was 103.25 (Table 2). On general basis it was estimated that number of seeds of seven treatments was found more than 120 seeds per fruit while remaining treatments produced fruits with number of seeds less than 120 seeds per fruit. However, treatment T_9 gave highest number of seeds 158.25 per fruit while treatment T_0 gave minimum number of seeds 103.25 seeds per fruit under given climatic conditions. Natesh *et al.* (2005) applied 0.1% dose of Zinc and Boron on chilli crop and observed a tremendous increase in seeds per fruit. Hence their findings are according to findings of my trial. Sultana *et al.* (2016) results related to this trial also resembles to my findings.

100 Seeds Weight (g)

Results showed that maximum 100 seeds weight obtained was 0.325g while minimum 100 seeds weight obtained was 0.237g (Table 2). On general basis it was estimated that seed weight of only three treatments was found more than 0.300g while remaining treatments produced seeds with 100 seeds weight less than 0.300g. However, treatment T_8 gave highest seed weight of 0.325g while treatment T_0 gave minimum seed weight of 0.237g under given climatic conditions. It is remarkable to pronounce that obtained results are according to the findings of Natesh *et al.* (2005) and Sultana *et al.* (2016).

Table 1. Growth contributing traits of Chilli affected by Zinc and Boron.

Treatments	Plant height (cm)	No. of branches/ plant	Stem thickness (cm)	Fruit length (cm)	Fruit diameter (cm)	Fruit firmness (Ib)	Fruit pedicel length (cm)
Control	57.84d	19.00g	1.34d	7.82e	1.03d	8.12a	2.83d
$ZnSO_4$ (0.5)g	63.53d	19.00g	1.54c	9.84d	1.22bc	7.92abc	2.95c
$ZnSO_4$(0.75)g	67.95c	21.75f	1.62bc	11.07bcd	1.21bc	6.75cd	3.06b
$ZnSO_4$ (1.0)g	72.87b	23.50ef	1.64bc	11.39abc	1.45bc	6.17d	3.16ab
B_2O_3 (0.4)g	62.84d	24.25de	1.52c	10.67cd	1.10cd	6.30cd	2.92cd
B_2O_3 (0.6)g	64.88d	26.25d	1.58bc	10.57cd	1.31ab	8.00ab	3.12bc
B_2O_3 (0.8)g	68.43c	31.75bc	1.60bc	12.41a	1.44a	7.85bc	3.13ab
$ZnSO_4$ +B_2O_3 (0.5 + 0.4) g	69.90c	30.75c	1.59bc	11.36abc	1.42ab	8.02bc	3.13ab
$ZnSO_4$ +B_2O_3 (0.75 + 0.6)g	73.75b	36.00a	1.71ab	12.49a	1.28ab	7.75b	3.17a
$ZnSO_4$ +B_2O_3 (1.0 + 0.8)g	76.18a	33.50b	1.78a	12.16ab	1.32ab	6.35cd	3.13ab

Table 2. Yield contributing traits of Chilli affected by Zinc and Boron.

Treatments	Fruit weight (g)	Fruit yield/plant (g)	Fruit yield/hectare (tons)	Number of seeds/fruit	100-seeds weight (g)
Control	3.24d	826.5f	36.52f	103.25f	0.2375f
$ZnSO_4$ (0.5)g	3.32dc	834ef	39.14e	115.75ef	0.2525ef
$ZnSO_4$(0.75)g	4.05cd	981.5de	43.59de	118.00e	0.2700de
$ZnSO_4$ (1.0)g	5.12ab	992.5cd	44.95bcd	143.75bc	0.2850d
B_2O_3 (0.4) g	4.39bc	1028cd	46.39bc	127.25de	0.2500ef
B_2O_3 (0.6) g	4.64abc	1054.5abc	44.96cd	141.50bcd	0.2950cd
B_2O_3 (0.8) g	4.99ab	1.42.5bcd	46.80bc	147.25bc	0.2825d
$ZnSO_4$+B_2O_3 (0.5 + 0.4) g	4.58bc	1046bc	48.79abc	138.75bcd	0.3000abc
$ZnSO_4$+B_2O_3 (0.75 + 0.6) g	4.99abc	11131a	51.15a	151.75ab	0.3250ab
$ZnSO_4$+B_2O_3 (1.0 + 0.8)g	5.39a	1095ab	50.33ab	158.25a	0.3100a

Conclusion

It is concluded that foliar application of Zinc and Boron @ $ZnSO_4$ + B_2O_3 (0.75 + 0.6g) per liter of water increased growth and yield characters up to maximum and this dose can be recommended to farmers to get more yield and ultimately increase their profit.

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