Influence of Foliar Application of Boron and Copper on Growth and Yield of Tomato (*Solanum lycopersicum* L. cv 'Thilina')

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Abstract

An experiment was conducted at the Crop farm, Eastern University, Sri Lanka during the period of December 2013 to April 2014 to find out the response of foliar application of H_3BO_3 and $CuSO_4$ on growth and yield of tomato. Treatments were arranged in Completely Randomized Design (CRD) and replicated eight (8) times. There were 10 treatments namely, (T_1) H_3BO_3 =150 ppm; (T_2) H_3BO_3 = 250 ppm; (T_3) H_3BO_3= 350 ppm; (T_4) $CuSO_4$= 150 ppm; (T_5) $CuSO_4$= 250 ppm; (T_6) $CuSO_4$= 350 ppm; (T_7) H_3BO_3 (150 ppm) + $CuSO_4$(150 ppm); (T_8) H_3BO_3 (250 ppm) + $CuSO_4$ (250 ppm); (T_9) H_3BO_3 (350 ppm) + $CuSO_4$(350 ppm); (T_{10}) Control. The foliar applications were done thrice at 10-days intervals starting from 40 days after transplanting. Seedlings were raised in the nursery and transplanted in polybags (30cm x 45cm x 30 cm) 30 days after planting. The seedlings were raised following the recommendations developed by the Department of Agriculture, Sri Lanka. Potting media was prepared by mixing sand: top soil: decomposed cow dung at 1:1:1 ratio. The results showed that foliar application of $CuSO_4$ at 150 and 250 ppm increased the plant height, and H_3BO_3 at 250 ppm and combined application of H_3BO_3 (250 ppm) + $CuSO_4$ (250 ppm) increased the number of leaves/plant than control, respectively. Application of $CuSO_4$ at 250 and 350 ppm and combined application of H_3BO_3 (250 ppm) + $CuSO_4$ (250 ppm) produced the highest length of roots than that of control whereas application of H_3BO_3 at 150 and 250 ppm recorded the highest fruit yield compared to control on a dry basis and H_3BO_3 at 350 ppm increased the number of fruits. In all parameters tested, the poor performance was recorded in the control treatment.

Key words: *Boron, Copper, Foliar application, Solanum lycopersicum*

Introduction

Tomato (*Solanum lycopersicum* L.) is one of the important vegetable crops grown in the Batticaloa district of Sri Lanka. It is cultivated in an extent of 183 ha with the production of around 2.8 metric tons (Anonymous, 2012). Tomatoes are rich in vitamin C (40%), vitamin A (15%) and potassium 8% (Bhowmik *et al*., 2012). The red pigment in the tomato is known as ''lycopene'', is an antioxidant and neutralizing free radicals that can damage cells in the body (Bhowmik *et al*., 2012). The crop is cultivated in both the seasons, but the yields are extremely poor in the *Yala* season due to high temperatures. Plants also remove substantial amount of micronutrients from the soil (Beede *et al*., 1991). Therefore, additional application of nutrients is inevitable to boost the fruit yield. Foliar application of micronutrients is one of the easiest ways of access nutrients by plants. Studies have shown that application of micronutrients increased the productivity of the tomato and thereby improve the income of the growers (Alam and Raza, 2001).

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Boron is an important element and involved in division of cell, development of leaf and flower bud, glucose metabolism and hydrocarbons and their transport, growth of root, formation of cell wall and material transportation between cells in plants (Moghadam *et al.*, 2012). It also improves flower production and retention, pollen tube elongation and germination, and seed and fruit development. (Hanson, 1991). Application of boron increased growth and yield in plants (Ali *et al.*, 2009). Dutta *et al.* (2000) reported that the foliar application of B as boric acid improved fruit set and fruit weight over control in Litchi fruit. Copper is a vital micronutrient for plant growth and development and detrimental to photosynthetic membranes (Maksymiec, 1997). It is needed in small quantities and lack of copper leads to reduction in yield while excess copper inhibits various physiological functions (Monnet *et al.*, 2001). It is an important for many functions in plants such as photosynthesis, respiration, CO_2 assimilation, ATP synthesis and nitrogen metabolism (Demirevska-Kepova *et al.*, 2004, Guo *et al.*, 2010) and disease resistance (Tomazela *et al.*, 2006). The plant absorbs copper from soil and transports to the shoot depend on the ability of plants to transfer this metal across the soil-root interface and to the total amount of Cu present in the soil (Agata and Ernest 1998, Baker and proctor 1990). Application of Copper at 0.4% of concentration significantly increased terminal shoot length, the number of leaves and leaf area of guava (Singh and Singh, 2002). However, information is not readily available on the influence of foliar application of boron and copper on growth and yield of tomato. Therefore, the present study was conducted in order to find out the effect of boron and copper on the growth and yield of tomato.

Materials and Methods

The experiment was carried out at the Crop Farm of the Eastern University, Sri Lanka during the period December 2013 to April 2014. It falls into the DL_2 agro-ecological region of the LCDZ (Low Country Dry Zone) in Sri Lanka. Treatments were arranged in Complete Randomized Design (CRD) replicated eight (8) times. There were 10 treatments (Table 1). Boron was applied as H_3BO_3 and Copper was applied as $CuSO_4$.

Table 1: Treatments

Treatments	H_3BO_3 (ppm)			$CuSO_4$ (ppm)		
	150	250	350	150	250	350
T_1	x					
T_2		x				
T_3			x			
T_4				x		
T_5					x	
T_6						x
T_7	x			x		
T_8		x			x	
T_9			x			x
T_{10}	Control					

The foliar applications were done thrice at 10 days intervals starting from 40 days after transplanting (DAT). Seedlings were raised in the nursery and transplanted into polybags at 30 days after planting. Potting media was prepared by mixing equal parts of sand: red soil: rotted cow dung. The parameters viz. plant height, number of leaves per plant, length of roots, dry weight of fruits per plant, and number of fruits per plant were measured. Data were statistically analysed using SAS 9.1 and means were separated using Least Significant Difference test at 5% significant level.

Results and Discussion

Plant height

According to the analysis, significant ($P<0.05$) differences were observed in plant height among different foliar nutrient treatments (Table 1). At harvest, highest plant height was achieved in 350 ppm of $CuSO_4$ followed by combined application of H_3BO_3 (150 ppm) + $CuSO_4$ (150 ppm) treatments (Table 1) and control. The increment in height by the application of H_3BO_3 at 150, 250 and 350 ppm was 1.43%, 1.31%, 1.27% respectively while $CuSO_4$ at 150, 250 and 350 ppm was 1.54%, 1.33% and 1.67% respectively compared to the control treatment. It was clear that the foliar application of $CuSO_4$ at 150, 250 and 350ppm increased the height of tomato plants. The trend was almost the same with all four sampling (Figure 1).

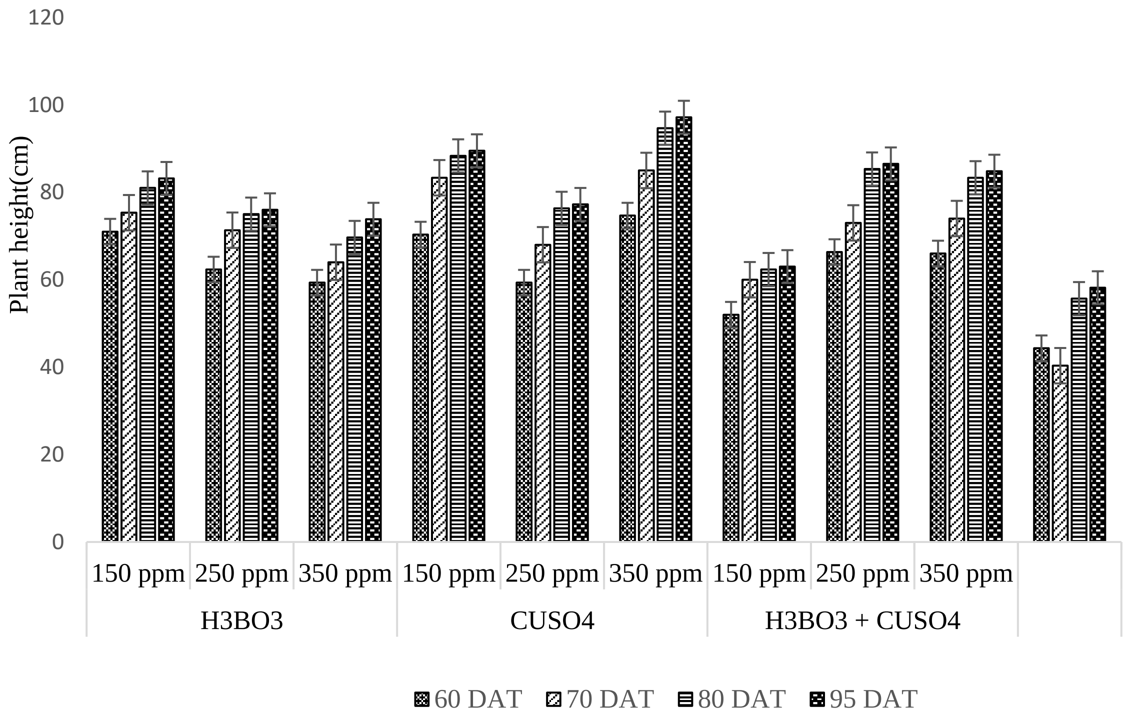

Figure 1. Effect of foliar application of H_3BO_3 and $CuSO_4$ on plant height

Tittonell *et al*. (2005) documented that the parameter which is used for evaluating the crop performance is the plant height. It is clear from this study that the foliar application of $CuSO_4$ and H_3BO_3 increased the height of tomato plants (Figure 1). This might be due to the fact that the accumulation of photosynthates and that in turn increased dry matter in plants and resulted in increased height. There is no evidence to support this response of $CuSO_4$ and the combined application of H_3BO_3 + $CuSO_4$. El-Mahdy (2007) reported that foliar application of B at the rate of 75 ppm increased plant height in pepper which was half the rate of B tested in this experiment.

Number of leaves/plant

At harvest, maximum ($P<0.001$) number of leaves/plant was observed at H_3BO_3 - 250 ppm and H_3BO_3 (250 ppm) + CuSO4 (250 ppm), followed by H_3BO_3 (150 ppm) +Cu (150 ppm) (Table 2). The minimum number of leaves/ plant was recorded at control treatment while all the other treatment did not show any difference. Hence, the application of B at 250 ppm increased the number of leaves/plant by 3.13% and combined application of H_3BO_3 (150 ppm) + $CuSO_4$ (150 ppm) and H_3BO_3 (350 ppm) + $CuSO_4$ (350 ppm) increased the number of leaves /plant by 2.05% and 2.15%, respectively than that of control. Oyinlola and Chude (2004) recorded higher number of leaves at 2 kg B ha^{-1} in the tomato cultivars of Roma VF while Singh and Sing (2002) reported that copper at 0.4% significantly increased the number of leaves in guava.

Length of roots

Table 2. Effect of foliar application of H_3BO_3 and $CuSO_4$ on length of root and number of leaves/plant

Treatment	Length of roots/ plant	Number of leaves/ plant
T_1-H_3BO_3 (150 ppm)	37.67^{ab}	99.33^{d}
T_2-H_3BO_3 (250 ppm)	47.80^{ab}	173.00^{a}
T_3-H3BO3 (350 ppm)	46.57^{ab}	105.00^{d}
T_4-$CuSO_4$ (150 ppm)	41.67^{ab}	94.00^{d}
T_5-CuSO4 (250 ppm)	48.43^{a}	142.33^{abc}
T_6-CuSO4 (350 ppm)	53.67^{a}	147.67^{ab}
T_7-H_3BO_3 (150 ppm)+$CuSO_4$ (150 ppm)	45.67^{ab}	113.00^{cd}
T_8-H_3BO_3 (250 ppm)+$CuSO_4$ (250 ppm)	50.33^{a}	165.67^{a}
T_9-H_3BO_3 (350 ppm)+$CuSO_4$ (350 ppm)	40.00^{ab}	119.67^{bcd}
T_{10}-Control	30.83^{b}	55.33^{e}
F test	*	*

*$P<0.05$; NS – not significant;

**Means followed by the same letter in each column are not significantly different to Least significant different at 5% level*

At harvest, maximum length of roots was observed in plants treated with $CuSO_4$ at 250 ppm and 150 ppm, and combined application of H_3BO_3 (250 ppm) +$CuSO_4$ (250 ppm) while the lowest length of roots was observed in control (Table 2). Therefore, $CuSO_4$ is responsible for increment of root length.

Dry weight of fruits/plant

Foliar application of boron, copper and its combination increased dry weight of fruits/plant (g). Foliar application of H_3BO_3 at 150 and 250 ppm significantly increased the tomato yield than that of $CuSO_4$ at 150 ppm and350 ppm, and control (Table 3). Application of H_3BO_3 at 150 and 250 ppm recorded 7.32% and 7.14% yield increment over the control, respectively. Lowest dry weight of fruits was observed in the control treatment (Table 3). This might be due to the fact that foliar application of boron enhanced pollen tube germination and grain setting and contribution of hormonal metabolism, increase in division and expansion of the cell.

Table 3. Effect of foliar application of H_3BO_3 and $CuSO_4$ on dry weight of fruits

Treatment	Dry weight of fruits/plant (g)
T_1-H_3BO_3 (150 ppm)	196.97 ^{a}
T_2-H_3BO_3 (250 ppm)	194.00 ^{a}
T_3-H_3BO3 (350 ppm)	173.92^{ab}
T_4-$CuSO_4$ (150 ppm)	85.53^{abc}
T_5-CuSO4 (250 ppm)	101.36^{abc}
T_6-CuSO4 (350 ppm)	58.80^{bc}
T_7-H_3BO_3 (150 ppm)+$CuSO_4$ (150 ppm)	111.63^{abc}
T_8-H_3BO_3 (250 ppm)+$CuSO_4$ (250 ppm)	113.48^{abc}
T_9-H_3BO_3 (350 ppm)+$CuSO_4$ (350 ppm)	62.08^{bc}
T_{10}-Control	27.18 ^{c}
F test	*

*P<0.05; NS – not significant;

**Means followed by the same letter in each column are not significantly different to Least significant different at 5% level.*

These results are in accordance with the Moeinian *et al*. (2011) who reported that boron application has a key role in plant metabolism, root growth will increase, hence better use of nitrogen and synthesis of more carbohydrates and proteins and plants use water more efficiently. Yadav *et al.* (2006) recorded that the greatest fruit weight with 0.10% boron (1000 ppm) which is four to six and a half (4-6.5) times higher than the concentrations used in this experiment.

Number of fruits/plant

Number of fruits/plant increased with time and reached its maximum at 80 DAT, and declines thereafter. At 70 DAT, highest number of fruits/plant was obtained with H_3BO_3 (350 ppm) followed by $CuSO_4$ (150 ppm) and Control. At 80 DAT, maximum number of fruits/plant was recorded in H_3BO_3 (350 ppm) and the minimum number was observed in the Control. At 95 DAT, the highest number of fruits/plant was achieved in H_3BO_3 (350 ppm) and in line with other treatments except $CuSO_4$ (350 ppm), combined application of H_3BO_3 (350 ppm) + $CuSO_4$ (350 ppm) and the control.
Higher number of fruits due to the application of boron might be due to the fact that boron encourages flower production and retention, pollen tube elongation and germination, and seed and fruit development. Oyewole and Aduayi (1992) documented that application of B at 2 ppm increased the number of leaves and number of flowers. Increase in these two factors might have caused to increase the number of fruits in tomato.

Significant heightening in fruit weight by the application of borax has also been reported by Dutta *et al*. 2004; Brahamchari *et al*. 1997 and Stino *et al*. 2011 in litchi and in mango cv. Himsagar (Dutta *et al*., 2000). The increase in fruit weight with the sprays of borax might be due to the contribution in hormonal metabolism, increase in cell division and expansion of cell (Babu and Singh, 2001). Beneficial effect of Cu on yield of annual crops has been reported by Singh *et al.* (2001). Khurshid *et al*. (2008) who reported that foliar application of Cu to orange trees, significantly increased fruit yield/ tree and fruit weight compared to the untreated trees while Fageria (2002) also observed that application of Cu increased yield of upland rice and common bean.

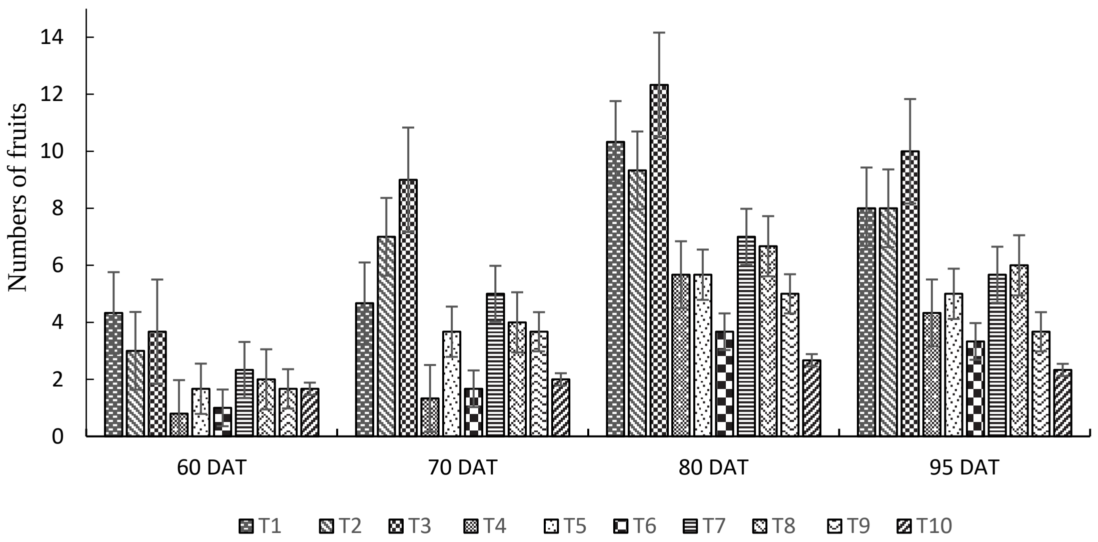

Figure 2: Effect of foliar application of H_3BO_3 and $CuSO_4$ on Number of fruits/plant

Conclusions

The results showed that foliar application of boron and copper had positive effects on the plant height, the number of leaves/plant, the length of roots and dry weight of fruits. However, application of $CuSO_4$ at 150 and 250 ppm increased the plant height, and $CuSO_4$ at 250 ppm and combined application of H_3BO_3 (250 ppm) + $CuSO_4$ (250 ppm) increased the plant height and the number of leaves/plant than control, respectively. Application of $CuSO_4$ at 250 and 350 ppm and combined application of H_3BO_3 (250 ppm) + $CuSO_4$ (250 ppm) produced the highest length of roots than that of control whereas application of H_3BO_3 at 150 and 250 ppm recorded the highest fruit yield and H_3BO_3 at 350 ppm increased the number of fruits compared to control in tomato cv. Thilina. It is concluded that application of H_3BO_3 at 150 and 250 ppm alone and combined application of H_3BO_3 (250 ppm) and $CuSO_4$ (250 ppm) at 10 days interval starting from 40 days after planting would increase the yield by 7.3% and 7.2% respectively.

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