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Effect of foliar application of Boron and Magnesium on growth and yield of green chilli (*Capsicum annum* L.)

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Abstract

An experiment was conducted to study the effect of foliar application of boron (B) and magnesium (Mg) on growth and yield of green chilli (Capsicum annum L.) cv. MIPC-1. Foliar application of Boron and Magnesium (T_0) Control; (T_1) B = 50 ppm; (T_2) B = 100 ppm; (T_3) B = 150 ppm; (T_4) Mg = 50 ppm; (T_5) Mg= 100 ppm; (T_6) Mg = 150 ppm; (T_7) B (50 ppm) + Mg (50 ppm); (T_8) B (100 ppm) + Mg (100 ppm); (T_9) B (150 ppm) + Mg(150 ppm) was done. The sources of Boron and Magnesium were boric acid (H_3BO_3) and Magnesium Sulphate ($MgSO_4.7H_2O$).The treatments were laid out in a Completely Randomized Design (CRD) and replicated four times. All the agronomic practices were carried out in accordance with Department of Agriculture, Sri Lanka. Maximum plant height (98 cm), number of branches (18 plant^{-1}), number of leaves (25 plant^{-1}), number of flowers (29 plant^{-1}), total dry weight (66 plant^{-1}), number of fruits (24 plant^{-1}), and unripe fruit yield (333 plant^{-1}) were observed with the foliar application of Boron (H_3BO_3) +Magnesium ($MgSO_4.7H_20$) at 100 ppm and minimum was found in the control treatment. Foliar application of Boron (H_3BO_3) + Magnesium ($MgSO_4.7H_20$) at 100 ppm increased yield by three-fold than that of control treatment. Therefore, it is concluded that combined application of B +Mg at 100 ppm was found to be effective in enhancing plant growth and fruit yield of chilli.

Keywords: *Boron, Chilli, Foliar application, Magnesium.*

Introduction

Hot pepper (*Capsicum annum* L.), is commonly referred to as chilli. It is one of the most important Solanaceae spice crops cultivated across the world. It is considered to be important for its pungency, colour, and aroma as well as its high phytochemical content (Asnin and Park, 2013). Sixteen elements are known to be vital for the growth and development (Silva and Uchida, 2000) and inadequate supply of these nutrients leads to a reduction in yield. Therefore, plants should be fed with the nutrients continuously in order to get a higher yield. Nutrients are provided to the plants through both soil and foliar. Foliar application is the quickest and an excellent method of supplying plant nutrients. However, it needs repeated sprays, can be washed off by rains and for which the plants should have sufficient leaf area and higher concentration might cause leaf damage (Fageria *et al.*, 2009). Boron (B) is taken up by plant roots as the neutral molecule H_3B0_3. B is important for both flower development and initial fruit or seed set (Borghi and Fernie, 2017) and maintaining the structural integrity of cell wall and cell membranes (Zhang *et al.*, 2014). It enhances the percentage of fruit-set by promoting pollen germination and elongation of pollen tube (Abdalla, 2007). The first signs B deficiency is the decrease in seed or fruit set. The first signs B deficiency is the decrease in seed or fruit set. Magnesium is the central element in chlorophyll molecule. It is the livewire behind photosynthesis in plants. Without magnesium, chlorophyll cannot capture

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sun energy needed for photosynthesis and an integral part in partitioning and utilization of photo-assimilates, photophosphorylation (including ATP formation in chloroplasts) and loading of sucrose in the phloem, photo-oxidation in leaf tissues and the generation of reactive oxygen species (Cakmak and Yazici, 2010 and Kawamura and Rao, 2007). Hence, boron and magnesium nutrient can be provided through foliar application. Considering the significance of foliar nutrients, this investigation was carried out to study the effect of foliar application of boron and magnesium on growth and yield of green chilli.

Materials and Methods

The experiment was carried out at the Crop Farm, Eastern University, Sri Lanka during the period September 2016 to November 2016 to study the effect of foliar application of boron and magnesium on growth and the yield of chilli (*Capsicum annuum* L.) cv MIPC -1. Seedlings were sown on a nursery bed in 4thAugust 2016 and transplanted on 4th September 2016 into poly bags containing a mixture of red soil, sand and rotted cattle manure in the proportion of 1:1:1. The treatments were laid out in a Completely Randomized Design (CRD) and replicated four times. Different concentrations of Boron and Magnesium were applied as foliar sprays. The experiment comprised of following treatments: (T_0) Control; (T_1) B = 50 ppm; (T_2) B = 100 ppm; (T_3) B = 150 ppm; (T_4) Mg= 50 ppm; (T_5) Mg= 100 ppm; (T_6) Mg = 150 ppm; (T_7) B (50 ppm) + Mg (50 ppm); (T_8) B (100 ppm) + Mg (100 ppm); (T_9) B (150 ppm) + Mg(150 ppm). The first application was done at flower bud initiation stage and second spray at 14 days after the first spray. The sources of Boron and Magnesium were boric acid (H_3BO_3) and Magnesium Sulphate ($MgSO_4.7H_2O$). Foliar applications were done at early morning for better absorption of nutrients. All the agronomic practices were carried out in accordance with the recommendation made by the Department of Agriculture, Sri Lanka. The parameters viz. plant height, number of leaves per plant, number of flowers per plant, total biomass (total fresh weight of plant) and fresh weight of pods at harvest were measured. Fresh weight of pods (green chilli) was recorded from six (6) picks. Data were statistically analysed using SAS 9.1 and means were separated using Duncan's Multiple Range Test (DMRT) test at 5 % significant level.

Results and Discussion

Plant height

Plant height was significantly different at different stages of growth (Table 1). At 2 weeks after transplanting (WAT) the highest plant height was obtained at T_8 and T_9 followed by T_6 and then by T_2 and T_3, respectively and the lowest plant height was obtained at T_0. At 5 WAT, maximum plant height was recorded in T_8 followed by T_9 and T_6, respectively. At 7 WAT, highest plant height was attained in T_8 followed by T_9 and the T_6. In all stages, plant height was the highest at T_8 and lowest was with the control treatment (T_0). This was mainly due to the contribution of the combined effect of Boron and Magnesium at the rate of 100 ppm.

Similar findings of increase in plant height due to the application of boron was also reported by Fakir *et al*. (2016) in wheat; Halder *et al*. (2007) in ginger (3 kg/ha); Haleema *et al.* (2018) (0.25%) in tomato; Verma *et al.* (1973) in tomato; Singh and Singh (1974) in garlic and Basavarajeswari *et al.* (2008) in tomato. It was also observed that foliar application of Boron at the rate of 75 ppm increased plant height in pepper (Shnain *et al.*, 2014). Foliar application of 5.0 g L^{-1} (5000 ppm) Magnesium Sulphate significantly increased plant height in wheat (El-Nour *et al.*, 2012). This might be due to the contribution of magnesium which is responsible for photosynthesis, act as a carrier of phosphorus, enhancement of nutrient uptake, synthesis of sugar and translocation of starch. Therefore, by combining both Boron and Magnesium together, the effect is double or more.

Table 1. Effect of foliar application of B and Mg on mean plant height

Treatment	Weeks After Transplanting (WAT)		
	2 WAP	5 WAP	7 WAP
T_0 : Control	27.02 ± 0.15^f	42.00 ± 0.11^g	51.00 ± 0.15^j
T_1 : B – 50 ppm	29.03 ± 0.11^e	56.00 ± 0.12^{ef}	70.00 ± 0.02^i
T_2 : B – 100 ppm	32.53 ± 0.03^c	63.00 ± 0.64^c	81.00 ± 0.29^g
T_3 : B – 150 ppm	33.03 ± 0.43^c	70.00 ± 0.23^b	86.00 ± 0.25^d
T_4 : Mg – 50 ppm	30.53 ± 0.37^d	55.00 ± 0.15^f	80.00 ± 0.24^h
T_5 : Mg – 100 ppm	31.03 ± 0.37^d	60.00 ± 0.59^d	84.00 ± 0.39^f
T_6 :Mg – 150 ppm	34.02 ± 0.25^b	69.00 ± 0.52^b	87.00 ± 0.38^c
T_7 : B + Mg – 50 ppm	31.03 ± 0.23^d	57.00 ± 1.11^e	85.00 ± 0.41^e
T_8 : B + Mg – 100 ppm	36.50 ± 0.31^a	73.00 ± 0.07^a	98.00 ± 0.23^a
T_9 : B + Mg – 150 ppm	37.00 ± 0.57^a	70.00 ± 0.05^b	91.00 ± 0.19^b
F Test	**	**	**

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

* Values are the means of 10 plants in 4 replications.

Number of branches

Boron and Magnesium had a significant influence on the number of branches plant^{-1} of chilli. Maximum number of branches plant^{-1} was recorded in treatment T_9 (B + Mg – 150 ppm) (18), (B + Mg – 100 ppm, T_8 (B + Mg – 150 ppm) (17), and T_6 (Mg – 150 ppm) (17) and significantly higher than the other treatments tested. However, the minimum number of branches plant^{-1} (10) was recorded in control plots, where no foliar nutrients were applied. This is in concurrence with the studies of Sharma *et al*. (2000) who reported that compound liquid fertilizer containing most macro and micro nutrients "Polyfeed and Multi" along with NPK had significantly increased the number of branches plant^{-1}. Application of boron had a marked effect on the number of branches was reported by Basavarajeswari *et al.* (2008) in tomato; Saha *et al.* (2010) in broccoli and Saptari and Dewi (2013) in chilli. Waskela *et al.* (2013) reported that the foliar application of Magnesium sulphate at 0.75% (7500 ppm) significantly increased the number of branches in guava. While Venkatramana (2012) documented that application of 40 g $MgSO_4$+ 4 g Borax had a remarkable influence on the number of branches.

Number of leaves

The number of leaves plant^{-1} was significantly affected by the foliar application of B and Mg (Table 02). The maximum number of leaves plant^{-1} (27, 25 and 25) was observed in T_9 (Boron and Magnesium at 150 ppm), T_8 (Boron and Magnesium at 100 ppm),) and T_6 (sole application of $MgSO_4$ at 150 ppm), respectively. While treatment T_3 (sole application of Boron at 150 ppm (24) and

100 ppm (22) produced a higher number of leaves plant^{-1} than T_0 (Control). Control gave the minimum number of leaves plant^{-1} (15). Foliar application of B at the rate of 75 ppm increased the number of leaves was reported by El-Mahdy (2007) in pepper and Harris and Puvanitha (2017) in tomato. While Waskela *et al.* (2013) reported that foliar application of Magnesium sulphate at 0.75% (7500 ppm) significantly increased the leaves per shoot. Venkataramana (2012) documented that application of 40 g $MgSO_4$ and 4 g Borax increased the number of leaves in pepper vine. These results were obtained partly due to the effect of Mg which involved in the synthesis of chlorophyll (Ibrahim, 2010) and activation of enzymes (Calvin cycle) and phosphoenol pyruvate carboxylase (C_3-plants pathway of CO_2 fixation) (Bidwell, 1979).

Table 2. Effect of foliar application of B and Mg on mean number of branches and leaves

Treatment	Number of Branches plant^{-1}	Number of Leaves
T_0 : Control	10 ± 0.577^{e}	15 ± 0.58^{f}
T_1 : B – 50 ppm	13 ± 0.577^{d}	18 ± 0.88^{e}
T_2 : B – 100 ppm	15 ± 0.577^{c}	22 ± 1.20^{cd}
T_3 : B – 150 ppm	16 ± 0.001^{bc}	21 ± 0.66^{cd}
T_4 : Mg – 50 ppm	15 ± 0.577^{c}	20 ± 1.15^{de}
T_5 : Mg – 100 ppm	16 ± 0.577^{bc}	23 ± 0.58^{bc}
T_6 :Mg – 150 ppm	17 ± 0.577^{ab}	25 ± 0.33 ^{ab}
T_7 : B + Mg – 50 ppm	15 ± 0.577^{c}	19.67 ± 0.88^{de}
T_8 : B + Mg – 100 ppm	18 ± 0.001^{a}	25 ± 1.20b^{a}
T_9 : B + Mg – 150 ppm	17 ± 0.577^{ab}	27 ± 0.88^{a}
F Test	**	**

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

* Values are the means of 10 plants in 4 replications.

Numbers of flowers

The result pertaining to the effect of boron and magnesium on the number of flowers plant^{-1} is given in Table 3. At 5 and 7 WAT there was a significant difference between treatments with respect to the foliar application of boron and magnesium. At 5 and 7 WAT, the number of flower plant^{-1} ranged from 8 - 28. At 5 and 7 WAT, the highest number of flowers plant^{-1} was observed in T_8 and T_9. At 7 WAT maximum number of flowers per plant^{-1} (29 and 28) was observed in plants receiving boron and magnesium at the rate of 100 and 150 ppm, respectively which were significantly higher than T_6 (26), T_7 (25) and T_3 (24),while minimum number of flowers plant^{-1} (12) were noticed in control treatment (T_0). The higher number of flowers plant^{-1} might be due to the adequate supply of B and Mg which results in increased plant height and the production branches that in turn increases the number of nodes and then the number of flowers.

Table 3. Effect of foliar application of B and Mg on average number of Flowers

Treatment	Weeks After Transplanting (WAT)	
	5 WAP	**5 WAP**
T_0 : Control	8 ± 0.58^{g}	12 ± 0.58^{g}
T_1 : B – 50 ppm	12 ± 0.58^{f}	18 ± 0.58^{f}
T_2 : B – 100 ppm	17 ± 0.58d^{c}	22 ± 1.00^{de}
T_3 : B – 150 ppm	15 ± 0.58^{de}	24 ± 1.15^{cd}
T_4 : Mg – 50 ppm	14 ± 0.01^{ef}	20 ± 1.15^{ef}
T_5 : Mg – 100 ppm	18 ± 1.15^{bc}	27 ± 0.58^{abc}
T_6 :Mg – 150 ppm	17 ± 1.00^{cd}	26 ± 1.15^{bc}
T_7 : B + Mg – 50 ppm	16 ± 1.00d^{cde}	25 ± 1.00^{bcd}
T_8 : B + Mg – 100 ppm	21.33 ± 0.33^{a}	29.33 ± 0.88^{a}
T_9 : B + Mg – 150 ppm	20 ± 0.58^{ab}	28 ± 1.53^{ab}
F Test	**	**

* Means followed by the same letter in each column are not significantly different to DMRT at 5% level.
* Values are the means of 10 plants in 4 replications.

Yield and yield components

Number of fruits

The foliar application of Boron and Magnesium significantly increased the number of fruits plant^{-1} (Table 4). The chilli crop that was supplied with combined application of B and Mg at the rate of 100 (24 fruits) and 150 ppm (22 fruits) produced maximum number of fruits plant^{-1} followed by combined application of B and Mg at the rate of 50 ppm (19 fruits) and Mg at the rate of 50 ppm 100 ppm (18 fruits). However, a minimum number of fruits plant^{-1} was recorded in the control plants (7) (Table 4). It was observed that as the number of branches plant^{-1} increased, the number of fruits plant^{-1} also increased. From this result, it is apparent that the B and Mg played an important role in increasing the number of fruits in chilli plants. The increase in the number of fruits might be due to the contribution of Boric acid and $MgSO_4$.

Fresh weight of fruits

Foliar application of B and Mg significantly influenced the fresh weight of fruits plant^{-1} (Table 4). The fresh weight of fruits plant^{-1} was remarkably highest (333g) in plants receiving the foliar application of boron and magnesium at 100 ppm followed by fresh weight of 306 g at the combined foliar application of H_3BO_3 and $MgSO_4$ at 150 ppm and then with the plants receiving boron alone at 150 ppm (Table 4). The control gave the lowest fresh weight of fruits. In this study, foliar application of B and Mg at 100 ppm increased yield by three-fold than that of control treatment (Table 4). Adequate quantity of micronutrients at the correct time is needed for greater growth which in turn leads to higher yield. Therefore, the higher yield was due to the effect of better flowering and higher fruit-set (Ram and Bose, 2000). Similar results have been reported by Budadeb (2012) and Uddin *et al.* (2008) in wheat; Khan *et al*. (2006) in paddy. Babaeian *et al*. (2012) showed that contribution of Mg in the yield of Barley. Venkatramana (2012) reported that foliar application of 1% $MgSO_4$ and 0.5% Borax increased the yield in pepper. This was due to the fact that boron was needed for vegetative growth and it had a great contribution in increasing the flower production and retention, elongation of pollen tube and germination and seed and fruit setting and development (Oosterhuis, 2001). Bhatia *et al.* (2001) recorded the highest yield of guava with the sole application of 1% H_3BO_3 (equivalent to 10,000 ppm) which are ten times (10) higher the concentration used in this experiment and it also due to the contribution of $MgSO_4$ too. However, Khayyat *et al.* (2007) recorded that the highest yield was obtained with the foliar spray of H_3BO_3 (1500 ppm) which is fifteen times (15) greater than the concentration used in this experiment.

Table 4. Effect of foliar application of B and Mg on average number and weight of fruits at harvest

Treatment	Number of fruits	Fresh weight of fruits (g)
T_0 : Control	7.0 ± 0.12^{g}	139.0 ± 1.00^{i}
T_1 : B – 50 ppm	14.0 ± 0.56^{f}	214.0 ± 1.15^{h}
T_2 : B – 100 ppm	16.0 ± 1.01^{ef}	266.0 ± 1.15^{e}
T_3 : B – 150 ppm	19.0 ± 1.15^{cd}	278.0 ± 1.73^{c}
T_4 : Mg – 50 ppm	17.0 ± 0.57^{de}	226.0 ± 1.15^{g}
T_5 : Mg – 100 ppm	18.3 ± 1.2^{cde}	260.0 ± 1.15^{f}
T_6 :Mg – 150 ppm	21.0 ± 1.15^{bc}	274.0 ± 1.15^{d}
T_7 : B + Mg – 50 ppm	19.0 ± 1.73^{cd}	256.3 ± 1.45^{f}
T_8 : B + Mg – 100 ppm	24.0 ± 1.73^{a}	333.0 ± 1.73^{a}
T_9 : B + Mg – 150 ppm	22.0 ± 1.2^{ab}	306.0 ± 1.15^{b}
F Test	**	**

* Means followed by the same letter in each column are not significantly different to DMRT at 5% level.
* Values are the means of 10 plants in 4 replications.

Conclusion

Foliar application of boron (B) and magnesium (Mg) had a significant effect on growth and fruit production of chilli. It revealed that combined application of B + Mg at the rate of 100 ppm improved plant height, number of branches plant^{-1}, number of leaves plant^{-1}, the number of flowers plant^{-1}, total weight plant^{-1}, number of fruits plant^{-1} and fruit weight plant^{-1}. However, the combined application of B + Mg at 150 ppm had an equal effect on the number of leaves plant^{-1}, number of flowers plant^{-1} and number of fruits plant^{-1}. Therefore, it is concluded that that combined application of B + Mg at 100 ppm was found to be effective in enhancing plant growth and fruit yield of green chilli.

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