Effect of Boron on flower and fruit set and yield of ratoon Brinjal crop

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ABSTRACT
This investigation was undertaken to study the effect of boron on flower and fruit setting and yield of ratoon crop of brinjal (Solanum melongina L) in the Eastern Region of Sri Lanka. The treatments were arranged in a Randomized Complete Design (RCBD) replicated three times. The treatments were defined as follows: T1-50 ppm, T2-100 ppm; T3-150 ppm and T4- Control along with recommended fertilizer. All other agronomic practices were in accordance with the Department of Agriculture. The results showed that foliar application of boron (H\textsubscript{3}BO\textsubscript{3}) at 150 ppm increased the number of flower buds/plant (70%), number of flowers/cluster (141%), number of flower clusters/plant (48%), total number of flowers/plant (122%), percentage of flower set (30%), percentage of fruit set (46%), number of fruits/plant (216%) and fresh weight of fruits/plant (88%) than that of control. It was, therefore, concluded that foliar application of H\textsubscript{3}BO\textsubscript{3} at 150 ppm (at flowering stage) could increase the percentage of flowering, fruit set and fruit yield per plant of ratoon crop of brinjal.

Key words: Brinjal, flower set, fruit set, ratoon, Boron

1. INTRODUCTION
Brinjal is known as eggplant or Aubergine (Solanum melongina L) belongs to the family solanaceae. It is one of the most popular and widely used low country vegetables in Sri Lanka and tropical countries as well. It is native to Sri Lanka and India. In Sri Lanka, total production of brinjal is 127,163 MT in an extent of 11760 ha in year 2012 (Ag stat, 2013). Brinjal is grown in an extent of about 169 ha in year 2012 (Ag stat, 2013) in Batticaloa District.

It is a hardy plant compared to other vegetables cultivated in Sri Lanka. It can, therefore, be grown in very dry areas under rain-fed conditions or with minimum irrigation facilities. Eggplant can be maintained for more than one year in production by pruning at the end of the harvesting season. Then the crop is fertilized and maintained as main crop and this is known as ‘‘ratoon crop.’’ Nonetheless, the yield of ratoon crop is far lower than the main crop, but in terms of cost of production it is cost effective.

Nutritionally, brinjal is low in energy (30 kcal/100g), protein (1.2%) and vitamin C (5 mg/100g), but is a very good source of dietary fiber, potassium, calcium, manganese, copper and vitamin also possess antioxidant ability (KAU-AgriInfotech portal, 2012). The yield potential and quality of fruits could be improved by maintaining proper fertilizer application. Nutrients play an important role in production of brinjal. It is clearly evident that chemical fertilizers ameliorate plant growth directly (Splittstoesser, 1990).

Micronutrients such as boron had great influence on plant growth and development. The essential physiological activities of boron linked to strength of cell wall and development, RNA metabolism, sugar transport, hormones development, respiration, cell division, Indole acetic acid (IAA) metabolism and as part of the cell membranes (Marchner, 1995). Boron deficiency causes delay in pollen germination and pollen tube development and ultimately it halts flowering and fruit setting (Halfacre, and Barden, 1979). Further, macronutrients are quickly absorbed and utilized by the
tissues of the plants by the catalyzing effect of micronutrients (Phillips (2004). Foliar spray of micronutrients is the common practice to overcome the deficiencies in order to improve the quality of fruit. Nutrients are generally quickly available to the plants by the foliar application than the soil application (Phillips et al., 2004 and Silberbush, 2002).

Boron also plays an important role in flowering and fruit formation Nonnecke (1989). Several studies have been conducted on effect of boron on flowering and fruit setting in tomato and potato which are belong to the same family Solanaceae. Nevertheless it is very rare to find studies on brinjal that also come under same family.

Most of the ratoon crops are raised as main crop. However, the yields are very low. Foliar application of boron may be able to improve flowering, fruit set and yield of ratoon crop. To date no systematic study has been carried out to test the effect of foliar application of boron on flowering, fruit setting and yield of ratoon crop of brinjal and no evidence is available on the response of boron application in the sandy regosols. Hence, this investigation was undertaken to study the effect of boron on flowering, fruit setting and yield of ratoon crop brinjal (variety Thinnavelli purple) in the regosol in the Batticaloa District in Sri Lanka

2. MATERIAL AND METHODS

The study was carried out during the period Jan- March 2013 on a sandy soil at the Crop Farm of Eastern University of Sri Lanka, Chenkalady, Sri Lanka, with the variety of brinjal ‘‘Thinnavelli purple’’ (Latitude between 7° 43’ and 7° 431/2’ N and the Longitude between 81° 42’ and 81° 43’ E) which falls within dry zone of Sri Lanka and DL2 agro-ecological zone. The texture of the soil was sandy with structure less single grain.

The experiment was carried out in a Randomized Complete Block Design (RCBD) replicated three times. There were twelve treatment combinations.

The ratoon brinjal crop (variety Thinnavelly purple) was allowed to grow as main crop with the addition of recommended fertilizer. All other agronomic practices were done as recommended by the Department of Agriculture. The treatments were comprised of 0, 50, 100 and 150 ppm of boron (H$_3$BO$_3$). Plants were sprayed 3 times at full bloom and other two were given at an interval of 10 days. Foliar sprays were applied using a hand sprayer.

Data were collected on number of flower buds, flowers/axil, number of flowers plant$^{-1}$, number of flower clusters/plant, flower setting percentage, number of pods and fruit set percentage. Total yield (g) was measured using digital balance. Data were reported as mean of six plants of each replicate of a treatment. The data were analyzed using SAS software and the mean comparison was done by using LSD at 5% level.

3. RESULTS AND DISCUSSION

Number of flower buds per plant

Number of flower buds is the prime factor which determines the ultimate yield of a plant. Foliar application of boron had an effect on number of flower buds per plant (Table 1). It was found that the application of 150 ppm of boron (H$_3$BO$_3$) produced (p<0.02) maximum number of flower buds (47), followed by foliar application of 50 ppm (34) and control (28). This might be due to adequate amount of boron present to foliage which is used for development and growth of new cell in the plant meristem. It is also reported that boron maintains substantial amount of carbohydrate movement from senescing foliage region such as leaves and bark to flowering meristematic cells (Rashid et al., 2004).

Number of flowers/cluster

Number of flowers on an axil is an important parameter that determines yield of a plant. Highest number of flowers/axil was recorded (p< 0.01) in plants receiving 150 ppm of H$_3$BO$_3$ than other treatments tested (Table 1). The number of flowers/cluster was similar in the foliar application of H$_3$BO$_3$ at 50 and 100 ppm and control. Therefore, higher the boron concentration was necessary to increase the number of flowers/cluster. There was no evidence to support this finding. Therefore, it
was concluded that foliar application of H$_3$BO$_3$ enhanced the number of flowers/cluster by 2.4 times compared to control treatment.

**Total number of flower clusters/plant and total number of flowers/plant**

Total number of flower clusters/plant and total number of flowers/plant are presented in Table 2. Maximum number of flower clusters per plant (16.33) was obtained (p< 0.05) in plants receiving 150 ppm of H$_3$BO$_3$, followed by 100 ppm (13), and control (11) (Table 2). Therefore, foliar application of 150 ppm increased the number of flower cluster/plant by 48.45 % compared to that of control.

In total number of flowers, highest total number of flowers per plant was obtained (p< 0.001) with 150 ppm of boron while lowest number of flowers was obtained with control treatment. Therefore, application of boron increased the total number of flowers by 122% than control treatment tested. It may be attributed to the effect of boron in IAA metabolism which increases number of flowers and stimulates the phosphorus uptake by roots of plants that in turn promoted development of flower clusters (Day, 2000). This is in contrast to studies where total number of clusters/plant of tomato increased with increase in concentration of H$_3$BO$_3$ at 1250 ppm (Shnain, 2014).

Oyewole and Aduayi (1992) noted that application of B at 2 ppm to tomato plants increased the number of flowers. However, in this experiment, the concentration of boric acid used was 75 times greater than that used by Oyewole and Aduayi (1992). Naz et al. (2012) documented in the tomato that plants treated with boron yielded higher number of flower clusters than control treatments.

**Percentage of flower set**

Maximum percentage of flower set (93.03 %) was attained with the foliar application of 150 ppm of H$_3$BO$_3$, followed by 50 ppm (74.04 %), and control (71.31 %). It is clear that boron treated plants showed higher percentage of flower set than untreated plants (Fig.1). This is due to effect of boron that stimulate phosphorus uptake which promotes flowering directly. Boric acid spray had favorable effect on retention of flowers. These results are in agreement with those of (Smit and Combrink (2005) who reported that too low levels B in root zone may be the reason for significant (fraction) abscission in flowers and optimal level of B for the growth and performance of tomato appeared to be 0.16 mg L$^{-1}$ (160 ppm).

**Percentage of fruit set**

The percentage of fruit set is represented by Fig. 2. Maximum percentage of fruit set was attained with the foliar application of 150 ppm (91.4%), followed by 50 ppm (68.23 %), and control (62.77 %). It is evident from the result that boron treated plants showed higher percentage of fruit set than untreated control. This may be attributed to imperative role of B in maintaining of cell integrity, enhancing respiration rate, increasing uptake of certain nutrients and metabolic activities such as IAA which increases the fruit set (Shnain et al., 2014]. Huang et al. (2000) reported that boron deficiency cause abnormal development of reproductive organ. Fruit set may be limited by a suboptimal boron supply particularly if no other means for pollination are applied (Smit and Combrink 2005). Naz et al. (2012) reported that application of B increases the percentage of fruit set in tomato plant which is also come under family Solonaceae. Ali et al. (2013) reported that 60 % of fruit setting percentage with 5 x 10$^6$ ppm of boron in plant of Solanaceae family and Nonnecke (1989) also attained similar findings. However, in this study 41.6 % of fruit setting was obtained with 150 ppm than that of control. It may be due to genetic variability and micro and macro environmental conditions that persist during the flowering and fruiting season.

**Number of fruits per plant**

Significant difference was observed in the average number of fruits per plant of boron treated plots (Table 3). Highest number of fruits/plant was recorded at the foliar application of 150 ppm than the other treatments tested. Number of fruits/plant obtained at the foliar application of 100 ppm was
significantly greater than that of control. Application of B at 150 and 100 ppm increased number of fruits per plant by 216% and 94.7% respectively. This attributed to the accessibility of boron by foliar feeding and the key role of boron on cell integrity, sugar transport, RNA metabolism and enhancing respiration rate, increasing uptake of certain nutrients and metabolic activities. Ali et al. (2013) documented that boron increases the number of fruits in tomato (30 fruits at 5x 10⁶ ppm). Shnain et al. (2013) reported higher number of fruits/plant at 1250ppm of boron in tomato. However, in this finding higher number of fruits was recorded at the foliar application of 150 ppm which was 8.3 times lesser than the concentration used by Shnain et al. (2013).

**Weight of fruits/plant**
Weight of fruits/plant was significantly (p< 0.001) affected by the foliar application of H₃BO₃ (Table 3). Highest weight of fruits/plant was recorded in the plants receiving 150 ppm of H₃BO₃, followed by plants receiving 100 ppm of H₃BO₃ and lowest weight was recorded in the treatments 50 ppm of H₂BO₃ and control. Foliar application H₂BO₃ at 150 and 100 ppm of H₂BO₃ increased weight of fruits by 88% and 49% respectively. This may be attributed to greater photosynthetic activity, resulting the increased production and accumulation of carbohydrates and favorable effect on vegetative growth and retention of flowers and fruits, which might have increased number and weight of fruits. The results of this finding is in agreement with studies done by Davis et al. (2003); Lalit Bhatt et al. (2004); Naga et al. (2013) and Basavarajeswari et al., (2008) in tomato.

4. CONCLUSION
It is clear from the results that foliar application of boron (H₃BO₃) at 150 ppm enhanced the number of flower buds/plant (70%), number of flowers/cluster (141%), number of flower clusters/plant (48%), total number of flowers/plant (122%), percentage of flower set (30%), percentage of fruit set (46%) number of fruits/plant (216%) and fresh weight of fruits/plant (88 %) of cv “Thinnavelli purple.” Application of 150 ppm showed a significant response in all the parameters tested than that of other levels tested. It was, therefore, concluded that 150 ppm of H₃BO₃ as foliar application could be used to increase the flowering, fruit set percentage and fruit yield per plant of ratoon crop of brinjal.

REFERENCES


Pocket book of Agricultural statistics (2013), Ag stat vol:X, Department of Socio Economics and Planning center, Department of Agriculture, Peradeniya, Agriculture Publication Unit.


Table 1: Effect of different concentration of B number of flower buds/plant and number of flower/axil

<table>
<thead>
<tr>
<th>Treatment (Boron ppm)</th>
<th>Number of flower buds per plant</th>
<th>Number of flowers/cluster</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>34.33b</td>
<td>3.3b</td>
</tr>
<tr>
<td>100</td>
<td>38.67ab</td>
<td>3.3b</td>
</tr>
<tr>
<td>150</td>
<td>47.00a</td>
<td>5.3a</td>
</tr>
<tr>
<td>Control</td>
<td>27.67b</td>
<td>2.2b</td>
</tr>
<tr>
<td>F Test</td>
<td>0.0218</td>
<td>0.0152</td>
</tr>
<tr>
<td>LSD</td>
<td>11.059</td>
<td>1.66</td>
</tr>
</tbody>
</table>

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

Table 2: Effect of different concentration of B on total number of flowers/plant and number of flower cluster/plant

<table>
<thead>
<tr>
<th>Treatments (Boron ppm)</th>
<th>Total number of flower clusters/plant</th>
<th>Total number of flowers/plant</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>11.67b</td>
<td>25.00bc</td>
</tr>
<tr>
<td>100</td>
<td>13.0ab</td>
<td>33.67b</td>
</tr>
<tr>
<td>150</td>
<td>16.33a</td>
<td>43.67a</td>
</tr>
<tr>
<td>Control</td>
<td>11.00b</td>
<td>19.67c</td>
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<tr>
<td>F Test</td>
<td>0.0437</td>
<td>0.0018</td>
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<tr>
<td>LSD</td>
<td>3.72</td>
<td>9.367</td>
</tr>
</tbody>
</table>

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

Figure 1: Effect of different concentration of B on percentage of flower-set of brinjal
Means followed by the same letter in each column are not significantly different to Least significant different at 5% level

**Figure 2:** Effect of different concentration of B on fruit set percentage of brinjal

**Table 3:** Effect of different concentration of B on number of fruits/plant and weight of fruits/plant

<table>
<thead>
<tr>
<th>Treatment (Boron ppm)</th>
<th>Number of fruits/plant</th>
<th>Number of flowers/cluster</th>
</tr>
</thead>
<tbody>
<tr>
<td>50</td>
<td>16.67bc</td>
<td>552.50c</td>
</tr>
<tr>
<td>100</td>
<td>24.67b</td>
<td>815.28b</td>
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<tr>
<td>150</td>
<td>40.10a</td>
<td>1030.83a</td>
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<tr>
<td>Control</td>
<td>12.67c</td>
<td>548.33c</td>
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<tr>
<td>F Test</td>
<td>0.0006</td>
<td>0.001</td>
</tr>
<tr>
<td>LSD</td>
<td>9.17</td>
<td>191.57</td>
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</table>

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