Impact of foliar application of micronutrients on growth, yield and its attributes of bitter gourd [Momordica charantia] cv. F$_1$ LHB – Swathi

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Abstract
The present experiment was carried out during June to October 2018 in Departmental Research Field of Department of Horticulture, SHU/ATS, Prayagraj. The experiment was conducted in Factorial Randomized Block Design (FRBD), with sixteen treatments, replicated thrice with two Micronutrients i.e. Zinc and Boron on Bitter Gourd. The treatments were T$_0$ (Control), T$_1$ (Boron 0.25%), T$_2$ (Boron 0.50%), T$_3$ (Boron 0.75%), T$_4$ (Zinc 0.25% + Boron 0.25%), T$_5$ (Zinc 0.25% + Boron 0.50%), T$_6$ (Zinc 0.25% + Boron 0.75%), T$_7$ (Zinc 0.50% + Boron 0.25%), T$_8$ (Zinc 0.50% + Boron 0.50%), T$_9$ (Zinc 0.50% + Boron 0.75%), T$_{10}$ (Zinc 0.75%), T$_{11}$ (Zinc 0.50% + Boron 0.75%), T$_{12}$ (Zinc 0.75%), T$_{13}$ (Zinc 0.75% + Boron 0.25%), T$_{14}$ (Zinc 0.75% + Boron 0.50%) and T$_{15}$ (Zinc 0.75% + Boron 0.75%). From the findings it was found that the Boron level B$_2$ (Boron 0.75%) was found best in terms of growth, yield and quality of Bitter Gourd cv. F$_1$ LHB – Swathi, followed by Boron level B$_3$ (Boron 0.50%), in most of the parameters.

Keywords: Micronutrients, zinc and boron., bitter gourd

Introduction
Vegetables are rich and comparatively cheaper source of vitamins. The importance of vegetable crops in India can be judged from the fact that the majority of Indian population is vegetarian. India produces the largest variety of vegetables. Consumption of vegetable provides taste, palatability, increases appetite and provides fiber for digestion and prevents constipation. Bitter gourd (Momordica charantia L.; 2n= 2x=22), which belongs to family Cucurbitaceae, is an important vegetable mainly valued for its nutritional and medicinal properties. The origin of this crop is probably India with secondary centre of diversity in China (Grubben, 1977) [5]. India being the second largest producer of vegetables in the world next only to China, share about 15 per cent of the world output of vegetable and about 3 per cent of total cropped area in the country. The current production level is over 0.77 million tonnes from an area of 0.08 million hectares (NHB 2014-15). The productivity (6.87t/ha) of bitter gourd is far below than the national productivity (11t/ha). The per capita per day availability (210g) of vegetable is quite low against the requirement of about three hundred gram as recommended by human dieticians. Such a large gap can be filled up by increasing the production by the use of improved varieties/hybrids, balanced use of macro and micronutrient in combination with adopting better crop management technology. Micronutrients such as iron, zinc, boron, manganese, etc., have been reported to play a vital role in modifying the growth and development of many horticultural crops. They improve general condition of plants and are known to act as catalyst in promoting organic reactions taking place in plant. Foliar application of micronutrients to crop plants is gaining popularity in increasing crop yield and quality of improving the shelf life of the produce. Similarly, the influence of micronutrients on growth, development and yield of bitter gourd are of immense magnitude. It is realized that productivity of crop is being adversely affected in different areas due to deficiencies of micro nutrients (Bose and Tripathi, 1996) [1]. Recently which has been increased markedly due to intensive cropping, loss of top soil by erosion, loss of micro nutrients by leaching, liming of soil and decreased availability and use of farm yard manure. (Fageria et al., 2002) [4].
Materials and Methods
The present Experiment was conducted in Factorial Randomized Block Design (FRBD) with 16 treatments of Micronutrients with three replications in the Research field of Department of Horticulture, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during June to October, 2018. Total number of treatments were sixteen viz. T0 (Control), T1 (Boron 0.25%), T2 (Boron 0.50%), T3 (Boron 0.75%), T4 (Zinc 0.25%), T5 (Zinc 0.25% + Boron 0.25%), T6 (Zinc 0.25% + Boron 0.50%), T7 (Zinc 0.25% + Boron 0.75%), T8 (Zinc 0.50%), T9 (Zinc 0.50% + Boron 0.25%), T10 (Zinc 0.50% + Boron 0.50%), T11 (Zinc 0.50% + Boron 0.75%), T12 (Zinc 0.75%), T13 (Zinc 0.75% + Boron 0.25%), T14 (Zinc 0.75% + Boron 0.50%) and T15 (Zinc 0.75% + Boron 0.75%), Cultivar, F1 LHB - Swathi were used.

Climatic condition in the experimental site
The area of Prayagraj district comes under subtropical belt in the south east of Uttar Pradesh, which experience extremely hot summer and fairly cold winter. The maximum temperature of the location reaches up to 46°C- 48°C and seldom falls as low as 4°C- 5°C. The relative humidity ranges between 20 to 94%. The average rainfall in this area is around 1013.4 mm annually. However, occasional precipitation is also not uncommon during winter months.

Results and Discussion
The present investigation entitled “Effect of Foliar application of Micronutrients on Growth, Yield and Quality of Bitter Gourd [Momordica charantia] cv. F1 LHB - Swathi” was carried out during June to October 2018 in Research Field of Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj (U.P.) India. The results of the present investigation, regarding the effect of Micronutrients on growth, Flowering and yield of Bottle gourd, have been discussed and interpreted in the light of previous research work done in India and abroad. The experiment was conducted in Factorial Randomized block design with 16 treatments, three replications. The results of the experiment are summarized below.

A. Growth Parameters
In terms of Days taken for Germination minimum was recorded in B3 (Boron 0.75%) with (7.01 days) followed by Zn1 (Zinc 0.25%) (7.75 days) and maximum (8.57 days) was recorded in Boron Level B3 (Control). In different treatments of Zinc and Boron minimum was recorded in T3 (ZnB3; Boron 0.75%) with (6.78) days followed by T1 (ZnB3; Zinc 0.25% + Boron 0.75%) with (7.03) days whereas maximum (9.46) days was observed in treatment Control. In terms of Vine length (m) maximum (5.25 m) were recorded in B3 (Boron 0.75%), followed by Zn0 (Zinc 0%) with (4.69 m) whereas minimum (4.08 m) was recorded in Control. In different treatments of zinc and boron maximum was recorded in treatment T3 (ZnB3; Boron 0.75%) with (5.77) m followed by T1 (ZnB3; Zinc 0.25% + Boron 0.75%) with (5.32) m whereas minimum (3.53) m was observed in Control. Minimum days taken for germination and Maximum vine length, it might be due to enhanced photosynthetic and other metabolic activities which lead to increase in various plant metabolites responsible for cell division and elongation as opined by Hatwar et al. (2003) [7] and Hazra et al. (1987) [8]. These results are in agreement with the findings of earlier workers Narayanamma et al. (2009) [16] in bitter gourd, Rab and Haq (2012) [18] in tomato and Kumar et al. (2010) [10] in cauliflower.

In terms of Number of primary branches per plant, maximum branches (23.04) were recorded in B3 (Boron 0.75%), followed by B2 (Boron 0.50%) with (20.66) whereas minimum (19.05) was recorded in Control. In terms of different treatments of zinc and boron maximum was recorded in T1 (ZnB0B; Boron 0.75%) with (25.16) followed by T3 (ZnB3; Zinc 0.25% + Boron 0.75%) with (23.64) whereas minimum branches (17.61) was observed in Control. The increased number of branches/vine might be due to better sink developed by auxiliary branches to a large amount of available nutrients as reported by Maya (1996) [12] in sweet pepper cv. (California Wonder). The results of present experiment are in consonance with the findings of Sabina (1995) in geranium, Meenakshi and Vadivel (2003) [13] in bitter gourd, Rab and Haq (2012) [18] in tomato, Shukla (2011) [20] in gooseberry and Narayanamma et al. (2009) [16] in bitter gourd.

In terms of Number of days to first male flower emergence, minimum (41.79 days) were recorded in B3 (Boron 0.75%), followed by Zn0 (Zinc 0%) with (44.61 days) whereas maximum (48.77 days) was recorded in Control. In terms of different treatments of zinc and boron minimum was recorded in T1 (ZnB3; Boron 0.75%) with (40.87 days) followed by T11 (ZnB3; Zinc 0.50% + Boron 0.75%) with (41.52) whereas maximum (49.57 days) was observed in treatment T0 Zn0B0 (Zinc 0% + Boron 0%).

In terms of Number of days to first female flower emergence, minimum (46.26 days) were recorded in B3 (Boron 0.75%), followed by Zn0 (Zinc 0%) with (49.07 days) whereas maximum (53.11 days) was recorded in Boron Level B0 (Control). In different treatments of zinc and boron minimum was recorded in treatment T1 (ZnB3; Boron 0.75%) with (45.26) days followed by T11 (ZnB3; Zinc 0.50% + Boron 0.75%) with (45.64) whereas maximum (53.77) days was observed in Control. Minimum days for Number of days to first male and female flower emergence, it may be due to the fact that the boron has significant role in mobilization of food materials from source to sink. Similar results were have also been obtained by Shukla (2011) [20] in Gooseberry.

In terms of Number of days to first picking, minimum (63.94 days) were recorded in B3 (Boron 0.75%), followed by Zn0 (Zinc 0%) with (68.60 days) whereas maximum (71.96 days) was recorded in Control. In different treatments of Zinc and Boron minimum was recorded in treatment T15 (ZnB3; Zinc 0.75% + Boron 0.75%) with (63.14 days) followed by T11 (ZnB3; Zinc 0.50% + Boron 0.75%) with (63.83) whereas maximum (73.79) days was observed in Control. In terms of Number of days to last picking, minimum (106.04 days) were recorded in B3 (Boron 0.75%), followed by Zn2 (Zinc 0.50%) with (111.57) whereas maximum (117.30 days) was recorded in Control. In different treatments of Zinc and Boron minimum was recorded in treatment T1 (ZnB3; Boron 0.75%) with (104.72 days) followed by T15 (ZnB3; Zinc 0.75% + Boron 0.75%) with (105.67) whereas maximum (122.19) days was observed in Control. Minimum days for first and last picking, might be due to enhanced photosynthetic and other metabolic activities which lead to increase in various plant metabolites responsible for cell division and elongation as opined by Hatwar et al. (2003) [7] and Hazra et al. (1987) [8]. These results are in agreement with the findings of earlier workers Narayanamma et al. (2009) [16] in bitter gourd, Rab and Haq (2012) [18] in tomato and Kumar et al. (2010) [10] in cauliflower.

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In terms of Number of leaves per plant, maximum (93.69 leaves) were recorded in \( B_3 \) (Boron 0.75%), followed by \( Zn_0 \) (Zinc 0.25%) with (85.56 leaves), whereas minimum (77.51 leaves) was recorded in Control. In different treatments of Zinc and Boron maximum was recorded in treatment \( T_3 \) (\( ZnB_3 \): Boron 0.75%) with (96.60 leaves) followed by \( T_1 \) (\( ZnB_3 \): Zinc 0.25% + Boron 0.75%) with (94.24 leaves) whereas minimum (71.96 leaves) was observed in Control. In terms of Leaf area index, maximum (1.511 LAI) were recorded in \( B_3 \) (Boron 0.75%), followed by \( Zn_0 \) (Zinc 0%) with (1.509), whereas minimum (1.503 LAI) was recorded in Control. In different treatments of Zinc and Boron maximum was recorded in \( T_3 \) (\( ZnB_3 \): Boron 0.75%) with (1.513) followed by \( T_1 \) (\( ZnB_3 \): Zinc 0.25% + Boron 0.75%) with (1.512) whereas minimum LAI (1.502) was observed in \( T_8 \) (\( ZnB_0 \): Zinc 0.50%) and Control.

In terms of Harvest index, maximum (68.96) were recorded in \( B_3 \) (Boron 0.75%), followed by \( B_2 \) (Boron 0.50%) with (67.60), whereas minimum (65.51 HI) was recorded in Control. In different treatments of Zinc and Boron maximum HI was recorded in \( T_3 \) (\( ZnB_3 \): Boron 0.75%) with (69.51) followed by \( T_1 \) (\( ZnB_3 \): Zinc 0.25% + Boron 0.75%) with (69.14) whereas minimum HI (65.26) was observed in treatment \( T_1 \) (\( ZnB_0 \): Zinc 0.25%). It might be due to enhanced photosynthetic and other metabolic activities which lead to increase in various plant metabolites responsible for cell division and elongation as opined by Hatwar et al. (2003) [7] and Hazra et al. (1987) [8]. These results are in agreement with the findings of earlier workers Narayanamma et al. (2009) [16] in bitter gourd, Rab and Haq (2012) [18] in tomato and Kumar et al. (2010) [10] in cauliflower.

B. Yield Parameters

In terms of Fruit length, maximum (18.17 cm) were recorded in \( B_3 \) (Boron 0.75%), followed by \( Zn_0 \) (Zinc 0%) with (15.96 cm), whereas minimum (13.63 cm) was recorded in Control. In different treatments of Zinc and Boron maximum fruit length was recorded in \( T_3 \) (\( ZnB_3 \): Boron 0.75%) with (19.23 cm) followed by \( T_1 \) (\( ZnB_3 \): Zinc 0.25% + Boron 0.75%) with (18.41 cm) whereas minimum (12.13 cm) was observed in Control.

In terms of Fruit weight, maximum (127.66 g) were recorded in \( B_1 \) (Boron 0.75%), followed by \( Zn_0 \) (Zinc 0%) with (118.63 g), whereas minimum (95.02 g) was recorded in Control. In different treatments of Zinc and Boron. Maximum fruit weight was recorded in \( T_3 \) (\( ZnB_3 \): Boron 0.75%) with (139.98 g) followed by \( T_7 \) (\( ZnB_3 \): Zinc 0.25% + Boron 0.75%) with (127.25 g) whereas minimum (81.93 g) was observed in Control.

In terms of Fruit diameter, maximum (6.75 cm) were recorded in \( B_3 \) (Boron 0.75%), followed by \( Zn_0 \) (Zinc 0%) with (6.40 cm), whereas minimum (5.93 cm) was recorded in Control. In different treatments of Zinc and Boron maximum Fruit diameter was recorded in treatment \( T_3 \) (\( ZnB_3 \): Boron 0.75%) with (6.85 cm) followed by \( T_7 \) (\( ZnB_3 \): Zinc 0.25% + Boron 0.75%) with (6.79 cm) whereas minimum (5.78 cm) was observed in Control. Increased fruit size attributed due to micronutrients application might be attributed to enhanced photosynthesis, accumulation of carbohydrates and favourable effect on vegetative growth which increased the fruits variety besides increasing the fruit size. These results get support from the findings of Kumbhlar and Deshmukh (1993) [11], Bose and Tripathi (1996) [1] in tomato, Meenakshi et al. (2007) [14] and Narayanamma et al., (2009) [16] in bitter gourd.

In terms of Fruit yield per plant (kg), maximum (1.96 kg) were recorded in \( B_3 \) (Boron 0.75%), followed by \( Zn_0 \) (Zinc 0%) and \( B_2 \) (Boron 0.50%) with (1.71 kg), whereas minimum (1.24 kg) was recorded in Control. In different treatments of Zinc and Boron maximum was recorded in treatment \( T_1 \) (\( ZnB_3 \): Boron 0.75%) with (2.48 kg) followed by \( T_7 \) (\( ZnB_3 \): Zinc 0.25% + Boron 0.75%) with (1.90 kg) whereas minimum (0.64 kg) was observed in Control. The fruit growth and final yield depends on the continued supply of food material and water (Huett and Deltmann, 1988). Since boron helps in the absorption of water and carbohydrates metabolism (Haque et al., 2011) [6], its deficiency may cause sterility, small fruit size and poor yield (Davis, et al., 2003). The results of the present investigation in terms of number of fruits/vine are in collaborative with the findings of Narayanamma et al. (2009) [16] in bitter gourd and Meenakshi et al. (2007) [14] in bitter gourd and Venkatasalam and Krishnasamy (2011) [23], Rab & Haq (2012) [18] in tomato.

In terms of Harvest Duration (days), minimum (11.12 days) were recorded in \( B_3 \) (Boron 0.75%), followed by \( Zn_0 \) (Zinc 0%) with (12.17 days), whereas maximum (13.79 days) was recorded in Control. In different treatments of Zinc and Boron. Minimum was recorded in treatment \( T_3 \) (\( ZnB_3 \): Boron 0.75%) with (10.41 days) followed by \( T_7 \) (\( ZnB_3 \): Zinc 0.25% + Boron 0.75%) with (11.14 days) whereas maximum (14.70 days) was observed in Control.

In terms of Yield q/ha, maximum (174.18 q/ha) were recorded in \( B_3 \) (Boron 0.75%), followed by \( B_2 \) (Boron 0.50%) with (152.39 q/ha), whereas minimum (110.43 q/ha) was recorded in Control. In different treatments of Zinc and Boron maximum was recorded in treatment \( T_3 \) (\( ZnB_3 \): Boron 0.75%) with (220.41 q/ha) followed by \( T_7 \) (\( ZnB_3 \): Boron 0.50%) with (191.98 q/ha) whereas minimum (56.88 q/ha) was observed in Control. The increase in yield and yield attributes due to micronutrients application might be attributed to enhanced photosynthesis, accumulation of carbohydrates, development of cell wall and cell differentiations as they boost up overall vegetative growth, biological activity of the plants and retention of more flowers and fruits which increased number of fruits per vine and size of fruits besides increasing the yield. The production of more number of hermaphrodite flowers in watermelon by the application of calcium and boron might be due to attraction in the GA metabolism (Brantley and Warren, 1960). These results are in agreement with the findings of Kumbhlar and Deshmukh, (1993) [11] and Bose and Tripathi (1996) [1] in tomato, Meenakshi et al. (2009) Narayanamma et al. (2009) [16] and Patil et al. (2013) [17] in bitter gourd.

C. Quality Parameters

In terms of Fiber Content, maximum (1.40%) were recorded in \( B_3 \) (Boron 0.75%), followed by \( Zn_0 \) (Zinc 0%) with (1.31%), whereas minimum (1.16%) was recorded in Boron Level \( B_3 \) (Control). In different treatments of Zinc and Boron maximum was recorded in treatment \( T_3 \) (\( ZnB_3 \): Boron 0.75%) with (1.44%) followed by \( T_7 \) (\( ZnB_3 \): Zinc 0.25% + Boron 0.75%) and \( T_0 \) (\( ZnB_3 \): Zinc 0.50% + Boron 0.75%) with (1.40%) whereas minimum (1.15%) was observed in Control.

In terms of Ascorbic Acid (mg), maximum (104.18 mg) were recorded in \( B_3 \) (Boron 0.75%), followed by \( Zn_1 \) (Zinc 0.25%) with (91.17 mg), whereas minimum (67.76 mg) was recorded in Control. In different treatments of Zinc and Boron maximum was recorded in treatment \( T_3 \) (\( ZnB_3 \): Boron 0.75%)}
0.75%) with (110.58 mg) followed by T_{1} (Zn_{0.75}: Zinc 0.25% + Boron 0.75%) with (104.48 mg) whereas minimum (48.19 mg) was observed in Control.

In terms of Total Soluble Solid (°Brix), maximum (4.19 °Brix) were recorded in B_{0} (Boron 0.75%), followed by Z_{0} (Zinc 0.75%) and B_{2} (Boron 0.50%) with (4.08 °Brix), whereas minimum (3.92 °Brix) was recorded in Control.

In different treatments of Zinc and Boron maximum was recorded in treatment T_{3} (Zn_{0.75}:Boron 0.75%) with (4.22 °Brix) followed by T_{1} (Zn_{0.75}: Zinc 0.50% + Boron 0.75%) with (4.20 °Brix) whereas minimum (3.77 °Brix) was observed in Control.

In terms of Specific Gravity (g), maximum (3.19 g) were recorded in B_{0} (Boron 0.75%), followed by Z_{0} (Zinc 0%) with (2.66 g), whereas minimum (2.10 g) was recorded in Boron Level B_{0} (Control). In different treatments of Zinc and Boron. Maximum was recorded in treatment T_{3} (Zn_{0.75}:Boron 0.75%) with (3.26 g) followed by T_{1} (Zn_{0.75}: Zinc 0.25% + Boron 0.75%) with (3.23 g) whereas maximum (1.87 g) was observed in Control. This lead to higher concentration of NPK and micronutrients in leaves and resulted in better accumulation of assimilates resulting in better quality parameters (Meenakshi et al., 2007) [18] in bitter gourd. The TSS content of tomato fruits have been shown to correlate with available boron and are increased by both foliar and soil application of boron (Sathy et al., 2010) [19]. These results are in consonance with the findings of Shukla (2011) [20] in Indian goose berry and Rab and Haq (2012) [10] in tomato.

### D. Economics

In terms of Economics maximum gross return and Net Return was recorded in treatment T_{1} (Zn_{0.75}:Boron 0.75%) with Rs.440820/ha and Rs. 182556/ha respectively, minimum Gross Return Rs. 113760/ha was recorded in Control, and minimum Net Return Rs.7440/ha was recorded in treatment T_{3} (Zn_{0.75}:Boron 0.75% + Boron 0.75%), but Cost benefit ratio was recorded in treatment T_{4} (Zinc 0.25% + Boron 0%) with (1:1.43) and the minimum (1:1.02) was recorded in treatment T_{15} (Zn_{0.75}: Zinc 0.75% + Boron 0.75%). As the economics is the need of the farmers while taking decision regarding the adoption of the techniques and scientific knowledge Hence, T_{4} (Zinc 0.25% + Boron 0%) recorded highest cost benefit ratio is due to low cost of zinc and high productivity and enhanced shelf life of fruits, which increase the market value of the fruits.

### Table 1: Effects of Foliar application of Micronutrients on Growth parameters of Bitter Gourd

| Levels of Zinc (Zn) | Days taken for germination (Mean Brix) | Levels of Boron (B) | Levels of Zinc (Zn) | Levels of Boron (B) | Levels of Zinc (Zn) | Number of Primary branches per plant (Mean Brix) | Levels of Boron (B) | Levels of Zinc (Zn) | Number of days to first male flower emergence (Mean Brix) | Levels of Boron (B) |
|---------------------|--------------------------------------|--------------------|--------------------|--------------------|--------------------|-----------------------------------------------|--------------------|--------------------|-----------------------------------------------|--------------------|
| Z_{0.26} 0.468      | 24.73 4.68                           | Z_{0.75}           | 3.53 6.38           | Z_{0.25}           | 3.57 6.49           | 17.61 20.14                                   | Z_{0.75}           | 4.79 5.14           | 48.99 54.45                                   | 44.61              |
| Z_{0.25} 0.438      | 24.73 4.68                           | Z_{0.75}           | 3.53 6.49           | Z_{0.25}           | 3.57 6.49           | 17.61 20.14                                   | Z_{0.75}           | 4.79 54.45          | 48.99 54.45                                   | 44.61              |
| Z_{0.24} 0.428      | 24.73 4.68                           | Z_{0.75}           | 3.53 6.49           | Z_{0.25}           | 3.57 6.49           | 17.61 20.14                                   | Z_{0.75}           | 4.79 54.45          | 48.99 54.45                                   | 44.61              |

### Table 2: Effects of Foliar application of Micronutrients on Growth parameters of Bitter Gourd

| Levels of Zinc (Zn) | Number of days to first female flower emergence (Mean Brix) | Levels of Boron (B) | Levels of Zinc (Zn) | Leaf area index (Mean Brix) | Levels of Boron (B) | Levels of Zinc (Zn) | Number of leaves per plant (Mean Brix) | Levels of Boron (B) | Levels of Zinc (Zn) | Number of days to first Picking (Mean Brix) | Levels of Boron (B) |
|---------------------|-------------------------------------------------------------|--------------------|--------------------|----------------------------|--------------------|--------------------|--------------------------------------|--------------------|--------------------|---------------------------------------------|--------------------|
| Z_{0.26} 0.468      | 24.73 4.68                                                 | Z_{0.75}           | 3.53 6.49           | Z_{0.25}                   | 3.57 6.49           | 17.61 20.14                                   | Z_{0.75}           | 4.79 54.45          | 48.99 54.45                                   | 44.61              |
| Z_{0.25} 0.438      | 24.73 4.68                                                 | Z_{0.75}           | 3.53 6.49           | Z_{0.25}                   | 3.57 6.49           | 17.61 20.14                                   | Z_{0.75}           | 4.79 54.45          | 48.99 54.45                                   | 44.61              |
| Z_{0.24} 0.428      | 24.73 4.68                                                 | Z_{0.75}           | 3.53 6.49           | Z_{0.25}                   | 3.57 6.49           | 17.61 20.14                                   | Z_{0.75}           | 4.79 54.45          | 48.99 54.45                                   | 44.61              |

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Table 3: Effects of Foliar application of Micronutrients on yield parameters of Bitter Gourd.

| Levels of Zinc (Zn) | Fruit length (cm) | Levels of Boron (B) | Fruit weight (g) | Levels of Boron (B) | Fruit diameter (cm) | Levels of Zinc (Zn) | Harvest duration (days) |
|--------------------|-------------------|---------------------|------------------|---------------------|---------------------|--------------------|------------------------|
| Zn                 | B0                | B1                 | B2               | B0                  | B1                  | B2                  | Zn                     | B0                    | B1                 | B2               |
| Zn                 | 12.13             | 5.43               | 17.06            | 9.23                | 15.96               | 3.79                | 12.09                  | 112.09                | 0.133              | 6.75              |
| Zn                 | 13.75             | 5.73               | 15.90            | 18.41               | 15.94               | 10.58               | 12.94                  | 112.09                | 0.133              | 6.75              |
| Zn                 | 14.30             | 5.95               | 15.19            | 18.28               | 15.72               | 10.01               | 12.87                  | 112.09                | 0.133              | 6.75              |
| Zn                 | 14.31             | 3.01               | 14.68            | 6.76                | 4.76                | 16.64               | 11.74                  | 106.85                | 5.09               | 0.08              |

Mean (B) | 13.63 | 4.87 | 15.70 | 18.17 | 9.50 | 0.07 | 6.75 | 12.46 | 11.12 |

Factors | F-Test | SE(d) | C.D. | F-Test | SE(d) | C.D. | F-Test | SE(d) | C.D. |
| Factor (Zn) | S | 0.198 | 0.406 | Factor (Zn) | S | 0.726 | 1.491 | Factor (Zn) | S | 0.090 | 0.124 | Factor (Zn) | NS | 0.307 | N/A |
| Factor (B) | S | 0.198 | 0.406 | Factor (B) | S | 0.726 | 1.491 | Factor (B) | S | 0.090 | 0.124 | Factor (B) | NS | 0.307 | 0.631 |
| Factor(Zn X B) | S | 0.395 | 0.811 | Factor(Zn X B) | S | 1.453 | 2.981 | Factor(Zn X B) | S | 0.121 | 0.248 | Factor(Zn X B) | NS | 0.615 | N/A |

Table 4: Effects of Foliar application of Micronutrients on Fruit yield parameters of Bitter Gourd.

| Levels of Zinc (Zn) | Number of days to last Picking | Levels of Boron (B) | Harvest index | Levels of Zinc (Zn) | Fruit yield per plant | Levels of Boron (B) | Yield q/ha |
|--------------------|-------------------------------|---------------------|---------------|--------------------|-----------------------|---------------------|-----------|
| Zn                 | 122.19                        | 10.51               | 10.94         | 0.122              | 0.09                  | 65.29               | 66.68      |
| Zn                 | 117.46                        | 16.32               | 0.69          | 0.124              | 0.09                  | 65.29               | 66.68      |
| Zn                 | 116.72                        | 14.18               | 0.35          | 0.124              | 0.09                  | 65.29               | 66.68      |
| Zn                 | 112.84                        | 13.48               | 0.56          | 0.124              | 0.09                  | 65.29               | 66.68      |

Mean (B) | 117.30 | 13.62 | 10.89 | 0.06 | Factor (Zn) | S | 0.283 | 0.581 | Factor (Zn) | S | 0.068 | 0.140 | Factor (Zn) | S | 0.034 | 0.070 | Factor (Zn) | NS | 0.20 | 6.198 |
| Factor (B) | S | 0.283 | 0.581 | Factor (B) | S | 0.068 | 0.140 | Factor (B) | S | 0.034 | 0.070 | Factor (B) | S | 0.20 | 6.198 |
| Factor(Zn X B) | S | 0.567 | 1.163 | Factor(Zn X B) | S | 0.136 | 0.280 | Factor(Zn X B) | S | 0.068 | 0.139 | Factor(Zn X B) | S | 0.641 | 12.396 |

Factors | F-Test | SE(d) | C.D. | F-Test | SE(d) | C.D. | F-Test | SE(d) | C.D. |
| Factor (Zn) | S | 0.283 | 0.581 | Factor (Zn) | S | 0.068 | 0.140 | Factor (Zn) | S | 0.034 | 0.070 | Factor (Zn) | NS | 0.20 | 6.198 |
| Factor (B) | S | 0.283 | 0.581 | Factor (B) | S | 0.068 | 0.140 | Factor (B) | S | 0.034 | 0.070 | Factor (B) | S | 0.20 | 6.198 |
| Factor(Zn X B) | S | 0.567 | 1.163 | Factor(Zn X B) | S | 0.136 | 0.280 | Factor(Zn X B) | S | 0.068 | 0.139 | Factor(Zn X B) | S | 0.641 | 12.396 |

Conclusion
Based on the present investigation it is concluded that the Boron level B1 (Boron 0.75%) and treatment combination T3 (Boron 0.75%) was found best in terms of yield, Growth and quality parameters of Bitter Gourd cv. F1 LHB – Swathi. Followed by Boron level B2 (Boron 0.50%), in most of the parameters. In terms of cost benefit ratio maximum Gross Return and Net Return was recorded in treatment T3 (Boron 0.75%) and Cost Benefit ratio was found in treatment T1 (Zinc 0.25%) with (1:1.43).

References
1. Bose US, Tripathi SK. Effect of micronutrients on growth, yield and quality of tomato cv. Pusa Ruby in M.P. Crop Research. 1996; 12:61-64.
2. Brantley BB, Warren GF. Effect of nitrogen on flowering, fruiting and quality of the watermelon. Proc. of Amer. Soc. Hort. Sci. 1960; 75:644-649.
3. Davis JM, Sanders DC. Nelson PV, Lengnick L, Spery WG. Boron improves the growth, yield and quality and nutrient content of tomato. J Amer. Soc. Hort. Sci. 2003; 128:441-446.
4. Fageria NK, Baligar VC, Clark RB. Micronutrients in crop production. Adv. Agro. 2002; 77:185-268.
5. Grubben GJH, Tropical Vegetable and their Genetic Resources. BPGR, Rome, 1977, 51–52.
6. Haque ME, Paul AK, Sarkar JR. Effect of nitrogen and boron on the growth and yield of tomato (Lycopersiconesculentum M.) EBJBSM. 2011; 2:277-282.
7. Hatwar GP, Gondane SV, Urkude SM, Gahukar OV. Effect of micronutrients on growth and yield of chilli. Soil and Crop. 2003; 13:123-25.
8. Hazra P, Maity TR, Mandal AR. Effect of foliar application of micronutrients on growth and yield of okra (Abelmoschus esculentus L.) Prog. Hort. 1987; 19:219-222.
9. Huett DD, Dettmann EB. Effect of nitrogen on growth, fruit quality and nutrient uptake of tomatoes growth in sand culture. Aust J Exp Agric. 1988; 28:391-399.
10. Kumar P, Suresh, Bhagwati R, Choudhary KV, Preema D, Ronya T. Effect of boron and molybdenum on growth, yield and quality of cauliflower in mid altitude condition of Arunachal Pradesh. Veg. Sci. 2010; 37(2):190-193.
11. Kumbhar VS, Deshmukh SS. Effect of soil application of ferrous sulphate on the uptake of nutrients, yield and quality of tomato cv. Rupali. South Ind. Hort. 1993; 41:14-147.
12. Maya P. Studies on the effect of sapling cum nitrogen and phosphorus on growth and quality of sweet pepper cv. California Wonder. M. Sc. (Ag.) Thesis submitted to Tamilnadu Agric. Univ., Coimbatore, 1996.
13. Meenakshi N, Vadivel E. Effect of fertilization on growth and dry matter production of hybrid bitter gourd (Momordica charantia L.). The Orissa J. of Horticulture, 2003, 31(2).
14. Meenakshi M, Vadivel E, Kavitha M. Response of bitter gourd (Momordica charantia L.) on fruit yield and quality traits as influenced by fertilization levels. The Asian Journal of Horticulture. 2007; 2(2):126-130.
15. National Horticulture Board (NHB) Data Base, 2014-15. nhb.gov.in
16. Narayanamama M, Radha RK, Kameswari LP, Reddy RVSK. Effect of foliar application of micronutrients on the yield components, yield and nutrient content of bitter gourd. The Orissa J. of Horticulture, 2009, 37(2).
17. Patil BC, Padanad A, Laxman, Yashvant L, Kumar KH, Gopali JB et al. Response of foliar application of micronutrients on yield and economics of bitter gourd (Momordica charantia L.). The Orissa J of Horticulture. 2013; 18(2):677-679.

18. Rab A, Haq Ihsan-ul. Foliar application of calcium chloride and borax influences plant growth, yield and quality of tomato. (Lycopersicon esculentum Mill.) fruit. Turk J. Agric. For. 2012; 36:695-701.

19. Sathya S, Mani S, Mahendran PP, Arulmozhivelvan K. Effect of application of boron on growth, quality and fruit yield of PKM, Tomato. Indian J Agric. Res. 2010; 44:274-280.

20. Shukla AK. Effect of foliar application of alcium and boron on growth, productivity and quality of India gooseberry (Emblica officinalis). Indian J of Agric. Sci. 2011; 81(7):628-632.

21. Venkatasalam EP, Krishnasamy V. Effect of micro-nutrients on flower, pollen production, yield and quality in male parental line of tomato hybrid COTH - 1. Indian J. Horticulture. 2011; 68(1):75-78.