RESPONSE OF BELL PEPPER TO SHOOT PRUNING AND FOLIAR FEEDING OF MICRONUTRIENTS

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DEDICATED
TO
MY BELOVED PARENTS

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CERTIFICATE

This is to certify that the thesis entitled **'Response of Bell Pepper to Shoot Pruning and Foliar Feeding of Micronutrients'** submitted to the Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE**, embodies the result of a piece of *bona fide* research work carried out by **Sadia Awalin**, Registration No. **07-02523** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has been duly acknowledged.

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RESPONSE OF BELL PEPPER TO SHOOT PRUNING AND FOLIAR FEEDING OF MICRONUTRIENTS

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ABSTRACT

The experiment was conducted at the Horticulture farm of Sher-e-Bangla Agricultural University, Dhaka during October 2012 to April 2013. Capsicum cultivar “Lamuyo” was used as experimental materials. The experiment consisted of two factors: Factor A: Shoot pruning (two levels) as; P_0: No pruning and P_1: Shoot pruning and Factor B: Foliar applications of micronutrients (five levels) as; M_0: Control (no micronutrients); M_1: Boron @ 100 ppm as H_3BO_3; M_2: Zinc @ 100 ppm as $ZnSO_4$; M_3: Cupper @ 100 ppm as $CuSO_4$; M_4: Manganese @ 100 ppm as $MnSO_4$ and M_5: Mixed micronutrients @ 100 ppm each. The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. For pruning, maximum fruit setting (39.32%) and highest yield (26.60 t/ha) was obtained from P_1, while minimum fruit setting (34.43%) and lowest yield (23.58 t/ha) from P_0. For micronutrients, maximum fruit setting (40.53%) and highest yield (29.98 t/ha) was found from M_5, while minimum fruit setting (33.14%) and lowest yield (17.77 t/ha) from M_0. For interaction effect highest yield (30.43 t/ha) was recorded from P_1M_5 and lowest yield (16.77 t/ha) from P_0M_0. Therefore, shoot pruning and mixed micronutrients showed best potentiality for bell pepper cultivation.

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CHAPTER I

INTRODUCTION

Bell pepper or Capsicum (*Capsicum annuum*) is a flowering plant under the genus Capsicum and belongs to the family Solanaceae. It is relatively sweet, non-pungent with thick flesh and is the world's second most important vegetable after tomato (AVRDC, 1989). Tropical South America, especially Brazil is thought to be the original home of pepper (Shoemaker and Teskey, 1995). It is now widely cultivated in Central and South America, Peru, Bolivia, Costa Rica, Mexico, in almost all the European countries, Honkong and India. Most of the peppers cultivated in temperate and tropical areas belong to the botanical spices *Capsicum annuum*, thought to originate in Mexico and Central America. Economically it is the second most important vegetables crop in Bulgaria and is thought to be the original home of pepper (Panajotov, 1998). Small scale cultivation is found in peri-urban areas primarily for the supply to some city markets in Bangladesh (Saha, 2001).

From a nutritional prospective, bell pepper is rich in vitamins; chiefly, vitamin C and provitamin A. Concentrations of vitamin C is ranged from 63 to 243 (mg 100/g) depending on fruit colour (Howard *et al*., 1994). In a survey on content of vitamin C in fruits and vegetables, bell peppers represented the highest fourth out of 42 choices (Frank *et al*., 2001). A 100 g of edible portion of pepper provides 24 Kcal of energy, 1.3 g of protein, 4.3 g of carbohydrates and 0.3 g of fat (Zende, 2008). Also, it is one of the valuable medicinal plants in pharmaceutical industries, owing to high amounts of health promoting substances, particularly antioxidant, capsaicin and capsantin (Aminifard *et al*., 2012).

Capsicum is considered as a minor vegetable crop in Bangladesh and its production statistics is not available (Hasanuzzaman, 1999). The popularity of sweet pepper is increasing day by day in Bangladesh especially among the urban people because of its high nutritive value and possible diversified use in making different palatable foods. It is rich in capsaicin and has powerful antioxidant properties that may helps works against inflammation. Capsicum has different colors-range from green to yellow, red, orange, purple, and black. Other capsicum include the red, heart-shaped; the pale green, slender and curved bull's horn which range in color from yellow to red and sweet banana pepper which is yellow and banana shaped (Teshm Tadesse Michael *et al*., 1999).

Pepper plants have a branching habit; therefore, fruit development is controlled by restricting the branching pattern to 1, 2, 3 and 4 main branches. The reasons for pruning bell pepper under greenhouse conditions are to train plant to grow upright in order to facilitate light penetration all over the leaf canopy, improve fruit set and obtain early fruit ripening and high yield of large sized fruits (Jovicich *et al*., 2004; Zende, 2008). Moreover, pruning is effective in improving air circulation which reduces relative humidity and limits the spread of diseases (Esiyok *et al*., 1994). Pruning methods vary with different branching habits of *Capsicum* cvs. and under different plant densities (Dasgan and Abak, 2003; Maniutiu *et al*., 2010). The prime objective of the pruning practice is obtaining proper balance between fruit number and fruit size by improved canopy management. Due to the heavy vegetative growth and fruit load on the colored pepper plants (Shaw and Cantliffe, 2002), shoot pruning is important factor in proper utilization of production area (Maniutiu *et al*., 2010). Pruning plants to 2, 3 or 4 shoots was reported to be effective in increasing yield and reducing fruit size. Thus, the limitation of shoot number allows the increase in fruit quality (Cebula, 1995). Several studies have reported an increase in fruit yield of sweet pepper with increase in shoot number under soilless media in protected agriculture (Cebula, 1995; Jovicich *et al*., 2004; Maboko *et al*., 2012). However, there is little information on the effect of shoot pruning on bell pepper in a soil culture.

Foliar feeding is a relatively new, slightly controversial technique of feeding plants by applying liquid fertilizer directly to their leaves (Anonymous, 2004). Foliar fertilizers are being used in vegetables that contain various macro and micro nutrients. Foliar fertilizers immediately deliver nutrients to the tissues and organs of the crop. This is a practice of applying liquid fertilizers to leaves. The study showed that crop yield in chillies enhanced when micronutrients were applied in combination instead of alone. Foliar application of micronutrients produced the highest number of fruits per plant, dry fruit yield, net income and benefit cost ratio. Increasing frequency of Zn spraying from three to four times did not increase the number of chilli fruits per plant (Jiskani, 2005). It is realized that productivity of crop is being adversely affected in different areas due to deficiencies of micronutrients (Bose and Tripathi, 1996). The deficiency of micronutrients increased markedly due to intensive cropping, loss of top soil by erosion, loss of micronutrients by leaching, liming of soil and lower availability and use of farm yard manure (Fageria *et al*., 2002). Micronutrients are usually required in minute quantities, nevertheless are vital to the growth of plant. Improvement in growth characters as a result of application of micronutrients might be due to the enhanced photosynthetic and other metabolic activity which leads to an increase in various plant metabolites responsible for cell division and elongation as opined by Hatwar *et al.* (2003). The photosynthesis enhanced in presence of zinc and boron was also reported by Rawat and Mathpal (1984). However, considering the above circumstances, the present study was undertaken with the following objectives:

- To find out the influence of shoot prunning on the growth, fruit setting and yield of bell pepper;
- To know the effect of micronutrients on growth, fruit setting and yield of bell pepper; and
- To know the best combination of shoot pruning and foliar feeding of micronutrients on growth, fruit setting and yield of bell pepper.

CHAPTER II

REVIEW OF LITERATURE

Capsicum is considered as a minor vegetable crop in Bangladesh and its popularity is increasing day by day among the urban people because of its high nutritive value and possible diversified use in making different palatable foods. Due to some advantages, capsicum cultivation in Bangladesh is becoming more popular and total yearly production is increasing gradually. Although the farmers of Bangladesh are not knowledgeable regarding the procedures of increasing fruit setting, fruit size, individual fruit weight as well as yield. A very few research works related to capsicum cultivation especially emphasis on pruning and micronutrients have been carried out in Bangladesh. Nevertheless, some of the important and informative works regarding pruning performance and application of micronutrients so far been done at home and abroad of this crop have been reviewed below under the following headings-

2.1 Review in relation of pruning

Atherton and Rudich (1986) stated that one or two side-shoots under the first truss on the main stem were found profitable in some growing areas. An experiment was conducted by Sharfuddin and Ahmed (1986) under the field conditions of Bangladesh Agricultural Research Institute, Joydebpur during winter, 1985-86. They noted that plants under unpruned treatment produced maximum number (36) of fruits/plant. The highest yield of 120.50 t/ha was obtained from unpruned plants followed by one time pruning (100.43 t/ha), two times pruning (98.33 t/ha) and single stem pruning (73.41 t/ha), respectively. Overall, the highest yield of 123.36 t/ha was obtained from plants pruned to 3 stems and grown at a plant density of 27,777/ha.

In an experiment, Baki (1987) found that pruning showed a significant effect on plant height. Unpruned plants exhibited higher plant height and the highest number of inflorescence. Higher number of fruits was also obtained from unpruned plants. But maximum yield of tomato (96.08 t/ha) was obtained from unpruned plants with two stems at the closest spacing (75 × 50 cm). The pruned plant produced fruits relatively earlier than other treatments.

In Brazil, Campos *et al.* (1987) carried out an experiment to observe the effect of stem pruning and plant population on tomato productivity. They found that stem pruning increased the early yield and fruit weight but decreased both yield and fruit number/plant. The highest yield of marketable fruits was obtained in the control (54.8 t/ha) followed by the variant pruned above the 7^{th} truss (53.07 t/ha). Marketable yields rose from 46.8 t/ha with 20,000 plants/ha to 54.49 t/ha at the highest density.

Working with the tomato var. Manik, Rahman *et al*. (1988) reported that unpruned plants gave the highest yield (120.5 t/ha) and the lowest yield (39.0 t/ha) was obtained from the single stem pruning. Other characters like plant height, first flower opening and first harvesting time were not influenced by the pruning operation. Number of flower clusters, number of flowers and number of fruits/plant were maximum in unpruned plant, whereas fruit length, fruit diameter and individual fruit weight were the highest from single stem pruning followed by two times pruning (21 and 35 days after transplanting).

Guo *et al.* (1991) reported higher sweet pepper yields in two stem plants at 4.5 plants per m^2 than in four stem plants at 2.25 plants per m^2.

Tomato grown in hydrophonic culture in a basic greenhouse, Hernandez *et al*. (1992) found that fruit diameter and fruit length were greatest in plants for pruning one stem and the number of fruits was higher. Yield was the highest in unpruned plants followed by plants pruned 2 stems and one stem (3.826 and 3.093 kg/m^2, respectively).

Dhar *et al*. (1993) carried out an experiment of pruning and number of plants/hill on tomato. It was found that the highest yield (96.25 t/ha) was produced in the double branched plants followed by that in unpruned plants (66.21 t/ha) and single branched (61.29 t/ha) plants. In case of number of plants/hill, three plants/hill produced the highest yield (75.51 t/ha) followed by that from two plants (62.58 t/ha). The interaction effect was found significant for fruit size, weight and yield of tomato.

Davis and Estes (1993) found that early season yields were highest using early pruning (lateral shoots were 5-10 cm long) or delayed pruning (when lateral shoots were 30-60 cm long) opposed to no pruning and in row spacing of 46 cm. Total season yields/hectare of pruning plants increased as in row spacing decreased. For unpruned plants, however, total season yields were high at all spacing. Total season yields were lower from delayed pruning plants than from unpruned plants. Unpruned plants produced low yields of fruits >72 mm diameter but their total yield was greater than those of pruning plants. Net return/hectare was highest when i) plants spaced closely in row spacing were pruned early or ii) plants were spaced 46-76 cm apart and either pruned early or not pruned.

Poksoy *et al*. (1994) conducted an experiment to examine the effects of different pruning on the yield and quality of eggplant cultivars grown in green house conditions. Plants of the F_1 aubergine cultivars Dusky, Vittoria, Valentina, Indra, Sicilia, Palmira and Imperial were pruned to leave either 2 or 3 main shoots above 33-35 cm height, with lateral shoots pruned to leave a fruit and 3 leaves or left not pruned. Both pruning methods (i.e. to 2 or 3 shoots) significantly increased main-shoot length and 1^{st} class fruit yield. Total yield was not affected by pruning method. The highest total and 1^{st} class fruit yields were obtained with the cultivars Sicilia and Imperial.

In Bangladesh condition, a field experiment was carried out by Rahman *et al*. (1994) to assess the effect of pruning on yield of tomato (*Lycopersicon esculentum* Mill) cv. Manik. They observed that the highest yield (120.50 t/ha) was found from unpruned plants and the lowest yield (69 t/ha) from the single stem pruning plants.

A field trial was conducted by Cruces and Valdes (1995) with fruit thinning treatment consisted of leaving all 6, 4 or 3 fruits per truss of capsicum. Average individual fruit and seed weight was significantly increased compared to controls when 4 or 3 fruits were left per truss.

Cebula (1995) obtained the highest yield of capsicum with plants pruned to two shoots and the spacing of plants was 80 × 30 cm (4 plants/m^2) the higher (143.8 g) fruit size was observed when the plants pruned to two shoot level at 80 × 71.7 cm spacing.

Hossain *et al*. (1996) conducted an experiment on mulching and pruning on the growth and yield of tomato and they found that combined effect was insignificant. However mulching with black polythene and two times pruning (21 and 35 days after transplanting) in combination gave the highest yield (76.32 t/ha from cv. Ratan). Individual fruit weight was maximum (62.64 g) with three times pruning (21, 35 and 49 DAT) followed by two times pruning (61.51 g), one time pruning (59.02 g) and without pruning (47.21 g), respectively.

Uddin *et al*. (1997) conducted an experiment in the field of Kasetsart University, Kamaphaeng Saen Campus, Thailand from October 1995 to February 1996 to determine the effect of stem pruning (one stem, two stem, three stem and no pruning) and plant spacing (40 & 50 cm) on the yield was evaluated on indeterminate type F_1 hybrid tomato variety 'FMTT22'. Two stem pruning yielded the highest (56.20 t/ha) and closer spacing (40 cm) gave higher yield (55.34 t/ha). Two stem pruning along with 40 cm plant spacing showed superior interaction.

In a trial with spring tomatoes, Cuifen and Yanping (1997) found that leaving up to 4 fruits had no significant effects on fruit bud development and gave higher yields than leaving 2 or 3 fruits for capsicum.

Jovicich *et al.* (1998) found that the total marketable yield and extra large fruit per plant were greatest in four stem plants at a density of two plants per m^2. Saen and Pathom (1998) studied that the effect of three pruning methods (no pruning, two branch pruning and four branch pruning) on pepper yield and quality of variety CA-778. Pruning also increased plant height, fruit weight and fruit length. The four branch pruning increased fruit weight by 13 per cent.

Thapa (1999) concluded that pruning had a direct effect on yield of yellow pepper, because the pruned plants had 65.3 fruits and yield of 4.19 kg per plant as compared to 54.3 fruits and 3.24 kg yield per plant in non-pruned plants.

A field trial was conducted by Srinivasan *et al*. (1999) in Tamil Nadu, India, during the kharif seasons to study the effect of spacing, training and pruning method (pinching or no pinching of the side branches) on the growth and yield of hybrid tomato ARTH-4. They found that pruned plants were significantly taller than non-pruned plants.

Navarrete and Jeannequin (2000) conducted an experiment to determine the effect of de-shooting frequency on vegetative growth and fruit yield of capsicum, in order to help growers to determining the optimal frequency. Four de-shooting frequencies were compared on two cultivars; every 7, 9, 10, 14 and 21 days. De-shooting frequency affected vegetative growth and yield; when de-shooting was performed seldom (every 21 days), the stem diameter was decreased; the number of fruit m^{-2} was also reduced, leading to significantly lower yield. When the auxiliary buds were eliminated frequently (7 days), even those located near the apex, it reduced vegetative growth, but not yields.

Arin and Ankara (2001) conducted an experiment to determine the effect of low-tunnel, mulch and pruning treatments on yield and earliness tomato cv. Fuji F_1 tomato (*Lycopersicum esculentum* Mill.) in unheated glasshouse. Plant height, stem diameter, days to first harvest, early yield (g/plant), total yield (g/plant) and fruit weight (g/fruit) were determined during the growing period. Low-tunnel and mulching had a positive effect on plant growth development. The highest early yield was obtained from the plants pruned from the 4th truss and mulched with any mulch under low-tunnel. Total yield was highest in plants pruned from 8th truss and mulched with wheat straw.

Dasgan and Abak (2002) reported that a spacing of 80 × 30 cm with three shoots per plant was more economical for cultivation of capsicum. Further, they observed that the fruit quality characteristics such as fruit weight, fruit length, fruit diameter, fruit volume, fruit dry matter, TSS and pH of flesh were not significantly influenced by plant density and number of shoots per plant.

An experiment was carried out by Pessarakli and Dris (2003) to observe the effects of pruning and spacing on the yield and quality of eggplants. Various suggestions on pruning and spacing of eggplants and the most suitable pruning as well as the optimum spacing to increase the yield and quality of eggplant given by different investigators are discussed in this manuscript. In general, proper pruning and optimum spacing substantially increase eggplant yield and improve its fruit quality.

In the greenhouse production the effect of various side shoots pruning on productivity of eggplant was investigated by Amroszczyk *et al*. (2003). They found that pruning has a positive effect on irradiation on PAR range in the plant profile. The significant increase of the eggplant total yield was obtained with the introduction of a greater height of the second shoot. Higher accumulation of dry mass and chlorophyll 'a' and 'b' in the leaves on upper levels of the plants was noted. This tendency was not confirmed for assimilative starch. It was not found a significant effect of plant pruning on the content of dry mass, total sugars and L-ascorbic acid in fruits.

Dapgan and Kazym (2003) reported that plant density and pruning systems play a key role in the effective use of the area inside the greenhouse. Pepper (*Capsicum annuum* L.) cultivars, Amazon-long green and Balo bell-shape type, were grown in the winter cultivation period in a glasshouse. A constant space of 80 cm between rows with different within row spacings (45 cm, 30 cm and 15 cm) and shoot numbers (between one and four shoots per plant) were applied to optimize plant density and number of shoots. Wider within row spacing and higher shoot numbers per plant increased the number of leaves. While higher plant densities with a greater number of shoots reduced photosynthetically active radiation, they increased the leaf area index at fruiting level. In order to obtain high yields an assumption of 80 × 15 cm with two shoots per plant is suggested for peppers. When expensive seed is used then 80 × 30 cm spacing with three shoots per plant might be more economical. Number of shoots did not affect fruit quality characteristics, such as fruit weight, length, diameter, volume, dry matter, total soluble solids and the pH of the flesh in either cultivar.

Elio *et al*. (2005) reported that in greenhouse crops, fruit yield and quality can be increased by managing shoot pruning and plant density. The effect of plant population density (2, 3 and 4 plant/m^2, as function of in-row plant spacing: 66.5, 44.3 and 33.3 cm, respectively), and shoot pruning (1, 2 and 4 main stems) was studied for effects on fruit yield, fruit quality and plant growth of greenhouse grown sweet pepper (*Capsicum annuum* L. cv. Robusta) during Summer 1998 in Gainesville, Florida. Plants were grown in perlite bags and irrigated with a nutrient solution. Red fruits were harvested 84 and 118 days after transplanting. Additional fruit set was inhibited due to the high temperatures. Marketable yield (number and weight) per m^2 increased linearly with plant density and was greater on plants with four stems than in those with two or one stem. Extra large fruit yield per m^2 was not affected by plant density but was higher in four-stem plants. Total marketable yield and extra large fruit yields per plant were greatest in the four-stem plants at 2 plant/m^2. The stem length and the number of nodes per stem increased linearly with the decrease in plant spacing. Stem length and number of nodes per stem were greater in single-stem than in four-stem plants. Number and dry weight of leaves, stem diameter, and total plant dry weight were higher in four and two than in single-stem plants. Total stem weight in four-stem plants increased linearly with the decrease of plant density. Results indicated that 4 plant m^{-2} pruned to four stems increased marketable and extra large fruit yield in a short harvest period of a summer greenhouse sweet pepper crop in Northcentral Florida.

Lee and Liao (2006) reported that the SRC (sugarcane residue compost substrate) was used as ubstrate basket culture of sweet pepper to compare the training method of single stem, double stem and no training at the densities of four to six plants in each basket in the following experiment. The highest marketable fruit yield (49,952 kg/ha) was achieved by double-stem training at a density of six plants per basket resulted in higher proportion of large sized fruits.

In Poland, Ambroszczyk *et al*. (2007) carried out an experiment under green house condition to determine the method of eggplant (aubergine) pruning, optimizing the proportions between vegetative and generative plant development. The following pruning systems were applied: pruning to one shoot with leaving on every node 2 fruit sets and 1, 2 or 3 leaves, and pruning to two shoots with leaving on every node 1 fruit set and 1, 2 or 3 leaves. Among the treatments the most beneficial light conditions were observed in treatments pruned to one shoot with two fruit sets per node. Pruning strongly affected the effectiveness of fruit setting, especially in treatments pruned to two shoots. Plants pruned to two shoots with one fruit set and three leaves per node set fruits the most evenly on subsequent nodes. Intensive plant pruning did not reduce the eggplant yield in the present experiment. Also earliness of production was not affected by the systems of pruning. Mean early yield from first four harvests was 4.06 kg/m^2 (total) and 4.04 kg/m^2 (marketable) without statistical differences among treatments. Also total (10.44 kg/m^2) and marketable (9.41 kg/m^2) yield was not affected by the pruning system. Plants pruned more intensively (one shoot, two fruit sets per node) produced more I class fruits. Less intensive pruning resulted in the increase of the number of unmarketable fruits. Pruning affected fruit qualities, assessed on the base of dry matter, total sugar, vitamin C, and chosen element contents.

In Poland, Ambroszczyk *et al*. (2008) carried out an experiment to find the relations between pruning methods and chosen parameters of vegetative eggplant development in greenhouse conditions. Independence between different pruning methods and vegetative plant development particularly leaves characteristics as well as pigments and photosynthesis products content in leaves was stated. Eggplant of Tania F_1 hybrid was used in the early spring-summer production in a heated greenhouse. The following pruning systems were applied: pruning to one shoot with leaving on every node 2 fruit sets and 1, 2 or 3 leaves, and pruning to two shoots with leaving on every node 1 fruit set and 1, 2 or 3 leaves. With the introduction of a greater number of leaves and fruit sets on eggplant shoots irradiation in plant profile was reduced. The value of leaf area index (LAI) depended on the way of pruning.

An experiment was conducted by Shetty and Manohar (2008) to study the influence of pruning and growth regulators on the yield and quality of coloured capsicum (*Capsicum annuum* L.) cv. OROBELLE under greenhouse, Division of Horticulture, UAS, GKVK, Bangalore. In this experiment two pruning levels (2 branches per plant and 4 branches per plant) and growth regulators (NAA10 ppm and 25 ppm, GA_3 10 ppm and 25 ppm) at different combinations were used as treatments. Both during summer and winter, the number of days taken was least for 50 per cent flowering (34.18 and 32.63 days, respectively) and fruit set (7.12 and 5.54 days, respectively) with the treatment T_5 which was the combination of pruning to four branches per plant + NAA 10 ppm. This treatment had also significantly increased number of flowers per plant (34.34 and 39.41, respectively) and per cent fruit set (52.37 and 63.51%, respectively) fruit yield per plant (1.97 and 2.39 kg) and per hectare (118.20 and 143.40 t) in both summer and winter, respectively. Capsicum plants responded significantly to the pruning and application of growth regulators.

Maniutiu *et al*. (2010) conducted an experiment to establish the best plant density and plant directing method for bell peppers. A bifactorial experience has been organized: Factor A, plant density, with: A_1 - 30000 plants/ha; A_2-40000 plants/ha; Factor B, shoots pruning method, with: B_1-pruned with 2 shoots; B_2-pruned with 3 shoots. The pruning method has influenced neither early nor total yield. Under the combined influenced of both factors the best results have been obtained by variant III (40000 plants/ha, 2 shoots) and variant IV (40000 plants/ha, 3 shoots) for both the early and the total yield.

Two experiments were performed by Abdullah *et al*. (2013) to study the effect of pruning systems on vegetative growth, yield and quality traits of three hybrid bell pepper cultivars: ‘Pasodoble’, ‘Lirica’ and ‘Sondela’. Cultivars were grown under greenhouse conditions in drip fertigated soil culture and plants were pruned leading to one main branch, two and four side branches. Vegetative growth, yield and quality traits were affected by cultivars or pruning systems and their interactions. Pepper plants pruned to one branch resulted in a significant increase in early yield, fruit size and internal fruit quality with a decrease in total fruit yield followed by plants pruned to two branches. However, plants pruned to four branches produced the highest yield, due to higher number of fruits/plant. The best fruit number and total yield were obtained by pruning ‘Pasodoble’ F_1 plants to 4 branches.

Field experiment was conducted by Ashenafi and Tsegaw (2014) on farmer’s field from 2009 to 2010 at Humbo, to assess the effects of stage and intensity of reproductive organs pruning on yield and yield component of pepper. Four levels of pruning (control, one-reproductive organ, two-reproductive organs and three-reproductive organs) and three stages of pruning (bud, anthesis and fruit set). The interaction effect of three-reproductive organs pruned treatment with fruit set stage gave the highest for total leaf area of pepper and the least was obtained from the control. The highest early yield per plant was obtained from the control and significant reduction was observed with reproductive organs pruning. The highest total fruit yield per plant and total fruit yield per hectare were obtained from one-reproductive organ pruned treatment and the lowest total fruit yield per plant and per hectare were obtained from the three- reproductive organs pruned treatment.

2.2 Review in relation of micronutrients

Three micronutrients (Zn, Fe, B) were tried in three concentrations i.e. 0.1, 0.25 and 0.50% foliar spray in a field experiment conducted by Dongre *et al*. (2000) in Akola, Maharashtra, India during 1995-96. There were ten treatments replicated three times and applied at 30 and 60 days after transplanting. The observation on fruit yield per plant and quality of chili fruits per plant were recorded and analysed statistically. The treatment T_3 ($ZnSO_4$ 0.50%) exhibited the maximum yield (111.75 q/ha) and treatment T_5 ($FeSO_4$ 0.25%) produced the maximum number of seeds/fruit (57.93).

A field trial was conducted by Laxman and Mukherjee (2000) and indicated that yield and yield attributes of chilli (*Capsicum annuum* var. longum) cv. RCH-1 were greatly influenced by the foliar sprays of urea (0.5, 1 and 1.5%) and naphthaleneacetic acid [NAA] (25, 50 and 75 ppm). Increasing concentrations of urea and naphthaleneacetic acid increased percent fruit set, fruit weight, percent dry yield and yield/ha and decreased fruit drop percentage. The maximum yield was obtained with the treatment of 1.5% urea (193.06 q/ha).

Yogananda *et al*. (2004) conducted an experiment with ten grams seeds of bell pepper [*Capsicum annuum*] (cv. California Wonder) were soaked in 150 ml solution each of gibberellic acid (GA_3) at 100 (T_1), 150 (T_2) and 200 ppm (T_3); T_1 + cytokinin at 100 ppm (T_4), T_2 + cytokinin at 50 ppm (T_5), T_3 + cytokinin at 50 ppm (T_6), NAA at 40 ppm (T_7), Miraculon at 200 (T_8), 450 (T_9) and 750 ppm (T_{10}), $CuSO_4$ at 0.2% (T_{11}), $ZnSO_4$ at 0.2% (T_{12}), Borax at 0.4% (T_{13}), $MgSO_4$ at 0.2% (T_{14}), KNO_3 at 0.5% (T_{15}) and 1.0% (T_{16}) for 24 hour and dried back to original weight. A control (T_0) was included. Significantly higher germination (91.05%) was obtained with T_3 compared with other concentrations of GA_3, combination of GA_3 + cytokinin treatments and T_7. However, these treatments recorded higher germination over T_0 (81.5%). Significantly longer root (5.55 cm) and shoot (7.50 cm), higher germination rate (12.75), seedling dry weight (53.5 mg) and seedling vigour index (1174) were obtained from seeds invigourated with

T_3 compared to the control (4.27 cm, 5.75 cm, 9.04, 42.25 mg and 518, respectively). Seeds invigourated with the micronutrients significantly increased the seed germination. Among the micronutrients, T_{15} recorded significantly higher germination (89.75%) over the control. T_{11}, T_{12}, T_{13} and T_{14} also recorded significantly higher germination, root length, shoot length, seedling dry weight, germination rate and seedling vigour index over the control.

A field experiment was carried out by Shivaprasad *et al*. (2009) in Haveri, Karnataka, India, to study the effect of secondary and micronutrients on yield and quality of chilli cv. Bydagi. The recommended doses of inorganic NPK fertilizers (RDF) at 100:50:50 kg/ha was applied along with various doses of secondary and micronutrients (Ca at 25 and 50, S at 25 and 50, Fe at 10 and 20 kg/ha). The pooled results revealed that RDF+Ca+S+Fe at 50+50+20 kg/ha recorded significantly higher chilli yield (1189 kg/ha) compared to the rest of the treatments, except for RDF+Ca+S at 50+50 kg/ha (1119 kg/ha) and RDF+Ca+S+Fe at 25+25+10 kg/ha (1176 kg/ha). Significantly higher benefit:cost ratio (2.56) was recorded with RDF+Ca+S+Fe at 25+25+10 kg/ha compared to the rest of the treatments. However, it was on par with RDF+Ca+S+Fe at 50+50+20 kg/ha and RDF+Ca+S at 50+50 kg/ha (2.45 and 2.29, respectively).

Two field experiments were conducted by El-Bassiony *et al*. (2010) during the two successive summer seasons at the Experimental Farm of the National Research Centre in El-Nobaria region, Behira Governorate, to investigate the response of sweet pepper plants cv. California wonder to different rates of potassium fertilization (50, 100 and 200 kg/fed.) as potassium sulfate in addition to foliar application by potassium oxide (2 and 4 cm/L) and potassium humate (4 gm/L) as a stimulative dose. Potassium foliar applications were made 3 times in a 15 days interval with the same doses during the growing period (30, 45 and 60 days after transplanting). The highest potassium fertilization rate (200 kg/fed.) gave the tallest sweet pepper plants, the highest number of leaves and branches per plants and the highest fresh and dry weights of leaves as well as the highest total yield. Also, the obtained results reported that the fruit measurements expressed as fruit length, average fruit weight and vitamin C content, as well as leaves chemical composition (N, P, K and total chlorophyll) were increased with increasing potassium fertilization rate. On the other hand, spraying sweet pepper plants with potassium humate at rate of 4 gm/L markedly increased vegetative growth, yield, fruit quality and chemical composition. The favorable effects of the potassium on the growth, total yield and fruit parameters were obtained when sweet pepper plants fertilized with 200 kg/fed. potassium sulfate plus foliar application of potassium humate 4 gm/L followed statistically by 200 Kg/fed. potassium sulfate with foliar application of either 2 or 4 gm/L potassium oxide with no significant differenced between them but both of them were significantly higher than control.

The investigation was conducted by Datir *et al.* (2012) to determine the effects of foliar application of organically chelated micronutrients on growth and yield in chili (*Capsicum annum* L.). The micronutrients like iron, zink, copper and manganese were organically chelated with seed amino acids. A pot experiment was carried out to study the effect of foliar application of micronutrients, amino acids and amino acid micronutrient chelates on growth and yield of chili (*Phule Jyoti*) during 2009 and 2010 at the Yeola, District Nasik. Forty day's old seedlings of chili were transplanted in pots. The experimental plants were sprayed with three doses (0.5, 1.5 and 2.0 %) of organically chelated micronutrients along with unchelated micronutrients, amino acid solution and untreated control plants on 15th and 30th days after transplantation. The results based on two years mean revealed that out of five different treatments, the application of amino acid-micronutrient chelate at the concentration of 1.5 and 2.0% resulted in maximum plant height, number of primary branches, higher leaf area per plant, fruits per plant and more total yield per plant.

Field experiment was carried out by Deepa devi and Shanthi (2013) in the Department of Horticulture, Pandit Jawaharlal Nehru College of Agriculture and Research Institute, Karaikal during the year 2009. Among the 16 treatments, the combination of 100% RDF + 1.0% water soluble fertilizer + 5 spray produced maximum plant height, number of branches per plant, 50 per cent flowering and NPK uptake as compared to water spray and other treatments.

Field trial on chilli (cv. *Bogra* local) was conducted by Shil *et al*. (2013) in Grey Terrace Soil under AEZ-25 (Level Barind Tract) at Spice Research Centre, Bogra during rabi seasons. The objectives were to evaluate the response of chilli to zinc and boron and to find out the optimum dose of zinc and boron for maximizing the yield. Treatments for this study comprised of four levels each of zinc (0, 1.5, 3.0, and 4.5 kg/ha) and boron (0, 1.0, 2.0, and 3.0 kg/ha) along with a blanket dose of N_{130} P_{60} K_{80} S_{20} Mg_{10} kg/ha. The experiment was set up in a randomized block design (factorial) with 3 replications. The integrated use of zinc and boron was found superior to their single applications. The interaction effect between zinc and boron was significant in case of yield of dry chilli and weight of ripe chilli/plant. The highest yield (1138 kg/ha) was recorded from Zn_3B_1 kg/ha, which was closely followed by Zn_3B_2, Zn_4B_2 and the lowest (703 kg/ha) in control (Zn_0B_0). The yield benefit over control varied from 4.4 to 61.9% due to interaction effect. Consecutive three years studies showed almost similar trend of results. However, from regression analysis, the optimum-economic dose of zinc was found to be 3.91 kg/ha whereas it was 1.70 for boron.

From the above review of literature it is revealed that pruning and different micronutrients have significant effect on growth, yield contributing characters and yield of capsicum.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from October 2012 to April 2013 to study the response of bell pepper (*Capsicum annuum*) to shoot pruning and foliar feeding of micronutrients. This chapter includes a brief description of the methods and materials that were used for conducting the experiment.

3.1 Experimental site

The experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka, Bangladesh. The experiment was carried out during rabi season. The location of the study was situated in $23^{0}74^{/}$N latitude and $90^{0}35^{/}$E longitude (Anon., 1989). The altitude of the location was 8 m from the sea level (The Meteorological Department of Bangladesh, Agargaon, Dhaka).

3.2 Climatic condition of the experimental site

The experimental site was under the subtropical climate, characterized by three distinct seasons, winter season from November to February and the pre-monsoon or hot season from March to April and the monsoon period from May to October. Details of the meteorological data during the period of the experiment was collected from the Bangladesh Meteorological Department, Agargoan, Dhaka and presented in Appendix I.

3.3 Characteristics of soil of the experiment

The soil of the experimental area belongs to the Modhupur Tract (UNDP, 1988) under AEZ No. 28. The selected plot was medium high land and the soil series was Tejgaon (FAO, 1988). The characteristics of the soil under the experimental plot were analyzed in the Soil Testing Laboratory, SRDI Farmgate, Dhaka and details soil characteristics are presented in Appendix II.

3.4 Planting materials

Capsicum variety “Lamuyo” (exotic variety) were used as experimental materials. The seeds were collected from Manik Seed Company, 145, Siddique bazar, Dhaka-1000.

3.5 Treatment of the experiment

The experiment consisted of two factors:

Factor A: Shoot pruning (two levels) as

i P_0: No shoot prunning
ii. P_1: Shoot pruning

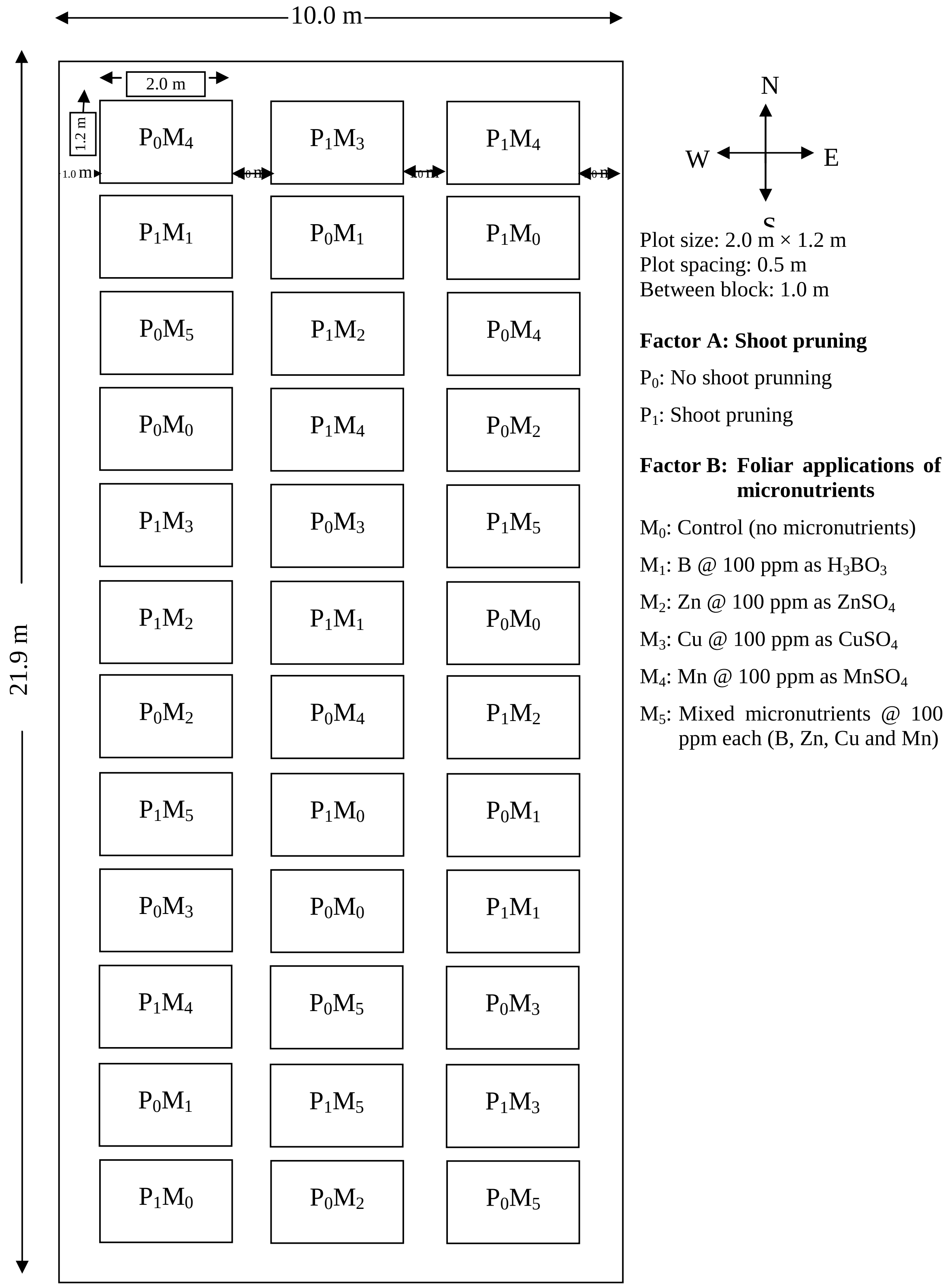
Factor B: Foliar applications of micronutrients (five levels) as

i. M_0: Control (no micronutrients)
ii. M_1: Boron (B) @ 100 ppm as H_3BO_3
iii. M_2: Zinc (Zn) @ 100 ppm as $ZnSO_4$
iv. M_3: Cupper (Cu) @ 100 ppm as $CuSO_4$
v. M_4: Manganese (Mn) @ 100 ppm as $MnSO_4$
vi. M_5: Mixed micronutrients @ 100 ppm each (B, Zn, Cu and Mn)

There were 12 (2 × 6) treatment combinations such as P_0M_0, P_0M_1, P_0M_2, P_0M_3, P_0M_4, P_0M_5, P_1M_0, P_1M_1, P_1M_2, P_1M_3, P_1M_4 and P_1M_5.

3.6 Design and layout of the experiment

The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The total area of the experimental plot was 219.0 m^2 with length 21.9 m and width 10.0 m which was divided into three equal blocks. Each block was divided into 12 plots where 12 treatments combination were allotted at random. There were 36 unit plots altogether in the experiment. The size of the each plot was 2.0 m × 1.2 m. The distance maintained between two blocks and two plots were 1.0 m and 0.5 m, respectively. Seeds were sown in the plot with maintaining distance between row to row and plant to plant was 50 cm and 30 cm, respectively. The layout of the experiment is shown in Figure 1.



3.7 Seedbed preparation

Seedbed was prepared on 5th October 2012 for raising seedlings of capsicum and the size of the seedbed was 3 m × 1 m. For making seedbed, the soil was well ploughed. Weeds, stubbles and dead roots were removed from the seedbed. Cow dung was applied to the prepared seedbed @ 10 t/ha. The soil was treated by Sevin 50WP @ 5 kg/ha to protect the young plants from the attack of ants and cutworms. Seeds were treated by Vitavex-200 @ 5 g/1kg seeds to protect some seed borne diseases such as leaf spot, blight, anthracnose, etc.

3.8 Seed sowing

Seeds were sown on 12th October, 2012 in the seedbed. Sowing was done in lines spaced at 5 cm distance. Seeds were sown at a depth of 2 cm and covered with a fine layer of soil followed by light watering by watering can. Thereafter, the beds were covered with polythene to maintain required temperature and moisture.

3.9 Raising of seedlings

Light watering and weeding were done several times as per needed. No chemical fertilizers were applied for raising of seedlings. Seedlings were not attacked by any kind of insect or disease. Healthy and 30 days old seedlings were transplanted into the experimental field on 12 November 2012.

3.10 Preparation of the main field

The plot selected for conducting the experiment was opened in the first week of November 2012, with a power tiller and left exposed to the sun for a week to kill soil born pathogens and soil inhabitant insects. After one week the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain until good tilth. The land was leveled, corners were shaped and the clods were broken into pieces. Weeds, crop residues and stables were removed from the field. The basal dose of manure and fertilizers were applied at the finally ploughing. The plots were prepared according to design and layout of the experiment. The soil of the plot was treated by Sevin 50WP @ 5 kg/ha to protect the young plants from the attack of ants and cutworm.

3.11 Application of manure and fertilizers

The fertilizers N, P, K and S in the form of urea, TSP, MoP and gypsum, respectively were applied (BARI, 2011). Half of the quantity of cowdung was applied during final land preparation. The remaining half of cowdung, the entire amount of TSP, gypsum and one third of urea and MoP were applied during pit preparation. Urea and MoP were applied in two equal installments at before flowering and fruit setting. Micronutrients were applied as per treatment mentioned in 3.5. The dose and method of application of fertilizer are shown in Table 1.

Table 1. Dose and method of application of fertilizers in capsicum field

Manure and Fertilizers	Dose (ha)	Application (%)			
		Final land preparation	Installments		
			Pit preparation	Before flowering	Fruiting stage
Cowdung	10 ton	50.00	50.00	--	--
Urea	250 kg	--	33.33	33.33	33.33
TSP	330 kg	--	100.00	--	--
MoP	250 kg	--	33.33	33.33	33.33
Gypsum	110 kg	--	100.00	--	--

Source: BARI, 2011

3.12 Transplanting

Healthy and uniform 30 days old capsicum seedlings were transplanting in the experimental plots on 12 November, 2012. The seedlings were uprooted carefully from the seed bed to avoid damage to the root system. To minimize the damage to the roots of seedlings, the seed beds were watered one hour before uprooting the seedlings. Transplanting was done in the afternoon. The seedlings were watered immediately after transplanting. Seedlings were sown in the plot with maintaining distance between row to row and plant to plant was 50 cm and 40 cm, respectively and total 12 plants were accommodated in each plot. The young transplants were shaded by banana leaf sheath during day time to protect them from scorching sunshine up to 7 days until they were set in the soil. They (transplants) were kept open at night to allow them receiving dew. A number of seedlings were also planted in the border of the experimental plots for gap filling.

3.13 Intercultural operation

After raising seedlings, various intercultural operations, such as gap filling, weeding, earthing up, irrigation pest and disease control etc. were accomplished for better growth and development of the capsicum seedlings.

3.13.1 Gap filling

The transplanted seedlings in the experimental plot were kept under careful observation. Very few seedlings were damaged after transplanting and such seedling were replaced by new seedlings from the same stock. Planted earlier on the border of the experimental plots same as planting time treatment. Those seedlings were transplanted with a big mass of soil with roots to minimize transplanting stock. Replacement was done with healthy seedling having a boll of earth. The transplants were given shading and watering for 7 days for their proper establishment.

3.13.2 Pruning of plants

Pruning operation was carried out at 21 days after transplanting (DAT). Shoot pruning was done with remaining four shoot in a plant with a sharp knife and in case of no pruning it was allowed normal growth of a plant.

3.13.3 Collection and application of micronutrients

Micronutrients were applied as per treatment. For each treatment 100 ppm were sprayed on the foliage of the plants during vegetative stage, flower initiation stage and 2 times at blooming by a mini hand sprayer.

3.13.4 Weeding

The hand weeding was done 15, 30 and 45, 60 after transplanting to keep the plots free from weeds.

3.13.5 Earthing up

Earthing up was done at 20 and 40 days after transplanting on both sides of rows by taking the soil from the space between the rows by a small spade.

3.13.6 Irrigation

Light watering was given by a watering cane at every morning and afternoon. Following transplanting and it was continued for a week for rapid and well establishment of the transplanted seedlings.

3.13.7 Pest and disease control

Insect infestation was a serious problem during the period of establishment of seeding in the field. In spite of Cirocarb 3G applications during final land preparation few young plants were damaged due to attack of mole cricket and cut worm. Cut worms were controlled both mechanically and spraying Darsban 29 EC @ 3%. Some of plants were infected by *Alternaria* leaf spot diseases caused by *Alternaria brassicae*. To prevent the spread of the disease Rovral @ 2 gm per liter of water was sprayed in the field. The diseased leaves were also collected from the infested plant and removed from the field.

3.14 Harvesting

Harvesting of fruits was started at 80 DAT and continued upto final harvest based on the marketable sized of fruits. Harvesting was done by hand picking.

3.15 Data collection

Three plants were randomly selected for data collection from the middle rows of each unit plot for avoiding border effect, except yields of fruits, which was recorded plot wise. Data were collected in respect of the following parameters to assess plant growth, yield attributes and yields.

3.15.1 Plant height

Plant height of bell pepper was measured from sample plants in centimeter from the ground level to the tip of the longest stem and mean value was calculated.

Plant height was also recorded starting from 30 days after transplanting (DAT) upto 105 days at 15 days interval and at final harvest to observe the vegetative growth rate of plants.

3.15.2 Number of leaves per plant

The total number of leaves per plant was counted from each selected plant. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot from 30 DAT to 105 DAT at 15 days interval and final harvest.

3.15.3 Days from transplanting to 1st flowering

Difference between the dates of transplanting to the date of 1st flower emergence of a plot was counted and recorded.

3.15.4 Number of flowers/plant

The number of flowers per plant was counted from each plot after flowering and recorded per plant basis.

3.15.5 Number of total fruits/plant

The number of total fruits per plant was counted after setting of fruits and recorded per plant basis.

3.15.6 Number of marketable fruits/plant

The number of marketable fruits per plant was counted and recorded per plant basis.

3.15.7 Fruit setting (%)

Fruit setting was calculated by using the following formula and recorded -

$$\% \text{ Fruit setting} = \frac{\text{Number of fruits per plant}}{\text{Number of flowers per plant}} \times 100$$

3.15.8 Days from transplanting to 1st harvest

Difference between the dates of transplanting to the 1st harvest of a plot was counted as days to 1st harvest. Days to 1st harvest was recorded when harvest of fruit were started.

3.15.9 Length of fruit

The length of individual fruit was measured in one side to another side of fruit from five selected fruits with a meter scale and average of individual fruit length recorded and expressed in centimeter (cm).

3.15.10 Diameter of fruit

The diameter of individual fruit was measured in several directions with meter scale and the average of all directions was finally recorded and expressed in centimeter (cm).

3.15.11 Pericarp thickness

The thickness of paricarp of individual fruit was measured in one side to another side of pericarp from five selected fruits with a meter scale and average of pericarp thickness recorded and expressed in millimeter (mm).

3.15.12 Individual fruit weight

The weight of individual fruit was recorded in gram (gm) by a beam balance from all fruits of selected three plants and converted individually.

3.15.13 Fruit yield/plot

Yield of bell pepper per plot was recorded as the whole fruit per plot and was expressed in kilogram.

3.15.14 Fruit yield/hectare

Yield per hectare of bell pepper was calculated by converting the weight of plot yield into hectare and was expressed in ton.

3.16 Statistical analysis

The data obtained for different characters were statistically analyzed using MSTAT-C software. The mean values of all the characters were evaluated and analysis of variance was performing by the ‘F’ test. The significance of the difference among the treatments means was estimated by Duncan’s Multiple Range Test (DMRT) at 5% level of probability (Gomez and Gomez, 1984).

3.17 Economic analysis

The cost of production was calculated to find out the most economic combination of shoot pruning and foliar application of micronutrients. All input cost like the cost for land lease and interests on running capital were computing in the calculation. The interests were calculated @ 13% in simple rate. The market price of bell pepper was considered for estimating the return. Analyses were done according to the procedure of Alam *et al*. (1989). The benefit cost ratio (BCR) was calculated as follows:

$$\text{Benefit cost ratio (BCR)} = \frac{\text{Gross return per hectare (Tk.)}}{\text{Total cost of production per hectare (Tk.)}}$$

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to determine the response of bell pepper to shoot pruning and foliar feeding of micronutrients. Data on growth, yield contributing characters and yields were recorded. A summary of the analysis of variance (ANOVA) of the data on different characters have been presented in Appendix III-VII. The results have been discussed with the help of tables and graphs and possible interpretations are given under the following sub-headings:

4.1 Plant height

Shoot pruning of bell pepper showed significant variation for plant height at 30, 45, 60, 75, 90, 105 days after transplanting (DAT) and final harvest (Appendix III). At 30, 45, 60, 75, 90, 105 DAT and final harvest, the longest plant (14.46, 20.53, 33.86, 43.82, 49.73, 55.36 and 59.95 cm, respectively) was recorded from P_1 (shoot pruning), while the shorter plant (13.77, 19.75, 32.45, 41.93, 48.47, 53.51 and 57.30 cm, respectively) was observed from P_0 (no shoot pruning) (Figure 2). Data revealed that shoot pruning enhanced vegetative growth as well as longest plan than unpruned plants. Pepper plants have a branching habit; therefore, fruit development is controlled by restricting the branching pattern of main branches and the reasons for pruning bell pepper are to train plant to grow upright in order to facilitate light penetration all over the leaf canopy which leads to better canopy with the longest plant. Baki (1987) found that pruning showed a significant effect on plant height and unpruned plants exhibited higher plant height. Rahman *et al*. (1988) reported that plant height was not influenced by the pruning operation. Poksoy *et al*. (1994) reported that pruning methods (i.e. to 2 or 3 shoots) significantly increased main-shoot length and as well as vegetative growth. Ambroszczyk *et al*. (2007) reported that pruning strongly affected the effectiveness of growth of crop.

Plant height of bell pepper varied significantly for different foliar application of fertilizers at 30, 45, 60, 75, 90, 105 DAT and final harvest (Appendix III). At 30, 45, 60, 75, 90, 105 DAT and final harvest, the tallest plant (15.55, 22.17, 36.31, 45.96, 52.17, 56.56 and 60.73 cm, respectively) was obtained from M_5 (mixed micronutrients @ 100 ppm each: B, Zn, Cu and Mn) which was statistically similar with M_2 (Zinc-Zn @ 100 ppm), while the shortest plant (12.71, 18.42, 27.49, 36.29, 44.15, 50.56 and 53.65 cm, respectively) was found from M_0 i.e. control condition (Figure 3). Foliar fertilizers immediately deliver nutrients to the tissues and organs of the crop. Improvement in growth characters as a result of application of micronutrients might be due to the enhanced photosynthetic and other metabolic activity which leads to an increase in various plant metabolites responsible for cell division and elongation as opined by Hatwar *et al.* (2003) which leads to produced tallest plant. Datir *et al*. (2012) reported that micronutrients like iron, zink, copper and manganese were organically chelated with seed amino acids and the application of amino acid-micronutrient chelate at the concentration of 1.5 and 2.0% resulted in maximum plant height.

Significant variation was observed due to the interaction effect of shoot pruning and foliar application of micronutrients in terms of plant height of bell pepper at 30, 45, 60, 75, 90, 105 DAT and final harvest (Appendix III). At 30, 45, 60, 75, 90, 105 DAT and final harvest, the tallest plant (16.44, 22.26, 38.35, 43.20, 52.49, 57.83 and 63.19 cm) was observed from P_1M_5 (shoot pruning + mixed micronutrients @ 100 ppm each, B, Zn, Cu and Mn), while the shortest plant (12.03, 18.23, 26.09, 34.29, 42.49, 49.30 and 50.80 cm) was recorded from P_0M_0 (no shoot pruning + control i.e. no micronutrients)at same DAT, respectively (Table 2).

Table 2. Interaction effect of shoot pruning and foliar application of micronutrients on plant height of bell pepper

Treatments	Plant height (cm) at						
	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT	Final harvest
P_0M_0	12.03 e	18.23 d	26.09 g	34.29 d	42.49 d	49.30 d	50.80 c
P_0M_1	14.98 abc	19.51 bcd	29.46 fg	39.49 c	47.69 bc	52.42 bcd	56.18 b
P_0M_2	14.88 abcd	19.46 bcd	33.89 cde	42.70 bc	49.52 ab	54.42 abc	58.32 ab
P_0M_3	13.89 cd	18.32 d	31.79 def	39.72 c	47.61 bc	52.50 bcd	58.00 ab
P_0M_4	12.15 e	20.37 abc	35.67 abc	46.68 ab	51.69 a	56.62 ab	60.26 ab
P_0M_5	14.66 bcd	22.08 a	37.79 ab	48.71 a	51.85 a	55.81 abc	60.26 ab
P_1M_0	13.27 de	18.60 cd	28.88 fg	38.29 cd	45.80 c	51.81 cd	56.50 b
P_1M_1	13.55 cde	20.83 ab	34.84 abcd	49.77 a	52.44 a	57.31 a	61.21 ab
P_1M_2	14.28 cd	22.12 a	36.06 abc	46.60 ab	50.65 a	57.15 a	61.84 ab
P_1M_3	13.26 de	20.50 abc	34.54 bcd	45.44 ab	50.85 a	55.93 abc	59.18 ab
P_1M_4	15.95 ab	19.45 bcd	30.50 ef	39.60 c	46.16 c	52.13 cd	57.79 ab
P_1M_5	16.44 a	22.26 a	38.35 a	43.20 bc	52.49 a	57.83 a	63.19 a
$LSD_{(0.05)}$	1.504	1.740	3.238	4.505	2.787	3.759	5.214
Level of significance	0.01	0.05	0.01	0.01	0.01	0.05	0.05
CV(%)	6.29	5.10	5.77	6.21	4.35	4.08	5.25

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

P_0: No shoot pruning
P_1: Shoot pruning

M_0: Control (no micronutrients)
M_1: Boron (B) @ 100 ppm
M_2: Zinc (Zn) @ 100 ppm
M_3: Cupper (Cu) @ 100 ppm
M_4: Manganese (Mn) @ 100 ppm
M_5: Mixed micronutrients @ 100 ppm each (B, Zn, Cu and Mn)

4.2 Number of leaves per plant

Number of leaves per plant of bell pepper showed statistically significant differences due to shoot pruning of bell pepper at 30, 45, 60, 75, 90, 105 DAT and final harvest (Appendix IV). At 30, 45, 60, 75, 90, 105 DAT and final harvest, the maximum number of leaves per plant (18.37, 36.64, 60.58, 76.21, 94.73, 114.58 and 134.34, respectively) was recorded from P_1, while the minimum number (15.60, 31.56, 53.86, 70.47, 85.94, 106.51 and 123.77 at 30, 45, 60, 75, 90, 105 DAT and final harvest, respectively) was obtained from P_0 (Figure 4). Shetty and Manohar (2008) reported that capsicum plants responded significantly to the pruning and pruned plants produced maximum number of leaves per plant than unprunned plants.

Number of leaves per plant of bell pepper differed significantly due to the effect of foliar application of micronutrients at 30, 45, 60, 75, 90, 105 DAT and final harvest (Appendix IV). At 30, 45, 60, 75, 90, 105 DAT and final harvest, the maximum number of leaves per plant (19.10, 38.20, 60.20, 78.23, 95.23, 116.87 and 136.13, respectively) was found from M_5 which was statistically similar with M_2, while the minimum number (14.93, 29.20, 51.67, 66.77, 84.00, 104.07 and 119.50, respectively) from M_0 i.e. control condition (Figure 5).

Shoot pruning and foliar application of micronutrients showed significant variation due to the interaction effect on number of leaves per plant of bell pepper at 30, 45, 60, 75, 90, 105 DAT and final harvest (Appendix IV). The maximum number of leaves per plant (19.80, 40.33, 60.80, 80.27, 99.13, 123.93 and 143.53, respectively) was recorded from P_1M_5 at 30, 45, 60, 75, 90, 105 DAT and final harvest, respectively, whereas the minimum number of leaves per plant (13.73, 25.40, 44.13, 61.20, 79.53, 101.07 and113.93, respectively) was observed from P_0M_0 at 30, 45, 60, 75, 90, 105 DAT and final harvest (Table 3).

Table 3. Interaction effect of shoot pruning and foliar application of micronutrients on number of leaves per plant of bell pepper

Treatments	Number of leaves per plant						
	30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT	Final harvest
P_0M_0	13.73 c	25.40 g	44.13 e	61.20 d	79.53 e	101.07 e	113.93 c
P_0M_1	14.73 c	31.73 def	52.33 d	71.47 bc	85.73 d	105.07 de	123.47 b
P_0M_2	18.00 ab	35.27 bcde	56.73 bcd	71.27 bc	8.33 cd	109.53 cde	125.87 b
P_0M_3	14.60 c	29.93 f	54.07 cd	71.93 bc	85.40 d	107.87 de	123.27 b
P_0M_4	13.93 c	30.93 ef	56.27 bcd	70.73 c	85.33 d	105.73 de	127.33 b
P_0M_5	18.40 a	36.07 abcd	59.60 abc	76.20 abc	91.33 bc	109.80 cde	128.73 b
P_1M_0	15.93 bc	33.00 cdef	59.20 abcd	72.33 bc	88.47 cd	107.07 de	125.07 b
P_1M_1	20.07 a	38.87 ab	64.27 a	76.80 ab	97.00 a	118.33 ab	142.27 a
P_1M_2	17.93 ab	37.07 abc	62.87 ab	81.47 a	97.47 a	117.53 abc	140.47 a
P_1M_3	18.13 ab	36.00 abcd	58.87 abcd	72.93 bc	93.27 b	109.43 cde	127.07 b
P_1M_4	18.33 a	34.60 bcde	57.47 abcd	73.47 bc	93.07 b	111.20 bcd	127.67 b
P_1M_5	19.80 a	40.33 a	60.80 abc	80.27 a	99.13 a	123.93 a	143.53 a
$LSD_{(0.05)}$	2.084	4.148	6.293	5.175	3.219	7.808	8.767
Level of significance	0.01	0.05	0.05	0.05	0.05	0.05	0.05
CV(%)	7.25	7.18	6.50	4.17	5.10	4.17	4.01

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

P_0: No shoot pruning
P_1: Shoot pruning

M_0: Control (no micronutrients)
M_1: Boron (B) @ 100 ppm
M_2: Zinc (Zn) @ 100 ppm
M_3: Cupper (Cu) @ 100 ppm
M_4: Manganese (Mn) @ 100 ppm
M_5: Mixed micronutrients @ 100 ppm each (B, Zn, Cu and Mn)

4.3 Days from transplanting to 1st flowering

Days from transplanting to 1st flowering showed statistically significant variation due to the effect of shoot pruning of bell pepper (Appendix V). The minimum days from transplanting to 1st flowering (53.11 days) was found from P_1, while the maximum (56.61 days) was attained from P_0 (Table 4).

Significant variation was observed in terms of days from transplanting to 1st flowering of bell pepper for foliar application of micronutrients (Appendix V). The minimum days from transplanting to 1st flowering (52.33 days) was found from M_5 which was statistically similar (53.17 days and 54.00 days) to M_2 and M_1, while the maximum (58.67 days) from M_0 which was statistically identical (55.50 days) with M_3 and M_4 (Table 4). Dongre *et al*. (2000) also reported similar findings.

Interaction effect of shoot pruning and foliar application of micronutrients varied significantly for days from transplanting to 1st flowering (Appendix V). The minimum days from transplanting to 1st flowering (46.67 days) was found from P_1M_5, while the maximum (60.00 days) was observed from P_0M_0 (Table 5).

4.4 Number of flowers per plant

Significant variation was recorded due to the effect of shoot pruning of bell pepper in respect of number of flowers per plant (Appendix V). The higher number of flowers per plant (32.03) was recorded from P_1, while the lower number (29.99) was obtained from P_0 (Table 4). Shetty and Manohar (2008) reported that capsicum plants responded significantly to the pruning.

Number of flowers per plant of bell pepper showed significant differences due to the effect of different foliar application of micronutrients (Appendix V). The highest number of flowers per plant (33.70) was recorded from M_5 which was statistically similar with M_2, whereas the lowest number (27.97) from M_0 i.e. control condition (Table 4). Laxman and Mukherjee (2000) also reported similar findings.

Table 4. Main effect of shoot pruning and foliar application of micronutrients on yield contributing characters of bell pepper

Treatments	Days from transplanting to 1st flowering	Number of flowers per plant	Number of total fruits per plant	Number of marketable fruits per plant	Fruit Setting (%)	Days from transplanting to 1st harvest
Shoot pruning						
P_0	56.61	29.99	10.38	7.90	34.43	120.72
P_1	53.11	32.03	12.76	8.70	39.73	116.61
$LSD_{(0.05)}$	2.233	0.835	0.344	0.229	1.315	3.931
Level of significance	0.01	0.01	0.01	0.01	0.01	0.05
Foliar application of micronutrients						
M_0	58.67 a	27.97 c	9.27 e	6.17 d	33.14 d	125.17 a
M_1	54.00 b	31.13 b	11.67 c	8.47 c	37.34 bc	116.50 b
M_2	53.17 b	32.80 a	12.87 b	9.17 b	39.31 ab	115.00 b
M_3	55.50 ab	30.47 b	11.10 cd	8.27 c	36.18 c	120.00 ab
M_4	55.50 ab	30.00 b	10.83 d	8.17 c	35.99 c	121.33 ab
M_5	52.33 b	33.70 a	13.67 a	9.57 a	40.53 a	114.00 b
$LSD_{(0.05)}$	3.868	1.447	0.595	0.397	2.277	6.809
Level of significance	0.05	0.01	0.01	0.01	0.05	0.05
CV(%)	5.89	3.90	4.30	4.00	5.13	4.79

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

P_0: No shoot pruning
P_1: Shoot pruning

M_0: Control (no micronutrients)
M_1: Boron (B) @ 100 ppm
M_2: Zinc (Zn) @ 100 ppm
M_3: Cupper (Cu) @ 100 ppm
M_4: Manganese (Mn) @ 100 ppm
M_5: Mixed micronutrients @ 100 ppm each (B, Zn, Cu and Mn)

Table 5. Interaction effect of shoot pruning and foliar application of micronutrients on yield contributing characters of bell pepper

Treatments	Days from transplanting to 1st flowering	Number of flowers per plant	Number of total fruits per plant	Number of marketable fruits per plant	Fruit Setting (%)	Days from transplanting to 1st harvest
P_0M_0	60.00 a	27.47 d	8.33 g	6.00 e	30.38 f	129.67 a
P_0M_1	55.00 ab	29.00 d	9.80 ef	7.67 d	33.99 de	115.00 bcd
P_0M_2	59.67 a	34.00 ab	12.60 cd	9.07 abc	37.06 bcd	122.67 ab
P_0M_3	56.33 ab	28.67 d	9.13 fg	7.53 de	31.87 ef	117.00 bcd
P_0M_4	55.33 ab	28.40 d	9.53 ef	7.67 d	33.57 def	121.67 ab
P_0M_5	53.33 b	32.40 bc	12.87 bcd	9.47 ab	39.72 ab	118.33 bc
P_1M_0	57.33 ab	28.47 d	10.20 e	6.33 de	35.90 cd	120.67 ab
P_1M_1	53.00 b	33.27 abc	13.53 b	9.27 abc	40.70 a	118.00 bc
P_1M_2	51.33 bc	31.60 c	13.13 bc	9.27 abc	41.56 a	109.67 cd
P_1M_3	54.67 ab	32.27 bc	13.07 bc	9.00 bc	40.49 ab	123.00 ab
P_1M_4	55.67 ab	31.60 c	12.13 d	8.67 c	38.41 abc	121.00 ab
P_1M_5	46.67 c	35.00 a	14.47 a	9.67 a	41.34 a	107.33 d
$LSD_{(0.05)}$	5.470	2.046	0.842	0.562	3.220	9.630
Level of significance	0.05	0.01	0.01	0.01	0.01	0.05
CV(%)	5.89	3.90	4.20	4.00	5.13	4.79

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

P_0: No shoot pruning
P_1: Shoot pruning

M_0: Control (no micronutrients)
M_1: Boron (B) @ 100 ppm
M_2: Zinc (Zn) @ 100 ppm
M_3: Cupper (Cu) @ 100 ppm
M_4: Manganese (Mn) @ 100 ppm
M_5: Mixed micronutrients @ 100 ppm each (B, Zn, Cu and Mn)

Number of flowers per plant showed significant variation due to the interaction effect of shoot pruning and foliar application of micronutrients (Appendix V). The highest number of flowers per plant (35.00) was recorded from P_1M_5, while the lowest number (27.47) was found from P_0M_0 (Table 5).

4.5 Number of total fruits per plant

Shoot pruning of bell pepper showed significant variation on number of total fruits per plant (Appendix V). The higher number of total fruits per plant (12.76) was obtained from P_1, while the lower number (10.38) was obtained from P_0 (Table 4). Baki (1987) found that pruning showed a significant effect on number of total fruits per plants. Hernandez *et al*. (1992) found that number of fruits was higher in plants for pruning one stem.

Foliar application of micronutrients significantly influenced on number of total fruits per plant of bell pepper (Appendix V). The highest number of total fruits per plant (13.67) was found from M_5 which was closely followed (12.87) by M_2, while the lowest number (9.27) was recorded from M_0 i.e. control condition (Table 4).

Significant variation was observed due to the interaction effect of shoot pruning and foliar application of micronutrients in terms of number of fruits per plant (Appendix V). The highest number of fruits per plant (14.47) was recorded from P_1M_5, while the lowest number (8.33) was observed from P_0M_0 (Table 5).

4.6 Number of marketable fruits per plant

Number of marketable fruits per plant showed significant variation due to shoot pruning of bell pepper (Appendix V). The higher number of marketable fruits per plant (8.70) was obtained from P_1, while the lower number (7.90) was obtained from P_0 (Table 4). Hernandez *et al*. (1992) found that number of marketable fruits was higher in plants for pruning one stem.

Foliar application of micronutrients significantly influenced on number of marketable fruits per plant of bell pepper (Appendix V). The highest number of marketable fruits per plant (9.57) was found from M_5 which was followed (9.17) by M_2, while the lowest number (6.17) from M_0 i.e. control condition (Table 4).

Significant variation was observed due to the interaction effect of shoot pruning and foliar application of micronutrients in terms of number of marketable fruits per plant (Appendix V). The highest number of marketable fruits per plant (9.67) was recorded from P_1M_5, while the lowest number (6.00) from P_0M_0 (Table 5).

4.7 Fruit setting

Fruit setting of bell pepper showed significant variation due to the effect of shoot pruning (Appendix V). The maximum fruit setting (39.73%) was found from P_1, while the minimum (34.43%) was attained from P_0 (Table 4). Shetty and Manohar (2008) reported that capsicum plants responded significantly to the pruning in respect of fruit setting.

Fruit setting of bell pepper varied significantly for different foliar application of micronutrients (Appendix V). The maximum fruit setting (40.53%) was found from M_5 which was statistically similar (39.31%) with M_2, while the minimum fruit setting (33.14%) was recorded from M_0 i.e. control condition (Table 4).

Interaction effect of shoot pruning and foliar application of micronutrients showed significant variation in terms of fruit setting (Appendix V). The maximum fruit setting (41.34%) was observed from P_0M_5, while the minimum (30.38%) was found from P_0M_0 (Table 5).

4.8 Days from transplanting to 1st harvest

Shoot pruning of bell pepper showed significant effect on days from transplanting to 1st harvest (Appendix V). However, minimum days from transplanting to 1st harvest (116.61) were attained from P_1, while the maximum days (120.72) were found from P_0 (Table 4). Abdullah *et al*. (2013) reported that pepper plants pruned to one branch resulted in a significant increase in early yield.

Days from transplanting to 1st harvest of bell pepper varied significantly due to different foliar application of micronutrients (Appendix V). The minimum days from transplanting to 1st harvest (114.00) was found from M_5 which was statistically similar (115.00 days and 116.50 days) to M_2 and M_1, while the maximum days (125.17) was recorded from M_0 i.e. control condition (Table 4).

Significant variation was obtained due to the interaction effect of shoot pruning and foliar application of micronutrients in terms of days from transplanting to 1st harvest (Appendix V). The minimum days from transplanting to 1st harvest (107.33) was found from P_1M_5, while the maximum days (129.67) was recorded from P_0M_0 (Table 5).

4.9 Length of fruit

Shoot pruning of bell pepper showed significant variation for length of fruit (Appendix VI). The maximum length of fruit (7.81 cm) was recorded from P_1, while the minimum length (7.22 cm) was found from P_0 (Table 6). Data revealed that pruning influenced length of fruit of bell pepper. Hernandez *et al*. (1992) found that fruit length were greatest in plants for pruning one stem. Abdullah *et al*. (2013) reported that pepper plants pruned to one branch resulted significant increase in fruit size.

Different foliar application of micronutrients showed significant variation on length of fruits (Appendix VI). The maximum length of fruit (8.55 cm) was found from M_5 which was statistically similar (8.18 cm) to M_2 and closely followed (7.62 cm) by M_1, where the minimum length (6.12 cm) was observed from M_0 (Table 6). Dongre *et al*. (2000) also reported similar findings.

Significant variation was observed due to the interaction effect of shoot pruning and foliar application of micronutrients in terms of length of fruit (Appendix VI).

The maximum length of fruit (8.80 cm) was found from P_1M_5, while the minimum length (6.02 cm) was observed from P_0M_0 (Table 7).

Table 6. Main effect of shoot pruning and foliar application of micronutrients on yield contributing characters of bell pepper

Treatments	Length of fruit (cm)	Diameter of fruit (cm)	Pericarp thickness (mm)	Individual fruit weight (g)	Yield per hectare (ton)
Shoot pruning					
P_0	7.22	5.04	6.12	59.40	23.58
P_1	7.81	5.24	6.50	61.03	26.60
$LSD_{(0.05)}$	0.355	0.193	0.240	1.571	0.750
Level of significance	0.01	0.05	0.01	0.04	0.01
Foliar application of micronutrients					
M_0	6.12 d	4.22 d	5.03 c	57.61 c	17.77 e
M_1	7.62 bc	5.26 bc	6.60 ab	60.67 ab	25.77 c
M_2	8.18 ab	5.47 ab	6.76 a	61.99 ab	28.41 b
M_3	7.36 c	5.15 bc	6.30 b	59.10 bc	24.44 d
M_4	7.27 c	5.08 c	6.18 b	59.25 bc	24.18 d
M_5	8.55 a	5.66 a	6.99 a	62.68 a	29.98 a
$LSD_{(0.05)}$	0.614	0.334	0.415	2.721	1.300
Level of significance	0.01	0.01	0.01	0.01	0.01
CV(%)	6.82	5.43	5.49	4.77	4.33

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

P_0: No shoot pruning
P_1: Shoot pruning

M_0: Control (no micronutrients)
M_1: Boron (B) @ 100 ppm
M_2: Zinc (Zn) @ 100 ppm
M_3: Cupper (Cu) @ 100 ppm
M_4: Manganese (Mn) @ 100 ppm
M_5: Mixed micronutrients @ 100 ppm each (B, Zn, Cu and Mn)

Table 7. Interaction effect of shoot pruning and foliar application of micronutrients on yield contributing characters of bell pepper

Treatments	Length of fruit (cm)	Diameter of fruit (cm)	Pericarp thickness (mm)	Individual fruit weight (g)	Yield per hectare (ton)
P_0M_0	6.02d	4.03 f	4.77 e	55.89 c	16.77 g
P_0M_1	6.93 cd	5.11 bcd	6.23 bcd	58.37 bc	22.37 e
P_0M_2	8.45 ab	5.66 a	6.97 a	62.63 ab	28.39 bc
P_0M_3	6.76 cd	4.68 de	5.92 d	58.47 bc	21.99 e
P_0M_4	6.84 cd	5.04 cd	6.05 cd	58.65 abc	22.44 e
P_0M_5	8.29 ab	5.72 a	6.77 ab	62.40 ab	29.54 ab
P_1M_0	6.21 d	4.41 ef	5.29 e	59.33 abc	18.77 f
P_1M_1	8.30 ab	5.41 abc	6.97 a	62.96 a	29.18 ab
P_1M_2	7.92 ab	5.29 abc	6.56 abcd	61.35 ab	28.43 bc
P_1M_3	7.95 ab	5.62 ab	6.67 abc	59.74 abc	26.88 cd
P_1M_4	7.69 bc	5.12 bcd	6.31 bcd	59.85 abc	25.92 d
P_1M_5	8.80 a	5.60 ab	7.20a	62.96 a	30.43 a
$LSD_{(0.05)}$	0.868	0.473	0.587	3.848	1.838
Level of significance	0.05	0.01	0.05	0.04	0.01
CV(%)	6.82	5.43	5.49	4.77	4.33

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

P_0: No shoot pruning
P_1: Shoot pruning

M_0: Control (no micronutrients)
M_1: Boron (B) @ 100 ppm
M_2: Zinc (Zn) @ 100 ppm
M_3: Cupper (Cu) @ 100 ppm
M_4: Manganese (Mn) @ 100 ppm
M_5: Mixed micronutrients @ 100 ppm each (B, Zn, Cu and Mn)

4.10 Diameter of fruit

Diameter of fruit varied significantly due to shoot pruning of bell pepper (Appendix VI). The maximum diameter of fruit (5.24 cm) was recorded from P_1, while the minimum diameter (5.04 cm) was obtained from P_0 (Table 6). Hernandez *et al*. (1992) found that fruit diameter were greatest in plants for pruning one stem.

Significant variation was recorded for diameter of fruit of bell pepper for different foliar application of micronutrients (Appendix VI). The maximum diameter of fruit (5.66 cm) was found from M_5 which was statistically similar (5.47 cm) to M_2 and closely followed (5.26 cm) by M_1, while the minimum diameter (4.22 cm) was recorded from M_0 i.e. control condition (Table 6). Laxman and Mukherjee (2000) also reported similar findings.

Different shoot pruning and foliar application of micronutrients varied significantly due to the interaction effect in terms of diameter of fruit (Appendix VI). The maximum diameter of fruit (5.60 cm) was recorded from P_1M_5, while the minimum diameter (4.03 cm) was observed from P_0M_0 (Table 7).

4.11 Pericarp thickness

Shoot pruning of bell pepper showed statistically significant variation on pericarp thickness under the present trial (Appendix VI). The maximum pericarp thickness (6.50 mm) was observed from P_1, while the minimum pericarp thickness (6.12 mm) was found from P_0 (Table 6).

Pericarp thickness of bell pepper varied significantly for different foliar application of micronutrients in bell pepper (Appendix VI). The maximum pericarp thickness (6.99 mm) was found from M_5 which was statistically similar (6.76 mm and 6.60 mm) with M_2 and M_1, while the minimum thickness (5.03 mm) was attained from M_0 i.e. control condition (Table 6). Dongre *et al*. (2000) also reported similar findings.

Significant variation was found due to the interaction effect of shoot pruning and foliar application of micronutrients in terms of pericarp thickness (Appendix VI). The maximum pericarp thickness (7.20 mm) was recorded from P_1M_5, while the minimum thickness (4.77 mm) was observed from P_0M_0 (Table 7).

4.12 Individual fruit weight

Significant variation was recorded on individual fruit weight for shoot pruning of bell pepper (Appendix VI). The higher weight of individual fruit (61.03 g) was observed from P_1, while the lower weight (59.40 g) from P_0 (Table 6). Shetty and Manohar (2008) reported that capsicum plants responded significantly to the pruning for individual fruit weight. Hossain *et al*. (1996) reported that individual fruit weight was 59.02 g in one time pruning and 47.21 g for without pruning.

Different foliar application of micronutrients showed significant variation on individual fruit weight of bell pepper (Appendix VI). The highest weight of individual fruit (62.68 g) was recorded from M_5 which was statistically similar (61.99 g and 60.67 g) with M_2 and M_1, while the lowest weight (57.61 g) was found from M_0 i.e. control condition (Table 6).

Significant variation was observed due to the interaction effect of shoot pruning and foliar application of micronutrients in terms of individual fruit weight (Appendix VI). The highest weight of individual fruit (62.96 g) was attained from P_1M_5, while the lowest weight (55.89 g) was observed from P_0M_0 (Table 7).

4.13 Yield per plot

Significant variation was recorded for shoot pruning of bell pepper in terms of yield per plot (Appendix VI). The highest yield per plot (6.38 kg) was recorded from P_1, while the lowest yield per plot (5.66 kg) from P_0 (Figure 6).

Yield per plot of bell pepper showed significant differences for different foliar application of micronutrients (Appendix VI). The highest yield per plot (57.20 kg) was found from M_5 which was closely followed (56.82 kg) by M_2, while the lowest yield per plot (4.27 kg) was observed from M_0 (Figure 7).

Shoot pruning and foliar application of micronutrients varied significantly due to their interaction effect in terms of yield per plot of bell pepper (Appendix VI). The highest yield per plot (7.30 kg) was recorded from P_1M_5, while the lowest yield per plot (4.02 kg) was found from P_0M_0 (Figure 8).

4.14 Yield per hectare

Yield per hectare showed significant variation for shoot pruning of bell pepper under the present trial (Appendix VI). The highest yield per hectare (26.60 ton) was attained from P_1, while the lowest yield per hectare (23.58 ton) was recorded from P_0 (Table 6). Dasgan and Abak (2002) found that fruit yield per hectare was not significantly influenced by the number of shoots per plant. Elio *et al*. (2005) reported that fruit yield can be increased by managing shoot pruning and 4 plant m^{-2} pruned to four stems increased marketable and extra large fruit yield in a short harvest period of a summer greenhouse sweet pepper crop. Shetty and Manohar (2008) reported that capsicum plants responded significantly to the pruning in respect of yield per hectare. Abdullah *et al*. (2013) reported that pepper plants pruned to one branch resulted in a significant increase in fruit yield.

Significant variation was recorded for yield per hectare of bell pepper for different foliar application of micronutrients (Appendix VI). The highest yield per hectare (29.98 ton) was recorded from M_5 which was closely followed (28.41 ton) by M_2, while the lowest yield per hectare (17.77 ton) was observed from M_0 i.e. control condition (Table 6). Laxman and Mukherjee (2000) also reported similar findings from their earlier experiments.

Interaction effect of shoot pruning and hectare foliar application of micronutrients showed significant variation in terms of yield per hectare (Appendix VI). The highest yield per hectare (30.43 ton) was found from P_1M_5, while the lowest yield per hectare (16.77 ton) was observed from P_0M_0 (Table 7).

4.15 Economic analysis

Input costs for land preparation, fertilizer, irrigation and manpower required for all the operations from seed sowing to harvesting of bell pepper were recorded for unit plot and converted into cost per hectare (Appendix VII). Price of bell pepper was considered as per market rate. The economic analysis presented under the following headings-

4.15.1 Gross return

The combination of shoot pruning and foliar application of micronutrients showed different values in terms of gross return under the trial (Table 8). The highest gross return (Tk. 1,825,800) was obtained from the treatment combination P_1M_5 and the second highest gross return (Tk. 1,772,400) was found in P_0M_5. The lowest gross return (Tk. 1,006,200) was obtained from P_0M_0.

4.15.2 Net return

In case of net return, different treatment combination showed different levels of net return under the present trial (Table 8). The highest net return (Tk. 1,203,419) was found from the treatment combination P_1M_5 and the second highest net return (Tk. 1,155,951) was obtained from the combination P_0M_5. The lowest (Tk. 400,430) net return was obtained P_0M_0.

4.15.3 Benefit cost ratio

In the combination of shoot pruning and foliar application of micronutrients the highest benefit cost ratio (2.93) was noted from the combination of P_1M_5 and the second highest benefit cost ratio (2.88) was estimated from the combination of P_0M_5. The lowest benefit cost ratio (1.66) was obtained from P_0M_0 (Table 8). From economic point of view, it is apparent from the above results that the combination of P_1M_5 was the best among rest of the combinations.

Table 8. Cost and return of bell pepper cultivation as influenced by shoot pruning and foliar application of micronutrients

Treatments	Cost of production (Tk./ha)	Yield of bell pepper (t/ha)	Gross return (Tk./ha)	Net return (Tk./ha)	Benefit cost ratio
P_0M_0	605,770	16.77	1,006,200	400,430	1.66
P_0M_1	612,889	22.37	1,342,200	729,311	2.19
P_0M_2	611,703	28.39	1,703,400	1,091,697	2.78
P_0M_3	615,262	21.99	1,319,400	704,138	2.14
P_0M_4	615,262	22.44	1,346,400	731,138	2.19
P_0M_5	616,449	29.54	1,772,400	1,155,951	2.88
P_0M_0	611,703	18.77	1,126,200	514,497	1.84
P_1M_1	618,822	29.18	1,750,800	1,131,978	2.83
P_1M_2	617,635	28.43	1,705,800	1,088,165	2.76
P_1M_3	621,195	26.88	1,612,800	991,605	2.60
P_1M_4	621,195	25.92	1,555,200	934,005	2.50
P_1M_5	622,381	30.43	1,825,800	1,203,419	2.93

Market price of bell peeper: @ Tk. 60,000/ton

P_0: No shoot pruning
P_1: Shoot pruning

M_0: Control (no micronutrients)
M_1: Boron (B) @ 100 ppm
M_2: Zinc (Zn) @ 100 ppm
M_3: Cupper (Cu) @ 100 ppm
M_4: Manganese (Mn) @ 100 ppm
M_5: Mixed micronutrients @ 100 ppm each (B, Zn, Cu and Mn)

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted during the period from October 2012 to April 2013 to study the response of bell pepper to shoot pruning and foliar feeding of micronutrients. Capsicum variety "Lamuyo" (exotic variety) were used as experimental materials. The experiment consisted of two factors: Factor A: Shoot pruning (two levels) as; P_0: No shoot prunning & P_1: Shoot pruning and Factor B: Foliar applications of micronutrients (five levels) as; M_0: Control (no micronutrients); M_1: Boron (B) @ 100 ppm; M_2: Zinc (Zn) @ 100 ppm; M_3: Cupper (Cu) @ 100 ppm; M_4: Manganese (Mn) @ 100 ppm and M_5: Mixed micronutrients @ 100 ppm each (B, Zn, Cu and Mn). The two factors experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. Data on growth, yield contributing characters and yields were recorded and statistically significant variation was observed for different treatment.

At 30, 45, 60, 75, 90, 105 DAT and final harvest, the longer plant (14.46, 20.53, 33.86, 43.82, 49.73, 55.36 and 59.95 cm, respectively) was recorded from P_1, while the shorter plant (13.77, 19.75, 32.45, 41.93, 48.47, 53.51 and 57.30 cm, respectively) from P_0. At 30, 45, 60, 75, 90, 105 DAT and final harvest, the maximum number of leaves per plant (18.37, 36.64, 60.58, 76.21, 94.73, 114.58 and 134.34, respectively) from P_1, while the minimum number (15.60, 31.56, 53.86, 70.47, 85.94, 106.51 and 123.77 at 30, 45, 60, 75, 90, 105 DAT and final harvest, respectively) from P_0. The minimum days from transplanting to 1st flowering (53.11 days) was found from P_1, while the maximum (56.61 days) from P_0. The higher number of flowers per plant (32.03) was recorded from P_1, while the lower number (29.99) from P_0. The higher number of total fruits per plant (12.76) was obtained from P_1, while the lower number (10.38) from P_0. The higher number of marketable fruits per plant (8.70) was obtained from P_1, while the lower number (7.90) from P_0. The maximum fruit setting (39.73%) was found from P_1, while the minimum (34.43%) from P_0. However, minimum days from transplanting to 1st

harvest (116.61) were attained from P_1, while the maximum days (120.72) from P_0. The maximum length of fruit (7.81 cm) was recorded from P_1, while the minimum length (7.22 cm) from P_0. The maximum diameter of fruit (5.24 cm) was recorded from P_1, while the minimum diameter (5.04 cm) from P_0. The maximum pericarp thickness (6.50 mm) was observed from P_1, while the minimum thickness (6.12 mm) from P_0. The higher weight of individual fruit (61.03 g) was observed from P_1, while the lower weight (59.40 g) from P_0. The higher yield per plot (6.38 kg) was recorded from P_1, while the lower yield per plot (5.66 kg) from P_0. The highest yield per hectare (26.60 ton) was attained from P_1, while the lowest yield per hectare (23.58 ton) from P_0.

At 30, 45, 60, 75, 90, 105 DAT and final harvest, the tallest plant 15.55, 22.17, 36.31, 45.96, 52.17, 56.56 and 60.73 cm, respectively) was obtained from M_5, while the shortest plant (12.71, 18.42, 27.49, 36.29, 44.15, 50.56 and 53.65 cm, respectively) from M_0 i.e. control condition. At 30, 45, 60, 75, 90, 105 DAT and final harvest, the maximum number of leaves per plant (19.10, 38.20, 60.20, 78.23, 95.23, 116.87 and 136.13, respectively) was found from M_5, while the minimum number (14.93, 29.20, 51.67, 66.77, 84.00, 104.07 and 119.50, respectively) from M_0. The minimum days from transplanting to 1^{st} flowering (52.33 days) was found from M_5, while the maximum (58.67 days) from M_0. The highest number of flowers per plant (33.70) was recorded from M_5, whereas the lowest number (27.97) from M_0. The highest number of total fruits per plant (13.67) was found from M_5, while the lowest number (9.27) from M_0. The highest number of marketable fruits per plant (9.57) was found from M_5, while the lowest number (6.17) from M_0. The maximum fruit setting (40.53%) was found from M_5, while the minimum fruit setting (33.14%) from M_0. The minimum days from transplanting to 1^{st} harvest (114.00) was found from M_5, while the maximum days (125.17) from M_0. The maximum length of fruit (8.55 cm) was found from M_5, where the minimum length (6.12 cm) from M_0. The maximum diameter of fruit (5.66 cm) was found from M_5, while the minimum diameter (4.22 cm) from M_0. The maximum pericarp thickness (6.99 mm) was found from M_5, while the minimum thickness

(5.03 mm) from M_0. The highest weight of individual fruit (62.68 g) was recorded from M_5, while the lowest weight (57.61 g) from M_0. The highest yield per plot (7.20 kg) was found from M_5, while the lowest yield per plot (4.27 kg) from M_0. The highest yield per hectare (29.98 ton) was recorded from M_5, while the lowest yield per hectare (17.77 ton) from M_0.

At 30, 45, 60, 75, 90, 105 DAT and final harvest, the tallest plant (16.44, 22.26, 38.35, 43.20, 52.49, 57.83 and 63.19 cm) was observed from P_1M_5, while the shortest plant (12.03, 18.23, 26.09, 34.29, 42.49, 49.30 and 50.80 cm) from P_0M_0 at same DAT, respectively. The maximum number of leaves per plant (19.80, 40.33, 60.80, 80.27, 99.13, 123.93 and 143.53, respectively) was recorded from P_1M_5 at 30, 45, 60, 75, 90, 105 DAT and final harvest, respectively, whereas the minimum number of leaves per plant (13.73, 25.40, 44.13, 61.20, 79.53, 101.07 and113.93, respectively) from P_0M_0 at 30, 45, 60, 75, 90, 105 DAT and final harvest. The minimum days from transplanting to 1^{st} flowering (46.67 days) was found from P_1M_5, while the maximum (60.00 days) from P_0M_0. The highest number of flowers per plant (35.00) was recorded from P_1M_5, while the lowest number (27.47) from P_0M_0. The highest number of total fruits per plant (14.47) was recorded from P_1M_5, while the lowest number (8.33) from P_0M_0. The highest number of marketable fruits per plant (9.67) was recorded from P_1M_5, while the lowest number (6.00) from P_0M_0. The maximum fruit setting (41.34%) was observed from P_0M_5, while the minimum (30.38%) from P_0M_0. The minimum days from transplanting to 1^{st} harvest (107.33) was found from P_1M_5, while the maximum days (129.67) from P_0M_0. The maximum length of fruit (8.80 cm) was found from P_1M_5, while the minimum length (6.02 cm) from P_0M_0. The maximum diameter of fruit (5.60 cm) was recorded from P_1M_5, while the minimum diameter (4.03 cm) from P_0M_0. The maximum pericarp thickness (7.20 mm) was recorded from P_1M_5, while the minimum thickness (4.77 mm) from P_0M_0. The highest weight of individual fruit (62.96 g) was attained from P_1M_5, while the lowest weight (55.89 g) from P_0M_0. The highest yield per plot (7.30 kg) was recorded from P_1M_5, while the lowest yield per plot (4.02 kg) from P_0M_0. The highest yield per hectare (30.43 ton) was found from P_1M_5, while the lowest yield per hectare (16.77 ton) from P_0M_0.

The highest gross return (Tk. 1,825,800) was obtained from the treatment combination P_1M_5 and the lowest gross return (Tk. 1,006,200) from P_0M_0. The highest net return (Tk. 1,203,419) was found from the treatment combination P_1M_5 and the lowest (Tk. 400,430) net return P_0M_0. In the combination of shoot pruning and foliar application of micronutrients the highest benefit cost ratio (2.93) was noted from the combination of P_1M_5 and the lowest benefit cost ratio (1.66) was obtained from P_0M_0.

Conclusion:

Considering the findings of the experiment, it may be concluded that:

1. Shoot pruning was superior than no shoot prunning.
2. Foliar application of mixed micronutrients @ 100 ppm each (B, Zn, Cu and Mn as H_3BO_3, $ZnSO_4$, $CuSO_4$, and $MnSO_4$, respectively) was superior than the others.
3. The treatment combination of P_1M_5 (shoot pruning + mixed micronutrients @ 100 ppm each: B, Zn, Cu and Mn) showed better performance.

This experiment was conducted only one growing season. So, further such type of study may be conducted before final recommendation.

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APPENDICES

Appendix I. Characteristics of the soil of experimental field analyzed by Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka

A. Morphological characteristics of the soil of experimental field

Morphological features	Characteristics
Location	Horticultural Farm, SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Drainage	Well drained

B. Physical and chemical properties of the initial soil

Characteristics	Value
% Sand	27
% Silt	43
% Clay	30
Textural class	Silty-clay
pH	5.6
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	45

Source: SRDI, 2012

Appendix II. Monthly record of air temperature, rainfall, relative humidity, rainfall and Sunshine of the experimental site during the period from October 2012 to April 2013

Month	*Air temperature (°c)		*Relative humidity (%)	*Rainfall (mm)	*Sunshine (hr)
	Maximum	Minimum			
October, 2012	24.32	17.22	75	13	7.2
November, 2012	25.82	16.04	78	00	6.8
December, 2012	22.40	13.50	74	00	6.3
January, 2013	24.50	12.40	68	00	5.7
February, 2013	27.10	16.70	67	30	6.7
March, 2013	31.40	19.60	54	11	8.2
April, 2013	34.20	23.40	61	112	8.1

* Monthly average,

Source: Bangladesh Meteorological Department (Climate & weather division) Agargoan, Dhaka – 1212

Appendix III. Analysis of variance of the data on plant height at different days after transplanting (DAT) of bell pepper as influenced by shoot pruning and foliar application of micronutrients

Source of variation	Degrees of freedom	Mean square						
		Plant height (cm) at						
		30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT	Final harvest
Replication	2	0.169	0.697	5.346	15.623	4.090	0.032	2.916
Shoot pruning (A)	1	4.323*	5.473*	17.983*	31.973*	14.246*	30.696*	63.170 *
Micronutrients (B)	5	5.485**	9.701**	55.163**	71.079**	43.071**	26.308**	39.098**
Interaction (A×B)	5	5.921**	3.277*	36.727**	68.600**	20.042**	17.01 *	18.118*
Error	22	0.789	1.056	3.656	7.078	2.709	4.929	9.483

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix IV. Analysis of variance of the data on number of leaves per plant at different days after transplanting (DAT) of bell pepper as influenced by shoot pruning and foliar application of micronutrients

Source of variation	Degrees of freedom	Mean square					
		Number of leaves per plant at					
		30 DAT	45 DAT	60 DAT	75 DAT	90 DAT	105 DAT
Replication	2	0.724	1.083	0.630	8.431	3.074	15.892
Shoot pruning (A)	1	68.877**	233.071**	406.694**	296.988**	695.201**	586.482**
Micronutrients (B)	5	13.109**	59.512**	57.882**	95.164**	88.873**	120.125**
Interaction (A×B)	5	6.101**	7.487*	48.545*	25.036*	2.766*	35.134*
Error	22	1.515	6.002	13.812	9.339	3.613	21.263

**: Significant at 0.01 level of probability; *: Significant at 0.05 level of probability

Appendix V. Analysis of variance of the data on yield contributing character of bell pepper as influenced by shoot pruning and foliar application of micronutrients

Source of variation	Degrees of freedom	Mean square					
		Days from transplanting to 1st flowering	Number of flowers per plant	Number of total fruits per plant	Number of marketable fruits per plant	Fruit setting (%)	Days from transplanting to 1st harvest
Replication	2	7.194	1.604	0.160	0.043	2.399	5.583
Shoot pruning (A)	1	110.250**	37.618**	50.884**	5.760**	252.99**	152.111*
Micronutrients (B)	5	30.361*	25.239**	14.587**	8.344**	41.365**	109.267*
Interaction (A×B)	5	34.050*	8.954**	2.572**	0.619**	8.232*	100.578*
Error	22	10.437	1.460	0.247	0.110	3.759	32.341

**: Significant at 0.01 level of probability;   *: Significant at 0.05 level of probability

Appendix VI. Analysis of variance of the data on yield contributing character and yield of bell pepper as influenced by shoot pruning and foliar application of micronutrients

Source of variation	Degrees of freedom	Mean square					
		Length of fruit (cm)	Diameter of fruit (cm)	Pericarp thickness (mm)	Individual fruit weight (g)	Yield per plot (kg)	Yield per hectare (kg)
Replication	2	0.100	0.065	0.006	2.060	0.034	0.597
Shoot pruning (A)	1	3.171**	0.370*	1.324**	23.863*	4.719**	81.924**
Micronutrients (B)	5	4.271**	1.490**	2.892**	22.071**	6.238**	108.305**
Interaction (A×B)	5	0.739*	0.305**	0.283*	6.580*	0.562**	9.751**
Error	22	0.263	0.078	0.120	5.163	0.068	1.178

**: Significant at 0.01 level of probability;   *: Significant at 0.05 level of probability

Appendix VII. Per hectare production cost of bell pepper

A. Input cost

Treatments	Labour cost	Ploughing cost	Seed Cost	Insecticide/ pesticides	Manure and fertilizers				
					Cowdung	Urea	MP	TSP	Gypsum
P_0M_0	130,000	100,000	45,000	60,000	60,000	4,400	8,910	5,500	3,885
P_0M_1	130,000	100,000	45,000	60,000	60,000	4,400	8,910	5,500	3,885
P_0M_2	130,000	100,000	45,000	60,000	60,000	4,400	8,910	5,500	3,885
P_0M_3	130,000	100,000	45,000	60,000	60,000	4,400	8,910	5,500	3,885
P_0M_4	130,000	100,000	45,000	60,000	60,000	4,400	8,910	5,500	3,885
P_0M_5	130,000	100,000	45,000	60,000	60,000	4,400	8,910	5,500	3,885
P_1M_0	130,000	100,000	45,000	60,000	60,000	4,400	8,910	5,500	3,885
P_1M_1	130,000	100,000	45,000	60,000	60,000	4,400	8,910	5,500	3,885
P_1M_2	130,000	100,000	45,000	60,000	60,000	4,400	8,910	5,500	3,885
P_1M_3	130,000	100,000	45,000	60,000	60,000	4,400	8,910	5,500	3,885
P_1M_4	130,000	100,000	45,000	60,000	60,000	4,400	8,910	5,500	3,885
P_1M_5	130,000	100,000	45,000	60,000	60,000	4,400	8,910	5,500	3,885

P_0: No shoot pruning
P_1: Shoot pruning

M_0: Control (no micronutrients)
M_1: Boron (B) @ 100 ppm
M_2: Zinc (Zn) @ 100 ppm
M_3: Cupper (Cu) @ 100 ppm
M_4: Manganese (Mn) @ 100 ppm
M_5: Mixed micronutrients @ 100 ppm each (B, Zn, Cu and Mn)

Appendix VII. Cont'd

B. Overhead cost

Treatment Combination	Cost of lease of land for 6 months (13% of value of land Tk. 15,00000/year	Miscellaneous cost (Tk. 5% of the input cost	Interest on running capital for 6 months (Tk. 13% of cost/year	Sub total (Tk) (B)
P_0M_0	97,500	20,885	69690	188,075
P_0M_1	97,500	21,185	70509	189,194
P_0M_2	97,500	21,135	70373	189,008
P_0M_3	97,500	21,285	70782	189,567
P_0M_4	97,500	21,285	70782	189,567
P_0M_5	97,500	21,335	70919	189,754
P_0M_0	97,500	21,135	70373	189,008
P_0M_1	97,500	21,435	71192	190,127
P_0M_2	97,500	21,385	71055	189,940
P_0M_3	97,500	21,535	71465	190,500
P_0M_4	97,500	21,535	71465	190,500
P_0M_5	97,500	21,585	71601	190,686

P_0: No shoot pruning
P_1: Shoot pruning

M_0: Control (no micronutrients)
M_1: Boron (B) @ 100 ppm
M_2: Zinc (Zn) @ 100 ppm
M_3: Cupper (Cu) @ 100 ppm
M_4: Manganese (Mn) @ 100 ppm
M_5: Mixed micronutrients @ 100 ppm each (B, Zn, Cu and Mn)