INFLUENCE OF PLANT HORMONE, MICRONUTRIENTS, ANTITRANSPIRANT AND POLYTHENE SHED ON SUMMER TOMATO

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CERTIFICATE

This is to certify that the thesis entitled **"Influence of Plant Hormone, Micronutrients, Antitranspirant and Polythene Shed on Summer Tomato"** 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 **Md. Jahangir Alam**, Registration No. **1305785** 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.

Date: November 05'2014
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ABSTRACT

A pot experiment was carried out at Horticulture Farm, Sher-e-Bangla Agricultural University, Dhaka during the period from May 2013 to September 2013. The experiment consisted of two factors: Factor A: P_0: without polythene shed and P_1: with polythene shed condition; Factor B: foliar application of F_0: tap water, F_1: 4-CPA, F_2: Zn, B, Mn, Se @ 100 ppm (separately), F_3: Kaolin @ 2% solution and F_4: Zn, B, Mn and Se@ 100 ppm, 4-CPA and Kaolin @ 2% solution. The two factors experiment was laid out in Complete Randomized Design (CRD) with three replications. In case of combined application of Zn, B, Mn, Se, 4-CPA and kaolin under rain protected condition, the result revealed significant variation in respect most of the characters studied. In case of polythene shed effect, P_1 provided the maximum yield (1145.07 g/plant) with improved quality. In case of foliar treatment effect, F_4 provided the maximum yield (1472.45 g/plant) and better quality. The maximum yield (1973.37 g/plant) and best quality (rich in Vitamin-C, β-carotene and TSS) tomato was found from the treatment combination P_1F_4.

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CHAPTER I

INTRODUCTION

Tomato (*Solanum lycopersicon)* is a flowering plant belongs to the family Solanaceae. Tomato is the rich source of vitamin-A, Vitamin-C and minerals and it keeps eye sight good. Night blindness occurs due to lack of Vitamin-A. Tomato contains lycopene pigment which is a vital anti-oxidant that helps to fight against cancerous cell formation as well as other kind of health complications and diseases (Kumavat and Chaudhari, 2013). A single tomato can provide 40% of the daily requirement of Vitamin-C which is a natural anti-oxidant. Tomatoes are rich with Vitamin-K which plays a major role in blood clotting.

From March to September, tomatoes are practically not grown in Bangladesh due to the weather of tropical region which has characterized by hot and humid condition. But, in this period, the country has imported tomatoes every year from India. High temperature like as tropical region and heavy rainfall (humid condition) is one of the major problems of unfruitfulness for summer tomato production in Bangladesh. High temperature is responsible to limit fruit set due to an impaired complex of physiological process in the pistil, which results in floral or fruit abscission. High temperature adversely affects on tomato physiology and quality attributes, resulting fruit quality defects, uneven ripening and significantly increased commercial damage (Mulholland *et al*., 1999). The plants grown under high daily average air temperature early in the season had lower fruit yield late in the season (Papadopoulos and HaoXiuMing, 2001). Use of rain protection measures with the transparent polythene sheet maximize pollination and fruit setting and it also promotes to develop attractive fruit colour which is beneficial for commercial marketing and influenced customer preference.

Using antitranspirants such as kaolin may reduce transpiration rates from the plant; consequently reduce the amount of used water and improved the water use efficiency while it did not reduce carbon assimilation (Nakano and Uehara, 1996). Kaolin is a non-toxic aluminosilicate ($Al_4Si_4O_{10}(OH)_8$) clay mineral. The use of kaolin-based particle film technology would be an effective tool to alleviate heat stress and to reduce water stress in tomato production under arid and semi-arid condition (Cantore *et al.*,2008). Studies conducted on tomato and potato has shown that foliar applications of kaolin particle films reduce plant stress, which is important for optimum plant growth, yield and quality (Anwar, 2005; Pace *et al*., 2007). However, Kaolin based particle used as an antitranspirants reduced plant and fruit inner temperature and increased marketable fruit yield (Cantore *et al.*,2008) and Kaolin based particle increased the water use efficiency by regulating stomatal movement (Mofta *et al*., 2002) as the experiment was conducted under rain protected condition and 80% water was added to the plant. When tomato products are heat processed the bioavailability of the lycopene actually increase rather than the anticipated decrease. Kaolin treatment increased lycopene content in fruits and did not affect contents of total soluble solids, fruit dry matter, juice P^H, titratable acidity or tomato fruit firmness (Cantore *et al*., 2008).

Growers in some countries are commercially producing tomatoes at higher temperature through exogenous application of synthetic hormones. In recent-past, a large number of investigators have studied the effect of various micronutrients on vegetative and reproductive parameters including deficiency symptom and fruit setting.

Application of Zinc (Zn) served as the source of energy for synthesis of auxin which helps in elongation of stem (Makhan *et al*., 1999-2000). Application of Zn, B, Mn and Se @100 ppm separately would be beneficial for growth and development of tomato plant. Patil *et al.* (2008) have concluded that the best treatment was the mixture of micronutrients (Zn, B, Mn and Se @100) ppm recording fruit yield of 27.98 t/ha and differed significantly from the control as well as other treatments.

The auxin type plant growth regulators (PGRs) comprising some of the compounds are used in agriculture. Indolebutyric acid (IBA) and naphthalene acetic acid (NAA) were found to increase root development in the stem cutting. 2,4-Dichlorophenoxyacetic acid (2,4-D) stimulates excessive, uncontrolled growth in broadleaf plants for which it is used as a herbicide. NAA and naphthalene acetamide (NAAM) are used to reduce the number of fruit that set in apple and GA_3 is mostly used in grape to increase fruit set, yield and quality, whereas 4-chlorophenoxyacetic acid (4-CPA) is widely used to increase fruit set in tomato (Karakurt, 2000). Nutritive content enriched with the application of PGR, especially 4-CPA and micronutrients (Gupta *et al*., 1997-99). Hormone application reduces number of days to fruit-set and significantly increased fruit-set percent, fruit number per plant, and fruit size therefore marketable fruit yield (Makoto, 2000).

Application of Boron (B) promotes the receptivity of stigma by extending the time of pollination and makes viable the pollen resulting higher fertilization and fruit setting. Application of B increased fruit firmness which increased shelf life of tomato (Abdur *et al*., 2009-10), increase fruit sets per plant, increase individual fruit weight per plant and increase brix % in tomatoes. The visible effects of low manganese (Mn) deficiency are pronounced on middle leaves; under acute deficiency condition significant decrease in the concentration of ascorbic acid, soluble proteins, starch, sugars and high phenols reflect poor quality of tomato fruits under manganese deficiency (Dube and Chatterjee, 2001). Application of selenium (Se) had positive effects on the chemical composition and antioxidant constituents of tomato (Schiavon *et al*., 2013). So, application of Se enriches the fruits chemical composition of tomatoes which are beneficial for human health.

Foliar feeding is the best way for summer tomato production (Trejo *et al*., 2007; Sajid *et al*., 2013), resulting higher yield as well as higher income from per unit area of land. Summer tomato in Bangladesh is a high value crop which ensures higher income from per unit area of land (Karim *et al*., 2009; Zaman *et.al* (2006)).

The experiment may inspire the growers to cultivate summer tomato commercially as well as to improve health and economic status of peoples of Bangladesh. Our initiative was to use some elements such as plant growth regulator 4-CPA (4-Chloro Phenoxy Acetic Acid); micronutrients Zn as Zinc Sulphate ($ZnSO_4$), B as Boric Acid (H_3BO_3), Mn as Manganese Sulphate ($MnSO_4$), Se as Sodium Selenate and Kaolin as an antitranspirant which is non-toxic clay particle “aluminosilicate” ($Al_4Si_4O_{10}(OH)_8$) under rain protected conditions by which we can improve the yield and quality by regulating or reducing the adverse effect of high temperature and increased fruit setting of the tomato plant.

However, considering the above circumstances, the present study was under taken with the following objectives:

Objectives:

- To know the yield and quality performance of summer tomato “BRAI hybrid-4” under rain protected condition.
- To know the yield and quality of summer tomato by the foliar application of yield contributing elements.
- To know the combined effect of polythene shed and foliar application of yield contributing elements.

CHAPTER II

REVIEW OF LITERATURE

Tomato is one of the most important and widely used vegetables worldwide. The production level of summer tomato never meets the demand of Bangladesh. A large quantity was needed to import every year which may lead the process of losing foreign currency and reserve. Moreover, the country with high temperature and dry weather round the year lead the loss of production. Many researchers were conducted their research to find out the effect of micronutrients, plant growth regulators and antitranspirants. However, in this chapter, literature available in this aspect in the country and abroad was reviewed.

2.1 Review in relation to the application of micro nutrients

Roosta and Hamidpour (2013) was conducted an experiment to evaluate the effects of foliar applications of some micro and macro-nutrients on mineral nutrient content of tomato leaves and fruits through an aquaponic system in comparison with a hydroponic system. Fourteen days old tomatoes seedlings were transplanted in growing bed of aquaponic and hydroponic systems. Foliar nutrients application began 30 days after transplantation. Eight treatments were used, untreated control and foliar application at the rate of 250 mL $Plant^{-1}$with 0.5 g L^{-1} potassium sulfate (K2SO4), magnesium sulfate (MgSO4 7H2O), ferrous (Fe)- ethylenediamine-N,N'-bis (EDDHA), manganese sulfate (MnSO4 H2O), boric acid (H3BO3), zinc chloride (ZnCl2), and copper sulfate (CuSO4 5H2O). Foliar application of potassium (K), magnesium (Mg), iron (Fe), manganese (Mn), zinc (Zn), and copper (Cu) increased their corresponding concentrations in the leaves of aquaponic-treated plants. On the other hand, foliar spray of K, Fe, Mn, Zn, and Cu caused a significant increment of applied element concentrations in the fruits of hydroponic-grown plants. These findings indicated that foliar application of some elements can effectively alleviate nutrient deficiencies in the leaves of tomatoes grown on aquaponics.

Schiavon *et al.* (2013) was conducted a field experiment to evaluate the impact of selenium on chemical composition and antioxidant constituents of tomato. They have concluded in such a way, although selenium (Se) is a known anticarcinogen, little is known regarding how Se affects other nutritional qualities in crops. Tomato (Solanumlycopersicon) was supplied with 0-50 micro M selenate and analyzed for elemental composition and antioxidant compounds. When supplied at low doses (5 and 10 micro M) via the roots, Se stimulated the synthesis of phenolic compounds in leaves and reduced the levels of Mo, Fe, Mn, and Cu in roots. At higher doses (25 and 50 micro M Se) leaf glutathione levels were 3-5-fold enhanced. Supply of selenate via foliar spray (0, 2, or 20 mg Se per plant) resulted in Se-biofortified tomato fruits, with Se levels low enough not to pose a health risk. The Se-biofortified fruits showed enhanced levels of the antioxidant flavonoids naringeninchalcone and kaempferol and a concomitant decrease of cinnamic acid derivatives. Thus, tomato fruits can be safely enriched with Se, and Se biofortification may enhance levels of other neutraceutical compounds.

Sivaiah *et al*. (2013) was conducted field experiment during rabi-2010 to find out the response of foliar application of micronutrients on vegetative and reproductive growth attributes, in two varieties of tomato viz-UtkalKumari and Utkal Raja. The treatments consisted of boron, zinc, molybdenum, copper, iron, manganese, mixture of all and control and the experiment was laid out in RBD with three replications. All the Micronutrients except manganese at 50 ppm were applied at 100 ppm in three sprays at an interval of ten days starting from 30 days after transplanting. A `ll the treatments resulted in improvement of plant growth characteristics viz. plant height, number of primary branches, compound leaves, tender and mature fruits per plant in both the varieties out of which application of micronutrients mixture showed the maximum effect. In tomato cv. UtkalKumari, maximum growth rate (85.7%) was observed with application of zinc, followed by application of micronutrients mixture (78.2%) and boron (77.5%). Tomato cv. Utkal Raja, maximum increase in branches per plant was observed with the application of manganese (148.7%) followed by micronutrient combination (144.1%). In UtkalKumari, the fruit yield per plant ranged from 1.336 kg to1.867 and in Utkal Raja, it ranged from 1.500 kg to 1.967 kg. In both the varieties, combined application of micronutrients produced the maximum fruit yield followed by application of boron and zinc.

Gurmani *et al*. (2012) conducted a glasshouse pot experiment to study the effect of soil applied Zinc @ 0.5, 10 & 15 mg kg $^{-1}$) on the growth, yield and biochemical attributes in two tomato cultivars; VCT-1 and Riogrande. The result showed that Zinc application increased the plant growth and fruit yield in both cultivars. Maximum plant growth and fruit yield in both cultivars were achieved by the Zn application at 10 mg kg $^{-1}$ Soil. Application of 5 mg Zn kg $^{-1}$ had lower dry matter production as well as fruit yield when compared with Zn 10 and 15 mg kg^{-1}. The percent increase of fruit yield at 5 mg Zn kg-1 was 14 and 30% in VCT-1 and Riogrande, respectively. In the same cultivars, Zn application @ 10 mg Zn kg^{-1} caused the fruit yield by 39 and 54%, while 15 mg Zn kg^{-1} enhanced by 34 and 48%, respectively. Zinc concentration in leaf, fruit and root increased with the increasing level of Zn. Zn application at 10 and 15 mg kg^{-1} significantly increase chlorophyll, sugar, soluble protein, superoxide dismutase and catalase activity in leaf of both cultivars. The result of the study suggested that soil application of 10 mg Zn kg^{-1} soil have a positive effect on yield, biochemical attributes and enzymatic activities of both the tomato cultivars.

Naz *et al*. (2012) conducted an experiment to study the effect of boron on the growth and yield of Rio Grand and Rio Figue cultivar of tomato at Horticultural Research Farm, NWFP Agricultural University, Peshwar during 2008-09. They used different doses of B (0, 0.5, 1.0, 2.0, 3.0 and 5.0 kg ha^{-1}) with constant doses of nitrogen, phosphorus and potash was incorporated at the rate of 150, 100 and 60 kg ha^{-1}. Boron showed a significant effect on the growth and yield of tomato. In the experiment 2 kg ha^{-1} resulted in maximum numbers of flower clusters per plant, fruit set percentage, total yield and total soluble solid. Rio Grand cultivar of tomato showed significant effect on all parameters. Maximum number of flower clusters per plant, fruit set percentage and total yield were recorded with Rio Grand cultivar of tomato. They have further mentioned that 2 kg B ha^{-1} significantly affected flowering and fruiting of Rio Grand cultivar.

Yuanxin and Junhua (2011) conducted some experiments in a perlite bag culture under nutrient drip irrigation to study the effects of different concentrations of the trace elements boron and manganese on the yield, fruit quality and antioxidative capacity in tomato. The study showed that under reduced concentrations of boron, tomato yields and the antioxidative content in tomato were significantly reduced. Under high boron concentrations yields and the antioxidative capacity were increased however the ascorbic acid content was reduced. Similarly, under low manganese both yields and the total antioxidative capacity were reduced, however under high manganese levels, yields were not reduced nor were the concentration of ascorbic acid. Total solids were reduced under a high concentration of the micronutrient manganese.

Sbartai *et al*. (2011) conducted a field experiment to evaluate the response of tomato plants (*Lycopersicon esculentum* L. var. Rio Grande) to treatment with zinc and accumulation (trace element) in the roots and leaves of young plants. This is done by analyzing the effect of Zinc on the rate of chlorophyll and enzyme activity involved in the antioxidant system (CAT, GSH, APX). Plants previously grown on a basis nutrient solution is treated by increasing concentrations of $ZnSO_4$ (0, 50, 100, 250, 500 microM) for 7 days. The result showed that Zn does not affect the amount of chlorophyll at 50 and 100 microns, while it seems to inhibit the higher concentrations (250 and 500 microns). On the other hand, treatment with Zinc induced the activity of enzymes studied, namely (CAT, APX, GSH) especially for higher concentrations. Finally, the determination of Zinc in the roots and leaves of tomato shows a greater accumulation in the roots compared to leaves.

Salam *et al*. (2010) conducted an experiment at the vegetable research farm of the Horticulture Research Centre, Bangladesh Agricultural Research Institute, Joydevpur, Gazipur during the period 2006-2007 to investigate the effects of boron and zinc in presence of different level of NPK fertilizers on quality of tomato. There were twelve treatment combination which comprised for level of boron and zinc viz., i) B_0Zn_0 = 0 kg B $_+$ 0 kg Zn/ha ii) $B_{15}Zn_{20}$ = 1.5 kg B + 2.0 kg Zn/ha iii) $B_{20}Zn_{40}$ = 2.0 kg B + 4.0 kg Zn/ha iv) $B_{25}Zn_{60}$ = 2.5kg B + 6.0 kg Zn/ha and three levels of NPK fertilizers viz., i) 50% less than the recommended NPK fertilizer dose (50%< RD), ii) Recommended NPK fertilizer dose (RD), iii) 50% more than the recommended NPK fertilizer dose (50% >RD). The highest pulp weight (88.14%), dry matter content (5.34%), TSS (4.50%), ascorbic acid (10.95mg/100gm), lycopene content (112.00 µg/100gm), chlorophyll-b (56.00 µg/100g), marketable fruits at 30 days after storage (67.48%) and shelf life (16 days) were recorded with the combination of 2.5 kg B + 6 kg Zn/ha and recommended dose of NPK fertilizers (N = 253. P = 90 Kg and K = 125kg/ha). Cakmak et al. (1999) reported that zinc also helps in various metabolic processes; its deficiency inhibits growth and development of plants.

Naga Sivaiah *et al*. (2010) was conducted a field experiment during spring to find out the response of foliar application of micronutrients on vegetative and reproductive growth attributes, in two varieties of tomato viz- UtkalKumari and Utkal Raja. The treatments consisted of boron, zinc, molybdenum, copper, iron, manganese mixture of all and control and the experiment was laid out in RBD with three replications. All the micronutrients except manganese (at 50ppm) were applied at 100ppm in three sprays at an interval of ten days starting from 30 days after transplanting. All the treatments resulted in improvement of seed yield, 100 seed weight, seed yield per plant in both the varieties. In both the varieties, application of micronutrients mixture reached the maximum seed yield followed by boron treatment; in respect both the parameters, while the lowest yield was obtained in the control.

Patil *et al*. (2010) was conducted an experiment to evaluate the effect of foliar application of micronutrients on flowering and fruit-set of tomato. They have showed the flowering parameters like days required for initiation and 50 percent flowering, number of clusters, number of flowers, total number of flowers and fruit setting percentage per plant were influenced significantly due to different treatments. The minimum number of days (30.00) for initiation of flowering and 50% flowering (38.86) were recorded with Boron 50ppm and 100ppm while the maximum number of days were recorded in control. The treatment Boron 100ppm + Iron 200ppm + Zinc 200ppm was most effective in increasing number of clusters (13.85) and number of flowers (51.24) per plant. Maximum number of flowers per cluster and percent fruit setting (47.76%) was recorded with Boron 50ppm + Iron 100ppm+ Zinc 100ppm, while minimum was recorded in control.

Tavassoli *et al*. (2010) performed an experiment to investigate zinc (Zn) and manganese (Mn) nutrition effects on greenhouse tomato in a perlite-containing media. Experimental treatments were: (1) control (Mn and Zn – free nutrition solution), (2) Application of Mn in a concentration equal to the full Hoagland's nutrient solution (4.06 mg/L), (3) application of Zn in a concentration equal to the full Hoagland's nutrient solution (4.42 mg/L), (4) application of Mn and Zn in concentrations equal to the 50% Hoagland's nutrient solution (2.03 mg/L Mn + 2.21 mg/L Zn), and (5) application of Mn and Zn in a concentration equal to the full Hoagland's nutrient solution (4.06 mg/L Mn + 4.42 mg/L Zn). Results showed that the highest fresh-fruit yield and leaf dry matter and content of Mn and Zn in fruit were obtained from single or combined application of Mn and Zn in concentrations equal to the full Hoagland's nutrient solution. In addition, Zn and Mn nutrition significantly affected the fruit concentrations of crude protein, nitrogen and phosphorus, while the effect of these treatments on fruit size of tomato was not significant.

Abdur *et al.* (2009-10) was conducted an experiment to investigate the influence of CaCl2 and borax on growth, yield, and quality of tomato. The experiment was laid out with a randomized complete block design. Calcium chloride (0.3% and0.6%) and borax (0.2% and 0.4%) solutions were applied as foliar sprays either alone or in combination and data were recorded for plant height, branches per plant, flowers per cluster, fruits per plant, yield, fruit weight, fruit firmness, and total soluble solid content of the fruit. The application of CaCl2 alone significantly increased the plant height and fruits per plant and decreased the incidence of blossom end rot. Borax alone significantly enhanced the number of branches per plant, number of flowers per cluster, fruits per cluster, fruits per plant, fruit weight, fruit firmness, and total soluble solid content of the fruits. Foliar application of CaCl2 (0.6%) + borax (0.2%) resulted in the maximum plant height (86.60 cm), branches per plant (7.21), flowers per cluster (32.36), fruits per plant (96.37), fruit weight (96.33 g), yield (21.33 t ha^{-1}), fruit firmness (3.46 kgcm^{-2}), and total soluble solids (6.10%) and the lowest blossom end rot incidence (6.25%).

Huang and Snapp (2009) was conducted was a field experiment to evaluate the effects of K and B on yield and quality of fresh market tomatoes cv. "Mountain Spring" at Southwest Michigan with well-drained soil (Alfisol Hapludalf, Oakville fine sand). Treatments applied during fruit development included three fertigation regimes (1 N: 0.8K, 1N:1.7 K and 1N: 2.5K) in the presence and absence of a weekly foliar spray of B (300 mg). Increasing K concentrations in the fertilizer increased K content in leaf tissue, but in some cases reduced tissue calcium (Ca) and B. Fruit quality was influenced by nutrition, as the greatest rate of K was associated with increased crack susceptibility as indicated by a fruit bioassay and a 14% increases in incidence of the defect "shoulder check" in field-grown fruit compared to less rates of K nutrition. Boron foliar spray increased tomato marketable yield and fruit quality, reducing shoulder check incidence by 50% compared to zero-B treated plants in 2003. Because of yield and quality improvements, B was a cost effective treatment as shown by partial budget analysis, where as increasing K nutrition did not provide consistent economic benefits. Moderate K rates were associated with the greatest marketable yield, and the 1N: 1.7 K plus foliar B nutrient regime produced the greatest quality fruit. Overall data were consistent with the need of carefully evaluate K and B nutrition in tomatoes, in the context of soil type, yield potential, fruit quality and nutrition regime.

Patil *et al.* (2008) conducted a field experiment to study the effect of foliar application of micronutrients on growth and yield of tomato (Megha) during 2005-06 and 2006-07 at the All India Coordinated Vegetables Improvement Project (AICVIP) in the University of Agricultural Sciences, Dharward. The results based on two years mean revealed that out of nine different treatments, the application of boric acid @ of 100 ppm resulted in maximum number of primary branches (18.30), yield per plant (2.07 kg) and fruit yield (30.50 t/ha). Followed by best treatment was the mixture of micronutrients (B, Zn, Mn and Fe @100 ppm and Mo @50 ppm) recording fruit yield of 27.98 t/ha and differed significantly from the control as well as other treatments. The maximum benefit ratio of 1.80 was obtained with application of boron recording Rs 97.850/ha of net returns followed by the mixture of micronutrients (1.74) recording (1.74) recording Rs 88.900/ha net returns compared to control (1.40) which recorded minimum net returns of Rs 53.250/ha.

Trejo *et al.* (2007) was conducted a field experiment to evaluate the effect of such foliar fertilizer on fruit quality of tomato (*Lycopersicon esculentum* var. floradade), plants were grown on an alkaline soil (pH 8.1) containing low concentrations of available micronutrients. The experiment was conducted under greenhouse conditions in a random array with four replications per treatment. The treatments evaluated were: (1) control, (2) soil fertilizer application (N-P-K at 150-60-00 kg/ha) and (3) a combination of soil fertilizer application with foliar applications of micronutrients (sprayed once a week). Twelve foliar applications were carried out during the experiment. Electrical conductivity (EC), P^H, Brix value (degrees Brix) and titrable acidity (TA) were measured to evaluate fruit quality while foliar analysis of micronutrients was carried out in order to establish the nutrient status of leaves. Data were statistically analysed using ANOVA, orthogonal contrast and Tukey's tests. Positive effects of foliar fertilization as a complement of soil fertilization were observed on TA (approximately 27 and 75% higher than the control and soil fertilization, respectively) and degrees Brix (about 25 and 55% more than control and soil fertilization, respectively). Micronutrient concentration in leaf was increased as a result of foliar fertilization as well. They have concluded that foliar fertilization is appropriate to feed tomato plants in alkaline soils, resulting in better micronutrient status of plants and higher quality of fruits.

Basavarajeshwari *et al.* (2005-07) carried out a field experiment to study the effect of foliar application of micronutrients on growth and yield of tomato at the all Indian Coordinated Vegetables Improvement Project (AICVIP) in the University of Agricultural Sciences, Dharwad. The result based on two years mean revealed that out of nine different treatments, the application of boric acid @ of 100 ppm resulted in maximum number of primary branches (18.30), yield per plant (2.07 kg) and fruit yield (30.50 t/ha). Followed by the best treatment was the mixture of micronutrients (Bo, Zn, Mn and Fe 100ppm and Mo @ 50ppm recording fruit yield of 27.98 t/ha and differed significantly from the control as well as other treatments.

Smit and Combrink (2004) used four nutrient solutions with only B at different levels (0.2; 0.16; 0.32 and 0.64 mgL^{-1}) in greenhouse tomatoes planted in acid-washed river sand. Leaf analysis indicated that the uptake of Ca, Mg, Na, Zn and B increased with higher B levels. At the low B level, leaves were brittle and appeared pale-green and very high flower abscission percentages were found. Fruit lacked firmness at the low B level and this problem worsened during storage. At the 0.16 mg kg^{-1} B-level; fruit set, fruit development, colour, total soluble solids, firmness and shelf life seemed to be close to optimum. The highest B-level had no detrimental effect on any of the yield and quality related parameters. However using "Solubor" as a source of B, high levels decreased soluble Mn concentrations in nutrient solutions, probably owing to the precipitation of insoluble MnO_2. This was reflected in reduced leaf-Mn concentrations.

Naresh Babu (2002) was carried out an investigation in Nagaland, India during 1998-2000 to determine the effects of foliar application of boron (50, 100, 150, 200, 250 and 300 ppm) on the growth, yield and quality of tomato cv. Pusa Ruby. Boron improved the yield and quality of the crop. The highest yield (327.18 and 334.58 q/ha) was obtained when the plant was drenched with 250 ppm aqueous solution of boron. B also had positive effects on plant height, number of branches, flowers and number of fruit set per plant, resulting in an increase in the number of fruits per plant and total yield. At lower rates, B improved the chemical composition of tomato fruits and at higher rates increased the total soluble solids, reducing sugar and ascorbic acid contents of the fruits. He has concluded that acidity of fruits showed a marked increase with increasing levels of B up to 250 ppm.

Chude *et al*. (2001) showed that B deficiency on crop field led to reduction in yield of crops. They further mentioned that application of compound fertilizer (NPK) mixed with B fertilizer increased the yield of tomatoes. Sobulo (1975) obtained the highest yield of tomato when a mixture of NPK and 0.01% borax was applied compared with mixtures of NPK and other micronutrients. Gulati *et al.* (1980) got the highest yield of tomato with 1.5 $mgkg^{-1}$ in green house trial. Adelana (1986), obtained significant increase in yield of tomato when he applied between 0.5 to 1.5 kg ha^{-1} for rain fed trial.

Dube and Chatterjee (2001) conducted an experiment to study manganese deficiency effects in tomato (*Lycopersicon esculentum*) var. Pusa Ruby where plants were grown in refined sand at two deficiencies i.e. 0.0011 and 0.055 mg/L and one adequate 0.55 mg/L levels of manganese. Manganese deficiency at 0.0011 mg Mn/L reduced the fruit yield more than the biomass. At low management levels, the concentrations of Mn, chlorophyll, starch, hill activity and acid phosphatase were decreased, whereas the concentration of sugars, activity of peroxidase, catalase and ribonuclease were increased significantly in tomato leaves. The visible effects of low manganese deficiency were pronounced on middle leaves under acute deficiency condition i.e. at 0.0011 mg MN/L. A significant decrease in the concentration of ascorbic acid, soluble proteins, starch, sugars and high phenols reflect poor quality of tomato fruits under manganese deficiency.

Zinc plays a fundamental role in several critical functions in the cell such as protein metabolism, gene expression, structural and functional integrity of biomembranes and photosynthetic carbon metabolism (Cakmak, 2000). Some of metabolic changes brought about by Zn deficiency could be well explained by the function of Zn as a structural component of a special enzyme or involvement in specific steps in particular metabolic pathway (Marschner, 1995). However, there are changes in the synthesis and metabolism of Zn deficient plants that could not be explained directly by the presence of Zn in the metabolic pathway or enzyme structure. Such responses are regarded to be rather indirect effects of Zn deficiency. Concerning the central role of Zn in stability of biomembranes and proteins (Cakmak, 2000), Zn deficiency can affect the photochemical process in the thylakoids, and thus inhibits biophysical process of photosynthesis. The flow of electrons through PSII is indicative of the overall rate of photosynthesis and is an estimation of photosynthetic performance.

Boron is an essential micronutrients required for normal plant growth and development. It performs a wide range of functions in tomato plants. It is a very sensitive element and plants differ widely in their requirements but the ranges of deficiency and toxicity are narrow. It maintains a balance between sugar and starch in plant body. It translocates sugar and carbohydrates in different parts of the plant body. It is important in pollination and seed production. It is necessary for normal cell division, nitrogen metabolism and protein formation. It is essential for proper cell wall formation. Boron plays an important role in the proper function of cell membranes and the transport of K to guard cells for proper control internal water balance. The requirement of B in vegetables generally more than other crops.

Makhan *et al*. (1999-2000) was conducted a field experiment for the response of foliar application of micronutrients on tomato variety at Vegetable Research Farm and Laboratory of CCS Haryana Agricultural University. The experiment was laid out randomized block design with three replications consisting of eight treatments of micronutrients and control making a total nine treatments. The treatments were ammonium molybdate, borax, copper sulphate, ferrous sulphate, manganese sulphate, zinc sulphate, mixture of all micronutrients and control. The micronutrients were applied as foliar spray @5 g per liter (0.5%) at the interval of ten days i.e. 40, 50, 60 days after transplanting. Mixture was made by taking all the micronutrients in equal proportion i.e. 0.83 g and mixed thoroughly. Five weeks old seedlings were transplanted for the experimentation.The result indicates that application of all the micronutrients, significantly enhanced plant height over control. Highest increase in plant height (54.80 cm) was recorded with application of Zinc sulphate. They have concluded that Zinc may serve as source of energy for synthesis of auxin which helps in elongation of stem.

Paithankar *et al.* (1994-95) was conducted a field trial at the main garden of the Department of Horticulture, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharashtra, India in a randomized block design with 16 treatments and three replications to evaluate the effect of boron and diammonium phosphate

(DAP) on the quality and performance of tomato. Foliar sprays of 0.1, 0.2 and 0.3% borax as well as 1, 2 and 3% DAP were given each alone and in combination at 60 days after transplanting. They have conclude that Borax at 0.3% provided the maximum fruit size and ascorbic acid content and the 0.3% borax + 3% DAP treatment recorded the maximum total soluble solids. The treatment 0.3% borax + 2% DAP reduced the cracking of fruits.

Alvarez *et al*. (1980) studied and experiment with deficient to toxic levels of Mn and B, the absorption and distribution of Fe in tomato plants (*Lycopersicon esculentum*, Var. Marglobe), grown hydroponically in a green house and B was added to disturb growth and hence nutrient demands. The experiment reveals that deficient or normal Mn levels antagonize Fe absorption, but the reverse was true when Mn reached toxic values; nevertheless, Mn effect was always antagonistic on Fe transport. From the above-related results, together with P and Ca absorption and distribution, they suggested that Mn/Fe in the shoot is not related at all with plant growth. B levels influence Fe absorption and translocation paralleling the dry matter production.

2.2 Review in relation to foliar application of plant hormone

Baliyan *et al*. (2013) was conducted an experiment to know the effects of different concentrations of 4-chlorophenoxyacetic acid (4-CPA) plant growth regulator hormone on fruit set, yield and economic benefit of tomato (*Lycopersicon esculentum* Mill) growing in high temperatures in Botswana (Southern Africa). In a field experiment laid under complete randomized block design, tomatoes flowers were treated with four different concentrations of 00 ppm (control), 15ppm, 45ppm and 75ppm of 4-CPA growth regulator. Data collected involved number of fruit set, weight of small tomato, weight of cracked tomatoes, weight of cat face tomatoes, weight of rotten tomatoes, weight of pest damaged and marketable tomatoes. A two way analysis of variance (ANOVA) was performed using the SPSS software ver.19 to analyze the data. The application of 4-CPA hormone indicated a positive and significant effect on the fruit set and yields of tomato. A positive relationship between the hormone concentration and the fruit set as well as total yield of tomato was also established (higher the concentration, higher the fruit set and tomato yield). The 75 ppm concentration of4-CPA resulted not only the highest increase in fruit set but also increased the tomato yield and hence economic benefit in tomato production increased. It was concluded that use of 4-CPA hormone increased the fruit set, yield and economic benefit of summer tomato production. Suggested future research can be conducted to observe the effect of higher concentration of the 4-CPA hormone on fruit set, yield and fruit quality of tomatoes.

Choudhury *et al*. (2011) was carried out an investigation to assess the effect of different PGRs on tomato during summer season at Horticulture Farm of Sher-e-Bangla Agriculture University, Dhaka-1207. They have exposed the plant in plant growth regulators (PGR) viz. PGR_0 = Control, PGR_1= 4-CPA (4-chloro-phenoxy acetic acid) @ 20 ppm, PGR_2 = GA_3 (gibberellic Acid) @ 20 ppm and PGR_3= 4-CPA + GA_3 @20 ppm through foliar application. They have concluded that the growth and yield contributing characters of tomato plants were significantly differed due to different plant growth regulators. They have found the maximum plant height at 60 DAT, number of flowers cluster per plant, number of flowers per plant, number of fruits per plant, maximum individual fruit weight and maximum yield in the treatment PGR_3, and the minimum for all parameters were found in control (PGR_0) treatment.

Sasaki *et al*. (2005) was conducted a field experiment on reduction of high temperature inhibition in tomato fruit set by plant growth regulators. They examined the effect of plant growth regulators on fruit set of tomato (*Lycopersicon esculentu*m Mill.) under high temperature and in a controlled environment in the field under rain shelter. Tomato plants exposed to high temperature (34/20 ^{0}C) had reduced fruit set. Treatments of plant growth regulators reduced the fruit set inhibition by high temperature to some extent, especially treatment with mixture of 4-chlorophenoxy acetic acid (4-CPA) and gibberellins (Gas). They have found, in the field experiment, tomato treated with a mixture of 4-CPA and Gas showed increased fruit set and the number of normal fruits (excluding abnormal types such as puffy fruit) were more than the plants treated with 4-CPA alone during summer.

Bhosle *et al.* (2002) was carried out an investigation to know the effects of NAA (25, 50 and 75 ppm), gibberellic acid (15, 30 and 45 ppm) and 4-CPA (25, 50 and 75 ppm) on the growth and yield of tomato cultivars Dhanashree and Rajashree through the field experiment conducted in Rahuri, Maharashtra, India during the summer of 1997. They have concluded that the number of flowers per cluster, fruit weight and marketable yield increased with increasing rates of the plant growth regulators. Treatment with 30 ppm gibberellic acid resulted in the tallest plants, whereas treatment with 25 ppm 4-CPA and 45 ppm gibberellic acid resulted in the highest number of primary branches of Dhanashree (4.16) and Rajashree (5.38), respectively. The highest marketable yield of Dhanashree and Rajashree resulted from treatment with 75 ppm 4-CPA.

Karakurt (2000) was studied on foliar application of 4-CPA in tomato hybrids under greenhouse conditions with pruning of some flowers in the inflorescence. He has concluded that foliar application of 4-CPA and pruning had positive effects on crop yield, development and maturation.

Gupta *et al.* (1997-99) was conducted a field experiment in Allahabad, Bangalore, Karnataka, India to investigate the effect of the plant growth regulators (PGRs) IAA and NAA (25 and 75 ppm), and of the micronutrient mixtures Multiplex (2500 ppm) [Ca, Mg, S, Fe, Zn, Mo, Mn, B and NAA] and Humaur (2000 ppm) on the nutritive value of tomato (cv. Krishna) fruits. PGRs were applied at 25 and 75 days after transplanting (DAT). Treatment with micronutrient mixtures was conducted at 25 and 75 DAT. Higher nutritive content was obtained with the application of both PGRs and micronutrient mixtures than treatment with either PGR or micronutrient mixture. NAA at 75 ppm+Multiplex increased P content by 16.12% and iron content by 23.33%. The application of 75 ppm NAA+Humaur increased K content by 23.80% and Ca concentration by 52.38%. The Mg content increased by 43.84% due to the application of 25 ppm NAA+Humaur.

Cgsar *et al.* (1989-92) was carried out a study in Antalya, Turkey, to determine the effect of vibration and 4-CPA (5, 10, 15, 20 and 40 ppm, applied 1-3 times to all clusters on fruit set of tomatoes in grown in an unheated greenhouse. Harvested fruits were screened for 4-CPA residues. Tomato cv. Dario F< sub>1</ sub> was grown for autumn cropping, and Argus F< sub>1</ sub> was grown between December and March and in the spring. The highest yields were obtained in the 10-20 ppm 4-CPA treatments. Fruit deformation increased when increasing doses of 4-CPA were applied to Dario F< sub>1</ sub>. Argus F< sub>1</ sub> did not exhibit fruit deformation, but fruit diameter increased with increasing doses of 4-CPA. Fruits harvested from plants treated with 10, 20 and 40 ppm 4-CPA applied twice did not have 4-CPA residues. Vibration promoted fruit set during the autumn and spring seasons, but had no effect on fruit set between December and March, necessitating the use of 4-CPA at this time to promote fruit set.

Randolph *et al.* (1959) was conducted a field experiment on the effect of fruit-setting plant hormones and nitrogen level in relation to quality and storage life of tomatoes studied. The field plots were in commercial fields and consisted of replicated blocks in split-plot design. Plants were grown with two or more levels of nitrogen as ammonium sulphate applied usually in three side-dressed applications prior to, and during, the period when hormones were applied. Each nitrogen level was split into two plots, one untreated. The treated plot received hormone sprays, usually three replications of 50ppm-parts per million of 4-CPA spaced at 10-days to two week intervals. They have concluded that application of 4-CPA resulted in significant increase in both pointed and puffy fruit, as well as increase in early yield.

2.3Review in relation to foliar application of Antitranspirants

Yuly *et al*. (2011) was carried out a field experiment to know the effect of kaolin film particle application and water deficit on physiological characteristics in rose cut plants. They have studied of foliar applications of a kaolin clay particle film (Surround WP) on leaf temperature, chlorophyll content, shoot length, production and water relations in well-irrigated and water-stressed rose cut plants (Rose spp) during ten weeks. Plants were sprayed twice at first and fifth week after the experiment started with aqueous suspensions of Kaolin (Surround) at a dose of 5% (w/v). The interaction between kaolin applications and water status did not showed significances. Water stress decreased the stomatal conductance, leaf water content (LWC), shoot length and the number of marketable floral stems. Kaolin sprays did not affect on SPAD readings, chlorophyll fluorescence, stomatal conductance, LWC and shoot length. Kaolin reduced leaf temperature by 2.5˚C approximately at midday compared to plants non-sprayed with kaolin. These results show that kaolin foliar applications could be considered a useful tool at early growth stage in improving rose plant acclimation to high temperatures levels under greenhouse conditions in tropical regions.

Ibrahim and Selim was conducted a field experiment at a private farm near Mansoura city, Dakahlia Governorate, Egypt during two summer seasons (2008-2009) to study the effect of irrigation intervals and antitranspirant (Kaolin) on summer squash (*Cucurbita pepo* L.) growth, yield, quality and economics. They exposed the plant at three irrigation intervals (8, 12 and 16 days, from first irrigation) and spraying kaolin at (0.3 and 6%) as antitranspirants at 25, 40 and 55 days from planting and their interactions on growth, yield, fruit quality and water use efficiency of summer squash cv. Eskandrani. Result indicated that irrigation every 8 days throughout growing season resulted in highest foliage weight, leaves weight per plant, mean fruit weight, total fruit yield per feddan, marketable yield per feddan and seasonal applied water in both summer seasons. On the contrary, increasing irrigation intervals from 8 up to 16 days caused significant increases in leaves dry matter percentage, total soluble solids and dry matter percentage in fruits and water use efficiency in both seasons. On the other hand, all studied characters except leaves dry matter percentage, dry matter percentage in fruit and seasonal applied water were significantly increased with increasing kaolin levels was significantly for all the studied parameters in both seasons. The highest net return was observed with plants watered every 8 days and received kaolin at 6% concentration followed by watered every 12 days and received kaolin at 6% concentration that had higher benefit: cost ratio. From the economic and nutritional point of view, they have concluded that irrigation every 12 days intervals combined with spraying kaolin at 6% concentration to summer squash cv. Eskandrani produced satisfactory and good quality marketable fruit yield under similar conditions of this work.

Cantore *et al.* (2008) was conduct a field experiment on Kaolin–based particle film technology affects tomato physiology, yield and quality. They summarized environmental stress can affect development plant yield of tomato. This study was undertaken to investigate the underlying mechanism asserted by Kaolin on tomato physiology by evaluating its effect on inner fruit temperature, gas exchange at the leaf and canopy scales, above ground biomass, yield and fruit quality. The study was carried out under field conditions in Southern Italy. Treatments were plants treated with kaolin-based particle film suspension and untreated plants (Control). They have found that inner fruit temperature of kaolin treated plant 4.4°C lower than the control. Marketable yield of kaolin-treated plants were 21% higher than those measured in control plants. Kaolin treatment increase lycopene fruit content by 16% but did not affect total soluble solids contents, fruit dry matter, juiceP^H , titratable acidity or tomato fruit firmness. The use of kaolin-based particle film technology would be an effective tool to alleviate heat stress and to reduce water stress in tomato production under arid and semi-arid conditions.

Mofta and Al-humaid, (2002) was conducted an experiment to examine the effects of different types of antitranspirants (ATs), Kaolin and Vapor Gard, on vegetative growth, flowering, and chemical composition, of tuberose (*Polianthes tuberose* L.) cv. They have concluded that the performance of Kaolin was more effective than that of Vapor Gard (VG). This might be contributed to its mechanism in reducing leaf temperature, transpiration rate, improvement of plant water status and maintaining biomass production of tuberose plants. Due to the superiority of Kaolin particle film in regulating plant performance and chemistry, it is recommended to be used for reducing water loss by plants in Al-Qassim region, Saudi Arabia

CHAPTER III

MATERIALS AND METHODS

The pot experiment was conducted at Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka - 1207, Bangladesh in 2013 to determine the productive potentiality of summer tomato (BARI Hybrid-4) by the influence of foliar application of plant growth regulator 4-CPA (4-Chloro Phenoxy Acetic Acid) and micronutrients Zn as Zinc Sulphate ($ZnSO_4$), B as Boric Acid (H_3BO_3), Mn as Manganese Sulphate ($MnSO_4$), Se as Sodium Selenate and Kaolin as an antitranspirant which is non-toxic clay particle "aluminosilicate" ($Al_4Si_4O_{10}(OH)_8$). This chapter includes a brief description of materials used, treatments, location of the experiment, characteristics of soil, weather & climate and process of experimentations etc.

A brief description of methods and materials was given below:

3.1 Experimental site

3.2 Location

3.3 Characteristics of soil

3.4 Pot soil collection and preparation

3.5 Fertilizer mix with soil

3.6 Climate and weather

3.7 Collection of Seeds (planting materials)

3.8 Raising of seedlings

3.9 Fertilizer application in the pot soil

3.10 Pot preparation

3.11 Transplanting of seedlings in the pot

3.12 Treatment of the experimental

3.13 Design and layout of the experiment

3.14 Intercultural operations

3.1 Experimental site

A pot experiment was conducted at the horticulture farm of Sher-e-Bangla Agriculture University, Dhaka, Bangladesh during the period from April 2013 to September 2013.

3.2 Location

The location of the study site is 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).

3.3 Characteristics of Soil

The soil of the experiment was collected from the horticulture farm. 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, Soil Resources Development Institute (SRDI) Farmgate, Dhaka and details soil characteristics were presented in Appendix 1.

3.4 Pot Soil collection and preparation

The soil was collected one month prior to setting the experiment. The top soil at a 15 cm depth was collected from the Horticulture Farm Area of North-East corner, mixed thoroughly and makes it clean by removing stones, grass, roots and other debris.

3.5 Fertilizer mix with soil

Recommended dose of organic and inorganic fertilizer was added in the soil prior 21 days of filling the pot and wrapped with polythene sheet.

3.6 Climate and weather

The climate of the experimental area was sub-tropical in nature. It is characterized by its high temperature and heavy rainfall during Kharif season i.e. April to September and scanty rainfall associated with moderate temperature during robi season i.e. October to March (Anonymous, 1960).

3.7 Collection of seeds (planting materials)

The seeds of BARI Tomato Hybrid-4 were collected from the Horticulture Research Center, BARI, Gazipur-1701, Bangladesh.

3.8 Raising of seedlings

Soil of the seed bed was made loosen and friable as much as possible and organic matter mixed with soil. All weeds, stones and dead roots were removed. The seeds were sown on 7th May 2013 in the raised seed bed of 1m size. The seed bed was supported with partial shed at 1:00-3:00 pm in the high hot day by using coconut leaves. Proper care was taken to raise healthy seedlings.

3.9 Fertilizer application in the pot soil

The collected soil was measured as a cubic meter by applying length (m) **×** width (m) ×high (m). For field crops, a depth of soil is considered 15 centimeter (0.15m). So, one decimal land is (40.5m^2× 0.15 m) = 6.075 m^3 (approximate) which has considered as a root zone soil. Total volume of collected soil was calculated which has found 14.65 m^3 considering Length 3.5 m **×** width 3.1 m × height 1.35 m. Recommended fertilizer dose for summer tomato (BARI Hybrid-4) for very low status soil: Organic Matter, Urea (Total nitrogen: minimum 46%), MP (as Muriate of potash: 60% K_2O), TSP (as Triple Super Phosphate: 48% P_2O_5) and Gypsum (as $CaSO_4.2H_2O$ containing 19% S) for one decimal land is 50 kg, 1.6 kg, 0.68 kg, 0.5 kg, and 0.43 kg which has considered for 6.075 m^3 of root zone soil, respectively (Source: FRG 2012). Our total soil volume was 14.65 m^3 and one decimal is equal to 6.075 m$^{3.}$ So, a comparison was made to estimate the exact amounts of organic matter, MP, TSP and Gypsum which has found

$\text{organic matter (OM)} = \frac{50\times14.65}{6.075} = 120.6\ \text{kg}, MP: = \frac{0.68\times14.65}{6.075} = 1.64\ \text{kg},\ TSP = \frac{0.5\times14.65}{6.075} = 1.20\ \text{kg},\ \text{Gypsum}\ \frac{0.43\times14.65}{6.075} = 1.04\ \text{kg},$ respectively. Finally, the calculated amount of organic matter, half of MP and all required TSP and Gypsum were applied prior 21 days of filling the pot with soil. One decimal land can be accommodating 162 plants considering spacing row to row and plant to plant 50 cm × 50 cm. Our total plants under experimentation were 120 which have needed 1185 g of urea for three time of application. Each time @ 3.30 g urea per plant was applied at 10, 25 and 40 days after transplanting as a ring method. Rest half of MP (820 g for 120 plants) was applied in two split dose at 25 and 40 days after transplanting at the time of 2^{nd} and 3^{rd} dose of urea application. Each time @ 3.42 g MP was applied per plant.

3.10 Pot preparation

Plastic pots were used in this experiment. The height and width of each pot was 35 and 30 cm respectively. Two holes were made in the middle of the bottom of each pot and holes were covered by the broken pieces of earthen pot. All the pots were washed with ash and tap water by rubbing and sun dried. The fertilizer mixed soil was made well pulverized and dried in the sun. Final check was made to remove plant propagates, inert materials, visible insect and pests. In the lower part of all the pots were filled with general sun dried and clean soil; only upper 20 cm of the pot was filled with fertilizer mixed well prepared soil and topmost upper 5 cm of the pot was blank for irrigation purpose. Gravimetric method was used to find out proper strategy to irrigate pot plants. In this connection, plastic pot with soil was weighted using weighing balance and all the plastic pot was made in equal weight including soil which was 21.17kg where only empty plastic pot was 0.8 kg. Water was added in each pot to make it well saturated condition. After well saturation of the soil with water it was weighted and found 24.64 kg. So, water required (24.64 – 21.17) kg = 3.47 kg to make it well saturation. Pot with soil was allowed for two days in normal homestead environment. After two days, the plastic pot with wetted soil was weighted and it was found 22.53 Kg. A difference was made in between pot with wetted soil in water saturated condition and pot with soil after allowing two days. So, the loss of water = weight of pot soil in saturated condition – weight of pot soil after allowing two days = 24.64 kg – 22.53 Kg = 2.11 kg. As the experiment was conducted in rain protection measure, so strategy was followed to irrigate pot plants with 80% weight loss of water of the difference weight which was 1.688 Kg. After every two days of watering the pot, it was again added with 1.688 kg of water by measuring bucket.

3.11 Transplanting of seedlings in the pot

25 days aged single seedlings were transplanted on 02^{nd} June'2013 in the middle of each pot in the late afternoon of the same day. Immediate after transplanting the plants were irrigated with tap water. The pots were arranged inside the polythene shed and in outside the ploythene shed as per design of experiment.

3.12 Treatments of the experiment

The experiment consisted of two factors:

Factor A: Polythene shed

i. $\mathbf{P_0}$: Without Polythene Shed
ii. $\mathbf{P_1}$: With Polythene Shed

Factor B: Foliar application of yield and quality contributing elements

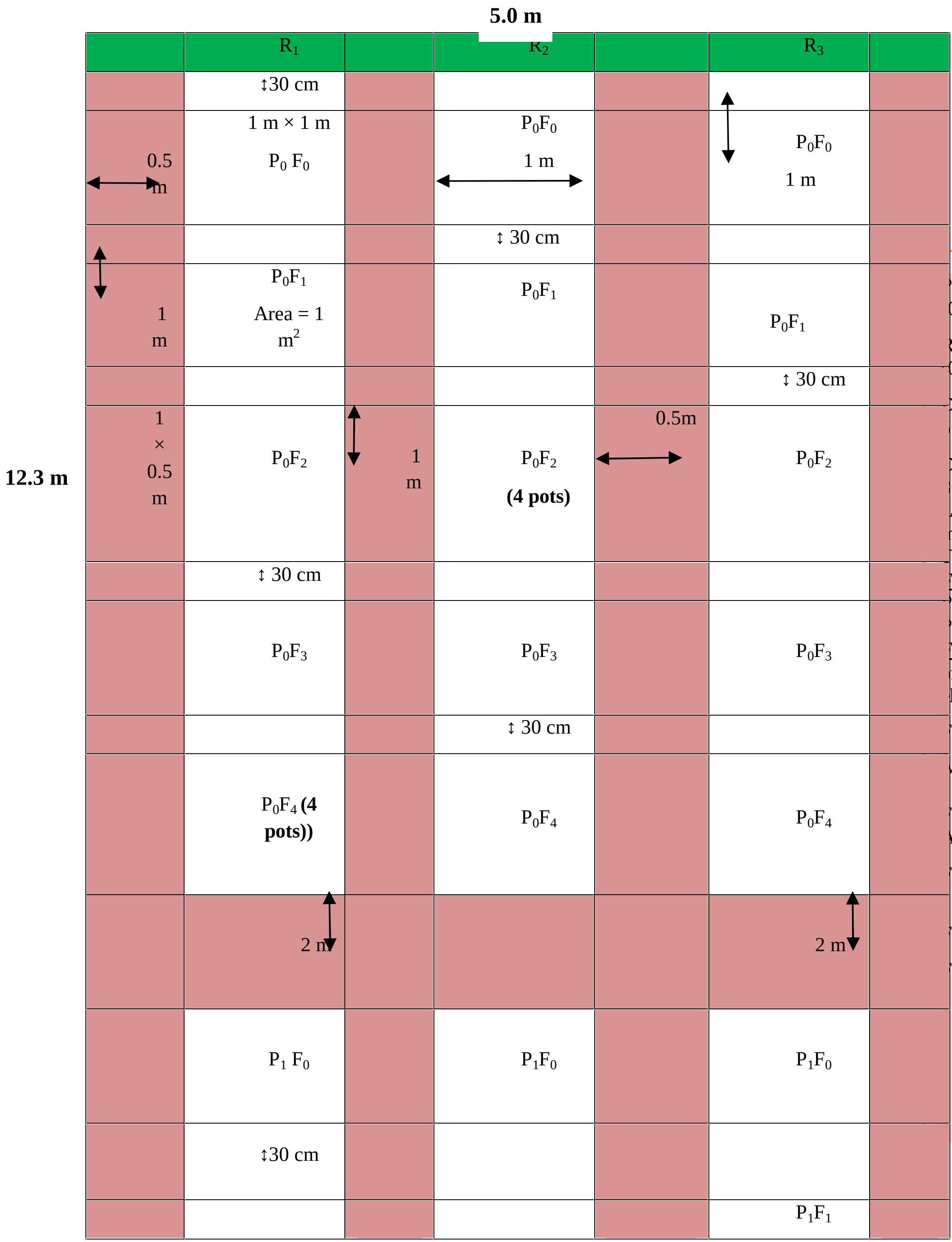
i. F_0: Control (Spraying of tap water only).
ii. F_1: Spraying of Plant growth regulator 4-CPA (4-Chloro Phenoxy Acetic Acid) as per manufactures recommendation (5 ml per liter of water).
iii. F_2: Spraying of Zn as Zinc Sulphate ($ZnSO_4$), B as Boric Acid, Mn as Manganese Sulphate ($MnSO_4$), Se as Sodium Selenate @ 100 ppm for each of the nutrient solution.
iv. F_3: Spraying of Kaolin as an antitranspirant which is non-toxic "aluminosilicate" ($Al_4Si_4O_{10}(OH)_8$) @2% solution.

v. F_4: Spraying of Plant growth regulator 4-CPA (4-Chloro Phenoxy Acetic Acid) as per manufactures recommendation (5 ml in per liter of water); Zn as Zinc Sulphate ($ZnSO_4$), B as Boric Acid, Mn as Manganese Sulphate ($MnSO_4$), Se as Sodium Selenate @100 ppm for each of the nutrient solution and Kaolin as an antitranspirant which is non-toxic "aluminosilicate" ($Al_4Si_4O_{10}(OH)_8$) @ 2% solution.

There were 10 (2×5) treatment combinations such as P_0F_0, P_0F_1, P_0F_2, P_0F_3, P_0F_4, P_1F_0, P_1F_1, P_1F_2, P_1F_3, and P_1F_4.

3.13 Design and layout of the experiment

The experiment was carried out in a Complete Randomized Design (CRD). The total plants were divided into two groups (Inside polythene shed to protect rain and without shed in field condition) with 3 replications. Four plants were exposed to each treatment. The total area of the experimental plot was 61.5 m^2. There were 30 unit plots altogether in the experiment. The distance between two replications and two treatments were maintained 50 cm and 30 cm, respectively. Seedlings were planted in the middle of the pot soil and 04 pots were placed in each plot. Plots were placed considering plants distanced between rows to row and plant to plant was 50 cm and 50 cm, respectively. The layout of the experiment is shown in Figure 1.



lant to plant distance: 50 cm 0.5 m)

ow to row distance: 50 cm 0.5 m)

istance between replications: 0 c m (0.5 m)

istance between treatments: 0 cm

ength = 12.3 m, Width = 5.0 n

otal Area = 61.5 m^2

actor A: Polythene shed

$_0$: Without Polythene Shed

$_1$: With Polythene Shed

actor B: Foliar application f yield contributing lements

$_0$: Control (Spraying tap vater only)

$_1$: 4-CPA (4-Chloro Phenoxy cetic Acid).

$_2$: Zinc, Boron, Manganese, Selenium (100 ppm)

$_3$: Kaolin @ 2%

$_4$: 4-CPA (5 ml one litre water) and Zinc, Boron, Manganese, Selenium (100 ppm) and Kaolin @2%.

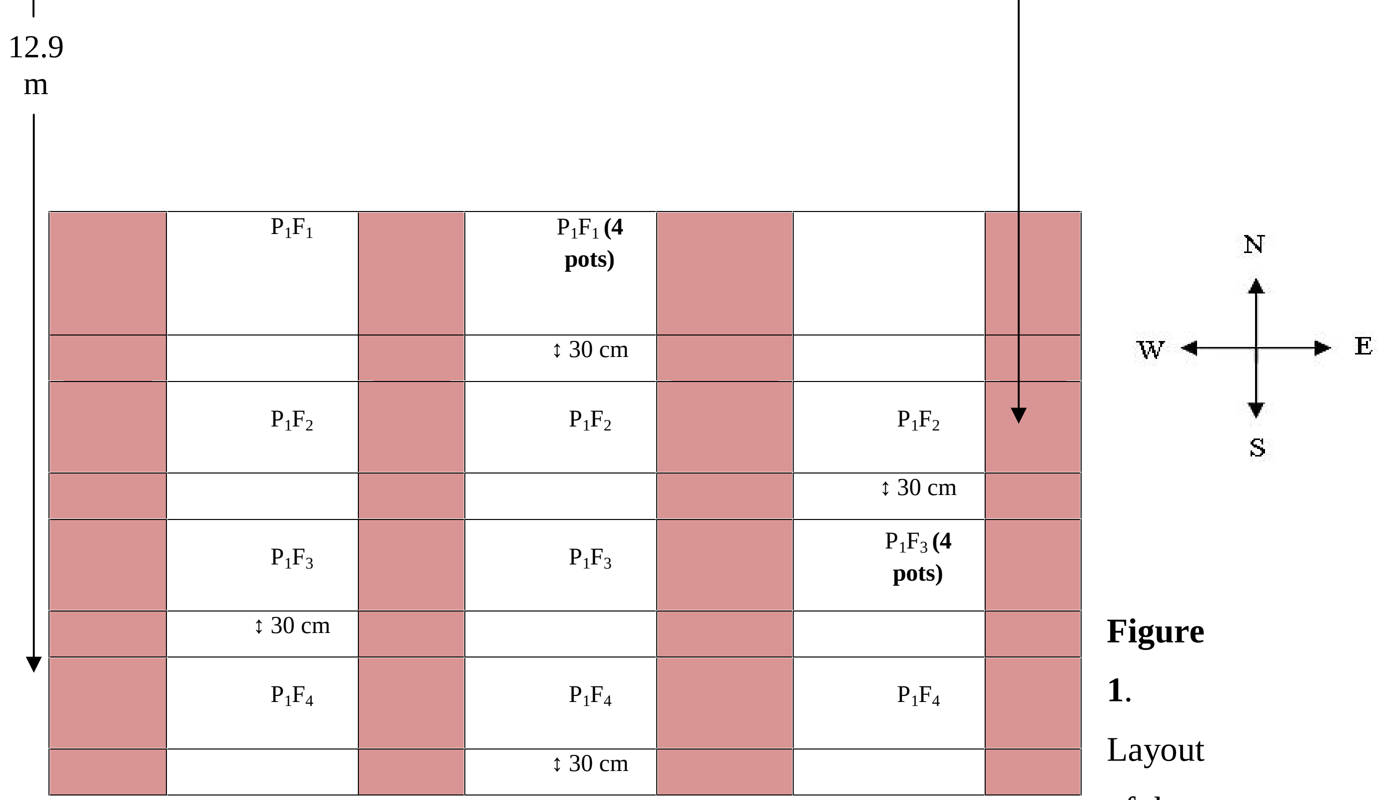


Figure 1. Layout of the experimental plot.

3.14 Intercultural operations

3.14.1 Irrigation

Immediate after transplanting, light watering to the individual seedling was provided to overcome water deficit. At two day interval the plants were supported with water by 1.688 Kg as a regular basis.

3.14.2 Supporting

All the plants were supported with bamboo sticks and threads as and when required.

3.14.3 Weeding

Weeding and soil loosening was done as and when required. It was done three times during experimentations.

3.14.4 Mulching

A layer of dried straw was putted in each container as mulch.

3.14.5 Pruning

All shoots from the base of all plants were removed at an 8 cm distance from the ground. It was maintained to a single stem by removing all side shoots at least once a week. Remove the shoot early in the morning on sunny days when they are very small (one inch or smaller). The small wound resulting from removing the shoot will heal quickly leaving less chance for fungal invasion.

3.14.6 Urea and MP application

Urea was applied in three times as a ring method at 10, 25 and 40 days after transplanting. MP also applied at 25 and 40 days after transplanting (DAT) together with urea application as per prescription of Olericulture Division, Horticulture Research Centre (HRC), Bangladesh Agriculture Research Institute (BARI), Gazipur, Bangladesh.

3.14.7 Use of pesticide

Admire was sprayed @ 1 ml per liter of water for 3 times at 10, 25 and 40 DAT of seedling in the all plants of the inside polythene shade and outside also.

3.14.8 Use of fungicide

Ridomil was sprayed @ 1 gm per liter of water for 3 times at 15, 30 and 45 DAT of seedling in the pot soil.

3.15 Application of the treatments

All the treatments were applied considering the design of the experiment. First application was made at 18 DAT in the day when first flower initiation was found in the experimental plot and second & third application was made at a 15 days interval which was 33 and 48 DAT. A specific concentration of the each nutrient solution was maintained. All the micro nutrients were made at a 100 ppm separately for each time of the application and it was sprayed on the leaves of the plants. 4-CPA was applied @ 05 ml per liter of tap water as per commercial formulation and it was applied in the flower and flowering stalk. All the micro nutrients and 4-CPA were applied separately in the same day. Kaolin 2% solution was prepared and sprayed at 19, 34 and 49 DAT on the plants.

3.16 Measurement of plant height

Height of plant was measured with a meter scale from the base of the plant to the tip of the leaf of the main stem for four times. First height was measured at 18 days after transplanting (DAT) before applying the first treatment on the same day. Second, third and fourth plant height was measured at 33, 48, and 63

DAT. All the foliar treatments of growth promoting elements were applied at 15 days interval. The final height was measured at the final harvesting time. The plant height was measured and expressed in centimeter. Recorded data was made an average.

3.17 Measurement of foliar coverage

Foliar coverage was measured with a meter scale. It was estimated at the point where the plan was highly covered the area by the expansion of leaves. It was done five times during experimentation. It was measured at 18, 33, 48 and 63 DAT at the time of treatments application and at the day of final harvest.

3.18 Measurement the length of internodes

The lengths of internodes of individual plants were measured at the final stage of harvesting. A meter scale used for estimating the length of internodes and expressed in centimeter (cm). Average data was used for statistical analysis.

3.19 Counts the number effective fruiting branches

The total number of branches of individual plant was counted by visual observation at the final harvesting of fruits. It was counted above 8 cm from the ground level because branches were removed through pruning practices up to 8 cm from the ground. Recorded data was used to make an average.

3.20 Counts the number of leaves

The total number of leaves of individual plant was counted and recorded. It was counted for first time at 40 DAT and the place of each stem was marked with plastic rope to identify the location of counting part of the steam. For the second time number of leaves were counted at the final harvest and it was made an average.

3.21 Measurement of length of petiole

The lengths of petioles of individual plants were measured at the final stage of harvesting. A meter scale used for estimating the length of petiole and expressed in centimeter and it was made an average.

3.22 Counts the number of buds

The numbers of flower buds were counted at the early stage before opening the flower. It was a continuous process and continued up to the final harvesting stage and it was made an average.

3.23 Counts the days to first flower initiation

It was estimated by the visual observation for each of the treatment. The date was noted and day required for flower initiation was counted.

3.24 Counts the number of fruits clusters

Total number of fruits cluster was counted at the final stage of harvesting for individual plant and treatment. Data were collected and it was made an average.

3.25 Counts the number of fruit sets and fruit sets percentage

Fruits were harvested in five times. Each time of harvesting data was recorded and final checked was made for total number of fruits and total weight of harvested fruits at the end of fifth harvesting. Number of flower was counted before opening the flower and it was recorded. Number of fruit set was calculated by the following formula:

Fruits Clusters

$$\% \text{ of fruit per plant} = \frac{\text{Nuber of total fruit set per plant}}{\text{Number of total flower per plant}} \times 100$$

3.26 Average fruit sets per cluster

Average fruits set per cluster were counted at the final stage of harvesting using recorded data. It was calculated by the following formula:

$$\text{Number of fruits per cluster} = \frac{\text{Total nuber of fruits per plant}}{\text{Total numberofclusters per plant}}$$

3.27 Number of fruits harvested per plants

Fruits were harvested considering commercial maturity stage of fruits. The maturity of the crop was determined on the basis of starting reddish coloring of fruits. The fruits of each pot plant were harvested separately. In each of the harvesting, the number of fruits data was recorded. In case of production under polythene shed, the harvesting started on 14 August 2013 (73 DAT) and completed 05 September 2013 (95 DAT). In case of open condition (without polythene shed), the harvesting started on 21 August 2013 and completed 19 September 2013; which means open condition takes 14 days more for final harvesting compared with polythene shed condition.

3.28 Fruit weight of individual plant

Fruits were harvested at the commercial maturity stage of fruit. In each of harvesting, the weights of harvested fruits were recorded using electric balance in the field. The final data was made at the final harvesting using calculator and Microsoft Excel Software. Average results are used for statistical analysis purpose.

3.29 Measurement of leaf temperature

The temperature was recorded using smart sensor infrared thermometer ($AR852B^+$) in degree centigrade (°C) and it was done three times during experimentations. During measurement of temperature the button of the instrument was pressed and red light was passed on the leaves surface and it was directly showed temperature in degree centigrade (^{0}C). In all the time of recording the temperature, it was estimated in the third day of application of each of the treatment. The day of the recording temperature was fully sunny and data was collected from 1:00 to 2:00 pm for all the day of measurement. Finally, an average was made of the recorded temperature.

3.30 Measurement of chlorophyll

A leaf from each plant was collected and brings it to the laboratory. The leaf was collected considering a specific distance of plant from the base and the age of the leaf was same which estimated by visual observation. Chlorophyll content was estimated by using SPAD meter. The measured chlorophyll content was expressed as percentage (%). It was estimated for three times and makes an average as a final data.

3.31 Harvesting of tomato

Tomatoes were harvested early in the morning when the fruits were developed red colors (breakers). Always avoided full sunny and hot weather and soon after harvesting fruits were stored at room temperature. A fruit harvested at the red ripe stage will be subjected to more bruising without enhancing quality.

3.32 Measurement of total soluble solids (TSS)

Brix refractometer (Model RHB 32 ATC) was used to measure TSS. One tomato sample was collected from each of the treatment. Tomato sample was cut with the sharp knife and inside was squeeze with the needle for sample juice. A drop of juice was placed on the transparent glass and it was covered by the upper glass. Brix refractometer was directly showed the TSS as percentage.

3.33 Measurement of P^H


Tomato extract

Two tomato samples were collected from each of the treatment which was fully ripened. Each sample was blended and it was made in liquid form. All the samples were taken in clean and transparent plastic pots. Electric P^H meter (model H 12211 P^H/OPR meter of Hanna Company) was adjusted in buffer solution of P^H7.0; later on again it was adjusted in buffer solution containing P^H 4.0. Finally, Electric P^H meter was inserted in first sample and data was recorded. Again, P^H meter was inserted in buffer solution containing P^H 4.0 to adjust the P^H meter and again it was inserted in second sample of tomatoes and data was recorded. The same procedure was followed to measure P^H of all other samples.

3.34 Measurement of Vitamin-C

Volumetric method is used to measure Vitamin-C or ascorbic acid in per 100 gm of tomato samples. It has expressed as mg Vitamin-C per 100 gm of tomatoes. It was measured in Biochemistry Laboratory of Sher-e-Bangla Agriculture University, Dhaka.

3.35 Measurement of fruit inner temperature

Smart Sensor (AR 867) was directly inserted in the fruit of each standing plants in field condition. The sharp point was inserted up to one inch and keeps it inside for thirty seconds. Smart sensor was viewed temperature in degree centigrade (^{0}C). Temperature was measured three times during experimentation to make average.

3.36 Measurement of β-Carotene

Tomato sample was collected in full red condition of same physiological stage from each of the treatment to measure β-Carotene. It was measured at the Institute of Food Science and Technology (IFST), Bangladesh Council of Scientific & Industrial Research (BCSIR), Dhanmondi, Dhaka – 1205, Bangladesh. Columnar Chromatography method was used to measure β-carotene from each of the sample. It was expressed as μ gram per 100 g of tomato.

3.37 Measurement of fruit firmness

Force gauge (Yamagata Univ. Japan: FG – 5000A) was used to measure firmness of fruits and it was expressed as Neuton. Tomato sample was collected in full red condition of same physiological stage from each of the treatment to measure firmness. Tomato sample was taken under forced by making pressure by the upper surface of the force gauge and force was applied to know the break point in the scale. Data was recorded three times during experimentation to make an average.

3.38 Statistical Analysis

The collected data were statistically analyzed to find out the level of significance using MSTAT-C software. The significance of the difference among the treatment mean was estimated by Least Significant Difference (LSD) Test at 1% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The research work was accomplished to identify the effect of different treatments on growth, yield and quality of tomato in Bangladesh. Some of the data have been presented and expressed in table(s) and others in figures for case of discussion, comparison and understanding. The analysis of variance of data respect of all the parameters has been shown in Appendix. The results of each parameter have been discussed and possible interpretations where ever necessary have been given under following headings.

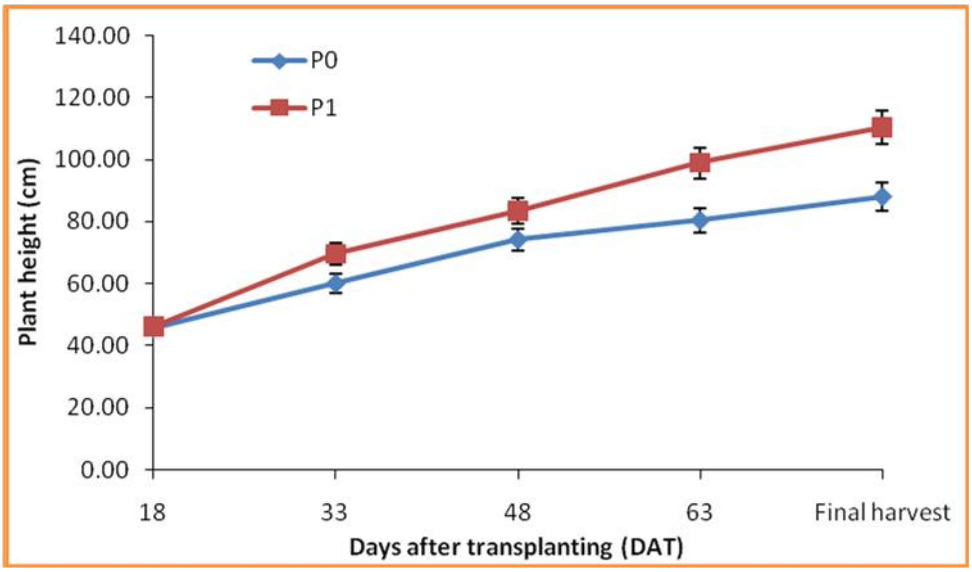
4.1 Plant height

The plant height is one of the most important factors which affect the growth and yield of tomato. It depends on several factors like genetic makeup, nutrient availability and application of plant growth regulators (PGR), climate, soil etc. Among those nutrient availability and PGR application are the important factors for desirable plant height.

The trend of the plant height at different days after transplanting (DAT) has been shown (Appendix II). A marked variation in plant height was observed due to the influence of non polythene shed (P_0) and polythene shed (P_1) treatment and statistically it was highly significant at 33, 48, 63 DAT and at the final harvest (Figure 2). The highest plant height (103.88 cm) was recorded with polythene shade (P_1) treatment whereas the shortest plant height (103.13 cm) was recorded without polythene shed (P_0) treatment at final harvest.

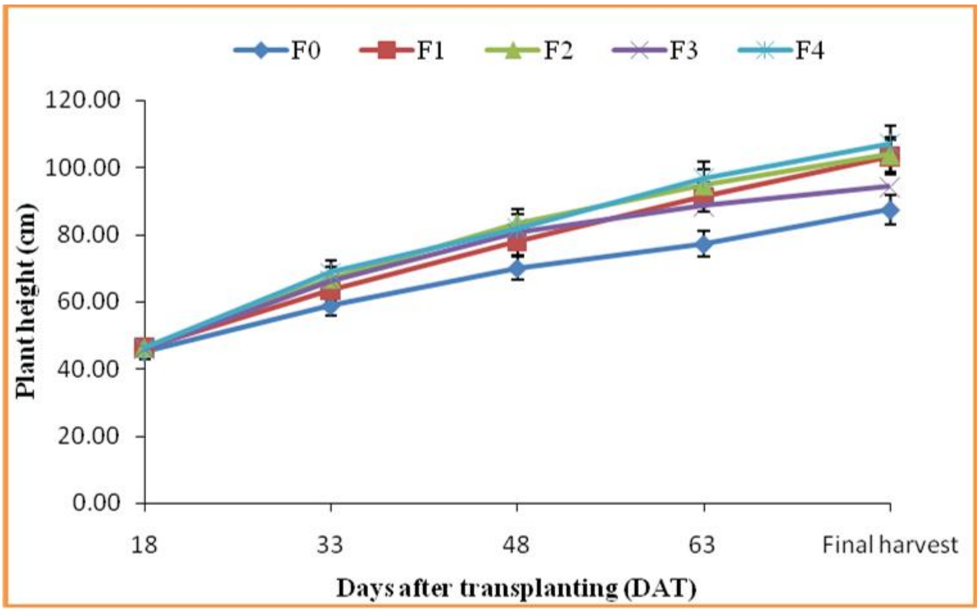
Plant height was significantly affected by different foliar treatments which have been shown (Appendix II). Plant height of tomato varied significantly for different treatments which were water (F_0); 4-CPA (F_1); Zn, B, Mn, & Se (F_2); Kaolin (F_3) and 4-CPA, Zn, B, Mn, Se and Kaolin (F_4) at 33, 48, 63 DAT and at final harvest (Figure 3). The tallest plant (113.67 cm) was marked from 4-CPA, Zn, B, Mn, Se and Kaolin (F_4) treated plants whereas the shortest plant (77.50 cm) was scored from control (F_0) treated plants at final harvest.

Significant variation was observed due to the interaction effect of polythene shed and different treatments in terms of plant height (Appendix II). Plant height of tomato observed statistically significant difference among treatments at 33, 48, 63 DAT and at final harvest (Table 1). The tallest plant (113.93 cm) was observed from P_1F_4 which is statistically similar with P_1F_2 (113.13) and P_0F_4 (113.33) treatment and smallest plant (77.0 cm) was recorded from P_0F_0 treatment at final harvest. The study disclosed that Zn, B, Mn & Se treated plant with polythene shed condition performed the better result in terms of plant height. It might be due to the synthesis of auxin by the application of Zn in tomato plants. Auxin is a growth promoting PGR which enhance the growth of tomato plants. Makhan *et al*. (1999-2000) reported that Zinc may serve as source of energy for synthesis of auxin which helps in elongation of stem.



[P_0: Without Polythene shed and P_1: With Polythene shed]

Figure 2: Effect of Polythene shed on plant height at different days after



transplanting (DAT). Vertical Bars indicate LSD value.

[F_0: Control; F_1: 4-CPA; F_2: Zn, B, Mn, Se; F_3: Kaolin and F_4: 4CPA, Zn, B, Mn, Se, Kaolin]

Figure 3: Effect of foliar application of yield contributing elements on plant height at different days after transplanting (DAT). Vertical Bars indicate LSD value.

Table 1: Interaction effect of polythene shed and foliar application of yield contributing elements on plant height at different days after transplanting (DAT)

Treatments	Plant height (cm) at different days after transplanting				
	18 DAT	33 DAT	48 DAT	63 DAT	at Final harvest
P_0F_0	45.00NS	56.00d	70.00 d	70.33d	77.00d
P_0F_1	46.67	57.00d	83.33 c	101.00c	105.33c
P_0F_2	46.00	62.00c	87.33 ab	105.00ab	112.00ab
P_0F_3	45.33	60.33c	86.00 bc	103.00bc	108.00b
P_0F_4	45.67	65.00b	88.00a	106.67a	113.33a

P_1F_0	45.33	61.67c	72.00d	71.00d	78.00d
P_1F_1	46.00	70.00a	83.00c	101.33c	106.00bc
P_1F_2	46.33	71.67a	88.33a	107.00a	113.13a
P_1F_3	46.33	72.00a	86.33b	103.67b	108.33b
P_1F_4	46.67	72.33a	88.67a	106.33a	113.93a
LSD	1.554	2.306	3.54	2.47	2.31
CV (%)	1.79	4.52	3.45	4.75	5.12

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly and NS: Non Significant as per 0.01 (1%) level of probability.

[P_0: Without Polythene shed and P_1: With Polythene shed
F_0: Control; F_1: 4-CPA; F_2: Zn, B, Mn, Se; F_3: Kaolin and F_4: 4-CPA, Zn, B, Mn, Se, Kaolin]

4.2 Foliar coverage

Significant variation was observed between P_0 and P_1 treatments in terms of foliar coverage (Appendix III). Foliar coverage of summer tomato statistically significantly varied in between P_0 and P_1 at final harvest (Table 2). The topmost result in terms of foliar coverage (73.96 cm) was recorded from P_1 where as P_0 was scored as the lowest (54.61 cm) at final harvest.

At final harvest, statistically significant variation was observed among the foliar treatments in terms of foliar coverage (Appendix III). Foliar coverage of tomato exposed statistically significant variation among the treatments water (F_0), 4-CPA (F_1), Zn, B, Mn, & Se (F_2), Kaolin (F_3) and 4-CPA, Zn, B, Mn, Se and Kaolin (F_4) at final harvest (Table 3). The maximum foliar coverage (71.57 cm) was marked from 4-CPA, Zn, B, Mn, Se and Kaolin (F_4) treated plants whereas the minimum (56.93 cm) was scored from water (F_2) treated plants at final harvest (Table 3).

Interaction effect of polythene shed and different treatments in terms of foliar coverage also noted significant variation (Appendix III). The maximum foliar coverage (81.67 cm) at final harvest was recorded from P_1F_4 treatment combination whereas the minimum was (40.80 cm) recorded from P_0F_2 (Table 4).

4.3 Length of internodes

Significant variation was recorded for the length of internodes due to the effect of polythene shed (Appendix III). Results indicated the longest internodes (5.54 cm) from P_1 whereas the shortest internodes (4.49 cm) were found from P_0 (Table 2).

Length of internodes showed significant variation with the effect of different treatments (Appendix III). Length of internodes was the highest (5.44 cm) from F_4 which was statistically similar (5.27 cm) with F_1 treatment whereas the lowest (4.48 cm) was observed from F_0 (Table 3).

In case of interaction effect of polythene shed and different foliar application of the treatments, the length of the internodes of tomato plant exposed significant variation (Appendix III). It was remarked the longest internodes (6.30 cm) from P_1F_4 treatment and the shortest internodes (4.12 cm) from P_0F_3 treatment (Table 3).

4.4 Number of effective branches per plant

Number of effective branches per plant was exposed significant inequality with the polythene shed treatment (Appendix III). Maximum number of effective branches per plant (10.33) was observed from P_1 whereas the minimum number of effective branches per plant (8.73) was found from P_0 at final harvest which has notified in Table 2.

Different foliar treatments significantly influenced the effective branches per plant (Appendix III). F_4 treated plants produced the maximum number of effective branches per plant (11.07) while the minimum number of effective branches per plant (7.18) was obtained from F_0 treatment at final harvest (Table 3).

Interaction effect of polythene shed and different foliar application of the treatments showed statistically significant differences in terms of number of effective branches per plant at final harvest (Appendix III). Maximum number of effective branches per plant (11.33) was recorded from P_1F_4 which was statistically similar with P_1F_2 (11.30) while the minimum number of effective branches per plant (6.96) was recorded from P_0F_0 treatment combination (Table 4).

Table 2: Effect of polythene shed on growth parameters

Treatments	Foliar coverage (cm)	Length of Internodes (cm)	Number of effective branches per plant
P_0	54.61	4.49	8.73
P_1	73.96	5.54	10.33
LSD	1.139	0.175	0.491
CV (%)	5.23	4.74	5.13

P_0: Without Polythene shed and P_1: With Polythene shed

Table 3: Effect of foliar application of yield contributing elements on growth parameters

Treatments	Foliar coverage (cm)	Length of Internodes (cm)	Number of effective branches per plant
F_0	65.17b	4.48c	7.18c
F_1	65.27b	5.27a	9.84b
F_2	56.93d	4.93b	9.88b
F_3	62.50c	4.94b	9.68b
F_4	71.57a	5.44a	11.07a
LSD	1.801	0.277	0.777
CV (%)	5.23	4.74	5.13

[F_0: Control; F_1: 4-CPA; F_2: Zn, B, Mn, Se; F_3: Kaolin and F_4: 4-CPA, Zn, B, Mn, Se, Kaolin]

Table 4: Interaction effect of polythene shed and foliar application of yield contributing elements on growth parameters

Treatments	Foliar coverage (cm)	Length of Internodes (cm)	Number of effective branches per plant
P_0F_0	60.67e	4.30ef	6.96d
P_0F_1	56.33f	4.90d	8.87bc
P_0F_2	40.80g	4.53de	8.47bc
P_0F_3	53.80f	4.12f	8.57bc
P_0F_4	61.47e	4.59de	10.80b
P_1F_0	69.67d	4.67de	7.40c
P_1F_1	74.20b	5.63bc	10.82b
P_1F_2	73.07bc	5.33c	11.30a
P_1F_3	71.20cd	5.77b	10.80b
P_1F_4	81.67a	6.30a	11.33a
LSD	2.547	0.392	1.099
CV (%)	5.23	4.74	5.13

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly as per 0.01 (1%) level of probability

[P_0: Without Polythene shed and P_1: With Polythene shed
F_0: Control; F_1: 4-CPA; F_2: Zn, B, Mn, Se; F_3: Kaolin and F_4: 4-CPA, Zn, B, Mn, Se, Kaolin]

4.5 Number of leaves per plant

Number of leaves per plant of summer tomato showed significantly significant differences by the effect of polythene shed treatments at final harvest (Appendix III). The maximum number of leaves per plant (95.15) was recorded from P_1 where as the minimum number (94.73) was recorded from P_0 at final harvest (Table 5).

Number of leaves per plant of summer tomato differed significantly due to the effect of different foliar treatments at final harvest (Appendix III). F_4 treated plants produced the maximum number of leaves per plant (104.20) while the minimum number of leaves per plant (84.83) was obtained from F_0 treated plants (Table 6).

Polythene shed and different foliar application of the treatment showed significantly variation due to the interaction effect on number of leaves per plant of summer tomato at final harvest (Appendix III). The maximum number of leaves per plant (104.67) was recorded from P_0F_4 while the minimum number of leaves per plant (86.33) was recorded from P_0F_0 treated plants (Table 7). The study referred that without polythene shed condition plant produce the number of leaf of tomato where the leaf was little bit pale green in colour and thicken.

4.6 Length of leaves

Significant variation was recorded for the length of leaves due to effect of polythene shed (Appendix III). Results indicated that longest leaves (24.55 cm) were recorded from P_1 while the shortest leaves (15.53 cm) were recorded from P_0 (Table 5).

The length of leaves showed significant variation with different foliar application of the growth promoting elements as treatment (Appendix III). The length of leaves was highest (22.63 cm) in F_4 treated plants which was statistically similar with F_2 (22.30 cm) treated plants whereas lowest (16.25 cm) was observed in F_0 treated plants (Table 6).

Significant variation was observed due to the interaction effect of polythene shed and treatments in terms of length of leaves of summer tomato (Appendix III). It was remarked that longest leaves (27.47 cm) was found in P_1F_2 treated plants which was statistically similar with P_1F_4 (26.67 cm) whereas the lowest leaves length (13.67 cm) was found in P_0F_1 treated plants which was statistically similar to P_0F_0 (14.0 cm) and P_0F_3 (14.23) treated plants (Table 7).

4.7 Number of buds per plant

Significant variation was recorded due to the effect of polythene shed on number of buds per plant (Appendix IV). The higher number of buds per plant (109.52) was recorded from P_1 while the lower number of buds per plant (100.53) was obtained from P_0 which has notified in Table 5.

Different foliar application of the growth promoting elements as treatments significantly effect on the number of buds per plant (Appendix IV). The highest number of flower buds per plant (118.47) was recorded from F_4 treated plants where as the lowest number of flower buds per plant (92.80) was attained from F_0 i.e. control condition where F_3 (97.0) is statistically similar with F_0 (92.80) (Table 6). Treatment F_4 is the combination of treatment for foliar application of 4-CPA, Zn, B, Mn, Se and Kaolin. Hence, plant growth regulators with the combination application of micro nutrients play an essential role in flower buds development.

The number of buds per plant showed significant variation due to the interaction effect of polythene shed and treatment of foliar application (Appendix IV). The highest number of flower buds per plant (125.27) was recorded from P_1F_4 which is statistically similar with P_1F_1 (120.93) while the lowest number buds per plant (84.60) were recorded from P_0F_0 treatments (Table 7).

Table 5: Effect of polythene shed on growth and yield contributing parameters

Treatments	Number of leaves per plant	Length of leaves (cm)	Number of buds per plant
P_0	94.73	15.53	100.53
P_1	95.15	24.55	109.52
LSD	0.97	0.942	2.694
CV (%)	4.28	4.09	6.22

P_0: Without Polythene shed and P_1: With Polythene shed.

Table 6: Effect of foliar application of yield contributing elements on growth and yield contributing parameters

Treatments	Number of leaves per plant	Length of leaves (cm)	Number of buds per plant
F_0	84.83d	16.25c	92.80d
F_1	92.83bc	18.90b	111.47b
F_2	101.50b	22.30a	105.40c
F_3	91.33c	20.12b	97.00d
F_4	104.20a	22.63a	118.47a
LSD	1.85	1.490	4.260
CV (%)	4.28	4.09	6.22

[F_0: Control; F_1: 4-CPA; F_2: Zn, B, Mn, Se; F_3: Kaolin and F_4: 4-CPA, Zn, B, Mn, Se, Kaolin]

Table 7: Interaction effect of polythene shed and foliar application of yield contributing elements on growth and yield contributing parameters

	Number of leaves per plant	Length of leaves (cm)	Number of bu
F_0	86.33d	14.00d	84.(
F_1	92.67bc	13.67d	102.0
F_2	100.00b	17.13c	106.4
F_3	90.00c	14.23d	98.0
F_4	104.67a	18.60c	111.
F_0	83.33d	18.50c	101.0
F_1	93.00bc	24.13b	120.
F_2	103.00ab	27.47a	104.4
F_3	92.67bc	26.00ab	96.0
F_4	103.73ab	26.67a	125.
SD	3.25	2.107	6.0
(%)	4.28	4.09	6.2

neans having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly as per 0.01 (1%

[P_0: Without Polythene shed and P_1: With Polythene shed

F_0: Control; F_1: 4-CPA; F_2: Zn, B, Mn, Se; F_3: Kaolin and F_4: 4-CPA, Zn, B, Mn, Se, Kaolin]

4.8 Days to 50% flowering

The effect of the polythene shed showed statistically significant variation for days from transplanting to 50% flowering (Appendix IV). The minimum days from transplanting to 50% flowering (43.0) was found from $P_{1,}$ while the maximum days to 50% flowering (43.90) was recorded from P_0 which has been notified in Table 8.

Days from transplanting to 50% flowering of summer tomato varied significantly for different treatment of foliar application of growth promoting elements (Appendix IV). The minimum days from transplanting to 50% flowering (40.0) was found from F4 treated plants while the maximum days (47.50) was recorded from F_0 i.e. control condition (Table 9).

Significant variation was observed due to the interaction effect of polythene shed and treatment of foliar application in terms of days from transplanting to 50% flowering (Appendix IV). The minimum days from transplanting to 50% flowering (40.0) was recorded from P_1F_4 combined treatments while the maximum days (48.0) was found from P_0F_0 which was statistically similar with P_1F_0 (47.0) (Table 10).

4.9 Number of fruits cluster per plant

The number of fruits cluster per plant varied significantly with the effect of polythene shed (Appendix IV). The maximum number of fruits cluster per plant (7.47) was observed from P_1 whereas the minimum number of fruits cluster per plant (6.80) was recorded from P_0 which has notified in Table 8.

Different treatments of foliar application significantly influenced the number of fruits cluster per plant (Appendix IV). F_4 treated plants showed the maximum number of fruits cluster per plant (7.53), while the minimum number of fruits cluster per plant (6.33) was obtained from F_0 treated plant (Table 9).

The interaction effect of polythene shed and foliar application of different treatments showed statistically significant variation in terms of number of fruits cluster per plant (Appendix IV). The maximum number of fruits cluster per plant (8.07) was recorded from P_1F_4, while the minimum number per plant (6.0) was recorded from P_0F_0 treated plants (Table 10).

4.10 Number of fruits set per plant

Number of fruits set per plant was showed significant variation with the effect of polythene shed (Appendix IV). The higher number of fruits set per plant (27.47) was obtained from $P_{1,}$ while the lower number of fruits set per plant (21.23) was obtained from P_0 (Table 8). It might be due to the heat tolerant capability of summer tomato "BRAI hybrid–4" for their genetic makeup because transparent polythene shed promotes heats in some extent during day time.

Different treatments of foliar application significantly influenced the fruits set per plant (Appendix IV). The maximum number of fruits set per plant (33.17) was recorded from F_4 treated plants, while the minimum number of fruits set per plant (16.57) was obtained from F_0 i.e. controlled condition (Table 9). Results of the study showed that under high temperature, the combination of 4-CPA, B, Mn, Zn, Se and Kaolin induced higher number of fruit set to some extent. High temperature decreases the levels of auxin and gibberellin's like substances, especially in floral buds and developing fruits of tomato. Therefore, shortage of auxin and gibberellins could cause the reduction of fruit set under high temperature. It was assumed that the combined treatment of 4-CPA, Zn, B, Mn, Se and Kaolin reduced the affect of high temperature (Sasaki *et al.*, 2005) where Kaolin acts as an antitranspirant. Sivaiah *et al*. (2013) also reported that combine application of micronutrients produced the maximum fruit set and fruit yield. Thus, application of Kaolin under high temperature would have a positive role in fruit set of tomatoes and might be combined effects with 4-CPA and micro nutrients. Synthesized auxins are often used for promotion of fruit set in some fruit vegetable production including tomatoes.

Interaction effect of polythene shed and foliar application of the treatments showed statistically significant variation in terms of number of fruits set per plant (Appendix IV). The maximum number of fruits set per plant (40.07) was recorded from P_1F_4, while the minimum number of fruits set per plant (13.53) was recorded from P_0F_0 treated plants (Table 10).

4.11 Fruit sets%

The effect of the polythene shed showed significant variation on fruit sets % of summer tomato (Appendix IV). The maximum fruit sets % (24.81) was recorded from P_1, whereas the minimum fruit sets % (20.88) was recorded from P_0 at final harvest (Table 8). The study referred that polythene shed condition produced maximum percentage of fruit set.

Different treatments of the foliar application significantly influenced on the fruit sets % (Appendix IV). F_4 treated plants produced the maximum percentage of fruits set (27.76), while the minimum percentage of fruits set (17.69) was obtained from F_0 treated plants (Table 9).

The interaction effect of polythene shed and foliar application of the treatments showed statistically significant variation in terms of fruit set % (Appendix IV). The maximum percentage of fruits set (31.99) was recorded from P_1F_4, while the minimum (15.99) was recorded from P_0F_0 i.e. controlled condition (Table 10).

Table 8: Effect of polythene shed on yield contributing parameters

Treatments	Days to 50% flowering	Number of fruits cluster per plant	Number of fruits set per plant	Fruits sets (%)
P_0	43.90	6.80	21.23	20.88
P_1	43.00	7.47	27.47	24.81
LSD	0.799	0.362	2.190	0.935
CV (%)	5.27	0.98	4.85	2.11

P_0: Without Polythene shed and P_1: With Polythene shed.

Table 9: Effect of foliar application of yield contributing elements on yield contributing parameters

Treatments	Days to 50% flowering	Number of fruits cluster per plant	Number of fruits set per plant	Fruits sets (%)
F_0	47.50a	6.33b	16.57d	17.69d
F_1	42.00c	7.42ab	25.17b	22.53c
F_2	42.00c	7.20ab	25.30b	24.03b
F_3	44.50b	7.19ab	21.53c	22.22c
F_4	40.00d	7.53a	33.17a	27.76a
LSD	1.263	0.573	3.462	1.479
CV (%)	5.27	0.98	4.85	2.11

[F_0: Control; F_1: 4-CPA; F_2: Zn, B, Mn, Se; F_3: Kaolin and F_4: 4-CPA, Zn, B, Mn, Se, Kaolin]

Table 10: Interaction effect of polythene shed and foliar application of yield contributing elements on yield contributing parameters

Treatments	Days to 50% flowering	Number of fruits cluster per plant	Number of fruits set per plant	Fruits sets (%)
P_0F_0	48.00a	6.00d	13.53e	15.99cc
P_0F_1	42.00c	7.08bc	22.33cd	21.89bc
P_0F_2	42.00c	7.00bc	23.93bcd	22.51ab
P_0F_3	45.00b	6.92bcd	20.07d	20.47bc
P_0F_4	40.00d	7.00bc	26.27bc	23.53ab
P_1F_0	47.00a	6.67c	19.60d	19.38c
P_1F_1	42.00c	7.76ab	28.00b	23.16ab
P_1F_2	42.00c	7.40b	26.67bc	25.55b
P_1F_3	44.00b	7.46b	23.00bcd	23.97ab
P_1F_4	40.00d	8.07a	40.07a	31.99a
LSD	1.786	0.810	4.896	2.092
CV (%)	5.27	0.98	4.85	2.11

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly as per 0.01 (1%) level of probability

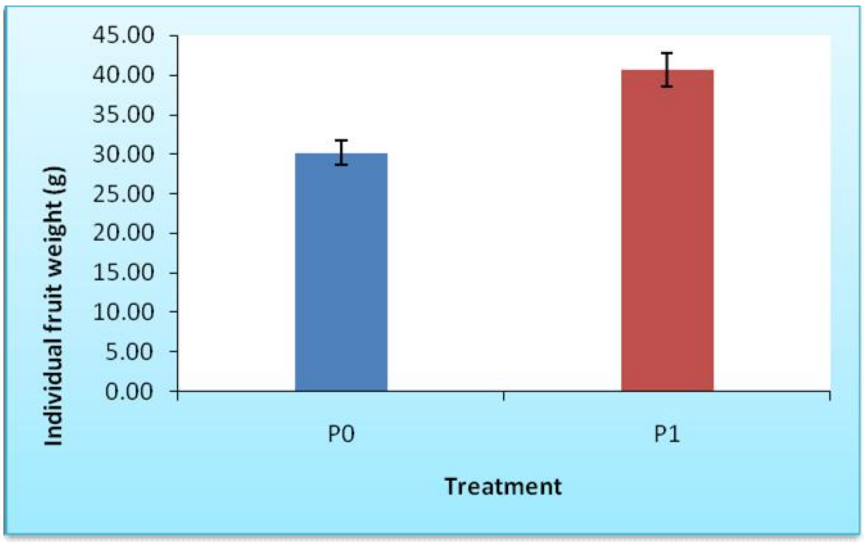
[P_0: Without Polythene shed and P_1: With Polythene shed
F_0: Control; F_1: 4-CPA; F_2: Zn, B, Mn, Se; F_3: Kaolin and F_4: 4-CPA, Zn, B, Mn, Se, Kaolin]

4.12 Individual fruit weight

Individual fruit weight of summer tomato was influenced significantly with the effect of polythene shed (Appendix V). P_0 condition was given maximum individual fruit weight (39.97 g) and minimum individual fruit weight (39.48 g) was obtained from P_1 (Table 11).

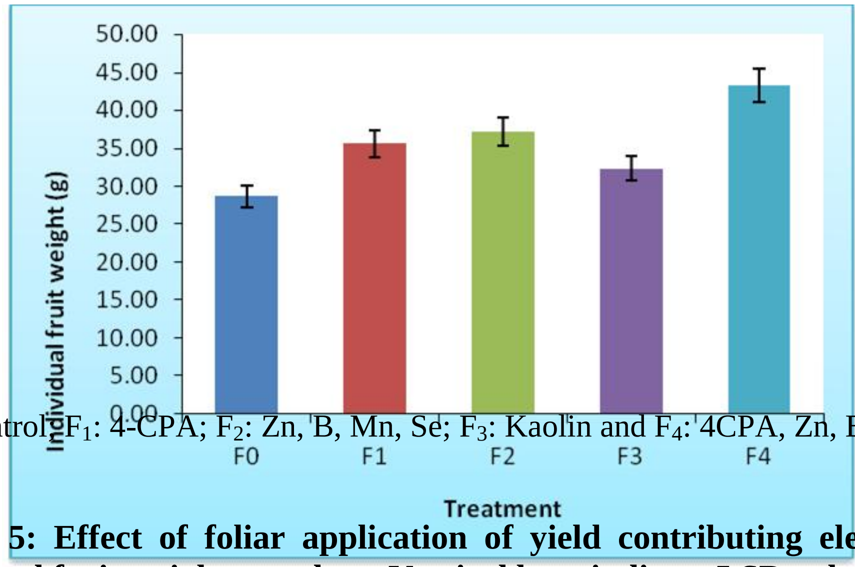
Individual fruit weight varied significantly with the application of different foliar treatments (Appendix V). Maximum individual fruit weight of tomato (49.33 g) was recorded from F_4 treatment while lowest individual fruit weight (22.07 g) was obtained from F_0 i.e. controlled condition (Table 12).

Interaction effect of polythene shed and different treatments of foliar application showed statistically significant variation in terms of individual fruits weight (Appendix V). The maximum individual fruits weight (49.47 g) was recorded from P_1F_4 which was statistically similar with P_0F_4 (49.20 g), whereas the minimum Individual fruits weight (21.94 g) was recorded from P_0F_0 which was statistically similar with P_1F_0 (22.20) (Table 13).



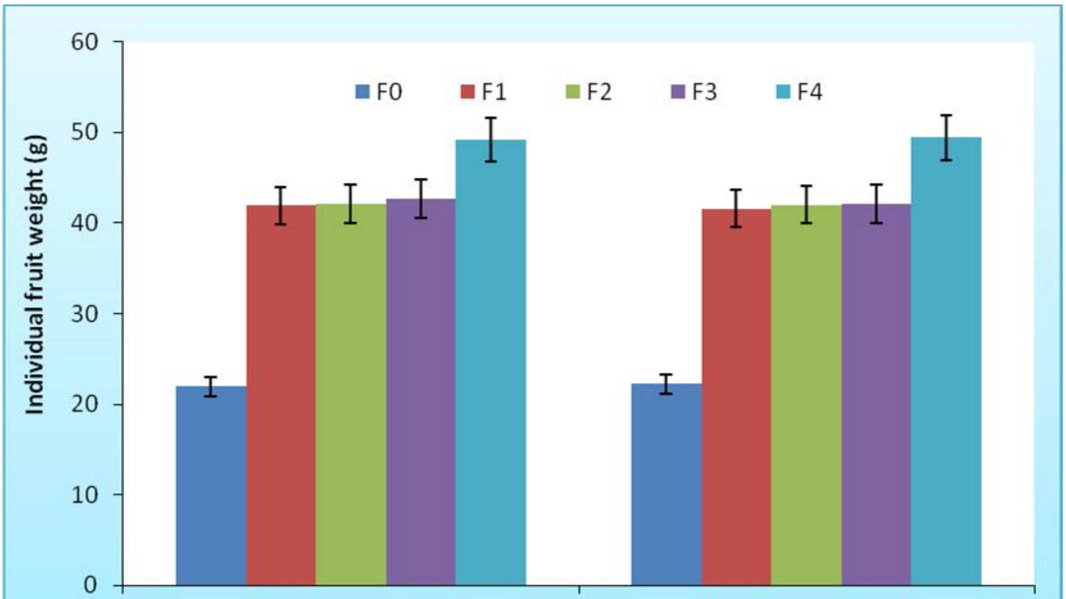
[P_0: Without Polythene shed and P_1: With Polythene shed]

Figure 4: Effect of polythene shed on individual fruit weight per plant. Vertical bars indicate LSD value.



[F_0: Control; F_1: 4-CPA; F_2: Zn, B, Mn, Se; F_3: Kaolin and F_4: 4CPA, Zn, B, Mn, Se, Kaolin]

Figure 5: Effect of foliar application of yield contributing elements on individual fruit weight per plant. Vertical bars indicate LSD value.



[P_0: Without Polythene shed and P_1: With Polythene shed
F_0: Control; F_1: 4-CPA; F_2: Zn, B, Mn, Se; F_3: Kaolin and F_4: 4-CPA, Zn, B, Mn, Se, Kaolin]

Figure 6: Interaction effect of polythene shed and foliar application of yield contributing elements on individual fruit weight per plant. Vertical bars indicate LSD value.

4.13 Number of fruits set per cluster

Average number of fruits set per cluster was showed significant variation with the effect of polythene shed (Appendix V). The maximum average number of fruits set per cluster (3.64) was observed from P_1, whereas the minimum (3.11) was recorded from P_0 (Table 11).

Different foliar application of treatments significantly influenced on average fruits set per cluster (Appendix V). The maximum average number of fruits set per cluster (4.36) was recorded from F_4 treated plants, while the minimum average number of fruits set per cluster (2.63) was obtained from F_0 (Table 12).

Interaction effect of polythene shed and different foliar treatments showed statistically significant variation in terms of average number of fruits set per cluster (Appendix V). The maximum average number of fruits set per cluster (4.97) was recorded from P_1F_4 and the minimum number fruits set per cluster (2.29) were recorded from P_0F_0 treatment combination (Table 13).

During experimentations, it was observed that the lower fruit clusters of the plant produced maximum number fruit set where as upper part of the plant produced low number of fruit set.

4.14 Total fruit weight per plant

It was observed from the results of the present experiment that polythene shed significantly varied the total fruit weight per plant (Appendix V). Total fruit weight of summer tomato per plant was observed the maximum (1145.07 g) from P_1, while the minimum fruit weight per plant (668.65 g) obtained from P_0 (Figure 4).

Total fruit weight varied significantly with the application of different foliar treatments (Appendix V). The total fruit weight of summer tomato per plant was observed the maximum (1472.45 g) from F_4 treated plant, while the minimum (495.88 g) obtained from F_0 treated plants (Figure 5). Baliyan *et al.* (2013) was concluded that the use of 4-CPA increased the fruit set, yield and economic benefit of summer tomato production.

Interaction effect of polythene shed and different treatments of foliar application greatly influenced the total fruit weight per plant (Appendix V). The total fruit weight of summer tomato per plant was observed the maximum (1973.37 g) from P_1F_4 treated plants, while the minimum fruit weight of tomato per plant (311.62 g) was found under P_0F_0 treatment (Figure 6).

Therefore, polythene shed (P_1) and foliar application of 4-CPA, Zn, B, Mn, Se and Kaolin (F_4) was the best combination for the production of summer tomato in term of quantity and quality. Hence, polythene shed P_1 in combination with F_4 represented as a most excellent treatment in terms of yield for the summer tomato production in Bangladesh

Table 11: Effect of polythene shed on fruits yield contributing parameters

Treatments	Number of fruits set per cluster	Total fruit weight per plant
P_0	3.11	668.65
P_1	3.64	1145.07
LSD	0.196	75.882
CV (%)	4.25	3.25

P_0: Without Polythene shed and P_1: With Polythene shed.

Table 12: Effect of foliar application of yield contributing elements on fruits yield contributing parameters

Treatments	Number of fruits set per cluster	Total fruit weight per plant
F_0	2.63c	495.88d
F_1	3.38ab	910.07b
F_2	3.53ab	950.22b
F_3	2.99b	705.69c
F_4	4.36a	1472.45a
LSD	0.309	119.981
CV (%)	4.25	3.25

[F_0: Control; F_1: 4-CPA; F_2: Zn, B, Mn, Se; F_3: Kaolin and F_4: 4-CPA, Zn, B, Mn, Se, Kaolin]

Table 13: Interaction effect of polythene shed and foliar application of yield contributing elements on fruits yield contributing parameters

Treatments combination	Number of fruits set per cluster	Total fruit weight per plant
P_0F_0	2.29cd	311.62f
P_0F_1	3.15ab	712.31de
P_0F_2	3.45ab	800.27cd
P_0F_3	2.90ab	547.53e
P_0F_4	3.75ab	971.53bc
P_1F_0	2.96c	680.15de
P_1F_1	3.61b	1107.83b
P_1F_2	3.60b	1100.17b

P_1F_3	3.08b	863.85cd
P_1F_4	4.97a	1973.37a
LSD	0.438	169.678
CV (%)	4.25	3.25

[P_0: Without Polythene shed and P_1: With Polythene shed
F_0: Control; F_1: 4-CPA; F_2: Zn, B, Mn, Se; F_3: Kaolin and F_4: 4-CPA, Zn, B, Mn, Se, Kaolin]

4.15 Chlorophyll content

Chlorophyll content of summer tomato was influenced significantly by polythene shed condition (Appendix V). P_1 scored the maximum chlorophyll content percentage (51.54%), whereas the minimum chlorophyll content (50.66%) was obtained from P_0 (Table 14).

Chlorophyll content of summer tomato varied significantly with the foliar application of different treatments (Appendix V). The maximum chlorophyll content percentage (53.32%) recorded from F_4 treated plants, while the minimum chlorophyll content (47.24 %) was found from F_0 treated plants (Table 15).

Interaction effect of polythene shed and differrent foliar application of treatments varied significantly on chlorophyll content of summer tomato (Appendix V). The maximum chlorophyll content percentage (53.43%) obtained from P_1F_4, while the minimum (47.07%) recorded from P_0F_0 which is statistically similar with P_1F_0 (47.41%) (Table 16).

4.16 Leaf temperature

Leaf temperature of summer tomato was influenced significantly by the use of polythene shed (Appendix V). The maximum leaf temperature (34.93^{0}C) was recorded from $P_{1,}$ whereas the minimum leaf temperature (34.75^{0}C) was obtained from P_0 condition (Table 14). It was observed that transparent polythene sheet enhance the internal temperature by trapping sunlight which may lead to increase the plant leaf temperature.

Leaf temperature of summer tomato varied significantly with the application of different foliar treatments (Appendix V). The maximum leaf temperature (35.76 ^{0}C) recorded from F_2 which was statistically similar with F_0 (35.60^{0}C) and F_1 (35.67^{0}C), while F_4 treated plant was exhibited the minimum leaf temperature (33.53^{0}C) which is statistically similar with F_3 (33.67^{0}C) (Table 15). Yuly *et al.* (2011) reported that Kaolin reduced leaf temperature by 2.5^{0}C approximately at mid day compared to plants non-sprayed with kaolin in rose cut flower which was similar to Mofta and Al-humaid (2002) agreement. Cantore *et al.* (2008) also found that Kaolin application decreased fruit inner temperature up to 4.4 ^{0}C.

Interaction effect of polythene shed and differrent treatments varied significantly on the leaf temperature of summer tomato (Appendix V). The maximum leaf temperature (35.97^{0}C) was found from P_1F_2 which was statistically similar with P_0F_0 (35.64^{0}C), P_0F_1 (35.83^{0}C), P_0F_2 (35.56^{0}C), P_1F_0 (35.55^{0}C), P_1F_1 (35.51^{0}C); whereas the minimum temperature (33.35^{0}C) recorded from P_0F_4 which was statistically similar to P_0F_3 (33.4^{0}C) P_1F_3 (33.93^{0}C) and P_1F_4 (33.71^{0}C) (Table 16). These results revealed that foliar applications of kaolin could be considered a useful tool for summer tomato production to reduce leaf temperature under polythene shed conditions.

4.17 Tomato P^H

For the effect of polythene shed, it was observed from the results of the present experiment that the polythene shed condition insignificantly varied P^H of the extract of summer tomato (Table 14) and (Appendix VI

Different foliar applications of the treatment insignificantly affect the P^H of summer tomato (Table 15) and (Appendix VI).

Interaction effect of polythene shed and differrent foliar treatments insignificantly varied the P^H of summer tomato (Table 16) and (Appendix VI).

4.18 Total soluble solids (TSS)

This research work exhibited distinct variations in total soluble solids (TSS) of summer tomato by the effect of polythene shed (Appendix VI). The maximum TSS in summer tomato (4.39 %) was found from P_1, while the minimum was (3.59 %) obtained from P_0 (Table 14).

Total soluble solids (TSS) in summer tomato varied significantly with the application of different foliar treatments (Appendix VI). The maximum TSS (4.57 %) was found from F_4 treated plants, which was statistically similar with F_1 (4.38) treated plants, whereas the minimum TSS (3.43 %) was found from controlled condition and it was statistically similar with F_3 (Table 15).

Interaction effect of polythene shed and differrent treatments of foliar application varied significantly on TSS of summer tomato (Appendix VI). It was observed that maximum TSS (5.0 %) was obtained from P_1F_4 treated plants, which was statistically similar with P_1F_1 (4.93 %) and P_1F_2 (4.83 %), whereas the minimum (3.30 %) was recorded from P_0F_2 which was statistically identical with P_0F_0 and P_0F_3 (Table 16).

Table 14: Effect of polythene shed on growth and quality parameters

Treatments	Chlorophyll content	Leaf temperature (^0C)	pH	TSS
P_0	50.66	34.75	3.70	3.59
P_1	51.54	34.93	3.72	4.39
LSD	0.759	0.672	0.310	0.136
CV (%)	4.27	3.56	5.25	6.32

P_0: Without Polythene shed and P_1: With Polythene shed.

Table 15: Effect of foliar application of yield contributing elements on growth and quality parameters

Treatments	Chlorophyll content	Leaf temperature (^0C)	pH	TSS
F_0	47.24c	35.60a	3.65	3.43c
F_1	49.55b	35.67a	3.65	4.38a
F_2	52.78ab	35.76a	3.87	4.07b
F_3	52.60ab	33.67b	3.72	3.48c
F_4	53.32a	33.53b	3.65	4.57a
LSD	1.200	1.063	0.491	0.215
CV (%)	4.27	3.56	5.25	6.32

[F_0: Control; F_1: 4-CPA; F_2: Zn, B, Mn, Se; F_3: Kaolin and F_4: 4-CPA, Zn, B, Mn, Se, Kaolin]

Table 16: Interaction effect of polythene shed and foliar application of yield contributing elements on growth and quality parameters

Treatments	Chlorophyll content	Leaf temperature (^0C)	pH	TSS
P_0F_0	47.07d	35.64a	3.54	3.33d
P_0F_1	47.67c	35.83a	3.76	3.83bc
P_0F_2	52.80b	35.56a	3.88	3.30d
P_0F_3	52.54b	33.40b	3.70	3.33d
P_0F_4	53.21a	33.35b	3.62	4.13b
P_1F_0	47.41d	35.55a	3.77	3.53cd
P_1F_1	51.43b	35.51a	3.53	4.93a
P_1F_2	52.77b	35.97a	3.87	4.83a
P_1F_3	52.67b	33.93b	3.73	3.63cd
P_1F_4	53.43a	33.71b	3.68b	5.00a
LSD	1.696	1.503	0.694	0.305
CV (%)	4.27	3.56	5.25	6.32

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly as per 0.01 (1%) level of probability

[P_0: Without Polythene shed and P_1: With Polythene shed

F_0: Control; F_1: 4-CPA; F_2: Zn, B, Mn, Se; F_3: Kaolin and F_4: 4-CPA, Zn, B, Mn, Se, Kaolin]

4.19 Inner fruits temperature

Inner fruits temperature of tomato was influenced significantly by the effect of polythene shed (Appendix VI). The highest fruits inner temperature was recorded (35.84^0C) from P_1 condition, whereas the lowest fruit inner temperature (35.21) was obtained from P_0 condition (Table 17).

Inner fruits temperature of tomato varied significantly with the foliar application of different treatments of growth promoting elements (Appendix VI). The maximum inner temperature of fruits (36.22^0C) recorded from F_0 treated plant while the minimum fruit inner temperature (34.80^0C) was found from F_3 treated plants which was statistically similar with F_4 (34.94^0C) (Table 18). The result of the present study is agreed with the result of Cantore *et.al.* (2008). They have concluded that inner fruit temperature of kaolin treated plant was 4.4°C lower than the control. The same result also revealed by Mofta and Al-humaid (2002).

Combination of polythene-shade and differrent treatments varied significantly on fruits inner temperature of tomato (Appendix VI). The maximum inner temperature of fruits (36.84^0C) was found from $P_1F_{0,}$ whereas the minimum (34.57^0C) recorded from P_0F_3 which was statistically similar to P_0F_4 (34.80^0C) treatment combination (Table 19).

4.20 Fruit firmness

Firmness of summer tomato was influenced significantly by the effect of polythene shed (Appendix VI). The maximum firmness of tomato (9.21 Neuton) was recorded from P_1, while the minimum (8.84 Neuton) obtained from P_0 i.e. controlled condition (Table 17).

Firmness of summer tomato varied significantly with the foliar application of different treatments of growth and yield promoting elements (Appendix VI). The maximum firmness (9.51 Neuton) of summer tomato recorded from F_4 treated plants which was statistically similar with (9.39 Neuton) F_3 treated plants, while the minimum firmness (8.10Neuton) obtained from F_0 (Table 18).

Interaction effect of the polythene shed and differrent treatments of foliar application varied significantly on the firmness of summer tomato (Appendix VI). The maximum firmness of summer tomato (9.89 Neuton) was found from P_1F_4 which was statistically similar with P_1F_3 (9.78) whereas the minimum firmness (8.01Neuton) recorded from P_0F_0 (Table 19). Therefore, polythene shed and foliar application of growth promoting elements was made tomato fruits harder which might be increase storage period of tomato.

4.21 Content of Vitamin-C

This research work exhibited distinct variations in terms of content of Vitamin-C of summer tomato which has greatly affected by the use of polythene shed (Appendix VI). The maximum Vitamin-C content (21.49 mg per 100 g of tomato) was found from P_1, while the minimum content of Vitamin-C (18.94) was obtained from P_0 (Table 17).

Vitamin-C content in summer tomato varied significantly with the foliar application of the treatments (Appendix VI). The maximum Vitamin-C content (21.47) was obtained from F_4 treated tomato plants, whereas the minimum content of Vitamin-C (17.25) was recorded from controlled condition of water treated plants (Table 18).

Interaction effect of the polythene shed and treatments of foliar application varied significantly for the content of Vitamin-C of summer tomato (Appendix VI). The maximum amount of Vitamin-C content (22.38) was obtained from P_1F_2 which was statistically similar to P_1F_1 (22.12), P_1F_3 (22.37) and P_1F_4 (22.20) while the minimum amount of Vitamin-C content (16.13) was recorded from P_0F_0 (Table 19). Therefore, polythene shed and foliar application of yield contributing elements produced better quality of tomato in terms of Vitamin-C which could be improve health status of the consumers.

4.22 Content of β-Carotene

In this study, content of β-carotene of tomato fruit also exhibited distinct variations under polythene shed treatment (Appendix VI). The maximum content of β-carotene (3895.25 μ gram per 100 g of tomato) recorded from P_1, while the minimum content of β-carotene (3190.55 μ gram per 100 g of tomato) was obtained from P_0 (Table 17).

Significant variation was observed in terms of content of β-carotene in summer tomato which has varied with the foliar application of the treatments (Appendix VI). The maximum content of β-carotene (3663.38 μ gram per 100 g of tomato) obtained from F_3 treated tomato plants which was statistically similar with $F_{1,}$ F_2 and F_4 whereas the minimum content was recorded from F_0 (3134.41 μ gram) i.e. controlled condition (Table 18).

Polythene shed and different treatments of foliar application of yield contributing substances showed significant variation due to the interaction effect on content of β-carotene of summer tomato (Appendix VI). The highest content of β-carotene (4051.85 μ gram per 100 g of tomato) was obtained from P_1F_3 which was statistically similar to $P_1F_{1,}$ P_1F_2 and P_1F_4 while the lowest (2915.08 μ gram per 100 g of tomato) was recorded from P_0F_0 (Table 19). Under polythene shed condition, tomato was developed redder colour at full ripening stage. Content of β-carotene was increased in the tomato fruits under polythene shed condition which might be due to the foliar application of micronutrients and rain protected condition.

Table 17: Effect of polythene shed on yield and quality parameters

Polythene shed	Inner fruit temperature (^0C)	Fruit firmness (Neuton)	Vitamin-C (mg per 100 g)	β-carotene (μ gram per 100 g)
P_0	35.21	8.84	18.94	3190.55
P_1	35.84	9.21	21.49	3895.25
LSD	0.259	0.191	0.430	79.511
CV (%)	1.98	2.47	10.24	9.45

P_0: Without Polythene shed and P_1: With Polythene shed

Table 18: Effect of foliar application of yield contributing elements on yield and quality parameters

Treatments	Inner fruit temperature (^0C)	Fruit firmness (Neuton)	Vitamin-C (mg per 100 g)	β-carotene (μ gram per 100 g)
F_0	36.22a	8.10b	17.25c	3134.41b
F_1	35.82ab	9.07ab	20.68b	3620.82a
F_2	35.85ab	9.06ab	20.77b	3649.35a
F_3	34.80b	9.39a	20.89b	3663.38a
F_4	34.94b	9.51a	21.47a	3646.55a
LSD	0.410	0.302	0.679	125.717
CV (%)	1.98	2.47	10.24	9.45

[F_0: Control; F_1: 4-CPA; F_2: Zn, B, Mn, Se; F_3: Kaolin and F_4: 4-CPA, Zn, B, Mn, Se, Kaolin]

Table 19: Interaction effect of polythene shed and foliar application of yield contributing elements on yield and quality parameters

Treatments	Inner fruit temperature (^0C)	Fruit firmness (Neuton)	Vitamin-C (mg per 100 g)	β-carotene (μ gram per 100 g)
P_0F_0	35.60b	8.01c	16.13d	2915.08c
P_0F_1	35.52b	9.09ab	19.24bc	3235.25bc
P_0F_2	35.57b	9.00ab	19.17bc	3270.13bc
P_0F_3	34.57c	9.00ab	19.40bc	3274.91bc
P_0F_4	34.80c	9.12ab	20.75b	3257.40bc
P_1F_0	36.84a	8.20b	18.37c	3353.74b
P_1F_1	36.11ab	9.06ab	22.12a	4006.40a
P_1F_2	36.13ab	9.11ab	22.38a	4028.56a
P_1F_3	35.04b	9.78a	22.37a	4051.85a
P_1F_4	35.08b	9.89a	22.20a	4035.69a
LSD	0.580	0.427	0.960	177.791
CV (%)	1.98	2.47	10.24	9.45

In a column means having similar letter (s) are statistically similar and those having dissimilar letter (s) differ significantly as per 0.01 (1%) level of probability

[P_0: Without Polythene shed and P_1: With Polythene shed
F_0: Control; F_1: 4-CPA; F_2: Zn, B, Mn, Se; F_3: Kaolin and F_4: 4-CPA, Zn, B, Mn, Se, Kaolin]

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted at the Horticultural Farm of Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh to determine the performance of summer tomato BARI hybrid – 4 with the effect of polythene shed and foliar application of yield contributing elements. The experiment consisted of two factors: Factor A: polythene shed condition and Factor B: different treatments of the foliar application of growth and yield contributing elements. The treatments were F_0: spraying tap water only, F_1: spraying 4-CPA (4-Chloro Phenoxy Acetic Acid) as per commercial formulation, F_2: spraying micronutrients solution (Zn, B, Mn and Se) @ 100 ppm, F_3: spraying kaolin @ 2% solution and F_4: combined application of 4-CPA, Zn, B, Mn, Se and kaolin. There were 10 (2 × 5) treatments combination. The two factorial experiments were laid out in Complete Randomized Design (CRD) with three replications. Data on growth, yield contributing characters and yields were recorded and significant variation was observed. The results of the experiment have been summarized below:

In case the use of polythene shed, the highest plant height (103.88 cm) was recorded with polythene shade (P_1) treatment whereas the shortest plant height (103.13 cm) was recorded without polythene shed (P_0) treatment at final harvest. The topmost result in terms of foliar coverage (73.96 cm) was recorded from P_1 where as P_0 was scored as the lowest (54.61 cm) at final harvest. The longest internodes (5.54 cm) were found from P_1 whereas the shortest internodes (4.49 cm) were found from P_0. The maximum number of effective branches per plant (10.33) was observed from P_1 whereas the minimum number of effective branches per plant (8.73) was found from P_0 at final harvest. The maximum number of leaves per plant (95.15) was recorded from P_1 where as the minimum number (94.73) was recorded from P_0 at final harvest. The longest leaves (24.55 cm) were recorded from P_1 while the shortest leaves (15.53 cm) were recorded from P_0. The higher number of buds per plant (109.52) was recorded from P_1 while the lower number of buds per plant (100.53) was obtained from P_0. The minimum days from transplanting to 50% flowering (43.0) was found from $P_{1,}$ while the maximum days to 50% flowering (43.90) was recorded from P_0. The maximum number of fruits cluster per plant (7.47) was observed from P_1 whereas the minimum number of fruits cluster per plant (6.80) was recorded from P_0. The higher number of fruits set per plant (27.47) was obtained from $P_{1,}$ while the lower number of fruits set per plant (21.23) was obtained from $P_{0.}$ The maximum fruit sets % (24.81) was recorded from P_1, whereas the minimum fruit sets % (20.88) was recorded from P_0 at final harvest. The maximum average number of fruits set per cluster (3.64) was observed from P_1, whereas the minimum (3.11) was recorded from P_0. P_0 condition was given maximum individual fruit weight (39.97 g) and minimum individual fruit weight (39.48 g) was obtained from P_1. Total fruit weight of summer tomato per plant was observed the maximum (1145.07 g) from P_1, while the minimum fruit weight per plant (668.65 g) obtained from P_0. P_1 scored the maximum chlorophyll content percentage (51.54%), whereas the minimum chlorophyll content (50.66%) was obtained from P_0. The maximum leaf temperature (34.93^{0}C) was recorded from $P_{1,}$ whereas the minimum leaf temperature (34.75^{0}C) was obtained from P_0 condition. It was observed from the results of the present experiment that the polythene shed condition insignificantly varied P^H of summer tomato. The maximum brix percentage in summer tomato (4.39 %) was found from P_1, while the minimum (3.59 %) obtained from P_0. The highest fruits inner temperature was recorded (35.84^{0}C) from P_1 condition, whereas the lowest fruit inner temperature (35.21) was obtained from P_0 condition. The maximum firmness of tomato (9.21 Neuton) was recorded from P_1, while the minimum (8.84 Neuton) was obtained from P_0 i.e. controlled condition. The maximum Vitamin-C content (21.49 mg per 100 g of tomato) was found from P_1, while the minimum content of Vitamin-C (18.94) was obtained from P_0. The maximum content of β- carotene (3895.25 µ gram per 100 g of tomato) recorded from P_1, while the minimum content of β-carotene (3190.55 μ gram per 100 g of tomato) was obtained from P_0.

In case of treatment combination, The tallest plant (113.67 cm) was marked from 4-CPA, Zn, B, Mn, Se and Kaolin (F_4) treated plants whereas the shortest plant (77.50 cm) was scored from control (F_0) treated plants at final harvest. The maximum foliar coverage (71.57 cm) was marked from 4-CPA, Zn, B, Mn, Se and Kaolin (F_4) treated plants whereas the minimum (56.93 cm) was scored from water (F_2) treated plants at final harvest. The length of internodes was the highest (5.44 cm) from F_4 which was statistically similar (5.27 cm) with F_1 treatment whereas the lowest (4.48 cm) was observed from F_0. F_4 treated plants produced the maximum number of effective branches per plant (11.07) while the minimum number of effective branches per plant (7.18) was obtained from F_0 treatment at final harvest. F_4 treated plants produced the maximum number of leaves per plant (104.20) while the minimum number of leaves per plant (84.83) was obtained from F_0 treated plants. The length of leaves was highest (22.63 cm) in F_4 treated plants which was statistically similar with F_2 (22.30 cm) treated plants whereas lowest (16.25 cm) was observed in F_0 treated plants. The highest number of flower buds per plant (118.47) was recorded from F_4 treated plants where as the lowest number of flower buds per plant (92.80) was attained from F_0 i.e. control condition where F_3 (97.0) is statistically similar with F_0 (92.80). The minimum days from transplanting to 50% flowering (40.0) was found from F4 treated plants while the maximum days (47.50) was recorded from F_0 i.e. control condition. F_4 treated plants showed the maximum number of fruits cluster per plant (7.53), while the minimum number of fruits cluster per plant (6.33) was obtained from F_0 treated plant. The maximum number of fruits set per plant (33.17) was recorded from F_4 treated plants, while the minimum number of fruits set per plant (16.57) was obtained from F_0 i.e. controlled condition. F_4 treated plants produced the maximum percentage of fruits set (27.76), while the minimum percentage of fruits set (17.69) was obtained from F_0 treated plants. The maximum average number of fruits set per cluster (4.36) was recorded from F_4 treated plants, while the minimum average number of fruits set per cluster (2.63) was obtained from F_0. The maximum individual fruit weight of tomato (49.33 g) was recorded from F_4 treatment while lowest individual fruit weight (22.07 g) was obtained from F_0 i.e. controlled condition. The total fruit weight of summer tomato per plant was observed the maximum (1472.45 g) from F_4 treated plant, while the minimum (495.88 g) obtained from F_0 treated plants. The maximum chlorophyll content percentage (53.32%) recorded from F_4 treated plants, while the minimum chlorophyll content (47.24 %) was found from F_0 treated plants. The maximum leaf temperature (35.76 ^{0}C) recorded from F_2 which was statistically similar with F_0 (35.60^{0}C) and F_1 (35.67^{0}C), while F_4 treated plant was exhibited the minimum leaf temperature (33.53^{0}C) which is statistically similar with F_3 (33.67^{0}C). Different foliar applications of the treatment insignificantly varied the P^H of summer tomato. The maximum TSS (4.57 %) was found from F_4 treated plants, which was statistically similar with F_1 (4.38) treated plants, whereas the minimum TSS (3.43 %) was found from controlled condition and it was statistically similar with F_3. The maximum inner temperature of fruits (36.22^{0}C) recorded from F_0 treated plant while the minimum fruit inner temperature (34.80^{0}C) was found from F_3 treated plants which was statistically similar with F_4 (34.94^{0}C). The maximum firmness (9.51 Neuton) of summer tomato recorded from F_4 treated plants which was statistically similar with (9.39 Neuton) F_3 treated plants, while the minimum firmness (8.10Neuton) obtained from F_0. The maximum Vitamin-C content (21.47) was obtained from F_4 treated tomato plants, whereas the minimum content of Vitamin-C (17.25) was recorded from controlled condition of water treated plants. The maximum content of β-carotene (3663.38 µ gram per 100 g of tomato) was obtained from F_3 treated tomato plants which is statistically similar with $F_{1,}$ F_2 and F_4 whereas the minimum content recorded from F_0 (3134.41 µ gram) i.e. controlled condition.

In case of interaction effect of polythene shed and different foliar application of the treatments of growth promoting elements, The tallest plant (113.93 cm) was observed from P_1F_4 which is statistically similar with P_1F_2 (113.13) and P_0F_4 (113.33) treatment and smallest plant (77.0 cm) was recorded from P_0F_0 treatment at final harvest. The maximum foliar coverage (81.67 cm) at final harvest was recorded from P_1F_4 treatment combination whereas the minimum was (40.80 cm) recorded from P_0F_2. It was remarked the longest internodes (6.30 cm) from P_1F_4 treatment and the shortest internodes (4.12 cm) from P_0F_3 treatment. The maximum number of effective branches per plant (11.33) was recorded from P_1F_4 which is statistically similar with P_1F_2 (11.30) while the minimum number of effective branches per plant (6.96) was recorded from P_0F_0 treatment combination. The maximum number of leaves per plant (104.67) was recorded from P_0F_4 while the minimum number of leaves per plant (86.33) was recorded from P_0F_0 treated plants. It was remarked that longest leaves (27.47 cm) was found in P_1F_2 treated plants which was statistically similar with P_1F_4 (26.67 cm) whereas the lowest leaves length (13.67 cm) was found in P_0F_1 treated plants which was statistically similar to P_0F_0 (14.0 cm) and P_0F_3 (14.23) treated plants. The highest number of flower buds per plant (125.27) was recorded from P_1F_4 which is statistically similar with P_1F_1 (120.93) while the lowest number buds per plant (84.60) were recorded from P_0F_0 treatments. The minimum days from transplanting to 50% flowering (40.0) was recorded from P_1F_4 combined treatments while the maximum days (48.0) was found from P_0F_0 which is statistically similar with P_1F_0 (47.0). The maximum number of fruits cluster per plant (8.07) was recorded from P_1F_4, while the minimum number per plant (6.0) was recorded from P_0F_0 treated plants. The maximum number of fruits set per plant (40.07) was recorded from P_1F_4, while the minimum number of fruits set per plant (13.53) was recorded from P_0F_0 treated plants. The maximum percentage of fruits set (31.99) was recorded from P_1F_4, while the minimum (15.99) was recorded from P_0F_0 i.e. controlled condition. The maximum average number of fruits set per cluster (4.97) was recorded from P_1F_4 and the minimum number fruits set per cluster (2.29) were recorded from P_0F_0 treatment combination. The maximum individual fruits weight (49.47 g) was recorded from P_1F_4 which was statistically similar with P_0F_4 (49.20 g), whereas the minimum Individual fruits weight (21.94 g) was recorded from P_0F_0 which is statistically similar with P_1F_0 (22.20). The total fruit weight of summer tomato per plant was observed the maximum (1973.37 g) from P_1F_4 treated plants, while the minimum fruit weight of tomato per plant (311.62 g) was found under P_0F_0 treatment. The maximum chlorophyll content percentage (53.43%) obtained from P_1F_4, while the minimum (47.07%) recorded from P_0F_0 which is statistically similar with P_1F_0 (47.41%). The maximum leaf temperature (35.97^{0}C) was found from P_1F_2 which was statistically similar with P_0F_0 (35.64^{0}C), P_0F_1 (35.83^{0}C), P_0F_2 (35.56^{0}C), P_1F_0 (35.55^{0}C), P_1F_1 (35.51^{0}C); whereas the minimum temperature (33.35^{0}C) recorded from P_0F_4 which was statistically similar to P_0F_3 (33.4^{0}C) P_1F_3 (33.93^{0}C) and P_1F_4 (33.71^{0}C). Interaction effect of polythene shed and differrent foliar treatments insignificantly varied the P^H of summer tomato. It was observed that the maximum brix percentage (5.0 %) was obtained from P_1F_4 treated plants, which was statistically similar with P_1F_1 (4.93 %) and P_1F_2 (4.83 %), whereas the minimum (3.30 %) recorded from P_0F_2 which was statistically identical with P_0F_0 and P_0F_3. The maximum inner temperature of fruits (36.84^{0}C) was found from P_1F_0, whereas the minimum (34.57^{0}C) recorded from P_0F_3 which was statistically similar to P_0F_4 (34.80^{0}C) treatment combination. The maximum firmness of summer tomato (9.89 Neuton) was found from P_1F_4 which was statistically similar with P_1F_3 (9.78) whereas the minimum firmness (8.01Neuton) recorded from P_0F_0. The maximum amount of Vitamin-C content (22.38) was obtained from P_1F_2 which was statistically similar to P_1F_1 (22.12), P_1F_3 (22.37) and P_1F_4 (22.20) while the minimum amount of Vitamin-C content (16.13) was recorded from P_0F_0. The highest content of β- carotene (4051.85 µ gram per 100 g of tomato) was obtained from P_1F_3 which was statistically similar to P_1F_1, P_1F_2 and P_1F_4 while the lowest (2915.08 µ gram per 100 g of tomato) was recorded from P_0F_0.

Conclusion:

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

1. Polythene shed (P_1) provided two weeks earlier and higher yield compared with non polythene shed condition (P_0). P_1 condition also provided the maximum content of β- carotene & Vitamin – C in per 100 g of tomato and TSS.
2. In case of foliar application of growth and yield promoting elements, F_4 treatment provided the maximum yield and quality parameters (β-carotene, Vitamin – C and TSS).
3. The present study revealed that the combined foliar application of yield contributing elements under polythene shed condition (P_1F_4) of 4-CPA (4-chloro Phenoxy Acetic Acid as per commercial formulation: 5ml per liter of water), micro nutrients Zn as Zinc Sulphate ($ZnSO_4$), B as Boric Acid (H_3BO_3), Mn as Manganese Sulphate ($MnSO_4$), Se as Sodium Selenate @100 ppm seperately and 2% solution of Kaolin as an antitranspirant (non-toxic clay particle: aluminosilicate: $Al_4Si_4O_{10}(OH)_8$) performed the best compared with all other treatments.
4. The present research work was carried out at the Horticulture Farm of Sher-e-Bangla Agricultural University, Dhaka for one season. Further trial of this research work in different locations of the country is needed to justify the result for precise recommendation of common farmers.

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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	Horticulture Field , SAU, Dhaka
AEZ	Madhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
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)	13.00
Exchangeable K (me/100 g soil)	0.10
Available S (ppm)	33

Source: SRDI, 2013

Appendix II. Analysis of variance of the data on plant height at different days after transplanting (DAT) of summer tomato BARI hybrid - 4 as influenced by polythene shed and foliar application of different yield contributing elements

Source of variation	Degrees of freedom	Mean square			
		Plant height (cm) at			
		18 DAT	33 DAT	48 DAT	6
Polythene shed (A)	1	1.2NS	672.133**	634.8**	25
Foliar Application (B)	4	1.3NS	87.367**	167.383**	35
Interaction (A×B)	4	0.7NS	13.633**	13.883**	11
Error	20	0.833	1.833	13.4	

**: Significant at 0.01 level of probability; NS: Non Significant at 0.01 level of probability

Appendix Ill. Analysis of variance of the data on growth promoting character of summer tomato BARI hybrid - 4 as influenced by polythene shed and foliar application of different yield contributing elements

Source of variation	Degrees of freedom	Mean square			
		Foliar coverage (cm)	Length of Internodes (cm)	Number of effective branches per plant	N pe
Polythene shed (A)	1	2807.201**	8.3**	19.184**	
Foliar Application (B)	4	167.995**	0.812**	12.207**	
Interaction (A×B)	4	105.258**	0.535**	1.696**	
Error	20	2.236	0.053**	0.416	

**: Significant at 0.01 level of probability

Appendix lV. Analysis of variance of the data on yield contributing character of summer tomato BARI hybrid - 4 as influenced by polythene shed and foliar application of different yield contributing elements

Source of variation	Degrees of freedom	Mean square		
		Days to 50% flowering (after transplanting)	Number of buds per plant	Number of fruits cluster per plant
Polythene shed (A)	1	1.2**	605.701**	3.387**
Foliar Application (B)	4	49.95**	654.248**	1.335**
Interaction (A×B)	4	0.45**	156.221**	0.092**
Error	20	1.1	12.512	0.226

**: Significant at 0.01 level of probability

Appendix V. Analysis of variance of the data on yield contributing character of summer tomato BARI hybrid - 4 as influenced by polythene shed and foliar application of different yield contributing elements

Source of variation	Degrees of freedom	Mean square				
		Average Number of fruits set per cluster	Individual fruit weight per plant (g)	Total fruit weight per plant (g)	Chlorophyl content (%)	Leaf Temperature (^{0}C)
Polythene shed (A)	1	2.148**	0.059**	702587**	5.87**	0.236**
Foliar Application (B)	4	2.554**	630.88**	796752.4**	41.039**	7.817**
Interaction (A×B)	4	0.286**	0.193**	131625**	3.921**	0.196**
Error	20	0.066	2.071	9924.978	0.992	0.779

**: Significant at 0.01 level of probability

Appendix Vl. Analysis of variance of the data on yield contributing character of summer tomato BARI hybrid - 4 as influenced by polythene shed and foliar application of different yield contributing elements

Source of variation	Degrees of freedom	Mean square					
		P^H	TSS	Fruit inner temperature (^{0}C)	Firmness (Neuton)	Vitamin-C (mg per 100 g)	Bita carotene (µ gram per 100 g)
Polythene shed (A)	1	0.002 NS	4.80**	2.983**	1.008**	48.82**	3724445.00**
Foliar Application (B)	4	0.057 NS	1.59**	2.306**	1.829**	16.999**	314285.10**
Interaction (A×B)	4	0.04 NS	0.466**	0.20**	0.221**	0.759**	33266.70**
Error	20	0.166	0.032	0.116	0.063	0.318	10896.77

**: Significant at 0.01 level of probability; NS: Non Significant at 0.01 level of probability