EFFECT OF CCC ON GROWTH, MORPHO-PHYSIOLOGICAL PARAMETERS AND YIELD OF TOMATO AT DIFFERENT MOISTURE LEVELS

SOHEL RANA

DEPARTMENT OF HORTICULTURE

SHER-E-BANGLA AGRICULTURAL UNIVERSITY

DHAKA -1207

JUNE 2015

EFFECT OF CCC ON GROWTH, MORPHO-PHYSIOLOGICAL PARAMETERS AND YIELD OF TOMATO AT DIFFERENT MOISTURE LEVELS

BY

SOHEL RANA

REGISTRATION NO. 08-3142

A Thesis
Submitted to the Faculty of Agriculture
Sher-e-Bangla Agricultural University, Dhaka,
in partial fulfilment of the requirements
for the degree of

MASTER OF SCIENCE
IN
HORTICULTURE

SEMESTER: JANUARY-JUNE, 2015

Approved by:

(Dr. Mohammad Humayun Kabir)
Associate Professor
Deptartment of Horticulture
SAU, Dhaka
Supervisor

(Prof. Abul Faiz Md. Jamal Uddin (Ph.D)
Professor
Deptartment of Horticulture
SAU, Dhaka
Co-Supervisor

....
Dr. Tahmina Mostarin
Chairman
Examination Committee

Dr. Mohammad Humayun Kabir

Associate Professor

Department of Horticulture

Sher-e-Bangla Agricultural University

SAU, Dhaka

Cell No. :+8801552409822

CERTIFICATE

This is to certify that the thesis entitled, ***"EFFECT OF CCC ON GROWTH, MORPHO-PHYSIOLOGICAL PARAMETERS AND YIELD OF TOMATO AT DIFFERENT MOISTURE LEVELS"*** *Submitted to the* ***Department of Horticulture****, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of* ***MASTER OF SCIENCE*** *in* ***Horticultur****e embodies the result of a piece of bonafide research work carried out by* ***SOHEL RANA****,* ***Registration No. 08-03142*** *under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

I further certify that such help or source of information, as has been availed of during the ***course of this investigation has been duly acknowledged by him.***

Dated: June,2015

(Dr. Mohammad Humayun Kabir)

Dedicated to

My

Beloved Parents

ACKNOWLEDGEMENTS

All of my gratefulness to almighty Allah who enabled me to accomplish this thesis paper.

I would like to express my heartiest respect, deepest sense of gratitude, profound appreciation to my supervisor ***Dr Mohammad Humayun Kabir****, Department of Horticulture, Sher-e-Bangla Agricultural University, Dhaka for his sincere guidance, scholastic supervision, constructive criticism and constant inspiration throughout the course and in preparation of the manuscript of the thesis.*

I would like to express my heartiest respect and profound appreciation to my co-supervisor, ***Prof. Abul Faiz Md Jamal Uddin (Ph.D),*** *Sher-e-Bangla Agricultural University, Dhaka for his utmost cooperation and constructive suggestions to conduct the research work as well as preparation of the thesis.*

I express my sincere respect to the Chairman ***Associate Prof. Dr Tahmina Mostarin*** *Examination Committee, Department of Horticulture and all the teachers of the Sher-e-Bangla Agricultural University, Dhaka for providing the facilities to conduct the experiment and for their valuable advice and sympathetic consideration in connection with the study.*

I would like to thank all of my family members who have helped me with technical support to prepare this thesis paper. I also thank all of my roommates and friends to help me in my research work.

Mere diction is not enough to express my profound gratitude and deepest appreciation to my mother, brothers, sisters, and friends for their ever ending prayer, encouragement, sacrifice and dedicated efforts to educate me to this level.

The Author

EFFECT OF CCC ON GROWTH, MORPHO-PHYSIOLOGICAL PARAMETERS AND YIELD OF TOMATO AT DIFFERENT MOISTURE LEVELS

BY

SOHEL RANA

ABSTRACT

An experiment was conducted at Horticulture farm, Sher-e-Bangla Agricultural University, Dhaka to study the effect of Chlorocholine chloride (CCC) on growth, morpho-physiological parameters and yield of tomato at different moisture levels. The experiment was laid out in a Completely Randomized Design with 3 replications and comprised of two factors: Factor A; (i) I_0 = 100% ET (Evapotranspiration) moisture, (ii) I_1 = 80% ET moisture and (iii) I_2 = 60% ET moisture and Factor B; (i) F_0 = Foliar spray with water (control), (ii) F_1 = Foliar spray with 1000 ppm CCC and (iii) F_2 = Foliar spray with 2000 ppm CCC. Application of different ET moisture with diffeent CCC levels showed significant variation on most of the parameters. In case of ET moisture levels, the highest fruit length (6.11 cm), fruit diameter (6.82 cm) and the highest total fruit weight plant^{-1} (1.23 kg) were recorded from I_1. The highest number of fruits sets plant^{-1} (29.11), highest fruit length (6.40 cm), highest fruit diameter (6.73 cm) and the highest total fruit weight plant^{-1} (1.48 kg) were found from F_1. Regarding the combined effect, the highest fruit length (6.81 cm), maximum diameter of fruit (7.21 cm) and the maximum total fruit weight plant^{-1} (1.27 kg) was found from the treatment combination I_1F_1. So 80% ET moisture and foliar spray of 1000 ppm CCC showed better performance for growth and yield of tomato.

LIST OF CONTENTS

LIST OF CONTENTS (Contd.)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

BARI	=	Bangladesh Agricultural Research Institute
CBR	=	Cost Benefit Ratio
CCC	=	Chlorocholine chloride
CRD	=	Completely Randomized Design
cm	=	Centimeter
^0C	=	Degree Centigrade
DAS	=	Days after sowing
ET	=	Evapotranspiration
et al.	=	and others *(at elli)*
FRG	=	Fertilizer Recommendation Guide
Kg	=	Kilogram
Kg/ha	=	Kilogram/hectare
g	=	gram (s)
LER	=	Land Equivalent Ratio
LSD	=	Least Significant Difference
MP	=	Muriate of Potash
m	=	Meter
P^H	=	Hydrogen ion conc.
TSP	=	Triple Super Phosphate
t/ha	=	ton/hectare
%	=	Percent

CHAPTER I

INTRODUCTION

Tomato (*Solanum lycopersicum*) belongs to the family solanaceae is one of the most important, popular and nutritious vegetable in Bangladesh. It ranks 3rd in terms of world vegetable production (FAO, 2007). It is the top listed canned vegetables (Choudhury *et al*., 1997). Tomato contains lycopene pigment which is a vital anti-oxident that helps to fight against cancerous cell formation as well as other kind of health complications and diseases (Kumavat and Chaudhari, 2013).

Tomato is one of the most highly praised vegetables consumed widely and it is a major source of vitamins and minerals. It is one of the most popular salad vegetables. It is widely employed in cannery and made into soups, conserves, pickles, ketchup, sauces, juices etc. Tomato juice has become an exceedingly popular appetizer and beverage. The well ripe tomato (per 100 g of edible portion) contains water (94.1%), energy (23 calories), calcium (1.0 g), magnesium (7.0 mg), vitamin A (1000 IU), ascorbic acid (22 mg), thiamin (0.09 mg), riboflavin (0.03 mg) and niacin (0.8 mg). At present Bangladesh occupies about 27 thousand acre of land and production of tomato is about 360 thousand metric ton (BBS, 2014). The average yield of tomato in Bangladesh is very low (7.42 t/ha) in comparison with that of other countries with the average yield of 52.82 t ha^{-1} in Japan, 63.66 t ha^{-1} in U.S.A, 30.39 t ha^{-1} in China, 15.67 t ha^{-1} in India (FAO, 2007).

Chlorocholine chloride (CCC) Known as cycocel, is a plant growth retardent which causes plants to be compact and stardy, with dark green leaves and shortened internodes and petioles. Michniewiecz and Kertzer (1965) found that tomato plants treated with CCC showed increased resistance to frost. In a tropics where water is often a limiting factor, the inducement of plants to drought tolerance with CCC could be very important.

Irrigation is a costly agricultural input, so its judicious application is necessary. Deficit water application could help not only in reducing production costs, but also in conserving water and minimizing leaching of nutrients and pesticides into ground water. With this in view, it was felt necessary to study the response of tomato plants to both quantitative and temporal variation in soil moisture. By restricting moisture at a non-susceptible phenological stage it may be possible to reduce irrigation water quantity and increase water-use efficiency. In crops, water stress has been associated with reduced yields and possible crop failure. The effects of water stress however vary between plant species. As the plant undergoes water stress, the water pressure inside the leaves decreases and the plant wilts. The main consequence of moisture stress is decreased growth and development caused by reduced photosynthesis, a process in which plants combine water, carbon dioxide and light to make carbohydrates for energy. Chemical limitations due to reductions in critical photosynthetic components such as water can negatively impact plant growth. The ability to recognize early symptoms of water stress is crucial to maintaining the growth of plants; the most common symptom is wilting (Kamrun, 2011).

Keeping all the above facts in view, the present experiment has been undertaken with following objectives-

1. To know the growth and yield of tomato at different moisture levels.
2. To find out the effect of CCC on morpho-physiological parameters and yield of tomato.
3. To know the growth, yield and other morpho-physiological parameters of tomato at different water lavels with different concentration of CCC.

CHAPTER 2

REVIEW OF LITERATURE

Tomato is an important vegetable crop and has received much attention of the researchers throughout the world. Moisture contents of soil and Chlorocholine chloride (CCC) also Known as Cycocel have remarkable effects on the morph-physiological characteristics and yield of tomato. Various investigations have been carried out in this line. Some of the available research works have been reviewed here.

2.1 Review in relation to the effect of Chlorocholine chloride and other growth regulators

Kumar *et al.* (2012) carried out an investigation to determine the effect of different rates of Cycocel on growth, yield and quality of tomato. The findings carried out on tomato, revealed that the application of cycocel at 300 ppm brought about the best results. Cycocel as retardant (CCC) exhibited the capacity for profuse branching, higher leaf count, higher flower cluster and better yield per plant as compared to control.

Altintas (2011) stated that the effects of prohexadione-calcium (Regalis@100 mg L^{-1})] and chlormequat chloride (2000 mg L^{-1}) on vegetative and generative growth of tomato plant. An underlying aim was to evaluate the growth of plants treated with pro-Ca with three phosphorus rates (40, 80 and 120 mg L^{-1}). Pro-Ca was applied to plants either as a spray or medium drench, while chlormequat chloride was applied only as a spray. Results showed that inhibiting effect of pro-Ca and chlormequat chloride applications on seedling height were significant and these two chemicals produced smaller seedlings compared to the control. Height reduction with chlormequat chloride was 56%, while with pro-Ca treatments it varied from 46 to 55%. Effects of chemicals on total weight of two trusses were not significant, although spray of pro-Ca together with the 40 mg L^{-1} phosphorus rate was promising in relation to chlormequat chloride and control plants. Based on the results of this study, it seems likely that pro-Ca, having an inhibiting effect on stem elongation without a negative effect on total weight of two trusses would be sufficient to control stem elongation. However, further researches are needed to suggest a strong opinion whether the pro-Ca treated tomato plants give same responses in every independent application of this chemical.

Hurtson (1985) carried out an experiment and find out that CCC treatment at flowering time suppressed the occurrence of tomato fruit puffiness in solution culture. Root application, truss spraying and whole plant spraying of CCC were all effective in correcting fruit puffiness, and truss spraying did not decrease fruit weight, unlike the other two treatments. For practical use, truss spraying might be the best method to control tomato fruit puffiness. Cytokinin contents in the xylem sap of tomatoes increased when CCC was applied to roots. This suggests that cytokinin biosynthesis in roots was increased by CCC treatment. Cytokinin activities in tomato fruits at an early developmental stage were also markedly increased by CCC treatment to roots. These results suggest that the CCC effect on the control of tomato fruit puffiness might be partly due to increased cytokinin activity in the developing fruit.

Khan *et al.* (2006) conducted an experiment to study the effect of 4 levels of gibberellic acid spray on the growth, leaf-NPK content, yield and quality parameters of 2 tomato cultivars (*Lycopersicon esculentum* Mill.), namely Hyb-SC-3 and Hyb-Himalata. They reported that irrespective of its concentration, spray of gibberellic acid proved beneficial for most parameters, especially in the case of Hyb-SC-3.

Nibhavanti *et al.* (2006) carried out an experiment on the effects of gibberellic acid, NAA, 4-CPA and boron at 25 or 50 ppm on the growth and yield of tomato (cv. Dhanshree) during the summer season of 2003. Plant height was greatest with gibberellic acid at 25 and 50 ppm (74.21 cm and 75.33 cm, respectively) and 4-CPA at 50 ppm (72.22 cm). The number of primary branches per plant did not significantly vary among the treatments. Gibberellic acid at 50 ppm resulted in the lowest number of primary branches per plant (69.55). The number of fruits per plant (38.86) was highest 50 ppm boron. The highest yields were recorded for boron at 25 and 50 ppm (254.2 and 264.4 quintal/ha).

Dhanasekaran *et al.* (2005) reported the effects of humic acid extracted from Neyveli lignite on the growth and yield of tomato (cv. PK.M-1). The treatments applied to foliage at 30 and 50 days after transplanting consisted of humic acid (0.3% solution), 50 ppm NAA, micronutrient mixture, humic acid + NAA, humic acid + nutrient mixture, NAA + micronutrient mixture, and humic acid + NAA + nutrient mixture. They reported that the application of humic acid either alone or in combination with NAA and/or nutrient mixture significantly improved the yield of tomato. The combined application of humic acid with NAA and nutrient mixture resulted in the superior yield and quality.

Singh *et al.* (2005) carried out an investigation to see the effects of different doses of PGRs (control, 25 or 75 ppm IAA, and 25 or 75 ppm NAA) and micronutrient (control, 2500 ppm Multiplex or 2000 ppm Humaur) mixtures and their interactions on plant growth, number of branches and yield of tomato at 35 and 70 days after transplanting (DAT). Plant growth was not affected significantly by any treatment and interaction, although the effect of PI (25 ppm IAA) x M2 (2000 ppm Humaur) interaction was better in increasing the plant growth at 75 DAT. The number of branches was significantly and highly increased by the application of 75 ppm IAA and 25 ppm NAA. The initiation time of first flowering and first fruiting was significantly and highly increased by the interaction P_4 (75 ppm NAA) x M_2 (2000 ppm Humaur). Application of 25 ppm IAA and 2000 ppm Humaur was significantly increased the tomato yield. P_4 (75 ppm NAA) x M_2 (2000 ppm Humaur) was also significantly increased the yield. It can be concluded that addition of PGR and micronutrient in tomato is useful for better production.

Sasaki *et al.* (2005) studied the effect of plant growth regulators on fruit set of tomato *(Solanum lycopersicum* cv. Momotaro) under high temperature and in a field (Japan) under rain shelter. Tomato plants exposed to high temperature (34/20 degrees C) had reduced fruit set. Treatments of plant growth regulators reduced the fruit set inhibition by high temperature to some extent, especially treatment with mixtures of 4-chlorophenoxyacetic acid (4-CPA) and gibberellins (GAs). They also reported that tomatoes treated with a mixture of 4-CPA and GAs showed increased fruit set and the numbers of normal fruits were more than the plants treated with 4-CPA alone during summer.

Djanaguiraman *et al.* (2004) conducted an experiment where the plants were sprayed with four different concentrations of Nitrophenols (ATONIK) at flowering and fruit setting stage. Observations were recorded in the flowers and developing fruits. Application of nitrophenols significantly increased the activity of antioxidant enzymes namely superoxide dismutase (SOD), catalase (CAT), peroxidase (POX) and auxin content coupled with decreased activity of polyphenol oxidase [catechol oxidase] (PPO) and IAA oxidase (IAAO) enzymes over the control significantly. Among the concentrations experimented, application of nitrophenols at 0.4% during fruit set stage was found to be the most effective in recording high antioxidant enzymes activity and auxin level which was reflected in an increased number of fruit clusters per plant, fertility coefficient and yield of tomato.

Gupta and Gupta (2004) studied the plants were sprayed with 25 or 75 ppm IAA and NAA, alone or in combination with the micronutrient mixtures Multiplex 2500 ppm and 2000 ppm Humaur in a field experiment conducted in Allahabad, India to determine the effects of the treatments on the P content of tomato fruits and products. Application of 75 ppm NAA + multiplex resulted in the highest P content in tomato fruits, as well as in ketchup, and tomato puree and juice during both years.

Gupta *et al.* (2003) observed the response of plant growth regulators and micronutrient mixtures on fruit size, colour and yield of tomato *((Solanum lycopersicum*, Mill). An experiment was conducted for two years (1997-99) in Uttar Pradesh, India to determine the effect of growth regulators (25 ppm IAA and 75 ppm NAA) at 25 and 50 days after transplanting (DAT) and/or micronutrient mixtures (2500 ppm Multiplex and 2000 ppm Humaur) at 25 and 50 DAT, respectively, on tomato cv. Krishna (F| hybrid). Among all treatments, the largest fruit size (6.67 cm diameter), most attractive ripe fruit color (Phantom, 2L-12) and the highest yield (63.61 t/ha) were observed with 75 ppm NAA + Multiplex micronutrient mixture at the maturity stage during 1998-99. The highest dry matter (2.7%) and ash content (1.0%) were obtained upon treatment with 75 ppm NAA + Humaur micronutrient mixture.

Kataoka *et al.* (2004) conducted an experiment on the effect of uniconazole on fruit growth in tomato cv. Severianin and reported that uniconazole (30 mg/litre) reduced fruit weight when applied to parthenocarpic fruits at approximately 0, 1 and 2 weeks after anthesis, but had no effect on fruit weight when applied at approximately 3 weeks after anthesis. To determine the antagonism between gibberellic acid (GA) and uniconazole in the regulation of fruit growth, flower clusters were treated with uniconazole (5 mg/L) and GA (5 or 50 mg/L). They reported that no notable gibberellin's activity was detected in treated fruits at 3 days to 4 weeks after treatment. The mean fresh weight of fruits at 4 weeks after treatment was lower than that of the control value. The results suggest that endogenous gibberellins in the early phase are important for fruit set and development.

Reddy *et al.* (2004) reported the effect of foliar application of enriched humic substances on the growth, yield and quality of tomato cv. S-22. The treatments comprised: control; humic acid + NAA + nutrient mixture; polycarboxylic acid + NAA + nutrient mixture; penshibao; and spic cytozyme. They reported that polycarboxylic acid + NAA + nutrient mixture gave maximum plant height in 60 days, number of flowers per plant, fruit set percentage, number of fruits per plant, fruit weight, fruit volume, fruit density, yield per plant, stover yield and contents of total soluble solids, reducing sugars, total sugars, titratable acidity and ascorbic acid. It also gave the earliest number of days taken for ripening.

Singh *et al.* (2003) stated that the effects of 2,4-D, beta naphthoxyacetic acid (2-naphthoxyacetic acid) and IAA (1, 10 or 100 ppm) applied as either as seed treatment or plant spray on the growth and yield of tomato cv. Pusa Ruby were studied in Kanpur, Uttar Pradesh, India. Seed germination varied from 8.2 to 40.2% during the initial evaluation. Flowering was initially observed in treated plants at 77-87 days after sowing. 2,4-D at all concentrations resulted in earlier flowering, whereas 1 ppm BNOA and all concentrations of IAA delayed flowering. Plants treated with 100 ppm BNOA exhibited the greatest seed germination and fruit set, and the lowest number of days to flowering. BNOA applied at 100 ppm as seed treatment gave the earliest fruit ripening (earlier than the control by 15 days).

Bhosle *et al.* (2002) reported the effects of NAA (25, 50 and 75 ppm), gibberellie 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 during the summer of 1997. They reported 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 was also found from treatment with 75 ppm 4-CPA.

Gupta *et al.* (2002a) conducted an experiment on the effect of IAA and NAA (25 and 75 ppm, respectively, at 25 and 50 days after transplanting) and the micronutrients mixtures Multiplex and Humaur (2500 and 2000 ppm, respectively), on the tomato cultivar Krishna was evaluated in Karnataka, India during 1997-98 and 1998-99. The application of auxins and micronutrients significantly improved the fruit size, dry matter, ash content and yield of tomato. The greatest fruit size and yield were obtained with 75 ppm NAA + Multiplex; while the highest dry matter and ash content were recorded for 75 ppm NAA + Humaur.

Gupta *et al.* (2002b) conducted an experiment to observed the effect of the plant growth regulators (PGRs) IAA and NAA (25 and 75 ppm), and 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.

Singh *et al.* (2002) investigated to examine the effects of p-chlorophenoxyacetic acid (PCPA at 50, 100 and 150 ppm), NAA (50 and 100 ppm) and their combination (PCPA at 50 ppm + NAA at 50 ppm) on the fruit set and development of tomato cv. DVRT-2 during 1999-2000 under the cold climatic conditions (10-12 degrees C). Spraying PCPA at 50 ppm to the flower clusters significantly improved the fruit set per cluster compared with the control, but increasing the concentration to 100 and 150 ppm had no significant effect on fruit set. NAA spray had no effect on fruit set per cluster when compared with the control. No significant variation was observed in fruit length and width over the control with different concentrations of PCPA, NAA or their combination. PCPA at 50 ppm gave a non-significant increase in average fruit weight, whereas NAA had no effect on this parameter. PCPA at 50 ppm significantly increased tomato yield, but increasing the concentration to 100 and 150 ppm had no significant effect on tomato yield. Similarly, spraying NAA did not affect tomato yield. PCPA spray induced fruit deformations (30-36% of fruits were deformed), whereas NAA spray had lower effect (5-8% of fruits were deformed).

Pundir and Yadav (2001) stated that GA_3 sprayed at 25 ppm significantly increased the growth characters, yield and yield components and also improved the quality of tomato cv. Punjab Chhuhara. NAA application increased total soluble solids percentage significantly. Application of 2, 4-D at 5 ppm also increased the yield, but retarded the growth attributes and yield at higher concentration.

Gupta *et al.* (2001) studied with Tomato (cv. Krishna) plants were treated with IAA (25 ppm at 25 days after transplanting, DAT) and NAA (75 ppm at 75 DAT), and supplied with Multiplex (2500 ppm) and Humaur (2000 ppm), in a field experiment conducted during the rabi seasons. The physicochemical characteristics of fruits were analyzed. Maximum total soluble solid content (5.4%) in mature tomato fruits was recorded from treatments of NAA and Humaur. Maximum lycopene and carotenoid contents were recorded from NAA and Multiplex. Reducing and non-reducing sugar contents were the highest (4 mg/100 g and 31.5 mg/100 g) when plants were treated with NAA and 1 lumaur.

Chung and Chori (2001) stated the foliar application of plant growth regulators affects distribution and accumulation of calcium ($45CaCl_2$) in tomato leaves. All tomato (cv. Sunroad) leaves, except the 7th and 8th or 5th to 8th leaves from the cotyledons, stem apices and the inflorescence, were removed to investigate the effect of plant growth regulators (PGR) on the leaves. The application of GA_2 to either of these leaves resulted in the accumulation of $45CaCl_2$ twice as high in the treated plants as in the plants which were sprayed with distilled water (control plants). When 2-(3-chlorophenoxy) propanoic acid (CPA) was applied onto the upper leaf, than $45CaCl_2$ accumulation was higher than in the control plants, whereas there was no difference when CPA was applied onto the lower leaf. IAA or NAA treated leaves showed lower amount of $45CaCl_2$ than the leaves of control plants, showing more inhibiting effect of NAA, in particular. The present study indicates that the application of various PGR does not interrupt the acropetal movement of calcium ion.

Rodrigues *et al.* (2001) conducted an experiment on the effects of plant growth regulators (NAA and parachlorophenoxyacetic acid at 10 and 50 ppm, respectively) and pollination on 8 flower truss sequences (1st and 2nd, 3rd and 4th, 5th and 6th, 7th and 8th, 9th and 10th, 11th and 12th, 13th and 14th, and 15th and 16th) on the performance of tomato cv. Rajashree were investigated in Maharashtra, India. The mean polar diameter, equatorial diameter, fruit weight, fruit set percentage, number of seeds per fruit and seed yield were the highest on initial truss sequences. Spraying with 10 ppm NAA followed by pollination on initial trusses resulted in the highest number of fruits (45.63) and seed yield (0.58 g per plant).

Sun *et al.* (2000) reported the role of growth regulators on cold water for irrigation reduces stem elongation of plug-grown tomato seedlings. The effect of growth regulators (abscisic acid, gibberellic acid (GA), paclobutrazol, ethephon, IAA and silver thiosulfate) and cold water irrigation at different temperatures (5, 15, 25, 35, 45 and 55 (^{0}C) on the reduction of stem elongation of plug-grown tomato seedlings was investigated. Paclobutrazol, ethephon and GA reduced the stem length of the tomatoes at several water temperatures. Cold water irrigation with the addition of 1.8 ppm GA or irrigation at room temperature could promote stem elongation. Irrigation at room temperature with the addition of 10 ppm paclobutrazol (GAs biosynthesis inhibitor) or cold water irrigation could inhibit stem elongation. The reduction in stem elongation in plug-grown tomato seedlings was due to the relationship of GAs metabolism and sensitivity.

2.2 Review in relation to the effect of moisture on the yield attributes of tomato

Accurate estimation of water consumption by plant is important not only in directing irrigation and improving water use efficiency of crop, but also in studying the interactions between plant and atmosphere (Wang *et al.,* 2006).

Vazquez *et al.* (2006) and Begum *et al.* (2001) reported that water deficiency enhanced the flower-dropping and fruit- dropping, which may be contributed to have minimum number of fruits per plant in minimum irrigation treatment. High tomato yield with irrigation was also showed by Vazquez *et al.* (2006); Machado and Oliveira (2005).

Higher soil water availability in mulch treatment compared to no mulch treatment was reported by Doring *et al.* (2005). Ara (2005) found large fruits at higher irrigation applied treatments. Zhang *et al.* (2005) reported high wheat grain yield in straw mulch with irrigation.

Souza *et al.* (2005) showed that significantly higher growth of common bean leaf in irrigated treatment (0.34 mol H_20 m'V). Lobo *et al.* (2004) noted higher yield of common bean grown with more irrigation water and he also showed that weather condition and soil water availability are primary factors affecting plant water status such as leaf water potential, stomatal resistance and transpiration. Culation of soil water balance based on evaporation and rainfall is easily understood and suitable for crop irrigation scheduling (Jones, 2004). Lobo *et al.* (2004) noted higher yield of common bean grown with more irrigation water.

Awal and Ikeda (2002) in peanut found higher yield in case of mulching with irrigation facilities. Higher TWU (Total Water Use) in irrigation treatments than no irrigation treatment. High irrigation levels significantly decreased the WUE (Water Use Efficiency) for seed yield. High water use efficiency in minimum irrigation levels may produce substantial yield with minimum water use. The results resembled the findings of Begum *et al.* (2001).

As irrigation water cost is high and irrigation facility is limited to around 30% of the total cultivable land in Bangladesh, it is imperative to use irrigation water more wisely to maximize the profit. Tomato is sensitive to water stress (Bose and Som, 1986; Begum *et al.,* 2001). She also reported that irrigation is indispensable and high frequency of irrigation is required for obtaining good yield of tomato in the clay terrace soil of Bangladesh. Sushant *et al.* (1999) also evaluated that longer pods obtained in high irrigation levels produced large number of seeds per pod. Mulch material protects the soil against water loss by evaporation, helping to improve soil water availability and possibly water infiltration within the root zone (Olasantan, 1999).

Abu-Awwad (1999) observed maximum onion root yield in the mulch applied plot with higher irrigation levels compared to open field. Mohapatro *et al.* (1998) mentioned that irrespective of irrigation level, mulch material gave higher maize yield because of better moisture conservation than no mulch treatment. Taller plant and higher dry weight of common bean growing with irrigation water compared to no irrigation and sufficient water in intensive irrigation treatment may enhance both cell division and enlargement that resulted taller plants and better growth. The number of primary branches was recorded the highest in excess moisture under 50% shades and the minimum was from those grown at 50% field capacity in identical environment (Murshed *et al.* 1997). They also reported that seed yield and yield attributes were higher in plants grown under full sunlight at 50% field capacity while excess moisture coupled with shading reduced seed yield drastically (Nandan and Prasad, 1998).

It was reported that 60% water depletion treatment significantly reduced fresh fruit yield compared with the other depletion treatments but did not affect soluble solids concentration. Irrigation cut off at 60 days prior to harvest significantly reduced the yield and soluble solids concentration. The percentage of peaceable fruits was significantly higher with irrigation cut off at 20 days before harvest (May and Gonzales, 1994).

Dadomo *et al.* (1994) carried out an experiment with irrigation at three rates i.e. 0.5, 0.9 or 1.3 x maximum evapotranspiration (Max ET). The treatment effects were dependent on the soil and climate in different locations. In general increased irrigation had a significant effect on the main yield components.

Tuzel *et al.* (1994) conducted an experiment in green house scheduled every three days or daily using irrigation rates calculated from pan evaporation using four pan coefficients of 0.6,0.8, 1.0 and 1.2. Plant growth and yield was not affected by irrigation interval, but the best pan coefficient for maximum early and total yields was 1.2. Similar a pan coefficient of 1.2 produced the greatest early and total yield, but tended to reduce fruit TSS and DM contents.

Ceme and Briski (1994) showed that the combination of 400 kg K_2O/ha, stubble manure and irrigation gave the highest total yield in the 1^{st} and 2^{nd} years (1.03 and 2.25 kg/plant, respectively). It was showed by Pemiola *et al.* (1994) that water stress caused an increase in diffusing resistance compared with the irrigated treatments, whereby the stomata remained almost fully closed most of the time. There was also a corresponding decrease in DM accumulation. The highest average marketable yield (66.4 ton/ha) was obtained with 100% restoration of Max ET. Restoration of 50% of Max ET resulted in the greatest water use efficiency.

Duraisamy *et al.* (1992) conducted an experiment with five irrigation treatments as; surface irrigation 1.0 IW/CEP ratio to a depth of 5 cm (T_1); Sprinkler irrigation at 1.0 IW/CEP ratio to a depth of 5 cm (T_2); Sprinkler irrigation at 0.75 IW/CEP ratio to a depth of 3.75 cm (T_3); Sprinkler irrigation at 0.75 IW/CEP ratio to a depth of 2.5 cm (T_4) and sprinkler irrigation at 0.25 IW/CEP ratio to a depth of 1.25 cm (T_5). The highest number of flowers and fruits at 65 and 80 days after transplanting and the highest fruit yield (16489 kg/ha) of tomato were obtained with surface irrigation (T_1). Water use efficiency was highest in T_4 (21.83 kg mm^{-1} ha^{-1}). Followed by T_3 (20.51 kg mm^{-1} ha^{-1}). Of these 2 treatments a significantly higher yield (13.996 kg ha^{-1}) was obtained T_3. T_3 resulted in a 21% saving in water compared with T_1.

Pugalia *et at.* (1992) described that tomato yield and quality were obtained with sprinkler irrigation applied daily from a height of 450-500 mm, fruit length (mm), fruit diameter (mm), fruit weight and yield decreased with the decreasing of irrigation levels. Reduced number of pods per plant due to water stress was also reported in earlier stage of bean growth (Peterson, 1989).

In Tunisia, Rudich and Luchinsky (1987) demonstrated that the water requirement of tamatoes was affected by better performances of cassava and sweet potato with the application of rice straw mulch and irrigation was significantly affected. They explained that the application of mulch and irrigation maintained a favorable soil environment (Ghuman and Lai, 1983).

Lin *et al.* (1983) reported water use in tomatoes in Taiwan ranged from 280 to 580 mm with corresponding WUE of 2.3 to 1.0 t/ha/cm. However, there was an additional 75-85 mm of precipitation and the water table varied between 1.4 and 1.8 m from the surface, so that, the crop could have extracted some of its water from the soil above the water table. Van Ootegam *et al.* (1982) studied the response of tamato to water application and concluded that the water requirement of tomato to be 525 mm with the yield of 113 t/ha and WUE of 2.95 t/ha/cm.

Doorenbas and Kassam (1979) reported that both excess and shortage of irrigation are detrimental to the growth and yield of tomato. They also showed that water stress during the growth stage of plant increases flower-drop and retards fruit-growth.

Sharma *et al.* (2007) conducted a study to investigate the effect of drip irrigation and different kinds of mulches on fruit yield, quality and water-use efficiency of strawberry cv. Chandler. Berry yield was significantly higher under the treatment of drip irrigation at 100 per cent of evaporation + black polyethylene mulch (78.6 q/ha) whereas lowest yields (12.13 q/ha) were recorded in non-irrigated treatment (rainfed + un-mulched control). Berry weight, volume and size were the maximum in drip irrigation with ‘V’ volume +hay mulch treatment. Berry weight and berry volume in drip irrigation with ‘V’ volume+ hay mulch treatment were found to be higher by 75.50 and 43.50 per cent respectively, than the treatment rainfed+ hay mulch. Sugar and anthocyanin content of strawberry were also maximum in drip irrigation, ‘V’+ hay mulch treatment, followed by drip irrigation 0.8’V’+ hay mulch treatment whereas, lowest values were observed under rainfed+un- mulched treatment. However, TSS and acidity values were higher by 12.45 and 29.12 per cent, respectively under rainfed+ un-mulched treatment over the drip irrigation, ‘V’+ hay mulch treatment being the minimum in TSS (7.66%) and acidity (0.73%) values. Highest water-use efficiency (1.27 q ha^{-1} cm^{-1}) was recorded under the treatment drip irrigation at 60 per cent of evapotranspiration + black polyethylene mulch which was 269.9 per cent higher than the lowest water-use efficiency (0.36 q ha^{-1} cm^{-1}) recorded under the rainfed + un-mulched control.

Westerfield (2005) conducted an experiment on tomato mulching and artificial irrigation and concluded that mulching will be benefited when mulch materials will be placed around their stems. He opined that mulching should be done soon after transplanting and materials such as weed-free straw, chopped leaves or compost can make excellent mulch and will help conserve moisture and reduce weed growth. He also suggested that application of mulch to a depth of 2 to 3 inches was more effective. He also explained that tomatoes needed about 1 to 2 inches of water per week depending on the type of soil they are growing in. He suggested watering of plants should be done thoroughly once or twice per week during dry weather condition with one or two heavy soakings which would be better than many light sprinklings. He considered drip irrigation or soaker hoses around plants and which resulted in conserving moisture and avoid getting the foliage wet which can cause disease. Irrigation should be laid near each plant above the soil but under the mulch layer.

Zhang *et al.* (2005) showed high grain yield of wheat growing in straw mulch with irrigation. He also said that adopted straw mulch was adopted as water-saving measure. They showed significantly improved WUE (Water Use Efficiency) by 8 to 10 % due to application of mulch.

Niu *et al.* (2004) conducted an experiment on the use of irrigation and mulching effect on yield of tomato (*Solanum lycopersicum*). They revailed that yields were higher under the straw mulch compared to the conventional mulch (plastic mulch) and irrigation with three micro-irrigation frequencies: control (no irrigation), daily, and twice weekly, increased yield with the straw mulches. Yields were not increased by irrigation of the plastic mulch treatment. Straw mulches have the potential to improve tomato yields in high-temperature environments by suppression water stress condition.

Kanthaswamy *et al.* (2004) reported that nutrient medium, irrigation regime, mulching and spacing positively affect the growth, yield and quality of tomato hybrid SH 7611 which resulted with increased fruit yield with better fruit quality.Higher yield in case of mulching with irrigation facilities was found in peanut (Awal and Ikeda, 2002).

Ramalan and Nwokeocha (2000) conducted an experiment at Research Farm, Institute of Agricultural Research, Samaru, Nigeria to evaluate water management options on the performance of tomato. The trial involved three furrow irrigation methods (conventional furrow, conventional furrow with cutback, and alternate furrow), two mulch treatments (without mulch and straw mulch), and three irrigation schedules (5-day interval, irrigation at 30 and 60 kPa soil moisture suction). The 18 treatments were laid out in a split-plot design in three replications. The irrigation method was assigned to the main plot while the mulch and irrigation schedule were in the subplots. Days to 50% flowering and fruiting of tomato were unaffected by furrow irrigation methods. They also conducted another field experiment during the dry season of 1993/1994 at the Irrigation of mulch and irrigation at the specified suction levels have had influence on growth of tomato. The rice straw mulch on furrows significantly delayed the attainment of 50% fruiting by 6 days compared to the un-mulched plots. Fruit sizes at the ages of 17, 19 and 21 weeks after planting, marketable fruit yield, crop water use and water use efficiency were significantly affected by all the three factors. Fruit weight was affected only by soil water suction. The interaction of furrow irrigation method, mulch and soil water suction had significant effect on water use efficiency (WUE) of the crop. Use of alternate furrow method was statistically at par, in terms of WUE with the conventional furrow method if it was mulched and irrigated at 5-days interval.

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental site

The present research work was conducted at Horticulture Farm in Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh. The experiment was carried out during Rabi season (November, 2014 to March, 2015). It was located in 24.09° N latitude and 90.26° E longitudes. The altitude of the location was 8 m high from the sea level (The Meteorological Department of Bangladesh, Agargoan, Dhaka).

3.2 Weather and climate

The climate of the experimental area was sub-tropical and characterized by high temperature; heavy rainfall during Kharif-1 season (March-June) and scanty rainfall during Rabi season (October-March) associated with moderately low temperature. The monthly average temperature, humidity, rainfall and sunshine hours prevailed at the experimental area during the cropping season are presented in Appendix 1.

3.3 Soil

The land belongs to the Agro-ecological zone "Madhupur tract" (AEZ-28) having the red brown traces soils and acid basin clay of Nodda soil series. The soil of the experimental site were well drained and medium high. The physical and chemical properties of soil of the experimental site sandy loam in texture and having soil p^H varied from 5.45 - 5.61. Organic matter content was very low (0.83). The physical composition such as sand, silt, clay content were 40%, 40% and 20% respectively. The physical and chemical characteristics of the experimental field soil are furnished in Appendix 2.

3.4 Materials used for the experiment

3.4.1 BARI Tomato-14

A high yielding tomato variety (BARI Tomato 14) was used as experimental material in the research work. The seeds of BARI Tomato-14 were collected from the Horticultural Research Centre (HRC), Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gajipur.

3.4.2 Chlorocholine chloride (CCC)

Chlorocholine chloride (CCC), the plant growth regulator, also used as an experimental materials. The seedlings that were transplanted in individual pot and Chlorocholine chloride (CCC) were applied as a foliar spray in different ppm level.

3.5 Seed bed preparation

Seed bed was prepared on last October 2014 for raising seedlings of tomato and the size of the seed bed was 3 m × 1 m. For making seedbed, the soil was well ploughed. Weeds, stubbles and dead roots were removed from the seedbed. Cow dung was applied to the prepared seed bed at the rate of 10 t/ha. The soil was treated by Sevin 50WP @ 5kg ha^{-1} to protect the young plants from the attack of ants and cutworms.

3.6 Seed Treatment

Seeds were treated by Vitavax-200 @ 5g kg^{-1} seeds to protect some seed borne diseases such as leaf spot, blight, anthracnose, etc.

3.7 Seed sowing

Seeds were sown by broadcasting method and covered with a fine layer of soil followed by light watering by water can. Thereafter the beds were covered with polythene to maintain required temperature and moisture.

3.8 Raising of seedlings

Light watering and weeding were done several times. No chemical fertilizers were applied for rising of seedlings. Seedlings were not attacked by any kind of insect or disease. Healthy and 30 days old seedlings were transplanted into the experimental pots on last November 2014.

3.9 Design of the experiment

The field experiment was conducted by Completely Randomized Design (CRD) with three replications. The study consisted of two factors viz. three levels of moisture and three levels of CCC.

3.10 Treatment of the experiment

Factor A.Moisture

I_0 = 100% ET(Evapotranspiration) moisture

I_2 = 80% ET moisture

I_3 = 60% ET moisture

Factor B. Chlorochorine chloride (CCC)

F_0 = Foliar spray with water (control)

F_1 = Foliar spray with 1000 ppm CCC

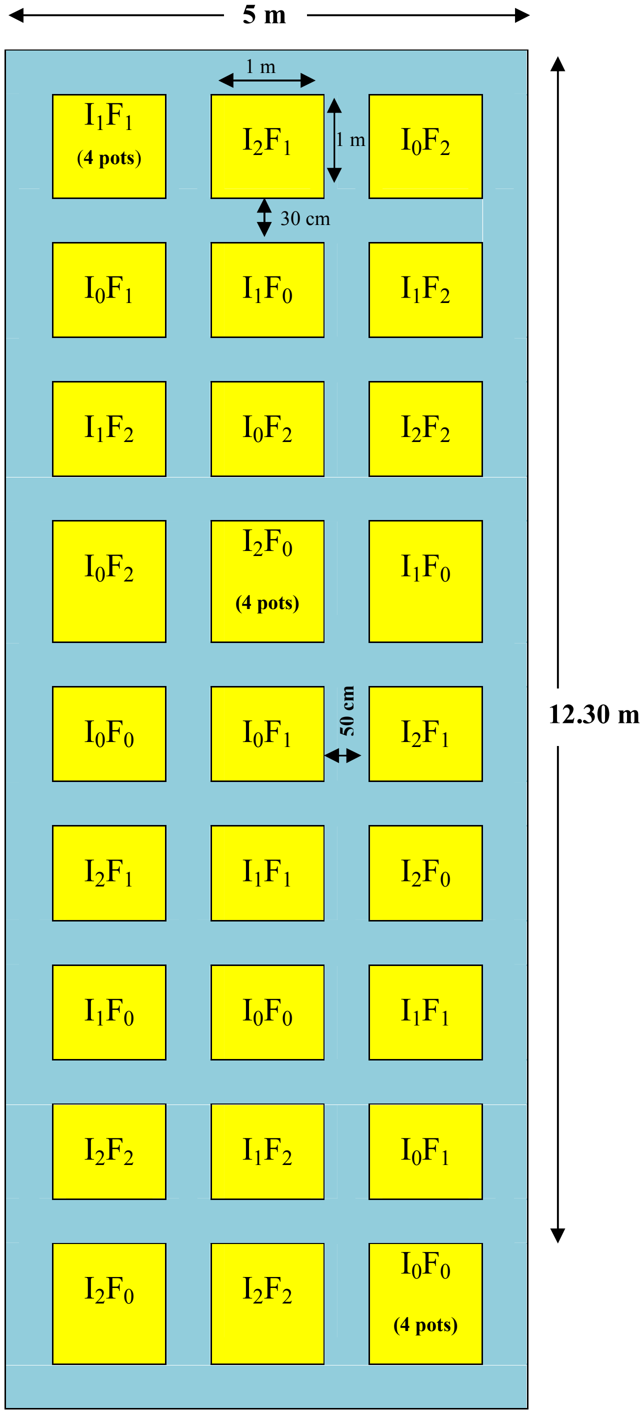
F_2 = Foliar spray with 2000 ppm CCC

3.11 Layout of the experiment

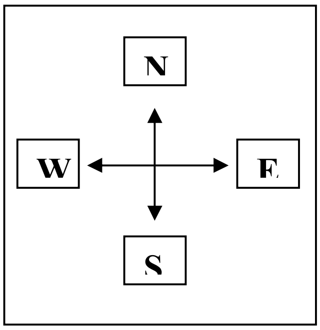
The experiment was laid out in a Completely Randomized Design (CRD) with three replications. As each replication comprised in nine treatment combination, the total number of pots was 108. The layout of experiment was shown in Fig. 1.

3.12 Soil preparation

Soil was collected from a fertile land of SAU Horticulture farm and prepared it with recommended fertilizer dose treated with Sevin 50WP @ 5 kg/ha to protect the young plants from the attack of ants and cutworm. Then kept it in the individual pot before the transplantation of seedling.



Legend



Treatments:

Factor A: Moisture levels

I_0 = 100% ET moisture

I_1 = 80% ET moisture

I_2 = 60% ET moisture

Factor B: CCC Levels

F_0 = Foliar spray of water (control)

F_1 = Foliar spray with 1000 ppm CCC

F_2 = Foliar spray with 2000 ppm CCC

Experiment layout:

Plant spacing = 50 cm × 50 cm

Row to Row distances = 50 cm

Distances between replication = 30 cm

Replication = 3

1 replication = 4 pots

Total plot area = 12.30 m × 5 m = 61.5 m^2

Fig. 1. Layout of the experiment

3.13 Application of manure and fertilizer

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 tomato 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 2nd and 3rd dose of urea application. Each time @ 3.42 g MP was applied per plant.

3.14 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 21.17 kg 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.

3.15 Transplanting

The seedbeds were watered before uprooting the seedlings to minimize the root damage. At the time of uprooting, care was taken so that root damage became the minimum. Healthy and 30 days-old seedlings were transplanted in experimental pots on 10 November 2014.

3.16 Intel-cultural operation

Gap filling

Very few seedlings were damaged after transplanting and these were replaced by the new seedlings from the same stock.

Weeding

The experimental pots were kept under careful observation. Weeding was done on the 7 January, 30 January and 20 February 2015.

Moisture

Gravimetric method was used to find out proper strategy to irrigate pot plants .In this method, plastic pot with soil was weighed using weighing balance and all the plastic pots was made in equal weight including soil which was 21.17 kg where only empty plastic pots was 0.8 kg. Water was added in each pot to make it well saturated condition .The difference between two weights is the evaporation rate. Pot with soil was allowed for two days tying with polythene sheet. After two days, the plastic pot with wetted soil was weighted. The loss of water = weight of pot soil in saturated water – weight of pot soil after allowing two days. The amount of water loss during the two days was recoverd completely by irrigation ,for control pots only. Other pots received 80% and 60% of the water added to the control plants.

Staking

Staking was provided with bamboo sticks. It helped the plant to keep erect and protect the plant against lodging.

3.17 Insects and diseases management

Diathane M45 was applied two times at 15 days interval @ 2 g L-1 in water to control late blight disease. Admire 200SL was applied to control the vector of virus disease of tomato plant.

3.18 Harvesting

Harvesting was done at 4 days interval during early ripen stage and ripen stage. Harvesting was started at 15 January and was completed by 10 March 2015.

3.19 Collection of data

The following data were recorded from the tomato plants during the study period.

Plant height (cm): Plant of each replication were selected from the experimental pots to measure the plant height and average plant height was measured in centimeter (cm). Plant height was measured from base to the tip of the longest leaf at 30, 60 and 90 days after transplanting (DAT). A meter scale was used to measure the plant height.

Foliage coverage: Plants were selected and measured their canopy size at 30, 60, and 90 days after transplant.

Number of branches: Number of branches was measured by counting branches of four selected plants at 30, 60, and 90 days after transplant and calculate their average range.

Number of leaf: The number of leaves was counted in four selected plants from each pot and their average was taken.

Leaf length (cm): Leaf length was measured by a scale of the longest leaves of the plants at 30, 60, and 90 days after transplant and calculate their average range

Length of internode (cm): Plants were selected to determine internode length of plants. A scale was used to measure the distances of two consequence node of a plant.

Number of fruits per cluster: Fruits of each cluster were counted of a plant then calculate in an average.

Number of fruits sets: Fruit sets were counted in four selected plants and calculate it on an average.

Fruit length at harvest: Fruit length was measured from the neck of fruit to the bottom of the same by using slide calipers of five fruits randomly selected from each of the pot.

Fruit diameter at harvest (cm): Fruit diameter was measured along the equatorial part of the same five represented fruit by distal slide calipers and their average was taken.

Total number of fruits per plant at harvest: The average value of the total number of fruit per plant harvested at different dates were counted.

Total weight of fruit per plant at harvest (kg): Fruit weight was taken after each harvest and recorded. Finally total weight was calculated.

Yield per plant: The yield per plant was calculated from the replications for each treatment.

Morpho-physiological characters: Chorophyll content, stomatal conductance,relative water content, CO_2 assimilation/photosynthesis rate was recorded from plants of individual replication as per treatment with the help of laboratory test.

3.20 Statistical analysis

The data obtained for yield contributing characters and yield were statistically analyzed to find out the significance of the differences among the treatments. The collected data from the experimental plot on morphology yield and yield contributing characters are compiled and analyzed using the Statistical, Mathematical Calculation and Data Management (MSTATC) package program. Morphological variation and yield performance among the treatments were studied by Analysis of Variance (ANOVA) by F-test. The significance of the difference between pairs of treatment means was evaluated by least significant difference (LSD) test at 5% and 1% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The present experiment was conducted to determine the effect of different levels of moisture with CCC on growth and morpho-physiological parameters and yield of tomato. The analyses of variance (ANOVA) of the data on different components are given in Appendix 1-12. The results have been presented and discussed, and possible explanations have been given under the following headings:

4.1 Growth parameters

4.1.1 Plant height

Plant height of BARI tomato-14 varied significantly due to the application of different level of moisture (Fig. 2 and Appendix 3). The highest plant height (32.56, 59.78 and 83.44 cm at 30, 60 and 90 DAT, respectively) was recorded from I_0 (100% ET moisture) followed by I_1 (80% ET moisture and the lowest plant height which was recorded from I_2 (60% ET moisture). In the experiment, moisture increased plant height. Similar result was observed by Altintas (2011).

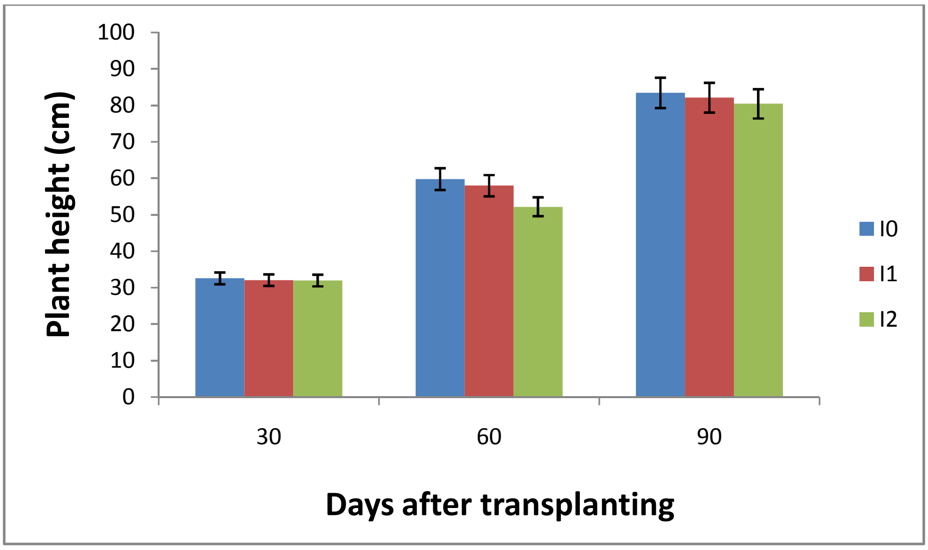


Fig. 2. Effect of ET moisture on plant height of tomato (Vertical bars indicate LSD value)

I_0 = 100% ET moisture, I_1 = 80% ET moisture, I_2 = 60% ET moisture

Significant variation was observed by the effect of CCC on plant height of tomato (Fig. 3 and appendix 3). Foliar spray of water influenced for better growth than spray of CCC. The longest plant (33.00, 59.78 and 84.89 cm at 30, 60 and 90 DAT respectively) was recorded from F_0 (Foliar spray of water; control) which was statistically identical with F_1 (Foliar spray with 1000 ppm CCC) at 60 DAT.The lowest plant height (31.78, 50.56 and 80.22 cm at 30, 60 and 90 DAT respectively) was achieved from F_2 (Foliar spray with 2000 ppm CCC) where CCC influenced to reduce the plant height. Similar result was also found by Rudich and Luchinsky (1987) and Ghuman and Lai (1983).

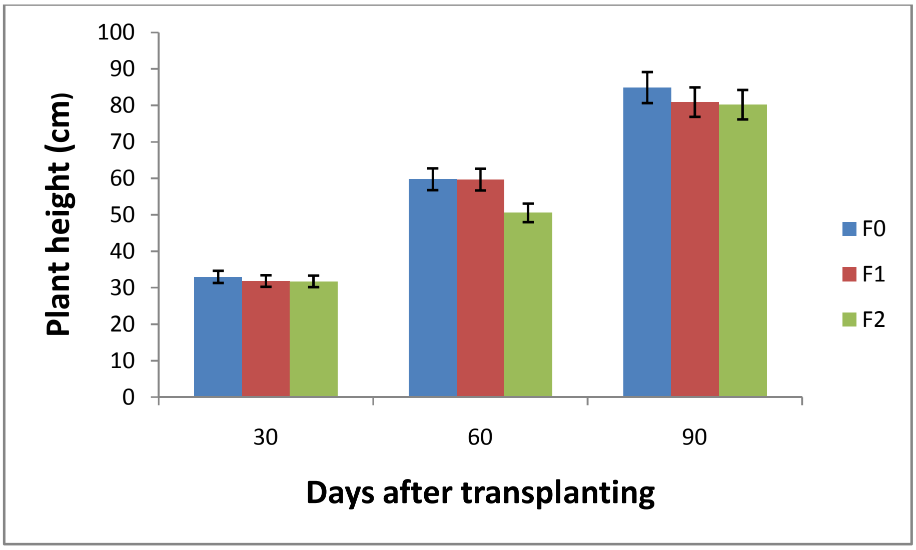


Fig. 3. Effect of CCC on plant height of tomato (Vertical bars indicate LSD value)

F_0= Foliar spray of water (control), F_1= Foliar spray with 1000 ppm CCC, F_2 = Foliar spray with 2000 ppm CCC

The interaction effect of moisture and CCC showed significant variation on plant height. The studied findings showed the variation among all treatments (Table 1 and appendix 3.The highest plant height (34.00, 61.67 and 91.00 cm at 30, 60 and 90 DAT respectively) was recorded from I_0F_0 which was statistically similar with I_1F_1 and I_2F_1 at 30 DAT where the lowest plant height (31.33, 34.00 and 81.00 cm at 30, 60 and 90 DAT respectively) was achieved from I_2F_2.

Table 1. Effect of ET moisture & CCC on plant height of tomato at different days after transplanting

Treatments	Plant height (cm)		
	30 DAT	60 DAT	90 DAT
I_0F_0	34.00 a	61.67 a	91.00 a
I_0F_1	32.33 ab	57.67 d	74.00 g
I_0F_2	31.67 b	61.67 a	81.33 e
I_1F_0	31.67 b	61.00 b	85.00 b
I_1F_1	32.33 ab	56.00 e	82.67 d
I_1F_2	32.00 b	60.00 c	82.67 d
I_2F_0	32.00 b	58.00 d	76.33 f
I_2F_1	32.67 ab	60.00 c	84.00 c
I_2F_2	31.33 b	34.00 f	81.00 e
$LSD_{0.05}$	**1.777**	**0.6070**	**0.6070**
CV (%)	**8.359**	**7.468**	**9.274**

(Means bearing same letters do not differ significantly at 5% level of significance)

I_0 = 100% ET moisture F_0= Foliar spray of water (control)
I_1 = 80% ET moisture F_1= Foliar spray with 1000 ppm CCC
I_2 = 60% ET moisture F_2 = Foliar spray with 2000 ppm CCC

4.1.2 Foliage coverage

The results of foliage coverage showed significant variation on plant height of tomato for different level of Moisture (Fig. 4 and Appendix 4). The highest foliage coverage (52.83, 77.00 and 88.89 at 30, 60 and 90 DAT respectively) was recorded from I_1 (80% ET moisture) which was statistically similar with I_0 at 30 DAT and the lowest foliage coverage (50.78, 74.11 and 77.78 cm at 30, 60 and 90 DAT) was recorded from I_2 (60% ET moisture) followed by I_0 (100% ET moisture) at 60 and 90 DAT respectively. This result might be due to cause of proper moisture level. similar result was found by Westerfield (2005).

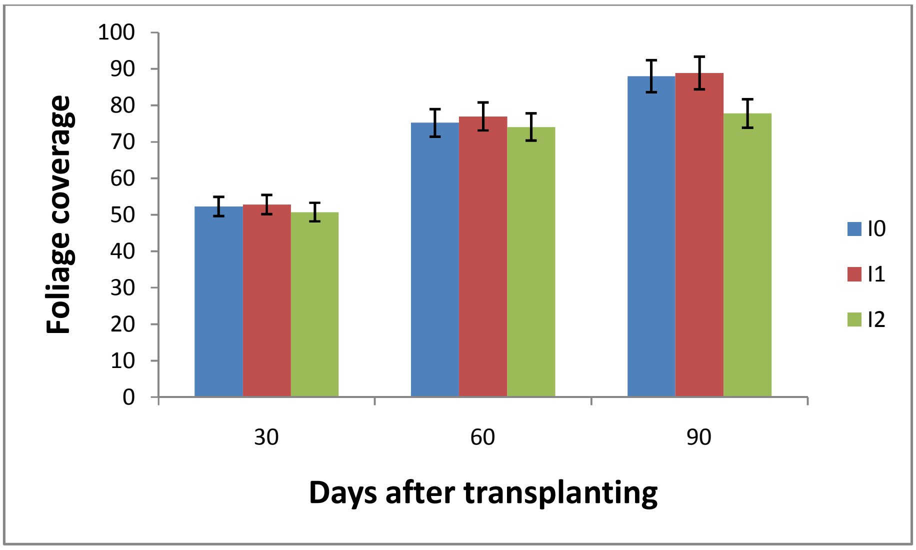


Fig. 4. Effect of ET moisture on foliage coverage of tomato (Vertical bars indicate LSD value)

I_0 = 100% ET moisture, I_1 = 80% ET moisture, I_2 = 60% ET moisture

Effect of CCC on foliage coverage of tomato showed the significant variation (Fig. 5 and appendix 4). Foliar spray was better than control stage of application of CCC. The increasing rate of foliage coverage was high in control level of CCC influenced for better growth than spray of CCC. The maximum foliage coverage (53.00, 76.67 and 89.78 cm at 30, 60 and 90 DAT, respectively) was recorded from F_1 (Foliar spray with 1000 ppm CCC) followed by F_2 (Foliar spray with 2000 ppm CCC) where the minimum foliage coverage (51.44, 73.67 and 76.56 cm at 30, 60 and 90 DAT) was achieved F_0 (Foliar spray of water; control). The result obtained from the present findings was conformity with the findings of Dhanasekaran *et al.,* (2005).

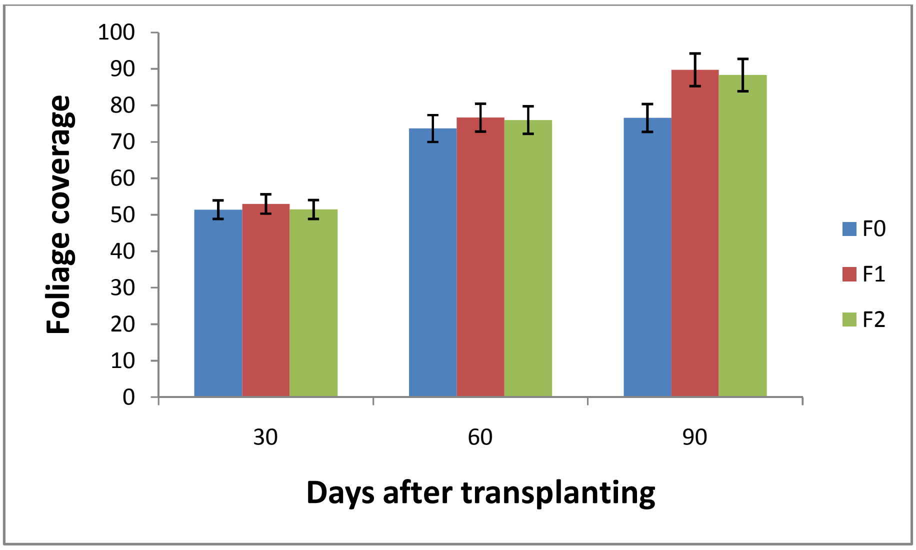


Fig. 5. Effect of CCC on foliage coverage of tomato (Vertical bars indicate LSD value)

F_0= Foliar spray of water (control), F_1= Foliar spray with 1000 ppm CCC, F_2 = Foliar spray with 2000 ppm CCC

Significant variation was found in the interaction effect of moisture and CCC on foliage coverage of tomato. The studied findings showed the highly variation among all treatments (Table 2 and appendix 4). The maximum foliage coverage (55.00, 79.33 and 93.00 cm at 30, 60 and 90 DAT respectively) was recorded from I_1F_1 followed by I_0F_1 at 30 DAT, I_1F_2 at 60 DAT and I_0F_0 at 90 DAT where the minimum foliage coverage (50.00, 72.67 and 53.67 cm at 30, 60 and 90 DAT respectively) was achieved from I_2F_0 followed by I_2F_1 and I_0F_0 at 30 DAT, I_0F_2 at 60 and 90 DAT.

Table 2. Effect of CCC on foliage coverage of tomato at different moisture levels

Treatments	Foliage coverage		
	30 DAT	60 DAT	90 DAT
I_0F_0	51.00 e	75.33 d	92.33 b
I_0F_1	54.00 b	73.00 f	86.00 f
I_0F_2	52.00 cd	74.00 e	87.67 e
I_1F_0	52.50 c	73.00 f	83.00 g
I_1F_1	55.00 a	79.33 a	93.00 a
I_1F_2	51.00 e	78.67 b	88.67 d
I_2F_0	50.00 f	72.67 f	53.67 h
I_2F_1	51.00 e	77.67 c	91.00 c
I_2F_2	51.33 de	75.33 d	88.67 d
$LSD_{0.05}$	**0.7988**	**0.6095**	**0.6144**
CV (%)	**9.356**	**7.563**	**8.269**

I_0 = 100% ET moisture　　F_0= Foliar spray of water (control)
I_1 = 80% ET moisture　　F_1= Foliar spray with 1000 ppm CCC
I_2 = 60% ET moisture　　F_2 = Foliar spray with 2000 ppm CCC

4.1.3 Number of branches plant^{-1}

Significant variation was observed due to the application of different level of moisture on number of branches plant^{-1} on tomato (Fig. 6 and Appendix 5). The highest number of branches plant^{-1} (2.63, 5.91 and 10.54 cm at 30, 60 and 90 DAT respectively) was recorded from I_1 (80% ET moisture) which was statistically identical with I_0 (100% ET moisture). In the findings 1.75, 3.62 and 7.41 at 30, 60 and 90 DAT respectively was the lowest number of branches plant^{-1} which was achieved from I_2 (60% ET moisture). Similar result was found by Murshed *et al.,,* (1997).

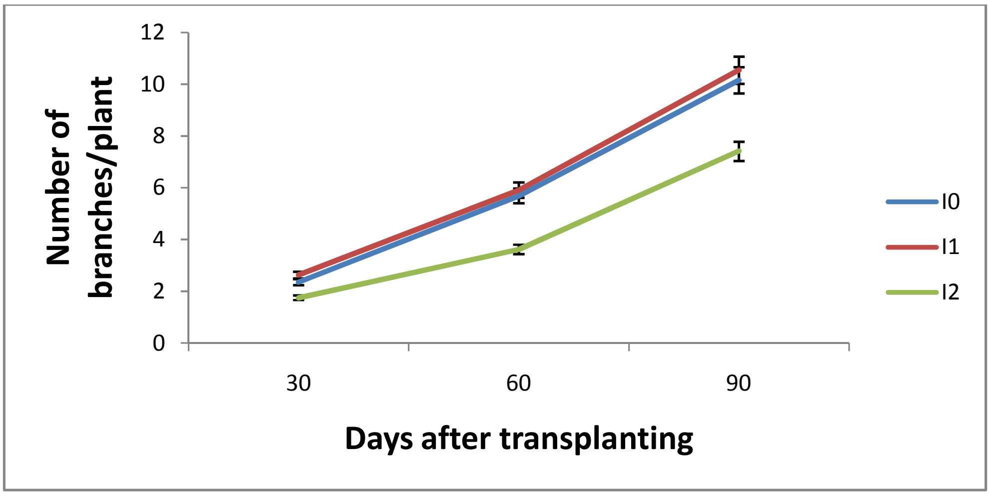


Fig. 6. Effect of ET moisture on number of branches plant^{-1} of tomato (Vertical bars indicate LSD value)

I_1=100% ET moisture, I_1 = 80% ET moisture, I_2 = 60% ET moisture

CCC significantly influenced on number of branches plant^{-1} of tomato (Fig. 7 and appendix 5). The maximum number of number of branches plant^{-1} (3.05, 6.69 and 11.14 cm at 30, 60 and 90 DAT respectively) was recorded from F_1 (Foliar spray with 1000 ppm CCC) followed by F_2 (Foliar spray with 2000 ppm CCC) where the minimum number of branches plant^{-1} (1.44 3.44 7.51 cm at 30, 60 and 60 DAT respectively) was achieved from F_0 (Foliar spray of water; control). Nibhavanti *et al.,* (2006) and Singh *et al.,* (2005) confirmed the similar result.

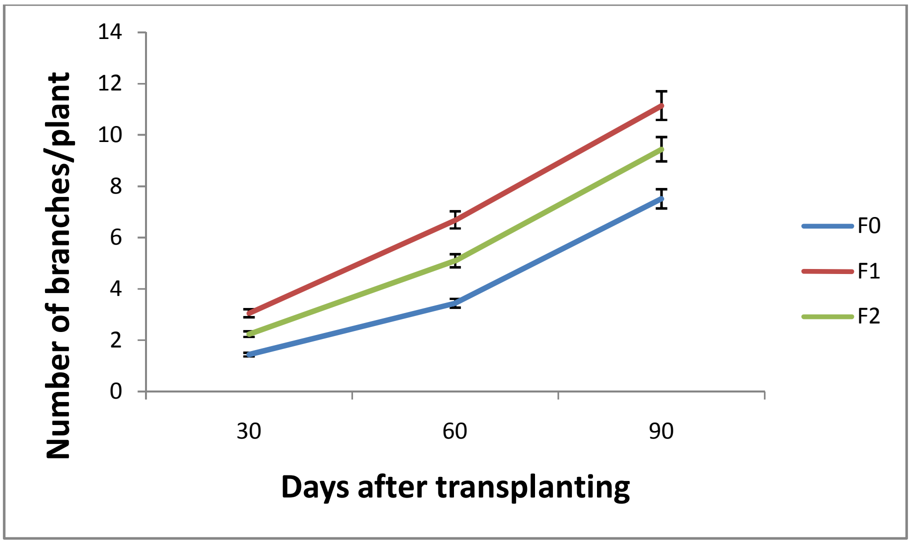


Fig. 7. Effect of CCC on number of branches plant^{-1} of tomato (Vertical bars indicate LSD value) F_0= Foliar spray of water (control), F_1= Foliar spray with 1000 ppm CCC, F_2 = Foliar spray with 2000ppm CCC

Combined effect of moisture and CCC showed significant variation on number of branches plant^{-1}(Table 3 and appendix 5) The maximum number of branches plant^{-1} (3.91, 7.91 and 12.35 cm at 30, 60 and 90 DAT respectively) was recorded from I_1F_1 followed by I_0F_2 and I_0F_1. Where the minimum number of branches plant^{-1} (1.50,2.91 and 5.63 cm at 30, 60 and 90 DAT respectively) was achieved from I_2F_2

Table 3. Effect of CCC on number of branches plant^{-1} of tomato at different moisture levels

Treatments	Number of branches plant^{-1}		
	30 DAT	60 DAT	90 DAT
I_0F_0	1.50 d	3.33 e	8.08 g
I_0F_1	2.83 b	7.41 a	11.40 b
I_0F_2	2.73 b	6.33 b	10.92 c
I_1F_0	1.50 d	4.08 d	8.83 f
I_1F_1	3.91 a	7.91 a	12.35 a
I_1F_2	2.50 c	5.75 b	10.40 d
I_2F_0	1.33 d	2.91 e	5.63 i
I_2F_1	2.41 c	4.75 c	9.60 e
I_2F_2	1.50 d	3.21 e	7.01 h
$LSD_{0.05}$	**0.1927**	**0.6095**	**0.2681**
CV (%)	**7.88**	**10.37**	**12.59**

I_0 = 100% ET moisture F_0= Foliar spray of water (control)
I_1 = 80% ET moisture F_1= Foliar spray with 1000 ppm CCC
I_2 = 60% ET moisture F_2 = Foliar spray with 2000 ppm CCC

4.1.4 Number of leaves plant^{-1}

Significant variation was found on number of leaves plant^{-1} of tomato at different level of moisture (Fig. 8 and Appendix 6). The highest number of leaves plant^{-1} (10.78, 19.11 and 27.33 cm at 30, 60 and 90 DAT respectively) was recorded from I_1 (80% ET moisture) which was statistically similar with I_0 at 90 DAT and followed by I_0 (100% ET moisture) at 30 and 60 DAT. The lowest number of leaves plant^{-1} (9.89, 17.33 and 24.33 cm at 30, 60 and 90 DAT) was recorded from I_2 (60% ET moisture). The result obtained from Westerfield (2005) was similar with the findings of the present study.

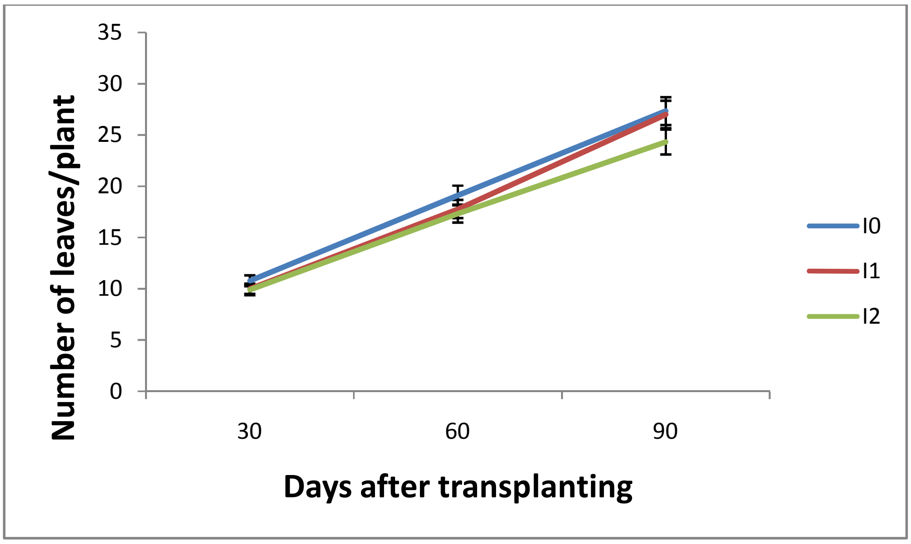


Fig. 8. Effect of ET moisture on number of leaves plant^{-1} of tomato(Vertical bars indicate LSD value)

I_0 = 100% ET moisture, I_1 = 80% ET moisture, I_2 = 60% ET moisture

The findings showed the significant effect of CCC on number of leaves plant^{-1} of tomato (Fig. 9 and appendix 6). The maximum foliage coverage (10.67 and 19.00 28.44 cm at 30, 60 and 90 DAT respectively) was recorded from F_2 (Foliar spray with 2000 ppm CCC) which statistically same with F_1 (Foliar spray with 1000 ppm CCC) at 30 DAT, statistically similar at 60 DAT and followed by F_1 (Foliar spray with 1000 ppm CCC) at 90 DAT where the minimum foliage coverage (9.67, 16.56 and 23.56 cm at 30, 60 and 90 DAT) was achieved from F_0 (Foliar spray of water; control). The result was in agreement with the study of Gupta *et al.,* (2001).

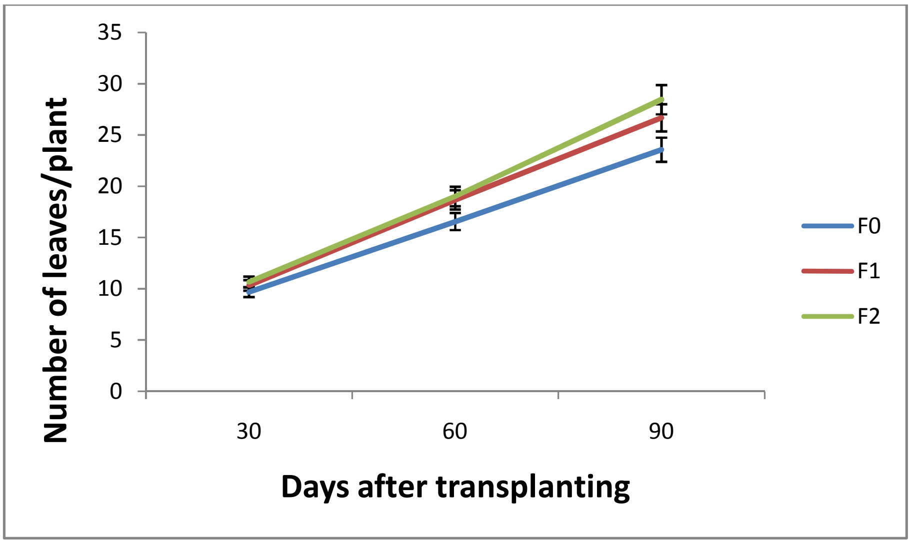


Fig. 9. Effect of CCC on number of leaves plant^{-1} of tomato(Vertical bars indicate LSD value)

F_0= Foliar spray of water (control), F_1= Foliar spray with 1000 ppm CCC, F_2 = Foliar spray with 2000 ppm

CCC Significant variation was found in the interaction effect of moisture and CCC on number of leaves plant^{-1} of tomato. The findings showed the significant variation among all treatments (Table 4 and appendix 6). The maximum number of leaves plant^{-1} (11.00, 21.33 and 32.00 cm at 30, 60 and 90 DAT respectively) was recorded from I_0F_2 which was followed by I_0F_1 at 60 and 90 DAT, where the minimum number of leaves plant^{-1} (9.33, 15.00 and 22.67 cm at 30, 60 and 90 DAT respectively) was achieved from I_2F_0.

Table 4. Effect of CCC on foliage coverage of tomato at different moisture levels

Treatments	Number of leaves plant^{-1}		
	30 DAT	60 DAT	90 DAT
I_0F_0	9.33 e	17.67 f	24.00 e
I_0F_1	10.33 c	19.67 b	30.00 b
I_0F_2	11.00 a	21.33 a	32.00 a
I_1F_0	10.33 c	17.00 g	24.00 e
I_1F_1	11.00 a	16.67 h	25.00 d
I_1F_2	10.33 c	18.33 d	28.00 c
I_2F_0	9.33 e	15.00 i	22.67 f
I_2F_1	9.67 d	18.00 e	25.00 d
I_2F_2	10.67 b	19.00 c	25.33 d
$LSD_{0.05}$	**0.1935**	**0.1935**	**0.5528**
CV (%)	**8.39**	**6.472**	**9.271**

(Means bearing same letters do not differ significantly at 5% level of significance)

I_0 = 100% ET moisture　　F_0= Foliar spray of water (control)
I_1 = 80% ET moisture　　F_1= Foliar spray with 1000 ppm CCC
I_2 = 60% ET moisture　　F_2 = Foliar spray with 2000 ppm CCC

4.1.5 Leaf length (cm)

The findings showed the significant variation on leaf length (cm) of tomato for different level of moisture (Fig. 10 and Appendix 7). The highest leaf length (36.44, 45.11 and 47.45 cm at 30, 60 and 90 DAT respectively) was recorded from I_0 (100% ET moisture) followed by I_1 (60% ET moisture). The lowest leaf length (cm) (35.29, 43.94 and 46.94 cm at 30, 60 and 90 DAT) was recorded from I_2 (60% ET moisture). The findings from the present study was similar with the findings of Pugalia *et al.,* (1992).

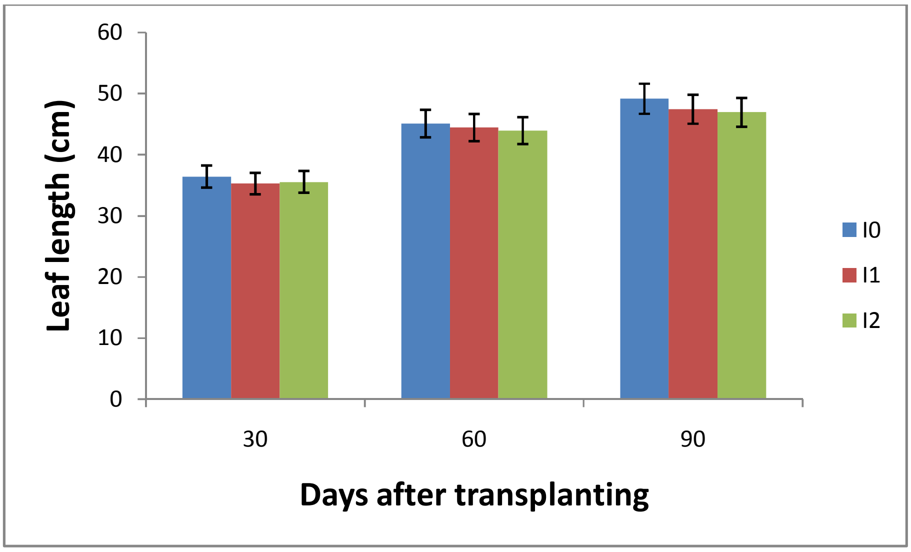


Fig. 10. Effect of ET moisture on leaf length of tomato (Vertical bars indicate LSD value)

I_0 = 100% ET moisture, I_1 = 80% ET moisture, I_2 = 60% ET moisture

Significant variation was observed on leaf length due to the application of CCC (Fig. 11 and appendix 7). The highest leaf length (28.83, 39.00 and 47.00 cm at 30, 60 and 90 DAT respectively) was recorded from F_1 (Foliar spray with 1000 ppm CCC) which was followed by F_2 (Foliar spray with 2000 ppm CCC) at 30 DAT, statistically same with F_2 (Foliar spray with 2000 ppm CCC) at 60 DAT while the minimum foliage coverage (26.06, 33.33 and 43.17 cm at 30, 60 and 90 DAT) was achieved from F_0 (Foliar spray of water; control). Similar was also found by Singh *et al.,* (2002) and Sun *et al.* (2000).

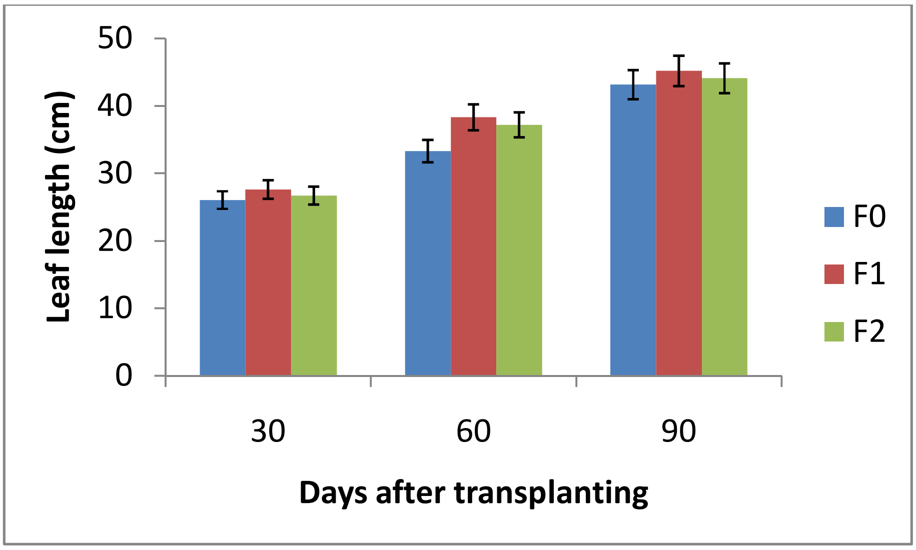


Fig. 11. Effect of CCC on leaf length of tomato (Vertical bars indicate LSD value)

F_0= Foliar spray of water (control),

F_1= Foliar spray with 1000 ppm CCC,

F_2= Foliar spray with 1000 ppm CCC,

Significant variation was found in the interaction effect of moisture and CCC on leaf length (cm) of tomato (Fig. 5 and appendix 7). The highest leaf length (28.83, 39.00 and 47.00 cm at 30, 60 and 90 DAT respectively) was recorded from I_0F_1 where as the lowest leaf length of tomato (26.00, 34.00 and 43.67cm at 30, 60 and 90 DAT, respectively) was found from I_0F_0 .

Table 5. Effect of CCC on foliage coverage of tomato at different moisture levels

Treatments	Leaf length (cm)		
	30 DAT	60 DAT	90 DAT
I_0F_0	26.00 f	34.00 g	43.67 g
I_0F_1	28.83 a	39.00 a	47.00 a
I_0F_2	26.67 d	37.00 e	44.67 e
I_1F_0	27.50 bc	34.00 g	44.33 f
I_1F_1	27.67 b	37.67 d	46.33 b
I_1F_2	27.33 c	36.00 f	44.17 f
I_2F_0	24.67 g	32.00 h	42.67 h
I_2F_1	26.33 e	38.33 c	45.67 c
I_2F_2	26.17 ef	38.67 b	45.00 d
$LSD_{0.05}$	**0.2162**	**0.2681**	**0.2737**
CV (%)	**8.563**	**10.294**	**7.527**

(Means bearing same letters do not differ significantly at 5% level of significance)

I_0 = 100% ET moisture F_0= Foliar spray of water (control)
I_1 = 80% ET moisture F_1= Foliar spray with 1000 ppm CCC
I_2 = 60% ET moisture F_2 = Foliar spray with 2000 ppm CCC

4.1.6 Lengths of internodes (cm)

Significant variation was found on length of internodes (cm) of tomato for different level of moisture at 60 and 90 DAT (Fig. 12 and Appendix 8). The highest length of internodes 8.11 cm was recorded from I_1 (80% ET moisture) which was statistically similar with I_0 (100% ET moisture) at 90 DAT while the lowest length of internodes 7.88 cm at 90 DAT was recorded from I_2 (60% ET moisture) .

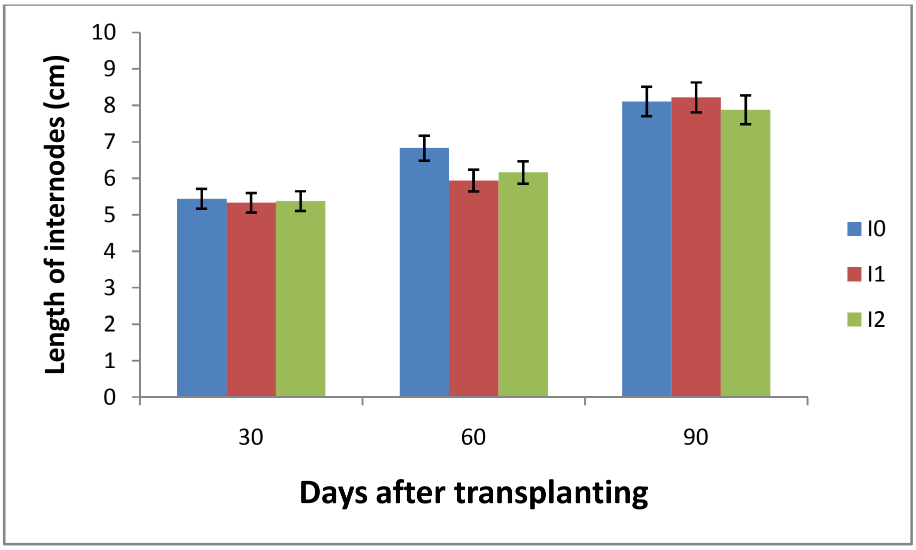


Fig. 12. Effect of ET moisture on length of internodes of tomato(Vertical bars indicate LSD value)

I_0 = 100% ET moisture, I_1 = 80% ET moisture, I_2 = 60% ET moisture

Non significant variation was found due to the effect of CCC on length of internodes of tomato (Fig. 13 and appendix 8).It was observed that the highest internodal length (5.50, 6.16 and 7.13 cm at 30, 60 and 90 DAT, respectively) was found from F_0 where the lowest (5.27, 4.76 and 4.40 at 30, 60 and 90 DAT respectively) was obtained from F_2.

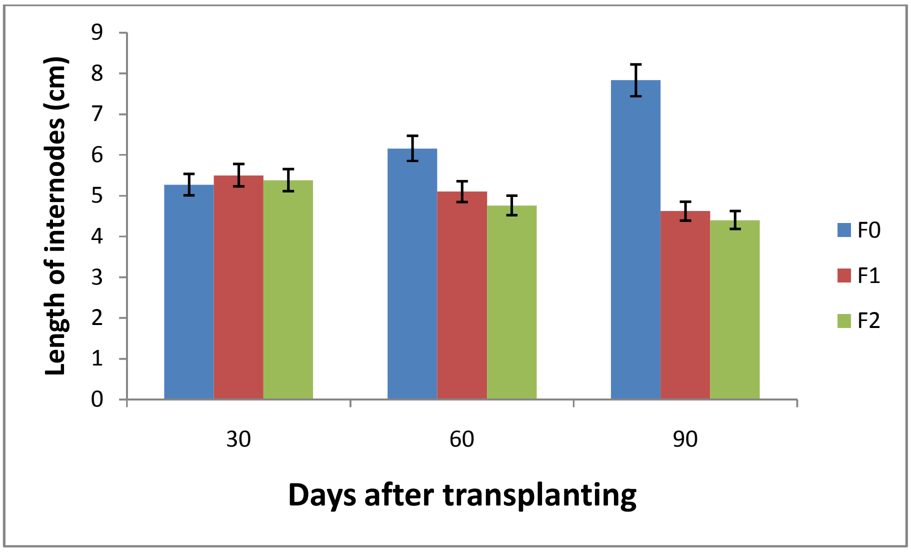


Fig. 13. Effect of CCC on length of internodes of tomato (Vertical bars indicate LSD value) F_0= Foliar spray of water (control),F_1= Foliar spray with 1000 ppm CCC, F_2 = Foliar spray with 2000 ppm CCC

Significant variation was found due to the interaction effect of moisture and CCC on length of internodes of tomato at 60 and 90 DAT (Table 6 and appendix 8). The highest length of internodes (6.83 and 8.50 cm at 60 and 90 DAT, respectively) was recorded from I_0F_0 followed by I_2F_0 at 60 and I_1F_0 90 DAT, respectively but at 30 DAT there was no significant effect of the treatment combinations. The lowest length of internodes (4.94 and 4.67 cm at 60 and 90 DAT respectively) was recorded from I_2F_2.

Table 6. Effect of CCC on Length of internodes of tomato at different moisture levels

Treatments	Length of internodes (cm)		
	30 DAT	60 DAT	90 DAT
I_0F_0	5.33	6.83 a	8.50 a
I_0F_1	5.50	5.33 d	5.00 d
I_0F_2	5.50	5.13 f	4.90 e
I_1F_0	5.00	5.50 c	7.83 b
I_1F_1	5.50	5.30 d	4.86 e
I_1F_2	5.50	5.00 g	4.75 g
I_2F_0	5.16	5.66 b	7.16 c
I_2F_1	5.50	5.20 e	4.76 f
I_2F_2	5.50	4.94 g	4.67 h
$LSD_{0.05}$	**NS**	**0.078**	**0.052**
CV (%)	**3.625**	**7.542**	**10.236**

(Means bearing same letters do not differ significantly at 5% level of significance)

I_0 = 100% ET moisture F_0= Foliar spray of water (control)
I_1 = 80% ET moisture F_1= Foliar spray with 1000 ppm CCC
I_2 = 60% ET moisture F_2 = Foliar spray with 2000 ppm CCC

4.2 Yield contributing parameters

4.2.1 Number of fruits cluster^{-1}

Different level of moisture showed significant effect on number of fruits cluster^{-1} of tomato at different days after transplanting (DAT) (Table 7 and Appendix 9). Results indicated that the highest number of fruits cluster^{-1} (9.44 and 10.67 at 60 and 90 DAT respectively) was found from I_0 (100% ET moisture) which was statistically identical with I_1 (80% ET moisture) at the same time where the lowest number of fruits cluster^{-1} (7.88 and 9.11 at 60 and 90 DAT, respectively) was achieved from I_2.

Different levels of CCC had significant effect on number of fruits cluster^{-1} of tomato at different days after transplanting (DAT) (Table 7 and Appendix 9). Results indicated that the highest number of fruits cluster^{-1} (9.33 and 10.44 at 60 and 90 DAT respectively) was found from F_2 (Foliar spray with 2000 ppm CCC) followed by F_1 (Foliar spray with 1000 ppm CCC) where the lowest number of fruits cluster^{-1} (8.22 and 9.44 at 60 and 90 DAT respectively) was achieved from F_0.

Table 7. Effect of CCC and different moisture levels on number of fruits cluster^{-1} of tomato

Treatments	Number of fruits cluster^{-1}	
	60 DAT	90 DAT
Effect of Moisture		
I_0	9.44 a	10.67 a
I_1	9.44 a	10.44 a
I_2	7.88 b	9.11 b
$LSD_{0.05}$	**0.4623**	**0.4844**
CV (%)	**7.294**	**9.346**
Effect of CCC		
F_0	8.22 c	9.44 c
F_1	9.22 b	10.33 b
F_2	9.33 a	10.44 a
$LSD_{0.05}$	**0.031**	**0.094**
CV (%)	**7.294**	**9.346**

(Means bearing same letters do not differ significantly at 5% level of significance)

I_0 = 100% ET moisture
I_1 = 80% ET moisture
I_2 = 60% ET moisture
F_0= Foliar spray of water (control)
F_1= Foliar spray with 1000 ppm CCC
F_2 = Foliar spray with 2000 ppm CCC

Significant variation was found in terms of interaction effect of moisture and CCC on number of fruits cluster^{-1} at different days after transplanting (Table 8 and Appendix 9). Results showed that the maximum number of fruits cluster^{-1} (10.30 and 11.33 at 60 and 90 DAT respectively) was obtained from I_0F_2 followed by I_1F_1 at 60 DAT and I_0F_1 and I_1F_1 at 90 DAT. Again, the lowest number of fruits cluster^{-1} (6.66 and 8.00 at 60 and 90 DAT respectively) was found from I_2F_0.

Table 8. Effect of CCC on number of fruits cluster^{-1} of tomato at different moisture levels

Treatments	Number of fruits cluster^{-1}	
	60 DAT	90 DAT
I_0F_0	9.00 d	10.00 d
I_0F_1	9.00 d	10.67 b
I_0F_2	10.3 a	11.33 a
I_1F_0	9.00 d	10.33 c
I_1F_1	10.0 b	10.67 b
I_1F_2	9.33 c	10.33 c
I_2F_0	6.66 g	8.00 f
I_2F_1	8.66 e	9.66 e
I_2F_2	8.33 f	9.66 e
$LSD_{0.05}$	**0.1935**	**0.2106**
CV (%)	**7.294**	**9.346**

(Means bearing same letters do not differ significantly at 5% level of significance)

I_0 = 100% ET moisture F_0= Foliar spray of water (control)
I_1 = 80% ET moisture F_1= Foliar spray with 1000 ppm CCC
I_2 = 60% ET moisture F_2 = Foliar spray with 2000 ppm CCC

4.2.2 Number of fruits sets plant^{-1}

Different levels of moisture had significant effect on number of fruits sets plant^{-1} of tomato at different days after transplanting (Table 9 and Appendix 10). Results indicated that the highest number of fruits sets plant^{-1} (9.00, 15.67 and 20.00 at 50, 70 and 90 DAT respectively) was found from I_0 (100% ET moisture) where the lowest number of fruits sets plant^{-1} (6.55, 12.56 and 16.33 at 50, 70 and 90 DAT respectively) was achieved from I_2 (60% ET moisture).

Different levels of CCC had significant effect on number of fruits sets plant^{-1} of tomato at different days after transplanting (Table 9 and Appendix 10). Results indicated that the highest number of fruits sets plant^{-1} (10.40, 15.33 and 19.11 at 50, 70 and 90 DAT respectively) was found from F_1 (Foliar spray with 1000 ppm CCC) followed by F_2 (Foliar spray with 2000 ppm CCC) where the lowest number of fruits sets plant^{-1} (5.33, 12.56 and 16.22 at 50, 70 and 90 DAT respectively) was achieved from F_0 (Foliar spray of water; control).

Table 9:Effect of different moisture levels and CCC on number of fruit sets of tomato

Treatments	Number of fruits sets plant^{-1}		
	50 DAT	70 DAT	90 DAT
Effect of Moisture			
I_0	9.00 a	15.67 a	20.00 a
I_1	8.44 b	13.78 b	17.22 b
I_2	6.55 c	12.56 c	16.33 c
$LSD_{0.05}$	**0.1095**	**0.1548**	**0.1117**
CV (%)	**7.392**	**11.263**	**9.267**
Effect of CCC			
F_0	5.33 c	12.56 c	16.22 b
F_1	10.4 a	15.33 a	19.11 a
F_2	8.22 b	14.11 b	18.22 a
$LSD_{0.05}$	**0.3533**	**1.117**	**1.012**
CV (%)	**7.392**	**11.263**	**9.267**

(Means bearing same letters do not differ significantly at 5% level of significance)

I_0 = 100% ET moisture F_0= Foliar spray of water (control)
I_1 = 80% ET moisture F_1= Foliar spray with 1000 ppm CCC
I_2 = 60% ET moisture F_2 = Foliar spray with 2000 ppm CCC

Significant variation was found in terms of interaction effect of moisture and CCC on number of fruits sets plant^{-1} at different days after transplanting (Table 10 and Appendix 10). Results revealed that the maximum number of fruits sets plant^{-1} (15.34, 20.00 and 23.67 at 50, 70 and 90 DAT respectively) was found from I_0F_1 followed by I_1F_2 and I_2F_1. Again, the lowest number of fruits cluster^{-1} (4.66, 11.00 and 14.33 at 50, 70 and 90 DAT respectively) was found from I_2F_0. The results obtained from the rest of the treatments showed intermediate results compared to highest and lowest number of fruits sets plant^{-1}.

Table 10. Effect of CCC on number of fruit sets of tomato at different moisture levels

Treatments	Number of fruits sets plant^{-1}		
	50 DAT	70 DAT	90 DAT
I_0F_0	6.00 f	13.33 e	18.00 b-d
I_0F_1	15.34 a	20.00 a	23.67 a
I_0F_2	7.00 e	13.67 d	18.33 bc
I_1F_0	5.33 g	13.33 e	16.33 de
I_1F_1	7.33 d	12.00 g	15.67 ef
I_1F_2	12.60 b	16.00 b	19.67 b
I_2F_0	4.66 i	11.00 h	14.33 f
I_2F_1	8.66 c	14.00 c	18.00 b-d
I_2F_2	5.00 h	12.67 f	16.67 c-e
$LSD_{0.05}$	**0.1896**	**0.1896**	**1.752**
CV (%)	**7.392**	**11.263**	**9.267**

(Means bearing same letters do not differ significantly at 5% level of significance)

I_0 = 100% ET moisture F_0= Foliar spray of water (control)
I_1 = 80% ET moisture F_1= Foliar spray with 1000 ppm CCC
I_2 = 60% ET moisture F_2 = Foliar spray with 2000 ppm CCC

4.3 Morpho-physiological properties of tomato

4.3.1 Relative water content (%)

Significant influence was found for different levels of moisture on relative water content of tomato (Table 11 and Appendix 12). Results showed that the highest relative water content (6.28) was found from I_0 (100% ET moisture) which was significantly different from other treatments where the lowest relative water content (5.28) was achieved from I_1 (80% ET moisture) followed by I_2 (60% ET moisture).

Different levels of CCC had significant effect on relative water content of tomato (Table 11 and Appendix 12). Results showed that the highest relative water content (6.36) was found from F_0 (Foliar spray of water; control) which was statistically different with F_1 (Foliar spray with 1000 ppm CCC) and F_2 (Foliar spray with 2000 ppm CCC) where the lowest relative water content (4.91) was achieved from F_2 (Foliar spray with 2000 ppm CCC).

Relative water content of tomato significantly varied due to the interaction effect of moisture and CCC (Table 12 and Appendix 12). Results signified that the maximum relative water content (7.83) was found from I_0F_0 followed by I_2F_1 and I_2F_0. Again, the lowest relative water content (4.62) was found from I_2F_2. The results obtained from all other treatment combinations gave mid level relative water content compared to other treatments.

Table 11. Effect of different moisture levels and CCC on different morpho physiological properties of tomato

Treatments	Relative water content (%)	Chlorophyll Content (µmol m-2)	CO_2 assimilation/ Photosynthesis rate (µmol m-2 s-1)
Effect of Moisture			
I_0	6.28 a	46.26 c	7.83 a
I_1	5.28 c	47.72 a	5.37 c
I_2	5.74 b	47.27 b	5.84 b
$LSD_{0.05}$	**0.1593**	**0.1580**	**0.3589**
CV (%)	**4.361**	**3.697**	**4.249**
Effect of CCC			
F_0	6.36 a	47.59 a	7.03 a
F_1	6.03 b	46.67 b	5.92 c
F_2	4.91 c	46.99 b	6.09 b
$LSD_{0.05}$	**0.150**	**0.3533**	**0.1108**
CV (%)	**4.361**	**3.697**	**4.249**

I_0 = 100% ET moisture　　F_0= Foliar spray of water (control)
I_1 = 80% ET moisture　　F_1= Foliar spray with 1000 ppm CCC
I_2 = 60% ET moisture　　F_2 = Foliar spray with 2000 ppm CCC

4.3.2 Chlorophyll Content (µmol m-2)

Chlorophyll Content of the plant significantly influenced by different levels of moisture (Table 11 and Appendix 12). Results showed that the highest chlorophyll Content (47.72) was found from I_1 (80% ET moisture) which was significantly different from other treatments where the lowest chlorophyll Content (46.26) was achieved from I_0 (100% ET moisture) and intermediate result was found from I_2 (80% ET moisture).

Different levels of CCC had significant effect on chlorophyll Content of tomato (Table 11 and Appendix 12). Results showed that the highest chlorophyll Content (47.59) was found from F_0 (Foliar spray of water; control) which was statistically different from others where the lowest chlorophyll Content (46.67) was achieved from F_1 (Foliar spray with 1000 ppm CCC) which was statistically identical with F_2 (Foliar spray with 2000 ppm CCC).

Chlorophyll Content of tomato significantly varied due to the interaction effect of moisture and CCC (Table 12 and Appendix 12). Results showed that the maximum chlorophyll content (50.03) was found from I_2F_1 followed by I_0F_0 and I_1F_0. Again, the lowest stomata Conductance (0.04) was found from I_0F_1.

4.3.3 CO_2 assimilation/photosynthesis rate (µmol m-2 s-1)

Data presented in Table 11 explained that CO_2 assimilation/photosynthesis rate of the plant significantly influenced by different levels of moisture (Appendix 12). Results showed that the highest CO_2 assimilation/photosynthesis rate (7.83) was found from I_0 (100% ET moisture) which was significantly different from other treatments where the lowest CO_2 assimilation/photosynthesis rate (5.37) was achieved from I_1 (80% ET moisture) and intermediate result was found from I_2 (80% ET moisture).

Different levels of CCC had significant effect on CO_2 assimilation of tomato (Table 11 and Appendix 12). Results showed that the highest CO_2 assimilation (7.03) was found from F_0 (Foliar spray of water; control) which was statistically different from others where the lowest CO_2 (5.92) was achieved from F_1 (Foliar spray with 1000 ppm CCC) followed by F_2 (Foliar spray with 2000 ppm CCC).

Chlorophyll content of tomato significantly varied due to the interaction effect of moisture and CCC (Table 12 and Appendix 12). Results indicated that the maximum CO_2 assimilation/ photosynthesis rate (8.28) was found from I_0F_1 which was closely followed by I_0F_2, I_0F_0, I_2F_0 and I_1F_0. Again, the lowest CO_2 assimilation/ photosynthesis rate (3.20) was found from I_1F_1 followed by I_2F_2.

Table 12. Effect of CCC on different morpho physiological properties of tomato at different moisture levels

Treatments	Relative water content (%)	Chlorophyll Content (μmol m-2)	CO_2 assimilation/ photosynthesis rate (μmol m-2 s-1)
I_0F_0	7.83 a	48.77 b	7.21 a-c
I_0F_1	5.99 c	42.80 f	8.28 a
I_0F_2	5.01 e	47.20 c	8.00 ab
I_1F_0	5.12 e	48.53 b	6.87 a-c
I_1F_1	5.62 d	47.17 c	3.20 d
I_1F_2	5.10 e	47.47 c	6.03 c
I_2F_0	6.14 b	45.47 e	7.00 a-c
I_2F_1	6.48 b	50.03 a	6.27 bc
I_2F_2	4.62 f	46.30 d	4.25 d
$LSD_{0.05}$	**0.1935**	**0.6120**	**1.751**
CV (%)	**4.361**	**3.697**	**4.249**

(Means bearing same letters do not differ significantly at 5% level of significance)

I_0 = 100% ET moisture — F_0= Foliar spray of water (control)
I_1 = 80% ET moisture — F_1= Foliar spray with 1000 ppm CCC
I_2 = 60% ET moisture — F_2 = Foliar spray with 2000 ppm CCC

4.4 Yield and yield contributing parameters

4.4.1 Fruit length

Average fruit length at the time of harvest was observed as significantly different by the different treatment of moisture (Table 13 and Appendix 11). Results revealed that the highest fruit length (6.11 cm) was found from I_1 (80% ET moisture) which was statistically identical with I_0 (100% ET moisture) where the lowest average fruit length (4.60 cm) was achieved from I_2 (60% ET moisture). Similar result was also found by Pugalia *et al.* (1992).

Different levels of CCC had significant effect on fruit length of tomato (Table 13 and Appendix 11). Results indicated that the highest fruit length[1] (6.40 cm) was found from F_1 (Foliar spray with 1000 ppm CCC) which was statistically similar with F_2 (Foliar spray with 2000 ppm CCC) where the lowest fruit length (4.93 cm) was achieved from F_0 (Foliar spray of water; control). The result found by Singh *et al.,* (2002) was similar with the present study.

Fruit length of tomato was significantly influenced by interaction effect of moisture and CCC (Table 9 and Appendix 11). Results revealed that the maximum fruit length (6.81 cm) was found from I_1F_1 which was statistically identical with I_0F_1, I_0F_0, I_0F_2, I_1F_0, I_1F_2, and I_2F_1 Again, the lowest fruit length (4.32 cm) was found from I_2F_0.

4.4.2 Fruit diameter

Significant influence was found for average fruit diameter at the time of harvesting by the different levels of moisture (Table 13 and Appendix 11). Results showed that the highest fruit diameter (6.82 cm) was found from I_1 (80% ET moisture) which was statistically different from all other treatment where the lowest average fruit diameter (5.47 cm) was achieved from I_2 (60% ET moisture). Intermediate level of fruit diameter was obtained from I_0 (100% ET moisture). Similar result was found by Pugalia *et al.,* (1992).

Different levels of CCC had significant effect on fruit diameter of tomato (Table 13 and Appendix 11). Results indicated that the highest fruit diameter (6.73 cm) was found from F_1 (Foliar spray with 1000 ppm CCC) which was statistically different from F_0 (Foliar spray of water; control) and F_2 (Foliar spray with 2000 ppm CCC) where the lowest fruit diameter (5.76 cm) was achieved from F_0 (Foliar spray of water; control). The result found by Singh *et al.,* (2002) was similar with the present study.

Fruit diameter of tomato significantly influenced by interaction effect of moisture and CCC (Table 12 and Appendix 11). Results revealed that the maximum fruit diameter (7.21 cm) was found from I_1F_1 followed by I_0F_1, I_1F_0 and I_0F_2. Again, the lowest fruit diameter (4.93 cm) was found from I_2F_0. The results obtained from the rest of the treatments showed intermediate results compared to highest and lowest fruit diameter.

4.4.3 Total number of fruits plant^{-1}

Different levels of moisture showed significant influence on total number of fruits plant^{-1} (Table 13 and Appendix 11). Results indicated that the highest total number of fruits plant^{-1} (32.22) was found from I_0 (100% ET moisture) followed by I_1 (80% ET moisture) where the lowest total number of fruits plant^{-1} (26.00) was achieved from I_2 (60% ET moisture).

Different levels of CCC had significant effect on total number of fruits plant^{-1} of tomato (Table 13 and Appendix 11). Results indicated that the highest total number of fruits plant^{-1} (29.11) was found from F_2 (Foliar spray with 2000 ppm CCC) which was statistically identical with F_1 (Foliar spray with 1000 ppm CCC) where the lowest total number of fruits plant^{-1} (26.11) was achieved from F_0 (Foliar spray of water; control).

Total number of fruits plant^{-1} of tomato varied significantly due to the interaction effect of moisture and CCC (Table 14 and Appendix 11). Results revealed that the maximum total number of fruits plant^{-1} (36.33) was found from I_0F_2 followed by I_0F_1 and I_1F_0. Again, the lowest total number of fruits plant^{-1} (24.33) was found from I_2F_0 followed by I_2F_2. The results obtained from the rest of the treatments showed intermediate results in respect of highest and lowest total number of fruits plant^{-1}.

Table 13. Effect of different moisture levels and CCC on different yield and yield contributing parameters of tomato

Treatments	Fruit length (cm)	Fruit diameter (cm)	Total number of fruits plant^{-1}	Total weight of fruit plant^{-1} (kg)
Effect of Moisture				
I_0	6.05 a	6.42 b	32.22 a	1.11 b
I_1	6.11 a	6.82 a	27.67 b	1.23 a
I_2	4.60 b	5.47 c	26.00 c	1.02 b
$LSD_{0.05}$	**0.1516**	**0.1548**	**0.3547**	**0.1048**
CV (%)	**8.369**	**6.592**	**9.621**	**5.389**
Effect of CCC				
F_0	4.93 b	5.76 c	26.11 b	1.14 ab
F_1	6.40 a	6.73 a	28.67 a	1.48 a
F_2	5.70 ab	6.22 b	29.11 a	1.04 b
$LSD_{0.05}$	**1.284**	**0.3589**	**0.5036**	**0.1095**
CV (%)	**8.369**	**6.592**	**9.621**	**5.389**

(Means bearing same letters do not differ significantly at 5% level of significance)

I_0 = 100% ET moisture F_0= Foliar spray of water (control)
I_1 = 80% ET moisture F_1= Foliar spray with 1000 ppm CCC
I_2 = 60% ET moisture F_2 = Foliar spray with 2000 ppm CCC

4.4.4 Total fruit weight plant^{-1}

Significant influence was found for different levels of moisture on total fruit weight plant^{-1} (Table 13 and Appendix 11). Results highlighted that the highest total fruit weight plant^{-1} (1.23 kg) was found from I_1 (80% ET moisture) which was significantly different from other treatments where the lowest total fruit weight plant^{-1} (1.02 kg) was achieved from I_2 (60% ET moisture) which was statistically identical with I_0 (100% ET moisture). Mohapatro *et al.,* (1998) and Pugalia *et al.,* (1992) observed similar result that was supported by the present findings.

Different levels of CCC had significant effect on total fruit weight plant^{-1} of tomato (Table 13 and Appendix 11). Results showed that the highest total fruit weight plant^{-1} (1.48 kg) was found from F_1 (Foliar spray with 1000 ppm CCC) which was statistically similar with with F_0 (Foliar spray of water; control) where the lowest total fruit weight plant^{-1} (1.04 kg) was achieved from F_2 (Foliar spray with 2000 ppm CCC). Similar result was observed by Rodrigues *et al.,* (2001).

Total fruit weight plant^{-1} of tomato significantly varied due to the interaction effect of moisture and CCC (Table 14 and Appendix 11). Results showed that the maximum total fruit weight plant^{-1} (1.27 kg) was found from I_1F_1 which was statistically similar with I_0F_0, I_0F_1, I_0F_2, I_1F_0, I_1F_2 and I_2F_1. Again, the lowest total fruit weight plant^{-1} (0.82 kg) was found from I_2F_2 followed by I_2F_0.

Table 14. Effect of CCC on different yield and yield contributing parameters of tomato at different moisture levels

Treatments	Fruit length (cm)	Fruit diameter (cm)	Total number of fruits plant^{-1}	Total weight of fruit plant^{-1} (kg)
I_0F_0	5.04 a-c	5.55 e	29.67 bc	1.09 ab
I_0F_1	6.67 a	6.93 b	30.67 b	1.09 ab
I_0F_2	6.44 ab	6.77 b	36.33 a	1.13 ab
I_1F_0	5.45 a-c	6.81 b	30.33 b	1.24 ab
I_1F_1	6.81 a	7.21 a	26.33 c	1.27 a
I_1F_2	6.12 ab	6.45 c	26.33 c	1.18 ab
I_2F_0	4.32 c	4.93 f	24.33 d	1.05 b
I_2F_1	5.73 a-c	6.05 d	29.00 bc	1.20 ab
I_2F_2	4.52 bc	5.44 e	24.67 cd	0.82 c
$LSD_{0.05}$	**1.741**	**0.273**	**1.752**	**0.1935**
CV (%)	**8.369**	**6.592**	**9.621**	**5.389**

(Means bearing same letters do not differ significantly at 5% level of significance)

I_0 = 100% ET moisture — F_0= Foliar spray of water (control)
I_1 = 80% ET moisture — F_1= Foliar spray with 1000 ppm CCC
I_2 = 60% ET moisture — F_2 = Foliar spray with 2000 ppm CCC

CHAPTER V

SUMMARY AND CONCLUSION

The present research work was conducted at Horticulture Farm in Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh to study the effect of Chlorocholine Chloride (CCC) on growth, morpho-physiological parameters and yield of tomato under different moisture levels. The experiment was carried out during Rabi season (November, 2014 to March, 2015). The experiment was conducted by Completely Randomized Design with eight replications. The study was comprised of two factors viz. Factor A; (i) I_0 = 100% ET moisture, (ii) I_1 = 80% ET moisture and (iii) I_2 = 60% ET moisture and Factor B; (i) F_0 = Foliar spray with water (control), (ii) F_1 = Foliar spray with 1000 ppm CCC and (iii) F_2 = Foliar spray with 2000 ppm CCC.

Data were collected on different growth, morpho-physiological parameters and yield of tomato. Most of the parameters were significantly influenced by different moisture levels, CCC and also their combination.

Results revealed that the highest plant height (32.56, 59.78 and 83.44 cm at 30, 30, 60 and 90 DAT, respectively), leaf length (36.44, 45.11 and 45.16 cm at 30, 60 and 90 DAT, respectively), length of internodes (6.83 and 8.11 cm at 60 and 90 DAT, respectively), number of fruits cluster^{-1} (9.44 and 10.67 at 60 and 90 DAT, respectively), number of fruits sets plant^{-1} (9.00, 15.67 and 20.00 at 50, 70 and 90 DAT, respectively) and the highest total number of fruits plant^{-1} (32.22) were recorded from I_0 (100% ET moisture).

Again, the highest foliage coverage (52.83, 77.00 and 88.89 cm at 30, 60 and 90 DAT, respectively), number of branches plant^{-1} (2.63, 5.91 and 10.54 cm at 30, 30, 60 and 90 DAT, respectively), number of leaves plant^{-1} (10.78, 19.11 and 27.33 cm at 30, 60 and 90 DAT, respectively), fruit length (6.11 cm), fruit diameter (6.82 cm) and the highest total fruit weight plant^{-1} (1.23 kg) was recorded from I_1 (80% ET moisture).

Similarly, the highest relative water content (6.28), stomata Conductance (0.21) and CO_2 assimilation/photosynthesis rate (7.83) were found from I_0 (100% ET moisture) but the highest chlorophyll Content (47.72) was found from I_1 (80% ET moisture).

Results also indicated that the lowest plant hight (32.00, 52.22 and 80.44 cm at 30, 60 and 90 DAT, respectively), foliage coverage (50.78, 74.11 and 77.78 cm at 30, 60 and 90 DAT, respectively), number of branches plant^{-1} (1.75, 3.62 and 7.41 cm at 30, 60 and 90 DAT, respectively), number of leaves plant^{-1} (9.89, 17.33 AND 24.33 cm at 30, 60 and 90 DAT, respectively), leaf length (35.29, 44.44 and 44.45 cm at 30, 60 and 90 DAT, respectively), length of internodes (6.16 and 7.88 cm at 60 and 90 DAT, respectively), number of fruits cluster^{-1} (7.88 and 9.11 at 60 and 90 DAT, respectively), number of fruits sets plant^{-1} (6.55, 12.56 and 16.33 at 50, 70 and 90 DAT, respectively), average fruit length (4.60 cm), average fruit diameter (5.47 cm), total number of fruits plant^{-1} (26.00) was achieved from I_2 (60% ET moisture) and the lowest total fruit weight plant^{-1} (1.02 kg) were achieved from I_2 (60% ET moisture).

Again, the lowest relative water content (5.28) and the lowest CO_2 assimilation/ photosynthesis rate (5.37) was achieved from I_1 (80% ET moisture) but the lowest stomata Conductance (0.05) was achieved from I_2 (60% ET moisture) and the lowest chlorophyll Content (46.26) was achieved from I_0 (100% ET moisture)

Results also disclosed that the longest plant (33.00, 59.78 and 84.89 cm at 30, 60 and 90 DAT, respectively) and highest internodal length (5.50, 6.16 and 7.13 cm at 30, 60 and 90 DAT, respectively) were found from F_0 (Foliar spray of water; control) but the maximum foliage coverage (53.00, 76.67 and 89.78 cm at 30, 60 and 90 DAT, respectively), maximum number of number of branches plant^{-1} (3.05 6.69 11.14 cm at 30, 60 and 90 DAT, respectively), highest leaf length (cm) (28.83, 39.00 and 47.00 cm at 30, 60 and 90 DAT, respectively), highest number of fruits sets plant^{-1} (10.40, 15.33 and 19.11 at 50, 70 and 90 DAT, respectively), highest fruit length (6.40 cm), highest fruit diameter (6.73 cm) and the highest total fruit weight plant^{-1} (1.48 kg) were found from F_1 (Foliar spray with 1000 ppm CCC).

Again, the highest foliage coverage (10.67 and 19.00 28.44 cm at 30, 60 and 90 DAT, respectively), number of fruits cluster^{-1} (9.33 and 10.44 at 60 and 90 DAT, respectively) and the highest total number of fruits plant^{-1} (29.11) were found from F_2 (Foliar spray with 2000 ppm CCC).

Similarly, the highest relative water content (6.36), highest stomata Conductance (0.19), highest chlorophyll content (47.59) and the highest CO_2 assimilation/ photosynthesis rate (7.03) was found from F_0 (Foliar spray of water; control)

The result obtained from the present study was found to be the lowest in terms of plant height (31.78, 50.56 and 80.22 cm at 30, 60 and 60 DAT, respectively), lowest intermodal length (5.27, 4.76 and 4.40 at 30, 60 and 90 DAT, respectively), fruit diameter (5.76 cm) and total fruit weight plant^{-1} (1.04 kg) were achieved from F_2 (Foliar spray with 2000 ppm CCC).

But the lowest foliage coverage (51.44, 73.67 and 76.56 cm at 30, 60 and 90 DAT), number of branches plant^{-1} (1.44 3.44 7.51 cm at 30, 60 and 60 DAT, respectively), foliage coverage (9.67, 16.56 and 23.56 cm at 30, 60 and 90 DAT, respectively), foliage coverage (26.06, 33.33 and 43.17 cm at 30, 60 and 90 DAT, respectively), number of fruits cluster^{-1} (8.22 and 9.44 at 60 and 90 DAT, respectively), number of fruits sets plant^{-1} (5.33, 12.56 and 16.22 at 50, 70 and 90 DAT, respectively), fruit length (4.93 cm) and the lowest total number of fruits plant^{-1} (26.11) were achieved from F_0 (Foliar spray of water; control).

Similarly, the lowest relative water content (4.91) were found from F_2 (Foliar spray with 2000 ppm CCC) where the lowest stomata conductance (0.06), lowest chlorophyll Content (46.67) and the lowest CO_2 assimilation/photosynthesis rate (5.92) were found from F_1 (Foliar spray with 1000 ppm CCC).

Results indicated that the highest plant height (34.00, 61.67 and 91.00 cm at 30, 60 and 90 DAT, respectively) and highest length of internodes (6.83 and 8.50 cm at 60 and 90 DAT, respectively) were recorded from I_0F_0 but the highest number of leaves plant^{-1} (11.00, 21.33 and 32.00 cm at 30, 60 and 90 DAT, respectively), highest leaf length (28.83, 39.00 and 47.00 cm at 30, 60 and 90 DAT, respectively), maximum number of fruits cluster^{-1} (10.30 and 11.33 at 60 and 90 DAT, respectively) and the maximum total number of fruits plant^{-1} (36.33) were found from I_0F_2. Again, maximum number of fruits sets plant^{-1} (15.34, 20.00 and 23.67 at 50, 70 and 90 DAT, respectively) were found from I_0F_1.

The highest foliage coverage (55.00, 79.33 and 93.00 cm at 30, 60 and 90 DAT respectively), maximum number of branches plant^{-1} (3.91, 7.91 and 12.35 cm at 30, 60 and 90 DAT, respectively), fruit length (6.81 cm), maximum fruit diameter (7.21 cm) and the maximum total fruit weight plant^{-1} (1.27 kg) was found from I_1F_1.

The maximum relative water content (7.83) and maximum relative water content (0.14) were found from I_0F_0 but the maximum chlorophyll Content (50.03) was found from I_1F_0 and the maximum CO_2 assimilation/photosynthesis rate (8.28) was found from I_0F_1.

Results also revealed that the lowest plant height (31.33, 34.00 and 81.00 cm at 30, 60 and 90 DAT, respectively), number of branches plant^{-1} (1.50 3.21 7.01 cm at 30, 60 and 90 DAT, respectively), lowest length of internodes (4.94 and 4.67 cm at 60 and 90 DAT, respectively) and lowest total fruit weight plant^{-1} (0.82 kg) was found from the treatment combination of I_2F_2.

But the minimum foliage coverage (50.00, 72.67 and 53.67 cm at 30, 60 and 90 DAT, respectively), number of leaves plant^{-1} (9.33, 17.67 and 24.00 cm at 30, 60 and 90 DAT, respectively), leaf length (cm) of BARI tomato-14 (26.00, 34.00 and 43.67cm at 30, 60 and 90 DAT, respectively), number of fruits cluster^{-1} (6.66 and 8.00 at 60 and 90 DAT, respectively), number of fruits cluster^{-1} (4.66, 11.00 and 14.33 at 50, 70 and 90 DAT, respectively), fruit length (4.32 cm), fruit diameter (4.93 cm) and the lowest total number of fruits plant^{-1} (24.33) were found from I_2F_0.

But in case of morpho-physiological parameters, the lowest relative water content (4.62) was found from I_2F_2, lowest stomata Conductance (0.04) was found from I_2F_1, lowest stomata Conductance (0.04) was found from I_0F_1 and lowest CO_2 assimilation/photosynthesis rate (3.20) was found from I_1F_1.

Conclusion

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

1. Application of CCC were found to contribute positively almost all parameters in plants subjected to mild moisture stress (80% ET moisture), where at higher moisture stress (60% ET moisture level) with 1000 ppm CCC were not afforded to express suitable physiological performance.
2. Under the present study, 80% ET moisture performed better for growth and yield parameters compared to lower water level.
3. The combined effect I_1F_1 performed better on growth, yield and yield attributes of tomato than other treatment combination.
4. Further study can be conducted at different agro-ecological zone of Bangladesh for precise recommendation.

REFERENCES

Abu-Awwad, A.M. (1999). Irrigation water management for efficient water use in mulched onion. *Journal of Agronomy & Crop Science*. **183**: 1-7.

Altintas, S.(2011).Effects of prohexadione-calcium with three rates of phosphorus and chlormequat chloride on vegetative and generative growth of tomato. *African Journal of Biotechnology*. **10**(75): 17142-17151

Ara, M.J.F. (2005). Effect of photosysthetically active radiation and moisture regimes on the performance of tomato (*Lycopersicon esculentum* Mill.). MS Thesis. Dept, of Agroforestry and Environment, BSMRAU, Gazipur, Bangladesh.

Awal, M.A. and, T. Ikeda. (2002). Recovery strategy following the imposition of episodic soil moisture deficit in stands of peanut (Arachis hypogaea L.). *Journal of Agronomy & Crop Science*. **188**: 185-192.

BBS, 2014.

Begum, M.N., A.J.M.S. Karim, M.A. Rahman, and K. Egashira.(2001). Effect of irrigation and application of phosphorus fertilizer on the yield and water use of tomato grown on a clay terrace soil of Bangladesh. *Journal of the Faculty of Agriculture, Kyushu University*. **45**(2): 611-619.

Bhosle, A. B.; S. B. Khrbhade; P.B. Sanap and M. K. Gorad. (2002). Effect of growth hormones on growth, yield of summer tomato (*Lycopersicon esculentum Mill*.). *Orissa Journal of Horticulture.* **30** (2): 63-65.

Bose, T.K. and, M.G. Som. (1986). Vegetable crops in India. B. Mitra Naya Prokash, Bidhan Sarani, Culcutta, India.

Ceme, M., L. Briski and B.J. Biceha. (1994). Nutrition and irrigation of tomato. *Acta Horticultural, Sorrento, Italy*. No. **376**: 319-322.

Choudhury, S.H. and Faruque, A.H.M. (1997). Effect of GA_3 on seedless of tomato. *Bangladesh Horticulture,* **67**(8): 13-16.

Dadomo. M.A., M. Gainga, Y. Dumas, P. Bussieres, J.I. Macua, M. Christou, and X. Branthome. (1994). Influence of water and nitrogen availability on yield componenets of processing tomato in the European Union countries. Acta, Horticulture Serrento, Italy. No**. 376**: 271-274.

Dhanasekaran, K. and R. Bhuvaneswari.(2005). Effect of nutrient-enriched humic acid on the growth and yield of tomato (*Lycopersicon esculentum* Mill.) *International Journal Agricultural Science,* 1(1): 80-83.

Djanaguiraman, M; D. D. Devi, J. A. Sheeba, U. Bangarusamy and R. C. Babu. (2004). Effect of oxidative stress on abscission of tomato fruits and its regulation by Nitrophenols. *Trap. Agricultural Research,* **16**: 25-36.

Doorenbas, M. and A.H. Kassam. (1979). Yield response to water. FAO Irrig. Drain, pp- 33. Rome.

Doring, T.F., M. M. Brandt, M.R. Finckh and H. Saucke.(2005). Effect of straw mulch on soil nitrate dynamics, weeds, yield and soil erosion in originally grown potatoes. *Field Crop Research*. **94**: 238-249.

Duraisamy, V.K., S.S. Bosu and K.V. Selvaraj. (1992). Studies on sprinkler irrigation for tomato. *South Indian Horticulture, India*. **40**(3): 184-185.

FAO (Food and Agricultural Organization). (2007). FAO Production Yearbook. Basic Data Unit. Statistic Division, FAO. Rome, Italy

FRG. 2012. Fertilizer Recommendation Guide, Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka 1215. 274p.

Ghuman, B.S. and R. Lai,. (1983). Mulch and irrigation effects on plant-water relations and performance of cassava and sweet potato. *Field Crop Research***.** **7**: 19-29.

Gupta, P. K. and A. K. Gupta.(2004). Influence of auxins and micronutrient formulations on phosphorus content in tomato (*Lycopersicon esculentum, Mill.)* fruits and its products. *Adv. PI. Science,* **17**(1): 129-132.

Gupta, P. K.; A. K. Gupta and M. L. Varshney. (2001). Effect of auxins (IAA & NAA) and micronutrient mixtures (Multiplex and Humaur) on biochemical parameters of tomato fruits. *Bionotes.* **3**(2): 38.

Gupta, P. K.; A. K. Gupta and S. Reddy.(2002a). Efficacy of auxins (IAA & NAA) and micronutrient mixtures (Multiplex & Humaur) on yield, dry weight and ash content of tomato fruits. *Bionotes,* **4**(1): 17-18.

Gupta, P. K.; A. K. Gupta and S. Reddy.(2002b). Efficacy of PGR (IAA and NAA) and micronutrient (Multiplex and Humaur) on growth parameters and yield of tomato fruits .*Bionotes*, **5**(2): 11-12

Gupta, P. K; A. K. Gupta and S. Reddy. (2003). Response of plant growth regulators and micronutrient mixtures on fruit size, colour and yield of tomato (*Lycopersicon esculentum. Mill.). Annual Agricultural Research,* **24**(1): 100- 103.

Hurtson R., (1985). Effects of CCC on the occurrence of tomato puffy fruits and the endogenous cytokinin activities. Scientia Horticulturae. **26**(2): 119-127

Jones, H.G. (2004). Irrigation scheduling: advantages and pitfalls of plant-based methods. *Journal of Experimental Botany*. **55**(407): 2427-2436.

Kanthaswamy, V., S. Nataranjan, C. Sibin, D. Veeraragavathatham, K. Srinivasan. (2004). Studies on the effect of media, fertigation, mulching and irrigation package on the performance of tomato *{Lycopersicon esculentum* Mill) hybrids. *Horticultural Science*, **18**(2): 468-478.

Kataoka, K.; A. Uemachi; M. Nonaka and S. Yazawa. (2004). Effects of endogenous gibberellins in the early stages of fruit growth and development of the 'Severianin' tomato. *J. Horticultural Science. Biotech*., **79**(1): 54-58.

Khan, M. M. A; G. Champa; M. Firoz; M. H. Siddiqui; M. Naeem and M. N. Khan. (2006). Effect of gibberellic acid spray on performance of tomato. Turkish J. *Biochem.,* **30**(I): 11-16.

Kumar, J., Lal, M. and Pal, K.(2012). Effect of cycocel on growth, yield and quality of tomato (*Lycopersicon esculentum* Mill.). *Hort Flora Res. Spectrum*, **1**(2): 162-164

Kumavat, S.D. and Chaudhari,Y.S. (2013). Lycopene and its role as prostate cancer chemo preventive agent. *International Journal of Research in Pharmacy and Chemistry*,**3**(3):545-551

Lin, S.S.M., J.N. Hubbell, A.C.S. Tsou and W.E. Splitts-toeser. (1983). Drip irrigation and tomato yield under tropical conditions. *Horticultural Science*, **18**(4): 460-461.

Lobo, F.A., M.A. Oliva and M. Resende. (2004). Infrared thermometry to schedule irrigation of common bean. *Pesq. Agropec bras., Brasilia***. 39**(2): 113-121.

Machado, R.M.A. and M.R.G. Oliveira. (2005). Tomato root distribution, yield and fruit quality under different subsurface drip irrigation regimes and depths*. Irrigation Science,* **24**:15-24.

May, D.M. and J. Gonjales. (1994). Irrigation and nitrogen management as they affect fruit quality and yield of incrasing tomatoes. *Acta Horticulture*, *Sorrento, Italy*, No.**376**: 227-234.

Mohapatro, B.K., D. Lenka, and P. Naik.(1998). Effect of plastic mulching on yield and water use efficiency in maize. Annual *Agricultural Research* **19**(2): 210-211.

Murshed, A.N.M.M., A. Hamid, M.A.A. Miah and J. Afroze. (1997). Effect of shading and moisture regime on growth, flowering, pod set and yields of chickpea*. Bangladesh Agronomy Journal*, **7**(1 &2): 61-68.

Nandan, R. and U.K. Prasad. (1998). Effect of irrigation and nitrogen on growth, yield, nitrogen uptake and water-use efficiency of French bean *{Phaseol vulgaris). Indian Journal of Agricultural Science*. **68**(2): 75-80.

Nibhavanti, B.; M. N. Bhalekar; N. S. Gupta and D. Anjali. (2006). Effect of growth regulators on growth and yield of tomato in summer. *Maharashtra J. Agric***., 31**(1): 64-65.

Niu, J.Y., Y.T. Gan and G.B.(2004). Dynamics of root growth in spring wheat mulched with plastic film. http:\\crop. cijoumals.org/cgi/ content/ abstract/ 44/ 5/1682.

Olasantan, F.O.(1999). Effect of time of mulching on soil temperature and moisture regime and emergence, growth and yield of white yam in western Nigeria. Soil & Tillage Research. **50**: 215-221.

Pemiola, M., A.R. Rivelli and V.Candido.(1994). Yield response to water and stress indexes on tomato. Acta Horticultural, Sorrento, Italy. No. **376**: 215-225.

Peterson, A.C.J. (1989). Effect of water stress on *Phaseolus valgaris* L, and *P. acutifolius*. *Horticultural Abstract*. **59**(4): 333.

Pugalia S., B. Cascio, G. Venezia and S. Pugali. (1992). The effect of irrigation system on tomato yields and properties in Alto Lazio. Irrigation-e-dienaggio, Italy. **93**(3): 56-62.

Pundir, J. P. S. and P. K. Yadav.(2001). On effect of GA^, NAA and 2, 4-D on growth, yield and quality of tomato var. Punjab Chhuhara. *Current Agric.,* **25**(1/2): 137-138.

Ramalan, A.A.and C.U.Nwokeocha.(2000). Effects of furrow irrigation methods, mulching and soil water suction on the growth, yield and water use efficiency of tomato in the Nigerian Savana. Department of Agricultural Engineering, Institute for Agricultural Research, Ahmadu Bello University,PMB 1044, Zaria, Nigeria. **45**(3): 317-330.

Reddy, M. P. P.; K. Dhanasekaran; K. P. Saravanan and D. Venkatakrishnan. (2004). Effect of foliar application of enriched humic substances on the performance of tomato (*Lycopersicon esculentum Mill.). Mysore Journal Agricultural Science,* **38**(4): 468-473.

Rodrigues, M. J; S. D. Warade and S. D. Patil. (2001). Effect of growth regulators and truss sequence on hybrid seed yield of tomato hybrid. *Adv. PI. Science,* **14**(2): 495-499.

Rudich, J. and V. Iuchinsky. (1987). Water Economy. The tomato crop. J.G. Atherton and J. Rudich, eds. Champman and Hall London, pp 335-367.

Sasaki, H.; T. Yano and A. Yamasaki.(2005). Reduction of high temperature inhibition in tomato fruit set by plant growth regulators. JARQ, *Japan Agricultural Research. Quart*.**9**(2): 135-138.

Sharma, I. P., S. Kumar and P. Kumar.(2007). Effect of drip irrigation and mulches on yield, quality and water- use efficiency in strawberry under mid hill conditions. ISHS Acta Horticulturae 696: VII. International Symposium on Temperate Zone Fruits in the Tropics and Subtropics- Part Two.

Singh, B.; N. Singh; S. K. Singh and S. Kumar. (2003). Effects of phytohormones with different methods of application on the growth and yield of tomato *(Lycopersicon esculentum Mill.). Prog. Agriculture,* **3**(1/2): 33-35.

Singh, J.; K. P. Singh and G. Kalloo. (2002). Effect of some plant growth regulators on fruit set and development under cold climatic conditions in tomato *(Lycopersicon esculentum Mill.). Prog. Horticulture,* **34**(2): 211-214.

Singh, R.; A. K. Sant and L. Singh. (2005). Effect of plant growth regulators and micro-nutrient mixtures on growth and yield of tomato *(Lycopersicon esculentum Mill.). Bioved*, **16**(1/2): 101-105.

Souza, G.M., J.O.F. Viana and R.F. Oloverira.(2005). Asymmetrical leaves induced by water deficit show asymmetric photosynthesis in common bean. Braz. *J. Plant Physiology*, **17**(2): 223-227.

Sun, Y. W.; J. Chen; M. Tseng; W. Chang and T. Sheen. (2000). The role of growth regulators on cold water for irrigation reduces stem elongation of plug-grown tomato seedlings. *Chinese Journal Agro meteorology*, **7**(4): 61-68. [Cited from, Horticultural Science Database, Rec. 103, 2000],

Sushant, R., S. Dixit, and G.R. Singh. (1999). Effect of irrigation, nitrogen and phosphorus on seed yield and water use of rajmash (*Phciseolus valgaris). Indian Journal of Agronomy*. **44**(2): 382-388.

The Meteorological Department of Bangladesh, Agargaon, Dhaka.

Tuzel, I.H., M.A. Ve and Y. Tuzel.(1994). Effect of different irrigation intervals and rates on spring season glasshouse tomato production; I. Yield and plant growths. Acta Horticulture, Adana, Turkey. No, **366**: 381-388.

Van Ootegem, W., J. Feyen, M. Badji and L. Bantanie. (1982). Optimazation of water consumption by a tomato crop in a semiarid climate. *Indian Journal of Agronomy*. **2**(1): 31-36.

Vazquez, N.A., Pardo, M.L. Suso, and M. Quemada.(2006). Drainge and nitrate leaching under processing tomato growth with drip irrigation and plastic mulching. Agriculture, Ecosystems & Environment. **112**(4): 313-323.

Wang, J., Q. Yu, L.H. Li, X.G. Li, Y.G.R. Yu and X.M. Sun.(2006). Simulation of diurnal variations of CO2, water and heat fluxes over winter wheat with a model coupled photosynthesis and transpiration. *Agricultural and Forest Meteorology*. **137**(3-4): 194-219.

Westerfield, R.R. (2005). Bulletin 1271/June, (2005), growing tomato. The University of Georgia and Ft. Valley State University, the U.S. Department of Agriculture and counties of the state cooperating.

Zhang, X., S. Chen., M. Liu, D. Pie and H. Sun. (2005). Improved water use efficiency associated with cultivars and agronomic management in the north China plain. *Agronomy Journal*. **97**: 783-790.

Appendices

Appendix1. Monthly record of air temperature, rainfall, relative humidity and sunshine of the experimental site during the period from November 2014 to April 2015

Year	Month	Air Temperature (^{0}c)			Relative humidity (%)	Rainfall (mm)	Sunshine (hr)
		Maximum	Minimum	Mean			
2014	November	28.5	17.9	23.2	68.5	0.0	233.2
2014	December	27.6	15.2	21.4	71.6	0.0	210.5
2015	January	24.6	13.5	19.10	66.50	3.00	194.10
2015	February	28.90	18.00	23.40	61.00	2.00	221.50
2015	March	33.60	29.50	31.60	72.70	3.00	227.00
2015	April	33.50	25.90	299.20	68.50	1.00	194.10

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix 2. The mechanical and chemical characteristics of soil of the experimental site as observed prior to experimentation

Particle size constitution:

Sand	:	40 %
Silt	:	40 %
Clay	:	20 %
Texture	:	Loamy

Chemical composition:

Constituents	:	0-15 cm depth
P^H	:	5.45-5.61
Total N (%)	:	0.07
Available P (µ gm/gm)	:	18.49
Exchangeable K (meq)	:	0.07
Available S (µ gm/gm)	:	20.82
Available Fe (µ gm/gm)	:	229
Available Zn (µ gm/gm)	:	4.48
Available Mg (µ gm/gm)	:	0.825
Available Na (µ gm/gm)	:	0.32
Available B (µ gm/gm)	:	0.94
Organic matter (%)	:	0.83

Source: Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

Appendix 3. Effect of Chlorocholine Chloride (CCC) on plant height of tomato at different moisture levels

Source of variation	Degrees of freedom	Mean square of plant height (cm)		
		30 DAS	60 DAS	90 DAS
Replication	2	0.461	0.3263	0.56
Factor A	2	3.821*	6.557*	5.941*
Factor B	2	5.261*	8.23*	10.628*
AB	4	2.191*	4.189*	3.634**
Error	16	1.854	1.478	1.457

Appendix 4. Effect of Chlorocholine Chloride (CCC) on foliage coverage of tomato at different moisture levels

Source of variation	Degrees of freedom	Mean square foliage coverage		
		30 DAS	60 DAS	90 DAS
Replication	2	0.723	0.168	0.442
Factor A	2	5.420*	4.379*	4.893*
Factor B	2	11.817*	9.186*	11.173**
AB	4	6.748**	6.397**	3.194*
Error	16	2.027	3.091	3.806

Appendix 5. Effect of Chlorocholine Chloride (CCC) on number of branches plant^{-1} of tomato at different moisture levels

Source of variation	Degrees of freedom	Mean square of number of branches plant^{-1}		
		30 DAS	60 DAS	90 DAS
Replication	2	0.166	0.352	0.340
Factor A	2	4.20*	2.938*	3.70*
Factor B	2	10.17*	6.179*	9.672**
AB	4	3.48**	4.384**	4.316*
Error	16	1.002	1.074	2.287

Appendix 6. Effect of Chlorocholine Chloride (CCC) on no. of leaves of tomato at different moisture levels

Source of variation	Degrees of freedom	Mean square of number of leaves plant^{-1}		
		30 DAS	60 DAS	90 DAS
Replication	2	0.212	0.323	0.393
Factor A	2	3.730*	5.124*	4.285*
Factor B	2	8.62**	8.086*	8.792*
AB	4	1.321*	3.634*	2.245*
Error	16	1.210	1.166	1.238

Appendix 7. Effect of Chlorocholine Chloride (CCC) on leaf length of tomato at different moisture levels

Source of variation	Degrees of freedom	Mean square of leaf length (cm)		
		30 DAS	60 DAS	90 DAS
Replication	2	0.134	0.241	0.325
Factor A	2	1.174*	1.260*	0.878*
Factor B	2	2.366**	2.293*	1.165**
AB	4	0.651*	1.141*	1.144*
Error	16	0.341	0.866	0.317

Appendix 8. Effect of Chlorocholine Chloride (CCC) on length of internodes of tomato at different moisture levels

Source of variation	Degrees of freedom	Mean square of length of internodes (cm)		
		30 DAS	60 DAS	90 DAS
Replication	2	0.127	0.022	0.031
Factor A	2	3.260^{NS}	0.398*	0.821*
Factor B	2	6.177^{NS}	1.134^{NS}	2.154^{NS}
AB	4	2.498^{NS}	0.364**	1.163*
Error	16	0.002	0.075	0.076

Appendix 9. Effect of Chlorocholine Chloride (CCC) on number of fruits cluster^{-1} of tomato at different moisture levels

Source of variation	Degrees of freedom	Mean square of number of fruits cluster^{-1}	
		60 DAT	90 DAT
Replication	2	0.725	1.566
Factor A	2	8.70*	7.941*
Factor B	2	12.62**	13.672*
AB	4	14.31*	8.691**
Error	16	2.210	2.579

Appendix 10. Effect of Chlorocholine Chloride (CCC) on number of fruit sets of tomato at different moisture levels

Source of variation	Degrees of freedom	**Mean square of number of fruits sets plant^{-1}**		
		50 DAT	70 DAT	90 DAT
Replication	2	0.103	0.204	0.053
Factor A	2	2.349*	2.171**	2.270**
Factor B	2	6.039*	4.033*	7.265*
AB	4	3.062**	3.572*	3.079*
Error	16	1.421	1.052	2.817

Appendix 11. Effect of Chlorocholine Chloride (CCC) on different yield and yield contributing parameters of tomato at different moisture levels

Source of variation	Degrees of freedom	Mean square			
		Fruit length (cm)	Fruit diameter (cm)	Total number of fruits plant^{-1}	Total weight of fruit plant^{-1} (kg)
Replication	2	0.071	0.009	0.137	0.029
Factor A	2	1.525*	1.275*	2.034*	0.687*
Factor B	2	5.016*	2.732*	8.79*	2.64*
AB	4	2.654*	0.213*	3.61*	1.21**
Error	16	1.193	0.238	2.12	0.117

Appendix 12. Effect of Chlorocholine Chloride (CCC) on different morpho physiological properties of tomato at different moisture levels

Source of variation	Degrees of freedom	Mean square			
		Relative water content	Stomata Conductance	Chlorophyll Content	CO_2 assimilation/ photosynthe sis rate
Replication	2	0.164	0.052	2.361	0.245
Factor A	2	3.852*	0.123*	5.341*	2.375*
Factor B	2	8.538*	0.360**	11.255*	5.239*
AB	4	2.725*	0.090*	3.027**	1.413*
Error	16	1.852	0.023	2.341	0.375