GROWING CHERRY TOMATO VARIETIES UNDER VARIABLE FREQUENCY OF DRIP IRRIGATION

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Most surely in the creation of the heavens and the earth and the alternation of the night and the day, there are signs for men who understand.

(Surah Al Zumar 3:190)

DEDICATED TO

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CERTIFICATE

*This is to certify that thesis entitled, **"GROWING CHERRY TOMATO VARIETIES UNDER VARIABLE FREQUENCY OF DRIP IRRIGATION"** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTER OF SCIENCE in HORTICULTURE,** embodies the result of a piece of bona fide research work carried out by **MD. IMAM HOSSAIN**, Registration No. **14-06290** 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 duly been acknowledged.

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- The author

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ABSTRACT

A pot experiment was conducted on the rooftop at the Academic Building, Sher-e-Bangla Agricultural University, Dhaka-1207 during November 2019 to March 2020 to evaluate the influences of irrigation frequency on the growth and yield of cherry tomato varieties under drip irrigation system. Four cherry tomato varieties and three levels of drip irrigation frequencies were used in this experiment. The cherry tomato varieties were: SAU Cherry Tomato-1 (V_1), Crimson Red (V_2), Australian Cherry (V_3), Sutton Cherry (V_4); and drip irrigation frequencies were: Once a day (I_1), Twice a day (I_2) and Thrice a day (I_3). All the drip irrigation treatments have received the same amount of water with different frequency of application. The experiment was outlined in the Completely Randomized Design with five replications. Significant variation was found with the treatments. Among the varieties, the maximum plant height (153.30 cm), flower number (995.20/plant), fruit number (645.50/plant) and fruit yield (3.37 Kg/plant) were found from V_1 while the minimum fruit yield (1.67 Kg/plant) was found from V_3. Irrigation once a day (I_1) gave the best results for growth and yield related parameters than other applications. The highest fruit yield (4.44 Kg/plant) was found from combination V_1I_1 and lowest yield (1.06 Kg/plant) was found from the combination V_3I_3. In view of the overall performances, SAU Cherry Tomato-1(V_1) with irrigation once a day (I_1) provided the best results for the growth and yield attributes.

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ABBREVIATIONS AND ACCORONYMS

Agric.	=	Agricultural
Agron.	=	Agronomy
AEZ	=	Agro-ecological Zone
ANOVA	=	Analysis of Variance
BADC	=	Bangladesh Agricultural Development Corporation
BARI	=	Bangladesh Agricultural Research Institute
Biol.	=	Biology
Chem.	=	Chemistry
Coeff.	=	Coefficient
cm	=	Centimeter
CV	=	Coefficient of variance
DAT	=	Days after transplanting
Dec.	=	Decimal
Deve.	=	Development
Eff.	=	Effective
ET_0	=	Evapotranspiration
et al.	=	And others
Ex.	=	Experiment
FAO	=	Food and Agriculture Organization
FC	=	Field Capacity
g	=	Gram
Hort.	=	Horticulture
i.e.	=	That is
Init.	=	Initial
Int.	=	International
Irr.	=	Irrigation
J.	=	Journal
Kc	=	Crop Coefficient
Kg	=	Kilogram
L	=	Liter
LSD	=	Least Significance Difference

Manag.	=	Management
MJ	=	Megajoules
mm	=	Millimeter
Rad	=	Radiation
CRD	=	Completely Randomized Design
Res.	=	Research
SAU	=	Sher-e-Bangla Agricultural University
Sci.	=	Science
spp.	=	Species
Tech.	=	Technology
TSS	=	Total Soluble Solids
UNDP	=	United Nations Development Programme
Viz.	=	Namely

CHAPTER I

INTRODUCTION

Cherry tomato (*Solanum lycopersicum* L. var. *cerasiforme*) is a cultivated variety of tomato belonging to the family Solanaceae. It is thought to have originated in Peru and Northern Chile. It is the probable ancestor of all the cultivated tomatoes. The variety is generally considered to be similar but not identical to the wild relatives of the domestic tomato (Prema *et al*., 2011). Cherry tomatoes are widely cultivated in Central America and distributed in California, Korea, Germany, Mexico and Florida. It is grown for its edible fruits; these are perfect for making processed products like sauce, soup, ketchup, puree, curries, paste, powder, rasam and sandwitch (Anonymous, 2009). It is a popular type of table tomato with small fruits (1.5-3.5 cm in diameter) on long panicles and its demand for has been increased in the market, chiefly due to the recognition of their high quality and good taste (Kobryn and Hallmann, 2005).

Cherry tomato is a tomato variety with small fruit, different shapes and colours and mainly used for fresh consumption. It has a sweeter taste, intense colour and flavour, generally round and weighing 10 to 30g (Prema *et al*., 2011). Its fruits are consumed more as a salad rather than as a vegetable. Cherry tomato often called 'Salad tomato too'.

It is also beneficial to human health because of its high contents of antioxidants and phytochemical compounds, including lycopene, β-carotene, flavonoids, vitamin C and many essential nutrients (Rosales *et al*., 2011). They are a great source of vitamin C (13 mg/100 g), dietary fibre (2.0 g), vitamin A (25%) and vitamin K and also a good source of vitamin E (Alpha Tocopherol), thiamine, niacin, vitamin B_6 , foliate, phosphorus, copper, potassium and manganese (Anonymous, 2009).

This tomato is a new crop in Bangladesh and becoming popular day by day but yield is low due to lack of proper irrigation and nutrient management system.

Irrigation is a vital agricultural practice affecting both the yield and fruit quality. Indeed, the irrigation schedule has a great impact on the growth, yield and fruit quality of tomato depending on the amount of water applied (Kere *et al*., 2003). Tomato is most sensitive to water shortage during the flowering and fruit formation stages (Jie *et al*., 2019).

It is a high water demand vegetable crop and is generally cultivated under surface irrigation but excessive use of irrigation water leads to over exploitation of groundwater resources and deterioration of the environment (Kang *et al*., 2004; Ma *et al*., 2005). Although sufficient water is a prerequisite for good plant growth and fruit development, over-watering reduces quality and increases the production costs (Amundson, 2012). In the furrow and the border irrigation system, loss of applied irrigation water from reservoir to the field under unlined irrigation system is as much as 71% (Navalawala, 1991). Such huge amount of water loss also causes abundant nutrient loss through seepage or percolation.

In Bangladesh, water is a scarce resource for irrigation use in many parts of the country. About 88% of the fresh water resources in Bangladesh are currently being used for agriculture (FAO, 2012). About 73.44% of the total cultivated area is irrigated from the groundwater and the remaining 26.56% area is irrigated with the surface water (BADC, 2019). So, there is a tremendous pressure on agriculture sector to reduce its share of water and at the same time to improve total production by enhancing productivity with increased water use efficiency. Thus, there is an urgent need to increase the productivity of crops with concomitant conservation of water resources.

Drip irrigation can be an effective way to achieve water conservation due to its potential for uniform distribution, localized application of water without irrigating the non-cropped area and reducing soil evaporation, easiness for automated control of water application of small to very small and frequent irrigation depths (Hanson *et al*., 2006 and Karlberg *et al*., 2007).

Drip irrigation is a type of micro-irrigation system that has potential to save water and nutrients by allowing water to drip slowly to the root zone of plants either from above the soil surface or buried below the surface. Drip irrigation has proved its superiority over other methods of irrigation and fertilizer application, especially in the cultivation of fruits and vegetables due to precise and direct application of water and nutrients in the active plant root zone. The superiority of drip irrigation over the sprinkling and surface irrigation has been reported by various authors, e.g., drip irrigation system saves irrigation water, increases water use efficiency, decrease leaching and volatilization ensures high quality products, increases crop yield and ensuring higher fertilizer use efficiency (Qureshi *et al*., 2001; Miller *et al*., 1981; Papadopoulos, 1995; Sivanappan, 1994 and Namara *et al*., 2005). Drip irrigation reduces water contact with crop leaves, stems and fruit, thus provides conditions less favourable for disease development. Therefore, optimal irrigation management and scheduling are essential to increase water-use efficiency (WUE) in agricultural production. In addition, frequency of water application is one of the most important factors in drip irrigation management because of its effect on soil water regime, root distribution around the drip holes, the amount of water uptake by roots and water percolating beyond the root zone (Assouline, 2002 and Wang *et al*. 2006).

For maximizing cherry tomato production, priority must be given on the efficient use of water, thus to both improve yield and control the water use efficiency through minimizing the non-beneficial water uses.

Considering the above facts and present situation this investigation has been undertaken with the two following objectives:

- To study the growth and yield performance of four cherry tomato varieties
- To study the influence of irrigation frequency on growth and yield of cherry tomato varieties

CHAPTER II

REVIEW OF LITERATURE

A comprehensive and critical review of past researches is very essential for any scientific investigation. It provides not only knowledge of work already done in the field but insight in the methods and procedures too. It furthers provides a basis for operational definitions of major concepts. Relevant reviews also support the results and discussion of the study.

Since drip irrigation technology is a new approach in Bangladesh, much work in this field has not been reported so far from extension point of view. However, some of significant research works the done in home and abroad related to this experiment have been presented (alphabetically) in this chapter.

Ahmed *et al*. (2010) conducted an experiment to study the effect of drip irrigation on growth, yield and quality of banana. They studied water quantity and efficiency with fertigation in comparison to farmer practice. The results indicated that the amount of applied irrigation water with drip irrigation system was lower than that needed under surface irrigation. The banana under drip irrigation system performed better in plant growth and flowered earlier in comparison with surface irrigation.

Alaoui *et al*. (2014) had an experiment using drip irrigation and plastic mulch to evaluate the effects of irrigation scheduling on water requirements and vegetative parameters of tomato under typical Massa greenhouses growing conditions. Capacitive sensors were used to automatically schedule irrigations. The result of that study show that irrigation dose and frequency did not affect stem diameter in grafted tomato plant, no significant effect on leaves number had been observed. But irrigation scheduling had a large effect on root's development. The root containers results indicated that a water stress equivalent to 50% ETc and 20% frequency can lead to deep root system; that makes possible to sustain a suitable vegetative canopy if doses and frequencies are well managed in a daily scale, it was possible save 50% of irrigation water.

Antony and Singandhupe (2004) studied the effect of different irrigation methods and schedules on morphology, yield and water use efficiency of capsicum (*Capsicum annum* L.) var. California Wonder. It was found that the plants grown under drip irrigation had more number of branches and plant heights compared to that of surface irrigated plants. Root mass was more in surface irrigated crop whereas total root length was more in drip irrigated crop.

Badr and Yazied (2007) conducted a two-year field experiment with subsurface drip-irrigated tomato to determine the effects of two N application rates and four-fertigation frequencies (intervals of 1, 3, 7, and 14 days) on tomato yield, N uptake and soil N status. Total tomato yield and yield components were responsive to N rate and to decreased fertigation frequency. The highest total fruit yields averaged (67.75, 65.13 and 63.29 t/ha) with the frequencies of 1, 3 and 7 days respectively. Yields with the longest duration were significantly lower than these values (54.32 t/ha). Wide differences N concentrations in leaves were observed in the early vegetative stage which were mainly dependent on the rate of N supply. Similarly, N rate and fertigation frequency resulted in significantly differences in N uptake, N recovery and N use efficiency (NUE). Total N uptake was appreciable higher with increasing N rate and with more frequent than with less frequent fertigation. The averaged N recovery across fertigation frequencies was 60 and 54 % and NUE was 221 and 194 kg yield/kg N with 200 and 300 kg N/ha applied respectively. Analysis of soil samples following tomato harvest indicated considerable influence of fertigation frequency on NO -N distribution in soil profile. The NO_3^- N in lower soil profiles (50-70 cm soil depth) with the high N rate treatments was marginally affected in daily, 3 days and weekly fertigation (15, 17 and 21 mg/kg soil), respectively. However, NO_3^- N in the corresponding soil depth was appreciable higher (80 mg/kg soil) in biweekly fertigation frequency, a fact which has important agronomic implications regarding the frequency of nitrate applications under drip irrigation.

Bangal *et al.* (1987) indicated that tomato was very much responsive to drip irrigation. Whereas the yield increased from negligible to 50 per cent in some locations, there was universally a high water economy at most of the locations with a saving of 30 to 50 per cent.

Barua and Phookan (2009) evaluated the effect of drip irrigation and plastic mulch on yield of broccoli (*Brassica oleracea* L. var. *italica*) and the results showed 64 to 124 % yield increase due to drip irrigation. Among the different drip irrigation levels, 100 % of irrigation requirement met through drip showed highest yield. Highest net return was observed for the treatment where 100 % of net volume of water was met with drip irrigation and plants were mulched with black plastic mulch.

Beyaert *et al*. (2007) studied the response of processing cucumber (*Cucumis sativus* L.) to irrigation and fertilization strategies on a loamy sand and found that dry matter accumulation, fruit yield, economic return and water use efficiency were compared for (a) non-irrigated with conventional broadcast fertilizer applications, (b) overhead sprinkler irrigated with conventional broadcast fertilizer applications, (c) surface drip irrigated with fertigation and (d) subsurface drip irrigated with fertigation. All irrigation methods enhanced yields, with drip irrigation coupled with fertigation showed significant advantages in terms of yield and economic returns compared with overhead irrigation and conventional fertilization practices.

Bhakare and Fatkal (2008) investigated the influence of micro irrigation and fertilizer levels through fertigation on growth, yield and quality of onion seed and they reported a saving of irrigation water (39.9 %) through drip system compared to surface irrigation. The water use and fertilizer use efficiency were maximum under fertigation treatments.

Bhogi *et al*. (2011) conducted an experiment on brinjal under drip and furrow irrigation with different recommended doses of fertilizers. The highest benefit cost ratio was recorded in 100 % ET with 100 per cent recommended fertilizer doses (4.99) as compare to furrow irrigation with 100 % fertilizer doses (3.72).

Cukaliev *et al*. (2008) determined the best irrigation and fertigation practice for tomato crop (*Lycopersicon esculentum* Mill.) to achieve highest yield with maximum fertilizer use efficiency. Five experimental treatments included the following: The first three treatments (T_1, T_2 and T_3) included a combination of drip irrigation and fertigation, treatment (T_4) included drip irrigation, but with conventional application of fertilizer, and the fifth treatment, (T_5), included furrow irrigation practice with conventional application of fertilizer. To determine fertilizer use efficiency, part of nitrogen was applied as labelled urea with 15N stable isotope. The results of this study indicated that to obtain acceptable/maximum tomato yield with high nitrogen fertilizer use efficiency (NFUE) the practice of drip irrigation in combination of fertigation with irrigation frequency of either two (T_1) or four (T_2) days is recommended.

Dingre *et al*. (2012) studied the feasibility of fertigation scheduling through drip on growth and yield of onion seed (*Allium cepa* L). The results revealed that 100 % water soluble fertilizers in 12 equal splits up to 2 months was significantly superior in respect of growth and quality parameters of the seed. The fertigation applied in 12 splits up to 2 months produced significantly higher seed yield (602 kg ha^{-1}). The lowest value of growth and seed yield were recorded when irrigation applied by surface method with conventional fertilizer (347 kg ha^{-1}). The findings showed that drip fertigation resulted into 12 to 74 % increase in the productivity of onion seed as compared to conventional method. It was concluded that drip fertigation of 100 % water soluble fertilizers in 12 weekly splits up to 2 months duration was found effective for growth, yield and quality for onion seed production.

Guohua *et al.* (2010) studied the effects of different irrigation methods: border irrigation, sprinkler irrigation and surface drip irrigation on root development and profile water uptake in winter wheat. Results showed that the main root distribution zone moved upward under sprinkler and surface drip irrigation when compared to the traditional border irrigation. Due to the appropriate soil water and higher root density in the surface soil layer under sprinkler and surface drip irrigation, the main water uptake zone was concentrated in the upper layer.

Gupta *et al*. (2015) evaluated the yield, quality and water/fertilizer use efficiency in tomato hybrid SH-TH-1 under drip irrigation and fertigation technology at the experimental farm of Division of Olericulture, SKUAST-K, Shalimar, Srinagar. The experiment was with four replications of 16 treatment combinations. Surface irrigation and manual fertilizer application were treated as control. Irrigation was given based on the estimated crop water requirement following alternate day irrigation schedule for drip irrigation while the surface irrigation was given according to the locally adopted frequency. Drip irrigation at 80% ET and fertigation with 60% recommended NPK significantly enhanced fruit yield of (989.3 q/ha), higher water use efficiency (49.9 q/ha-cm) and fertilizers use efficiency (10.9, 18.3 and 27.4 q/kg NPK, respectively). Average fruit weight, fruit length and fruit diameter also exhibited higher values (53.0 g, 4.48 cm and 4.75 cm, respectively with the same treatment combination. However quality characteristics like TSS, vitamin C, lycopene content and total sugar content were found much improved with the treatment combination of 80% ET through drip and 80% recommended NPK through fertigation.

Hakkim (2014) compared the effect of site specific drip fertigation in completely randomized design (CRD) with six treatments. Hybrid chilli (hot line) was used as the test crop. Fertigation was done once in five days starting from 15 up to 150 DAP. The different yield parameters like fruit length, fruit girth, fruit weight and number of fruits per plant also varied in the same trend as that of total green fruit yield. In case of low fertility area, highest BCR was obtained for the treatment site specific drip fertigation and daily drip irrigation (2.42) followed by the treatment site specific drip fertigation and alternate day drip irrigation (2.25). The lowest BCR was obtained under the treatment with manual application of fertilizer and alternate day drip irrigation (1.91). In case of high fertility area, corresponding values of BCR were 2.47, 2.43 and 2. 17 respectively.

Harmanto *et al*. (2005) four different levels of drip fertigated irrigation equivalent to 100, 75, 50 and 25% of crop evapotranspiration (ETc), based on Penman–Monteith (PM) method, were tested for their effect on crop growth, crop yield, and water productivity. Results were compared with the open cultivation system as a control. Two modes of irrigation application namely continuous and intermittent were used. The distribution uniformity, emitter flow rate and pressure head were used to evaluate the performance of drip irrigation system with emitters of 2, 4, 6, and 8 l/h discharge. The results revealed that the optimum water requirement for the Troy 489 variety of tomato is around 75% of the ETc. Based on this, the actual irrigation water for tomato crop in tropical greenhouse could be recommended between 4.1 and 5.6 mm day^{-1} or equivalent to 0.3–0.4 l plant^{-1} day^{-1}. Statistically, the effect of depth of water application on the crop growth, yield and irrigation water productivity was significant, while the irrigation mode did not show any effect on the crop performance. Drip irrigation at 75% of ETc provided the maximum crop yields and irrigation water productivity. Based on the observed climatic data inside the greenhouse, the calculated ETc matched the 75–80% of the ETc computed with the climatic parameters observed in the open environment. Moreover, the distribution uniformity was 93.4 to 90.6%.

Hebbar *et al*. (2004) judged the effects of fertigation with sources and levels of fertilizer and methods of fertilizer application on the growth, yield and fertilizer-use efficiency of hybrid tomato in red sandy loam soil. The investigation revealed that the total dry matter (TDM) production and leaf area index (LAI) were significantly higher in drip irrigation (165.8 g and 3.12 g) over furrow irrigation (140.2g and 2.25g). Water-soluble fertilizer (WSF) fertigation recorded significantly higher total dry matter and LAI (181.9 g and 3.69 g) over drip irrigation. The fruit yield of tomato was 19.9 % higher in drip irrigation (71.9 Mg ha^{-1}) over the furrow one (59.5 Mg ha^{-1}).

Kannan (2008) determined the effects of different irrigation methods and drip irrigation regimes, and fertigation schedules on the growth and yield of medicinal coleus (*Coleus forskohlii*). The irrigation methods and drip irrigation regimes include: I_1, drip irrigation at 100 % pan evaporation (PE); I_2, 80 % PE; I_3, 60 % PE; and a control (surface irrigation and soil application of fertilizer. The effects of the treatments on tuber yield per plant, tuber length, tuber girth, dry tuber yield, water use efficiency, nitrogen use efficiency and water productivity were studied. Irrigation water got saved due to drip-fertigation compared to surface irrigation and soil application of fertilizer ranged from 14.7 to 48.1 %. An increase in tuber yield (24 %) was evident with drip irrigation compared to conventional method of surface irrigation.

During the rabi season of 2008-09 Kohire and Das (2015) studied the effects of drip irrigation and fertilizer management on capsicum at Research area farms of Assam Agriculture University Jorhat (Assam) India. Result reviled that the effect of drip irrigation and fertilizer management treatments (T_3) were significant in respect of percent nitrogen content both in plant (2.18%) and fruits (1.19%). Similarly the highest uptake of P_2O_5 by plants (7.37 kg/ha) and by fruits (3.64 kg/ha) K_2O by plant (47.05 kg/ha) and by fruits (26.07 kg/ha) recorded in treatment T_3 at 100% EPR alone with the application of 75% RD of N and K through drip. The total Uptake of N (69.16 kg/ha) P_2O_5 (11.0 kg/ha) and K_20 (73.12 kg/ha) were also significant over the treatment T_9 (N-48.27 kg/ha) P_2O_5 (7.41 kg/ha) and K_2O (48.85 kg/ha) respectively. The nutrient status determined in terms of available N, P_2O_5, and K_2O in kg/ha was significantly influenced by different drip irrigation and fertilizer management. Significantly highest fruit yield (87.20 q/ha) was recorded in drip irrigation at 100 EPR along application of 75 % RD of N through drip irrigation over treatments.

Kumari *et al.* (2006) conducted a field experiment to studied the effect of drip irrigation at three levels of water application, i.e. 1.0, 0.8 and 0.6 of maximum evapo-transpiration and surface irrigation in combination with two mulches (black polyethylene and paddy husk) on the growth and yield of bell pepper cv. California Wonder. Results indicated that plants irrigated through drip on an average were taller at harvest by approximately 5.5 cm compared to those that received surface irrigation. Among all the treatments, the highest yield was obtained with drip 0.8 and black polyethylene mulch combination but the lowest was recorded in surface irrigation without mulch.

Kuscu *et al*. (2009) conducted field experiments for 2 years (2004 and 2005) on sandy loam soil in south Marmara region of Turkey to study the effect of five levels of pan evaporation replenishment (20, 40, 60, 80 and 100%) on marketable yield, irrigation water productivity (IWP), and economic return of tomato (*Lycopersicon esculentum*), pepper (*Capsicum annuum*), green bean (*Phaseolus vulgaris*), and eggplant (*Solanum melongena*) under a drip irrigation method. The highest mean marketable yield (2 years) of tomato (87.5 t ha^{-1}), pepper (59.2 t ha^{-1}), green bean (7.6 t ha^{-1}), and eggplant (46.5 t ha^{-1}) were recorded at 100, 100, 80, 100 and 80% of the pan evaporation replenishment, respectively. The IWP of tomato (23.6 kg m^{-3}), pepper (16.5 kg m^{-3}), green bean (2.6 kg m^{-3}), and eggplant (13.6 kg m^{-3}) was the maximum at 80%, 80%, 40%, and 80% of pan evaporation replenishment, respectively. The results revealed that a further increase in irrigation amount resulting from 100% of pan evaporation replenishment did not increase the marketable yield of crops but reduced the IWP significantly. The net return increased with the increase in pan evaporation replenishment. The results revealed that the pepper is the most profitable crop, followed by tomato, eggplant, and green bean.

Liu *et al.* (2013) investigated the suitable drip irrigation scheduling for tomato grown in solar greenhouse based on 20-cm pan evaporation (E_{pan}) in North China Plain. Irrigation treatments included three irrigation frequencies (I_1 10, I_2 20 and I_3 30 mm, and irrigation interval of 2-6 d for I_1, 4-9 d for I_2 and 8-12 d for I_3) based on accumulated pan evaporation (E_{pan}), and four plant-pan coefficients (K_{cp1} 0.5, K_{cp2} 0.7, K_{cp3} 0.9 and K_{cp4} 1.1). Results indicated that total irrigation amount, seasonal crop evapotranspiration (ET) and tomato yield (Y) were 185.1-365.8 mm, 249.1-388.0 mm and 99.6-151.8 t ha^{-1}, respectively. Irrigation frequency and amount increased the yield, and second-degree polynomial relationship was found between Y and ET (R^2=0.8671). Both irrigation frequency did not increase mean fruit weight, diameter and length significantly but increased fruit number, total soluble solids content (TSS), fruit firmness and water use efficiency (WUE) and irrigation WUE (IWUE) significantly. Irrigation amount increased external quality of tomato but reduced TSS content, fruit firmness, WUE and IWUE significantly. K_{cp3} and Kcp4 treatments had the highest fruit yield, but K_{cp2} and K_{cp3} treatments had the highest WUE. I_1K_{cp3} treatment (irrigation interval of 2-6 d, and K_{cp}=0.9) had higher IWUE, WUE, external quality, yield, and TSS yield too.

Mishra and Paul (2009) studied the impact of drip irrigation with plastic mulch on yield and returns of brinjal crop and obtained the highest yield of 34.8 t ha^{-1} as compared to other treatment. An increase in yield (65 %) and net income (83 %) was recorded in drip irrigation with mulch as compared to conventional surface irrigation. The benefit cost ratio was highest (2.18) for drip alone. The highest yield and net profit per mm of water were observed in case of 0.6 net irrigation volume drip along with mulch.

Nalge *et al.* (2007) conducted an experiment to study yield and moisture use of cotton under drip irrigation in vertisols at eight replications under rainfed (T_1), 50 per cent (T_2) and 100 per cent (T_3) irrigation through drip. Seed cotton yield was lowest under rainfed (0.862 t ha^{-1}) and at par under 50 per cent (1.552t ha^{-1})

and 100 per cent (1.580t ha^{-1}) irrigation, respectively. Total water use efficiencies were 1.606, 2.092 and 1.915 kg ha^{-1} mm^{-1} under T_1, T_2, and T_3 treatments, respectively.

Nilesh and Gulati (2004) conducted a field experiment to evaluate the effect of drip system and conventional furrow system of irrigation on the growth, yield and water use efficiency of American cotton (*Gossypium hirsutum*) cv. LH-846. The study revealed that the average plant height was maximum in drip system (158.9 cm) with a high level of irrigation (IW/CPE=1.0) as compared to furrow system (146.9 cm). The average number of bolls per plant were also found maximum in drip system (27.0 bolls per plant) as compared to the furrow system (20.3 bolls per plant). Result on seed-cotton yield was same as that for bolls production. The water use efficiency of 0.54 q (ha-cm)$^{-1}$ was found in drip system as compared to 0.37 q (ha-cm)$^{-1}$ in furrow system. Nitrogen use efficiency was found maximum in the drip system as compared to the furrow irrigation system.

Pawar *et al.* (2013) conducted a study on the effects of drip fertigation on growth, yield and economics of sugarcane (*Saccharum officinarum* L.).The experiment comprised of 100, 80 and 60 % of recommended fertilizer dose in water soluble form. The 100 % drip fertigation showed 41.8 % increase in yield. Yield increased 25.3 % by applying only 'N' through drip as against conventional method (133.4 t ha^{-1}). Fertigation also resulted into 40 % fertilizer saving. The drip irrigation used less quantity of water (103.7 mm) and saved 57 % water over surface irrigation method.

Pires *et al.* (2011) had an experiment to evaluate the effects of coconut (*Cocos nucifera* L.) fibre substrate volumes and drip irrigation frequencies on the vegetative growth and fruit yield of tomato plants under greenhouse conditions. The experimental design consisted of randomized blocks arranged in a 3 × 2 factorial with four replicates. Treatments consisted of three substrate volumes

(5.0; 7.5 and 10.0 L per plant) and two irrigation frequencies (once and five times a day). Leaf area index tended to increase in plants grown with the largest substrate volume (10 L). Although substrate volumes affected shoot dry matter, no effects on tomato yield and its components were observed. However, plants grown with 5 L of substrate and irrigated once a day produced a greater number of non-marketable fruit due to the higher incidence of calcium deficiency symptoms (blossom end rot). When plants were grown in 5 L or 7.5 L of substrate volume, high irrigation frequency favored the vegetative growth, stomatal conductance, CO_2 assimilation and transpiration and fruit yield. Fruit yield and healthy fruits were favored by high irrigation frequency and did not depend on the substrate volume.

Ponnuswamy and Santhi (1998) studied the effect of drip irrigation on soil moisture distribution pattern in cassava and revealed that the moisture content from the surface and subsurface decreased from 33.8 to 23.8 per cent and 32.2 to 22.7 per cent for drip irrigation with 100 and 50 per cent of surface applied water, respectively. More water penetrated into the deeper layers in drip system of irrigation and the crop utilized the water very effectively.

Popale *et al.* (2012) analysed the response of cauliflower to irrigation schedules under drip irrigation. Drip Irrigation schedules comprised of I_1 (0.4 CPE), I_2 (0.6 CPE), I_3 (0.8 CPE) and fertigation levels included F_1 (50 % RDF), F_2 (75 % RDF) and F_3 (100 % RDF). The control I_4 was furrow irrigation scheduled at 1.2 IW/CPW with 60 mm depth of irrigation. The results revealed that percentage of average water saving under drip irrigation system over surface irrigation was 43.45 % and it was 75.54, 63.87 and 50.95 % under I_1, I_2 and I_3 irrigation schedules, respectively. The mean water use efficiencies under surface irrigation and drip irrigation schedules were 22.03 and 73.48 kg $ha^{-1}mm^{-1}$, respectively.

Priyanka *et al*., (2015) evaluated the effect of deficit irrigation on growth and production of drip irrigated tomato under shade net house was studied through field experiment. Four levels of drip irrigation equivalent to 100, 80, 60 and 40% of crop evapotranspiration with five replications were considered for their effect on crop growth and crop yield inside the shade net house. Tomato (*Solanum lycopersicon*, Badshah Variety) plants were grown under the shade net house with 50% shade. Plant height, number of leaves and individual fruit weight were found to be highest with 80 % irrigation, giving highest yield of 108.30 $t.ha^{-1}$. Actual irrigation water application between 1.62 and 4.58 $mm.day^{-1}$ was thus recommended for tomato crop in a shade net house.

At Sher-e-Bangla Agricultural University, Dhaka, Rakibuzzaman *et al.* (2018) conducted an experiment during November 2017 to March 2018 to study the performance of drip and traditional irrigation system on growth and yield of BARI-14 tomato. Significant variations were found within the treatments. Plant height, number of leaves $plant^{-1}$, cluster $plant^{-1}$, number of flower $plant^{-1}$, number of fruit $plant^{-1}$, fruit length, fruit weight, yield $plant^{-1}$ were higher in drip than conventional irrigation system. In drip irrigation system, 80% water was saved in compare to conventional technique and increased 38% of water use efficiency. 30% increased yield of BARI-14 tomato was found with drip irrigation over the conventional system.

Rathore and Singh (2009) studied the optimization of nitrogen application and irrigation schedules in tuberose (*Polianthes tuberosa*). The study showed that irrigation applied at 0.8 IW/CPE ratio increased the number of florets per spike and bulb yield by 23 and 22 % over the control (flood irrigation) and by 30 and 44%, respectively, compared to the treatment receiving the minimum water at 0.4 IW/CPE. Water productivity based on consumptive use (WPCU), irrigation water (WPIR) and total water (WPTW) applied through irrigation and rainfall significantly improved the vegetative growth, spike and bulb yield with increasing ratio of water application from 0.4 to 0.8 IW/CPE ratio but failed to increase beyond 0.8 IW/CPE ratio which indicated that water application beyond 0.8 IW/CPE ratio is not being utilized by crop. Irrigation through drip system at 0.8 IW/CPE saved water by 39 % and increased dry matter in florets by 45 % compared to the traditional flood method.

Razzak *et al*. (2013) determined the most efficient pruning system and optimum irrigation rate under drip irrigation system on cherry tomato to achieve the maximum production and high fruit quality in protected agriculture. Two pruning systems, one and two branches and four irrigation rates, 100% (T_1, full water), 80% (T_2), 60% (T_3) and 40% (T_4) of crop evapotranspiration (ETc) were compared. The highest productivity in plants pruned to two branches was related to the increase in fruit cluster than that detected in plants pruned to one branch. But, the plants pruned to one branch exhibited improved fruit quality. The highest irrigation rates, T_1 and T_2, produced the highest fruit yield, although the increased water stress treatment (T_4) enhanced the fruit quality traits. Water-use efficiency increased with two branches pruning system and under water stress conditions. Irrigation treatment T_2 was considered more appropriate for optimizing water-use efficiency without any significant reduction in the total fruit yield. This study demonstrated that the best results of interaction effects for increasing fruit production and conserving water were obtained by pruning cherry tomato plants to two branches under the T_2 irrigation rate. Fruit weight and size were increased by pruning the plants to one branch under the T_2 irrigation rate. On the other hand, pruning the plants to one branch under the lowest irrigation rate (T_4) resulted in high fruit quality levels.

Razzak *et al*. (2016) conducted a greenhouse study to evaluate the response of cherry tomato cultivar Dulcito RZ to different irrigation levels and fruit pruning treatments. Treatments were three irrigation levels (50, 75, and 100%) based on the crop Evapotranspiration (ETc), and three fruit pruning treatments (6, 8, and 10 fruits truss^{-1}). Results showed that the highest irrigation level (100% ETc) increased fruit weight and size, and total and marketable yield. However, water stress treatment (50% ETc) increased fruit quality traits (total soluble solids, titratable acidity, vitamin C, and total sugars). Plants pruned to 6 fruits truss^{-1} yielded a heavier and larger fruit size, while unpruned plants had smaller fruit size with a significant increase in total and marketable yield due to increased number of fruits plant^{-1}. The increased incidence of fruit cracking with lower fruit load (6 fruits truss^{-1}) or with higher irrigation level (100% ETc) were related with the larger fruit size. The 50% ETc and full fruits truss^{-1} (zero fruit pruning) treatments caused the highest values of irrigation water use efficiency (25.6-25.8 and 29.9-30.4 kg m^{-3}, respectively). To maximize marketable yield of cherry tomato and conserving irrigation water, it is recommended to apply 10 fruits truss^{-1} pruning treatment along with the medium irrigation water level (75% ETc).

Rekha and Mahavishnan (2008) reported increased growth and yield with drip irrigation in several crops ranging between 7-11.2 % depending on the crops / varieties and method of irrigation. Also, the water and fertilizer saving through drip fertigation have been reported to be 40-70 and 30-50%, respectively.

Saleh *et al.* (2007) conducted two experiments to study the effect of irrigation frequency and timing on root developments, tomato yield (var. First Power) and soil water content. The first experiment was conducted in root containers (31 x 15 x 60 cm) with three irrigation frequencies, 1, 3 and 5 days were investigated. The second experiment was conducted in a greenhouse with two irrigation frequencies, 1 and 3 days and three irrigation timings, early morning (8:00h), afternoon (14:00h) and night (20:00h). The results indicated that increasing water supply increased the root development and root biomass. The 1-day irrigation frequency produced the highest root biomass while the least root biomass was obtained from the 5-days irrigation frequency, indicating that water stress promoted the development of root system in the deeper layer where available soil moisture content was higher than the top layers. The 5-days irrigation frequency saved 18 and 12 % of water at early growth stage compared to 1 and 3 days frequencies. The results of greenhouse experiment showed that the best irrigation frequency was 3- days. The average yield in 3-days frequency was 70 ton/ha while 63 ton/ha in 1-day frequency. The effect of irrigation timing varied with irrigation frequency. For 3 days frequency, irrigation at early morning was better than afternoon and night irrigations. The average yield for irrigation at early morning was increased by 15% and 14% than irrigation at afternoon and night, respectively. For 1 day frequency irrigation at night increased the yield by 11% and 3% than irrigation at early morning and afternoon correspondingly. The lowest soil water content and soil temperature were displayed by the treatment, which produced the highest yield. With the same amount of water, the early morning irrigation after every 3 days increased tomato yield by 11- 20 % compared to night and early morning irrigation of 1-day frequency. A similar increase in water use efficiency in the early morning irrigation every 3 days was also recorded. Therefore, a selection of the proper irrigation frequency and timing led to a higher yield and high water use efficiency.

Sanchita *et al*. (2010) conducted an experiment to evaluate the effect of different levels of nitrogen fertigation on growth, yield and economics of the broccoli crop. The results revealed that there were significant improvement in growth, yield and fertilizer use efficiency of broccoli under drip irrigation and fertigation. Fertigation saved fertilizers to the tune of 40 % as compared to conventional fertilization to maintain the same yield levels. Study on fertigation efficiency and economics of cultivation revealed that fertigation with 100 % recommended doses of N was the most efficient treatment with fertigation efficiency of 55.44% and 57.31%, respectively and cost benefit ratio of 1:4.41.

Sankar *et al.* (2008) studied the effect of micro irrigation on productivity of onion and found that both drip and micro irrigation systems improved growth, yield and yield attributing parameters of onion. Also, there was a saving of irrigation water of 37.8 % in drip and 32.5 % in sprinkler system compared to surface irrigation scheduled at 50 mm cumulative pan evaporation with 7 cm depth.

Sathya *et al*. (2008) indicated higher availability of N, P and K nutrients in root zone area of drip fertigated plot. They also showed that fertigation frequency reduced the concentration of immobile elements such as P, K and trace elements in irrigation water and significantly increased saving of fertilizer nutrients up to 40 % without affecting the yield of crops compared to the conventional method of nutrient application.

Sezen *et al.* (2010) conducted a study to determine the optimal irrigation strategy for drip irrigated fresh market tomato grown in different soilless culture in a glasshouse in the Mediterranean Region of Turkey. Volcanic ash, peat and their mixture were used as growth media. Four different irrigation levels (WL_1=75%; WL_2=100%; WL_3=125% and WL_4=150% of Class A Pan evaporation) and two watering frequencies (once and twice daily applications) were evaluated. Highest yield and fruit number were obtained from the ash+peat mixture (1:1) with twice a day watering at WL_4 irrigation level. Soluble solids of tomato fruit decreased with increasing available water. The highest irrigation water use efficiency (IWUE) value of 121.4 kg m^{-3} was obtained from once a day irrigation WL_1 irrigation level with peat+ash (1:1). IWUE decreased in all treatments as the amount of irrigation water increased.

Sharma *et al*. (2010) reported superiority of gravity fed drip irrigation system over conventional flood irrigation system in vegetable crops. They reported irrigation efficiency as high as 90-95 % with drip irrigation system.

Shedeed *et al*. (2009) evaluated the effect of method and rate of fertilizer application under drip irrigation system on growth, yield and nutrient uptake by tomato grown on sandy soil. Drip irrigation recorded significantly higher total dry matter production (3.60 t ha^{-1}) and leaf area index (3.15) over furrow irrigation (2.86 t ha^{-1} and 2.27), respectively. The fruit yield of tomato was 28 % higher in drip irrigation (43.87 t ha^{-1}) over furrow irrigation (34.38 t ha^{-1}). Fertigation with 100 % NPK water-soluble fertilizers increased tomato fruit yield significantly (58.76 t ha^{-1}) over furrow irrigated control.

Shirgure *et al*. (2004) had a field experiment on irrigation scheduling based on pan evaporation through drip irrigation system. Four levels of open pan evaporation-based irrigations were scheduled (0.6, 0.7, 0.8 and 0.9 of open pan evaporation) and the incremental growth, leaf nutrient status, yields and fruit quality was recorded. The incremental growth of plant height (0.63 m), stock girth (5.63 cm) and canopy volume (7.07 m^3) were higher with the irrigation scheduled at 0.8 of open pan evaporation. The average fruit yield (14.08 kg/tree), fruit weight (37.9 g), total soluble solids (7.24% Brix), juice percentage (45.58%) and acidity (6.16%) of the lime were higher with drip irrigation scheduled at 0.8 of open pan evaporation.

Singandhupe *et al*. (2003) conducted experiment to evaluate the response to urea fertilizer with drip irrigation and compared with conventional furrow irrigation for 2 years (1995 and 1996) at the Research Farm of Water Management Project, Mahatma Phule Agricultural University, Rahuri, Maharashtra, India. Application of nitrogen through the drip irrigation in 10 equal splits at 8-day interval saved 20-40% nitrogen as compared to the furrow irrigation when nitrogen was applied in two equal splits. Similarly, 3.7-12.5% higher fruit yield with 31-37% saving of water were obtained in the drip system. Water use efficiency in drip irrigation, on an average over nitrogen level was 68 and 77% higher over surface irrigation in 1995 and 1996, respectively. At 120 kg N ha^{-1}, the maximum tomato fruit yield of 27.4 and 35.2 t ha^{-1} in 2 years was recorded. Total nitrogen uptake in drip irrigation was 8-11% higher than that of furrow irrigation. At the highest level of applied nitrogen (120 kg N ha^{-1}), total average N uptake of 2 years was 64.5 (1995) and 104.7 kg ha^{-1} (1996). The apparent N recovery was 82.5% at 48 kg N ha^{-1} in comparison with 47.9% at 120 kg N ha^{-1}

during 1996.

Singh *et al.* (2009) investigated water application of different treatment of ET on tomato. Among different irrigation levels, drip irrigation at 80 per cent ET resulted in higher net returns and benefit cost ratio (1.76). The maximum net returns and benefit cost ratio (2.03) were found with drip irrigation at 80 per cent ET coupled with polyethylene mulch compared to other treatments. Drip irrigation besides giving a saving of 38 percent water resulted into 55 per cent higher fruit yield compared to surface irrigation.

A comparative study of drip and furrow irrigation methods was conducted at the farmer's field in Umar Kot. The total area under experiment about 4000m^2 was divided into two equal portions. One portion about 40m X 50m was occupied by drip and the other portion about 40m X 50m by furrow irrigation method. Soil at the experimental site was clay loam in texture for 0-60cm depth; average dry bulk density and field capacity was 1.16g/cm 3 and 28.5% respectively. The results reveal that the drip irrigation method saved 56.4% water and gave 22% more yield as compared to that of furrow irrigation method. Higher water use efficiency about 4.87 was obtained in drip irrigation method; whereas lower water used efficiency about 1.66 was obtained in furrow irrigation method. The present study suggests farming community to adopt drip irrigation method instead of old traditional flooding methods (Tagar *et al*., 2012).

Tanaskovik *et al*. (2011) studied the best irrigation and fertigation practice for tomato crop (*Lycopersicon esculentum* Mill.) in order to achieve highest yield with maximum water use efficiency (WUE). Five experimental treatments tested in that study included the following: the first three treatments (T_1, T_2, and T_3) included a combination of drip irrigation and fertigation, treatment four (T_4) included drip irrigation, but with conventional application of fertilizer, and the fifth treatment, (T_5), included furrow irrigation practice with conventional application of fertilizer. The results of that study show that the drip fertigation treatments (T_1, T_2, and T_3) gave significantly higher tomato yields in comparison with treatments T_4 and T_5, almost 24 % and 39%. Treatments under drip fertigation showed almost 28 % more water use efficiency in comparison with the treatment with conventional application of fertilizer and drip irrigation.

Ugalde *et al*. (2011) conducted the study to determine the effects of fertigation on bean crops in the central and southern areas of the state of Veracruz, Mexico. Three treatments were evaluated: (1) Gravity irrigation and solid manual fertilization (regional treatment) (RR-40), (2) Drip irrigation and solid manual fertilization (RG-40); in both treatments the fertilizer was applied at 15 days after the emergence of the crop, and (3) Drip irrigation and soluble fertilization, (RG-60). With the RG-60 treatment the water consumption got reduced to 85 per cent and the highest average yield (2256 kg ha^{-1}) was obtained, which surpassed in 145 per cent to that obtained with RG-40, and in 186 per cent to RR-40 (regional treatment).

Veeranna *et al*. (2001) investigated the effects of broadcast applications and fertigation of normal and water soluble fertilizers at 3 rates through drip and furrow irrigation. Fertilizer use efficiency of 5.28 was obtained in drip fertigation with 80 % water soluble fertilizer (WSF) was effective in producing about 31 and 24.7 % higher chilli fruit yield over soil application of normal fertilizers at 100 % recommended level in furrow and drip irrigation methods respectively with 20 % of saving in fertilizers.

Woltering *et al*. (2011) reported that total labour requirement for the drip irrigated African Market Garden was on average 1.1 man hours per day against 4.7 man hours per day for the Farmers Practice on a 500 m^2 garden.

Xiukang and Yingying. (2016) conducted two-season (2012 and 2013) study to evaluate the effects of irrigation and fertilizer rate on tomato (*Lycopersicum esculentum* Mill.) growth, yield, and WUE. The fertilizer treatment significantly influenced plant height and stem diameter at 23 and 20 days after transplanting in 2012 and 2013, respectively. As individual factors, irrigation and fertilizer significantly affected the leaf expansion rate, but irrigation × fertilizer had no statistically significant effect on the leaf growth rate at 23 days after transplanting in 2012. Dry biomass accumulation was significantly influenced by fertilizer in both years, but there was no significant difference in irrigation treatment in 2012. Our study showed that an increased irrigation level increased the fruit yield of tomatoes and decreased the WUE. The fruit yield and WUE increased with the increased fertilizer rate. WUE was more sensitive to irrigation than to fertilization. An irrigation amount of 151 to 208 mm and a fertilizer amount of 454 to 461 kg ha^{-1} (nitrogen fertilizer, 213.5–217 kg ha^{-1}; phosphate fertilizer, 106.7–108 kg ha^{-1} ; and potassium fertilizer, 133.4–135.6 kg ha^{-1}) were recommended for the drip fertigation of tomatoes in greenhouse.

Yadav *et al.* (2012) studied the effects of drip irrigation and fertigation in sugarcane and the data revealed that drip irrigation at 60, 80 and 100 % PE increased cane yield by 14.4, 26.4 and 44.6 %, respectively over the cane yield obtained with border strip irrigation. In addition to yield increase, the respective water saving was 32.9, 17.1 and 1.4 %. Drip irrigation also improved the quality of cane and the commercial cane sugar increased by 46.4, 35.8 and 15.1 % as a result of drip irrigation at 60, 80 and 100 % PE, respectively over that obtained with conventional flood irrigation treatment.

A well-designed drip irrigation system with appropriate intervals and water amount loses almost no water to runoff, deep percolation and evaporation. In this study, potted tomato plants were watered by different regimes of drip irrigation and the effects on vegetative growth, fruit yield and irrigation water use efficiency were examined in order to find an appreciate drip irrigation regime for greenhouse tomato in Jiangsu Province, China. The experiment was designed as a factorial split plot with 3 levels (2, 3 and 4 day) of irrigation frequencies or intervals as the main plot and 3 levels (1.8, 1.5 and 1.2 dm) of water amounts.

As confirmed by the growth curve analysis using a modified mathematic equation, the differences in plant vegetative growth among different drip irrigation regimes were minimum. The differences in fruit yield among irrigation water frequencies were significant (P≤0.05) and there was also a significant interaction (P≤0.05) between irrigation frequency and water amount. The highest fruit yield was recorded in the plot with irrigation interval of 3 days and irrigation water amount of 1.5 dm and the lowest fruit yield was recorded in the treatment of 4 day1.2 dm. This suggested that the fruit yield would be further lower if the irrigation interval was set longer and the irrigation water amount was set lower at the same time. In general, irrigation water use efficiency tended to increase with a decline of irrigation amount at the same irrigation interval, with the highest value recorded in the treatment of 3-day irrigation interval with 1.2 dm water amount. It was suggested that the 3-day irrigation interval and 1.5 dm water amount at each time were appropriate under the drip irrigation for greenhouse tomato (Zhai *et al*., 2010).

CHAPTER III

MATERIALS AND METHODS

This chapter demonstrates information regarding methodology that was exploited in the accomplishment of the experiment. It encompasses a brief outline of the location of the experiment, climate conditions and the materials used for the experiment. It also flourishes the treatments of the experiment, data collection and for procedures data analyses.

3.1 Study area

The study was carried out on the rooftop at the Academic Building, Sher-e-Bangla Agricultural University, Dhaka-1207 during November 2019 to March 2020. It lies within the 230 74 N latitude and the 900 35' E longitudes with an elevation of 8.2m from sea level (UNDP-FAO) in the Agro-Ecological Zone of Madhupur Tract (AEZ No. 28).

3.2 Climatic conditions

Experimental site was located in the subtropical monsoon climatic zone, characterized by a heavy rainfall during the months from April to September (Kharif season) and a scantly rainfall during the rest of the year (Rabi season). Plenty of sunshine and moderately low temperatures prevail during October to March (Rabi season), which is suitable for cherry tomato growing in Bangladesh.

3.3 Characteristics of the soil

The experimental site belongs to the general soil type, which is Shallow Red Brown Terrace Soils under Tejgoan Series where top soil is olive grey with common fine to medium distinct dark yellowish brown mottles and were clay loam in texture. Organic matter content was 0.84%. Soil pH ranged from 6.0-6.6. Experimental area was flat having good drainage system and available irrigation and it is above the flood level.

From experimental field, soil sample was collected from 0-15 cm depths and analysed by Soil Resources and Development Institute (SRDI), Dhaka. Physiochemical properties were present in the soil appropriately.

3.4 Experimental materials

3.4.1 Planting materials

Seeds of four tomato varieties were collected from the “Horticulture Innovation Lab. BD”. All the varieties are indeterminate except Crimson Red.

3.5 Water management

3.5.1 Installation of the drip irrigation system

The drip irrigation system was installed with the integrated drippers, compensated, with discharge rate of 1L/h (without pressure pump). The drip irrigation system was composed of water tank, control units, PVC tubing and buried drip tubes or drip tapes. A PVC tank was used as a reservoir of water and placed at the height of 2m from the base of experimental plots to provide efficient flow of water. The tap connected to the tank was opened fully to allow the water flow through the lateral. The main line was connected to sub lines to carry the water between two rows. In this method water is supplied directly near the roots of plants, drop by drop, with the help of drippers. Drippers are linked with side pipelets which are linked with main pipeline connected with water supplying source (Plate 1.a.b).

Usually, derivation lines were buried in each pots. The collected water over 30min was measured using a measuring cylinder to check uniformity of water flow from each dripper (Plate 1.c). Three electric timers were used to maintain three levels of irrigation frequencies.

3.5.2 Crop Water Requirement

Crop water requirement is the water required by the plants for its survival, growth, development and to produce economic parts. It includes the following parameters:

- Climatic data
- Soil characteristics, and
- Crop characteristics

Climatic data

It consists of the following traits:

- Evapotranspiration rate (ET_0)
- Temperature
- Relative Humidity
- Wind Speed
- Sun shine Hours, and
- Effective Rainfall

All the climatic data were calculated using the CLIMWAT 2.0, a computer software developed by FAO (Appendix I&II). CLIMWAT is a climatic database to be used in combination with the computer program CROPWAT 8.0 and allows the calculation of crop water requirements, irrigation supply and irrigation scheduling for various crops for a range of climatological stations worldwide.

Monthly reference crop evapotranspiration (ET_0) for each year of the climatic record was calculated based on the modified FAO Penman menthieth equation (Allen *et al*., 1998) using FAO CROPWAT software (Appendix I).

The input data include location, altitude, latitude and longitude of meteorological station; it used 20 years of metrological data, monthly average daily value of maximum and the minimum air temperatures (^oC), relative humidity, sunshine hours, radiation and wind speed at 2 m height. These input data were collected from Dhaka Meteorological Station (Table 1). In addition, the RUN ON soil and crop characteristics input data* from the study area were calculated by CROPWAT 8.0 (Appendix III&IV).

Table 1. Monthly reference evapotranspiration of the crop (ET_0)

Months	Min temp. °C	Max temp. °C	Humidity %	Wind km/day	Sun hours	Rad $MJ/m^2/day$	ET_0 mm/day
Jan	12.30	26.20	87	124	8.30	15.80	2.50
Feb	15.10	28.90	69	143	8.20	17.70	3.51
Mar	20.00	33.00	63	223	8.30	20.30	5.21
Apr	23.50	34.10	74	316	7.70	20.90	5.56
May	24.60	33.30	97	381	6.80	20.20	3.81
Jun	26.00	32.10	93	324	5.00	17.60	3.65
Jul	26.20	31.80	88	334	4.90	17.30	3.98
Aug	26.20	32.00	92	285	4.80	16.80	3.61
Sep	25.90	32.30	94	288	5.30	16.40	3.43
Oct	23.70	31.80	92	213	7.10	16.90	3.50
Nov	18.60	29.90	90	124	8.10	16.00	3.02
Dec	13.80	26.80	96	134	8.10	15.00	2.34
Average	21.30	31.00	86	241	6.90	17.60	3.68

*Input data were collected from Dhaka meteorological station and calculated by CLIMWAT 2.0

Net crop water requirement

Net crop water requirement was calculated by 'CROPWAT 8.0' based on the various growth stages of the tomato plant (Table 2). CROPWAT 8.0 is a computer program developed by the Land and Water Development Division of FAO. CROPWAT 8.0 for Windows is a computer program for the calculation of crop water requirements and irrigation requirements based on soil, climate and crop data (Appendix V). In addition, the program allows the development of irrigation schedules for different management conditions and the calculation of scheme water supply for varying crop patterns. CROPWAT 8.0 can also be used to evaluate farmers' irrigation practices and to estimate crop performance under both rainfed and irrigated conditions.

Direct measurement procedures are labourers and time consuming. So now a day CROPWAT model developed is used widely. All calculation procedures used in CROPWAT 8.0 are based on the two FAO publications of the Irrigation and Drainage Series, namely, No. 56 "Crop Evapotranspiration-Guidelines for computing crop water requirements" and No. 33 titled "Yield response to water".

Table 2. Crop water requirement calculated by CROPWAT 8.0

Month	Decade	Crop stage	Kc coeff.	ETc mm/day	ETc mm/dec	Eff rain mm/dec	Irr. Req. mm/dec
Nov	1	Init	0.60	1.91	19.10	18.80	0.30
Nov	2	Init	0.60	1.81	18.10	8.00	10.20
Nov	3	Init	0.60	1.68	16.80	6.40	10.30
Dec	1	Deve	0.67	1.73	17.30	5.30	12.00
Dec	2	Deve	0.81	1.89	18.90	2.50	16.50
Dec	3	Deve	0.95	2.28	25.10	2.10	23.00
Jan	1	Mid	1.10	2.68	26.80	1.30	25.50
Jan	2	Mid	1.14	2.86	28.60	0.40	28.20
Jan	3	Mid	1.14	3.25	35.70	2.30	33.40
Feb	1	Mid	1.14	3.63	36.30	3.90	32.40
Feb	2	Mid	1.14	4.01	40.10	5.20	34.90
Feb	3	Late	1.12	4.58	36.60	9.30	27.30
Mar	1	Late	1.03	4.83	48.30	12.90	35.40
Mar	2	Late	0.91	4.86	48.60	16.30	32.30
Mar	3	Late	0.83	4.48	22.40	10.70	10.60
Total					438.70	105.50	332.20

3.6 Treatments of the experiment

The two factorial experiment was conducted to evaluate the effect of irrigation frequency on growth and yield of some cherry tomato varieties. The factors were as follows:

Factor A: Tomato varieties

In the experiment, four tomato varieties were used. These were:

V_1 : SAU Cherry tomato-1(Golden Purna)

V_2 : Crimson Red

V_3 : Australian Cherry

V_4 : Sutton Cherry

Factor B: Irrigation Frequency

The drip irrigation were applied on this experiment are given below:

I_1 : Once a day

I_2 : Twice a day

I_3 : Thrice a day

All the drip irrigation treatments have received the same amount of water, but different frequency of application. And the irrigation frequency was maintained by three electric timers with 24 hours, 12 hours and 8 hours intervals respectively (Plate 1.c)

The treatment combinations were as follows:

V_1I_1, V_1I_2, V_1I_3, V_2I_1, V_2I_2, V_2I_3, V_3I_1, V_3I_2, V_3I_3, V_4I_1, V_4I_2 and V_4I_3

3.7 Design and layout of the experiment

The two factorial experiment was provoked in the Completely Randomized Design (CRD) with five replications; thus comprised of 60 pots in the experiment (Figure 1)

Replication 1			Replication 2			Replication 3		
V_1I_1	V_2I_2	V_3I_3	V_2I_2	V_1I_1	V_3I_1	V_3I_1	V_2I_2	V_3I_3
V_1I_2	V_2I_3	V_4I_1	V_3I_3	V_4I_3	V_4I_1	V_4I_1	V_2I_3	V_1I_2
V_1I_3	V_3I_1	V_4I_2	V_1I_3	V_3I_2	V_2I_1	V_1I_1	V_4I_2	V_1I_3
V_2I_1	V_3I_2	V_4I_3	V_4I_2	V_2I_3	V_1I_2	V_3I_2	V_2I_1	V_4I_3

Replication 4			Replication 5		
V_4I_1	V_3I_2	V_3I_3	V_1I_1	V_2I_2	V_1I_2
V_1I_2	V_3I_1	V_1I_1	V_3I_1	V_2I_3	V_3I_3
V_4I_2	V_2I_3	V_1I_3	V_1I_3	V_4I_1	V_4I_2
V_2I_1	V_2I_2	V_4I_3	V_2I_1	V_3I_2	V_4I_3

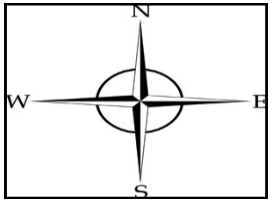


Fig 1. Layout of the experiment

3.7.1 Spacing and pot size

The volume of each pot was 30 L. Row to row distance was 60 cm and plant to plant distance 45 cm (Plate 1.e).

3.8 Production methodology

3.8.1 Seedbed preparation and raising of seedlings

Seeds of the four cherry tomato varieties were sown in four seedbeds at Horticulture Farm on the 1st October, 2019.

Before sowing, seeds were treated with Captan 75 WS @ 1.5 to 2.0 g a.i./litre for 5 minutes to protect seedlings from soil borne diseases. Twenty five days old seedlings were used in the experimental pots.

3.8.2 Preparation of pots

The pots were prepared with soil cow dung and necessary amount of manures and fertilizers. Loam soil: cow dung: sand = 2:2:1 was the ratio that were followed during pot preparation.

3.8.3 Application of manures and fertilizers

During pot preparation total cow dung and triple super phosphate (TSP) were applied in the pot. Half urea and half muriate of potash (MOP) were applied in the pot after three weeks of transplanting. Remaining urea and muriate of potash (MoP) were applied after five weeks of transplanting. Dose of manure and fertilizers used in the study are showing in the Table 3.

Table 3. Manures and fertilizer used as per BARI (2019) recommend action

Manures/Fertilizers	Recommended dose
Cowdung	10 t/ha
Urea	180 kg/ha
TSP	150 kg/ha
MoP	80 kg/ha

3.8.4 Transplanting of Seedlings

The Seedlings were raised in the seedbed in usual way and 25 days old seedlings were transplanted in the pots on November 01, 2019 and pots were tagged according to the treatments (Plate 1.f).

3.9 Intercultural operations

After transplanting the seedlings in the pots, different kinds of intercultural operations were accomplished for better growth and development of the plants, which were as follows:

3.9.1 Gap filling

A few gaps filling was done by healthy seedlings of the same stock where initial planted seedlings failed to survive.

3.9.2. Weeding

Weeding were done uniformly in all the pots when the seedlings were well established. After 20 days of the first one the second weeding was also done.

3.9.3. Staking

When the plants were well established, staking was done to each plants using bamboo sticks with rope to keep the plants erect (Plate 1.f). As the plants grew up within a few days of staking, other cultural operations were carried out.

3.9.4 Irrigation

After transplanting, the seedlings were properly irrigated according to treatments.

3.9.5. Pesticide application

In order to control pests the "Yellow sticking traps" were used during the whole growing season.

Moreover, to prevent disease infestation, 'Clybio' was used for 3 times at an interval of 15 days.

3.9.6 Harvesting

Harvesting of fruits were done on the basis of horticultural maturity, size, color and age being determined for the purpose of consumption as the fruit grew rapidly and soon get beyond the marketable stage. Throughout the harvesting period, frequent picking was done (Plate 1.i).

3.10 Data collection

Data were collected in respect of the following parameters:

Growth related parameters

- Plant height (cm)
- No. of branches per plant
- No. of clusters per plant

Duration related traits

- Days to 50% flowering from transplanting
- Days to first fruit harvesting from transplanting

Yield attributing parameters

- No. of flowers per cluster
- No. of flowesr per plant
- No of fruits per cluster
- No of fruits per plant
- Single fruit weight (g)
- Fruit length (mm)
- Fruit diameter (mm)
- Fruit yield per plant (kg)

Quality attributing parameter

- Brix percentage (%)

3.10.1. Plant height

The plant height was measured in cm from bottom of the plant to the tip of the plant using meter tape (Plate 1.g) maintaining certain days of interval and mean was computed.

3.10.2. Number of branches per plant

The number of branches per plant was counted manually at certain days of interval from selected plant from every pot and the average was calculated and expressed as average number of branches per plant.

3.10.3. Number of cluster per plant

Number of clusters was taken from selected plants after certain days of interval of transplanting. Each cluster was counted manually and the average was expressed as the number of clusters / plant (Plate 1.h).

3.10.4 Days to 50% flowering

Each plot was daily observed to record the date of 50% flowering. Then the period from the transplanting to the date of 50% flowering was recorded and expressed in term of the number of days.

3.10.5 Days to first harvesting

Days to first harvesting (visual observation) were recorded from the days from the date of tomato plant transplanting.

3.10.6. Number of flowers per cluster

The number of flower per cluster was counted manually from every cluster of the selected plant at a certain days of interval and the average was computed and finally expressed as the average number of flower per cluster (Plate 1.h).

3.10.7. Number of flowers per plant

The number of flowers per plant was recorded manually from every cluster of the selected plant at a certain days of interval and the average was computed and as expressed in average number of flower per plant.

3.10.8 Number of fruits per cluster

The number of fruit in every cluster was recorded manually from selected plant, then the average was calculated and expressed as the average number of fruit per cluster.

3.10.9. Number of fruits per plant

The number of fruits from selected plant was counted and then the average was calculated and expressed as the average number of fruit per plant.

3.10.10. Fruit length and diameter

Fruit length and diameter were measured by using the Digital slide caliper-515 (DC515) in millimetre (mm) and mean was calculated (Plate 1.j).

3.10.11. Single fruit weight

The fruits except 1st and last harvest were considered to take individual fruit weight. Fruit weight was measured by Electronic Precision Balance in gram (Plate 1.k). Total fruit weight of each pot was obtained by addition of weight of the total fruit number and average fruit weight was obtained from division of the total fruit weight by the total number of fruits.

3.10.12. Yield/plant

Yield per plant was calculated in kilogram (kg) by a balance from the total weight of fruits per plant which were harvested at different periods

3.10.13. Brix %

Brix % was measured by a refractometer (ERMA, Tokyo, Japan) at room temperature (Plate 1.l). At first every single fruit was blended and the juice extract was collected to measure brix and expressed in percentage. Mean was calculated from the each treatment.

3.11 Statistical analysis

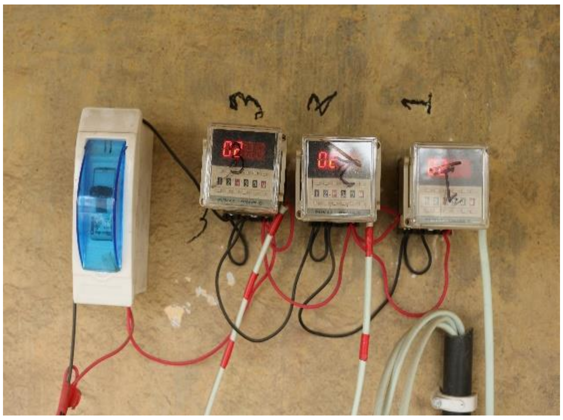
Collected data were statistically analysed using MSTAT-C computer package programme. Mean for every treatments were calculated and analysis of variance for each one of characters was performed by F–test (Variance Ratio).

Finally, the difference between treatments was assessed by Least Significant Difference (LSD) test at 0.05% level of significance (Gomez and Gomez, 1984).

(a)

(b)

(c)



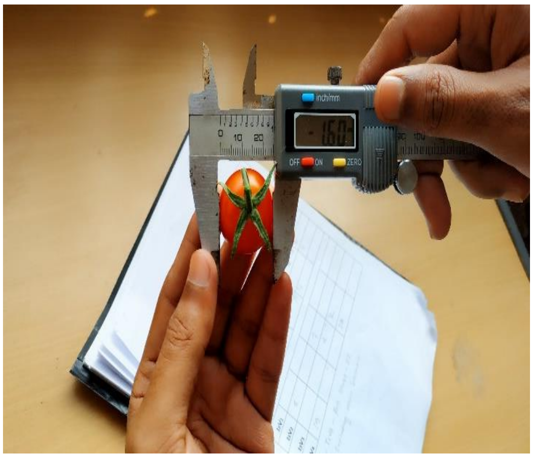
(d)

(e)

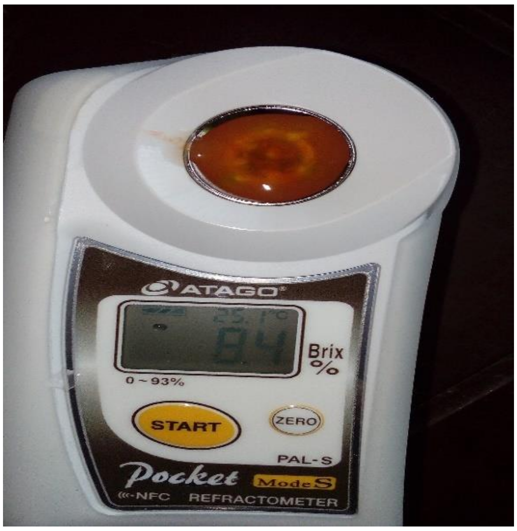
(f)

Plate 1: Pictorial presentation of different methodological works, equipment and data collection. (**a**),(**b**) Installation of drip irrigation system, (**c**) Measurement of water discharge rate (L/hr), (**d**) Three electric timers to maintain different irrigation frequencies, (**e**) Experimental setup, (**f**) Tagging of pots and staking of plants

(g) **(h)**



(i) **(j)**



(k) **(l)**

Plate 1 (continued): Pictorial presentation of different methodological works, equipment and data collection. **(g)** Measurement of plant height, using meter tape in centimetre (cm), **(h)** Cluster and flower counting, **(i)** Fruit harvesting, **(j)** Measurement of fruit length and diameter using digital caliper-515 in milimeter (mm), **(k)** Measurement of single fruit weight using electrical balance, **(l)** A refractometer measuring Brix (%)

CHAPTER IV

RESULT AND DISCUSSION

The experiment was performed to evaluate the vegetative growth of four cherry tomato varieties and their yield performance against different irrigation frequencies. Findings of the research work have been presented and discussed in this chapter. Illustration of this chapter has been focused by tables and figures to enhance their parallel and dissimilar traits through discussion, comprehension and perceiving. A summary of the analysis of variances in regard to all parameters have been arrayed in appendix. Results have been presented, discussed and possible interpretations are given under the following headings.

4.1. Plant height

Significant variation was found among the cherry tomato varieties in terms of plant height (Appendix VI) at 30 days, 45 days, 60 days and 90 days after transplanting. The maximum plant height was at 90 days after transplanting. The tallest plant was found from V_1 (153.30 cm) while the lowest was from V_2 (119.30 cm) at 90 days after transplanting. There was also significant difference between V_3 (138 cm) and V_4 (143.5 cm) in this respect (Figure 2). Gopal (2015) found that plant height varied due to the varietal differences. Fayaz *et al*. (2007) observed that the tallness, shortness and other morphological differences are varietal characteristics, which are controlled and expressed by certain genes.

Plant height of cherry tomato varieties exposed statistically significant inequality among treatments like once a day (I_1), twice a day (I_2), thrice a day (I_3) (Appendix VI). Tallest plant was found from I_1 ; i.e. 35.65 cm, 86.20 cm, 114 cm, 145.90 cm at 30, 45, 60, 90 DAT respectively but shortest was found from I_3, 31.75 cm at 30 DAT, 77.25 cm at 45 DAT, 96.80 cm at 60 DAT, 128.90 cm at 90 DAT (Figure 3). Deficit irrigation treatments significantly decreased all vegetative growth parameters including plant height of tomato plants. Where the highest significant values were obtained from the full irrigation treatment. These results are in harmony with those obtained by El-Dakroury (2008) who recommended that increasing irrigation level from 60% and up to 100% ETo significantly increased the vegetative growth parameters in some bean varieties.

Combined effect of different varieties and different irrigation schedules on the terms of plant height also exposed significant variation (Appendix VI) at 30 days, 45 days, 60 days and 90 days. Tallest plant was obtained from V_1I_1 (173.34 cm) and the shortest was obtained from V_3I_3 (118 cm) which is statistically similar with V_2I_2 (118.60 cm) at 90 DAT (Table 4). This may be due to the role of water in increasing the uptake of mineral elements from soil and translocation of photosynthetic assimilates, thus reflected increases in the plant growth parameters. In this concern, Ibrahim (2005) reported that increasing the irrigation regime, positively increased all vegetative growth parameters of tomato plants (plant height, number of branches, fresh and dry weight/plant). Oppositely, the water stress treatments (40% F.C) resulted in a significant decrease in vegetative growth of tomato plants, where plant height got reduced by 24% compared to the control treatment 100% F.C.

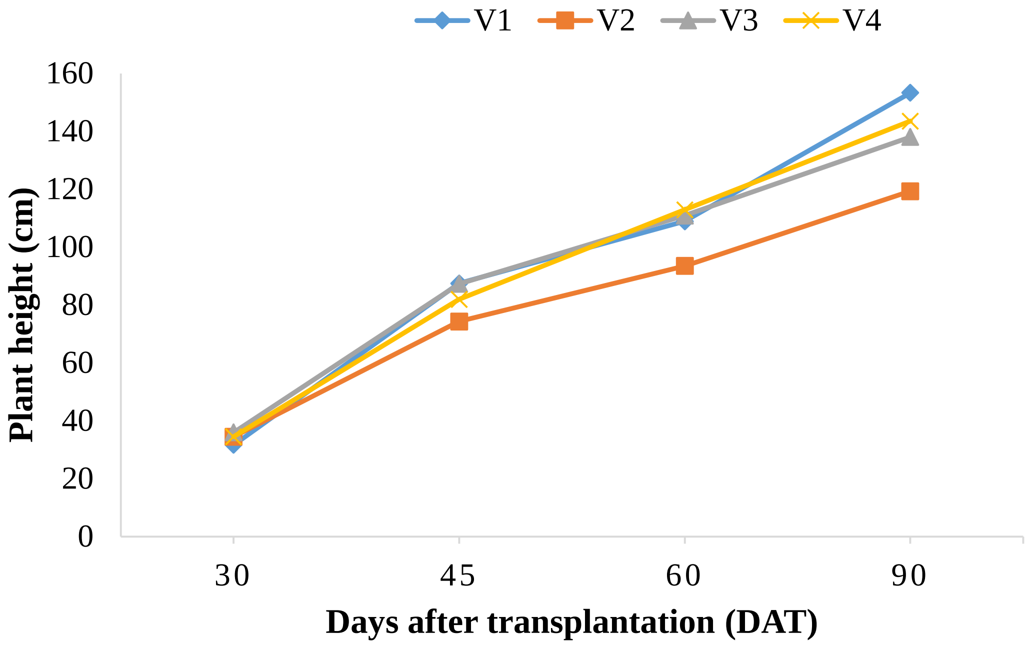


Fig.2. Performance of four cherry tomato varieties on plant height (cm) (Here, V_1: SAU Cherry Tomato-1, V_2: Crimson Red, V_3: Australian Cherry, V_4: Sutton Cherry)

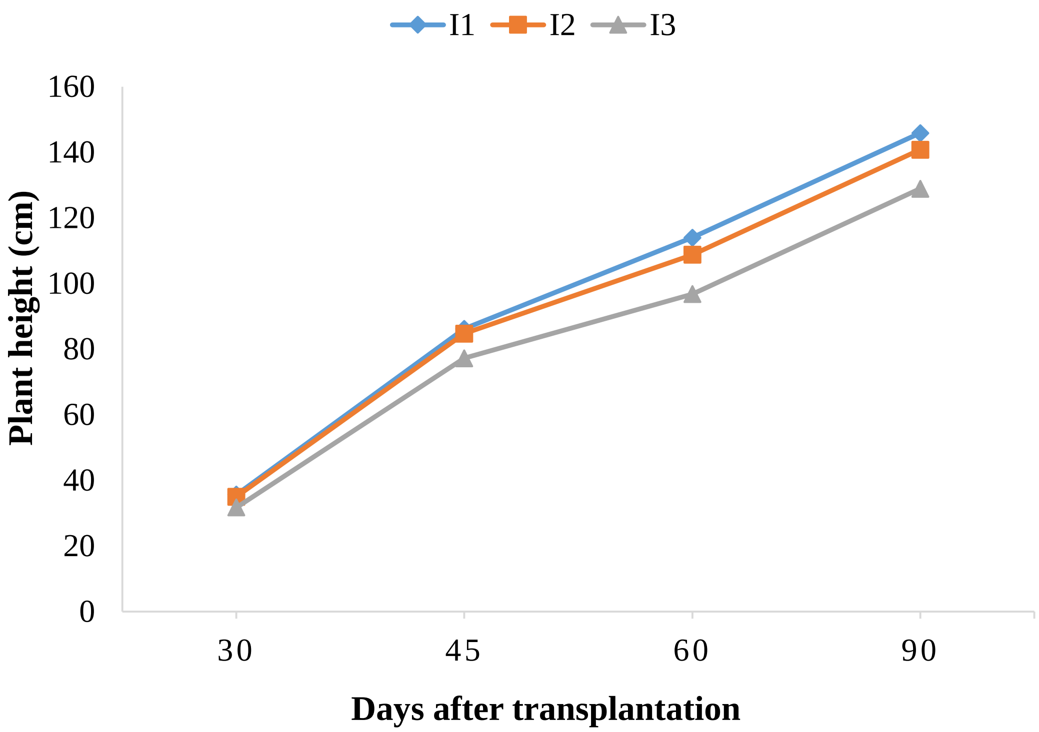


Fig.3. Effect of irrigation frequency on plant height; (Here, I_1: Once a day, I_2: Twice a day, I_3: Thrice a day)

Table 4. Combined effect of varieties and irrigation frequency on plant height at different days after transplanting of cherry tomatoes**

	Plant height (cm)							
Combinations*	30 DAT		45 DAT		60 DAT		90 DAT	
V_1I_1	36.40	a-d	93.00	b	121.60	bc	173.40	a
V_1I_2	32.20	ef	87.20	cd	106.20	e	148.00	bc
V_1I_3	26.40	g	82.20	ef	98.80	f	138.40	de
V_2I_1	32.20	ef	70.60	i	89.80	h	112.60	g
V_2I_2	33.80	d-f	73.80	hi	93.40	f-h	118.60	g
V_2I_3	37.40	a-c	78.40	fg	97.20	fg	126.80	f
V_3I_1	39.60	a	97.60	a	128.60	a	154.80	b
V_3I_2	36.00	b-d	89.40	bc	111.40	de	141.20	cd
V_3I_3	32.40	ef	74.80	gh	92.80	gh	118.00	g
V_4I_1	34.40	c-e	83.60	de	116.00	cd	143.00	cd
V_4I_2	38.20	ab	88.60	c	124.20	ab	155.20	b
V_4I_3	30.80	f	73.60	hi	98.40	fg	132.40	ef
CV %	7.77		3.86		4.12		4.44	
LSD (0.05%)	3.38		4.07		5.60		7.83	

*Here, V_1: SAU Cherry Tomato-1, V_2: Crimson Red, V_3: Australian Cherry, V_4: Sutton Cherry and I_1: Once a day, I_2: Twice a day, I_3: Thrice a day

**In a coloumn, means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

4.2. Number of branches per plant

Number of branches per plant showed statistically significant variation among four cherry tomato varieties at 30 day, 45 and 60 days after transplanting (Appendix VII). The maximum number of branches was in V_3 (6.67) which was statistically similar to V_2 (6.40) at 60 days after transplanting and the minimum was found in V_4 (5.73) at 60 days after transplanting (Fig. 4). The differences observed in number of primary branches per plant in cherry tomato plants might be due to genetic variations existing in genotypes (Omprasad *et al.*, 2018).

Branch number of cherry tomato varieties exposed statistically significant inequality among different level of irrigation frequency (Appendix VII).

In terms of irrigation frequency, the highest number of branches was found at I_1 (6.60) and lowest number of branches was found at I_3 (5.85) (Figure 4). Increasing irrigation intervals reduced the amount of water supply. Decreasing root system due to water stress leads to a decrease in shoot growth because there was a close correlation between roots and shoot development. Similar results were obtained by Ismail *et al*., (2007) in tomato too.

Branch number was influenced significantly among the combinations of cherry tomato varieties and irrigation frequency (Appendix VII). In combination highest number of branches was at V_3I_1 (7.60) and lowest at V_1I_3 (5.20) which was statistically similar to V_4I_3 (5.40), V_1I_2 (5.80) and V_4I_1 (5.80) at 60 DAT (Table 5). This may be due to the role of water in increasing the uptake of mineral elements from soil and translocation of photosynthetic assimilates, thus reflected increases in the leaf number and leaf area as well as branch per plant. Similar results had been also reported by Leilah (2009).

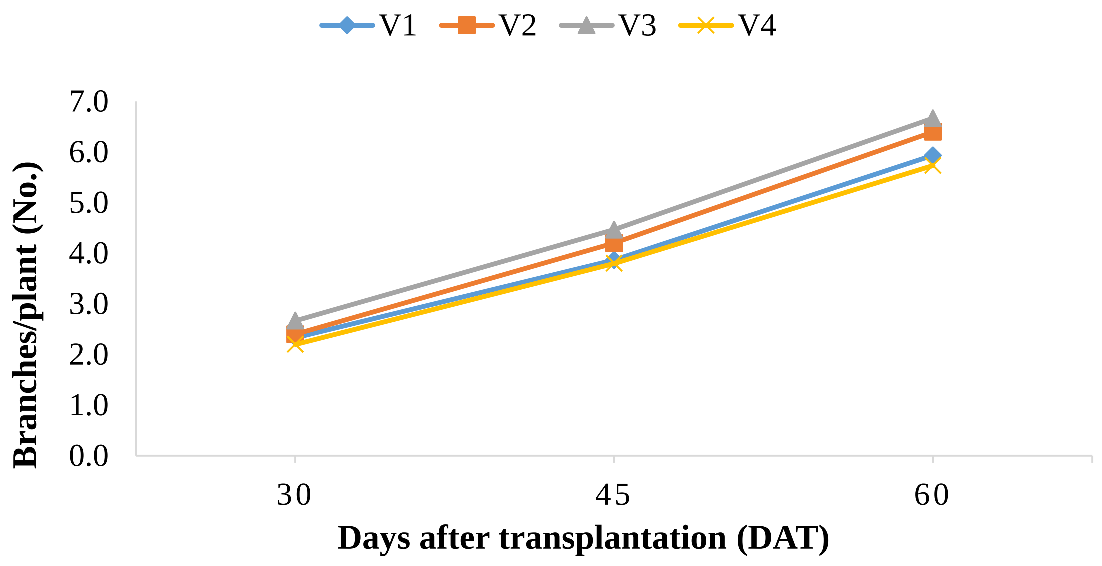


Fig. 4. Performance of four cherry tomato varieties on number of branch/plant (Here, V_1: SAU Cherry Tomato-1, V_2: Crimson Red, V_3: Australian Cherry, V_4: Sutton Cherry)

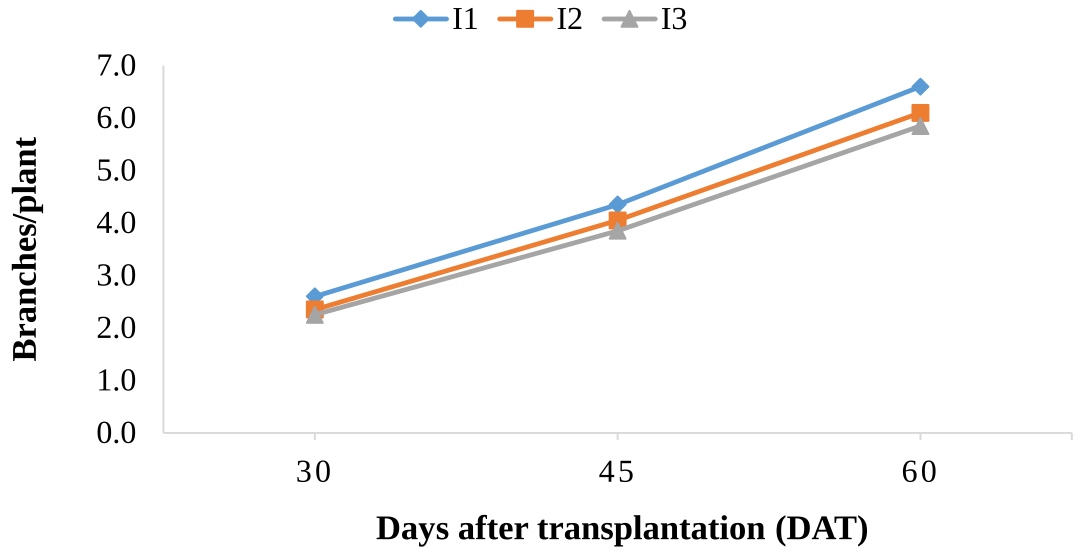


Fig.5. Effect of irrigation frequency on number of branch/plant (Here, I_1: Once a day, I_2: Twice a day, I_3: Thrice a day)

Table 5. Combined effect of varieties and irrigation frequency on number of branches/plant at different days after transplanting of cherry tomatoes**

	No. of Branches/plant		
Combinations*	30 DAT	45 DAT	60 DAT
V_1I_1	3.00 ab	4.80 ab	6.80 b
V_1I_2	2.00 d	3.60 ef	5.80 cde
V_1I_3	2.00 d	3.20 f	5.20 e
V_2I_1	2.20 cd	3.80 de	6.20 bc
V_2I_2	2.20 cd	4.00 cde	6.20 bc
V_2I_3	2.80 ab	4.80 ab	6.80 b
V_3I_1	3.20 a	5.20 a	7.60 a
V_3I_2	2.60 bc	4.40 bc	6.40 bc
V_3I_3	2.20 cd	3.80 de	6.00 cd
V_4I_1	2.00 d	3.60 ef	5.80 cde
V_4I_2	2.60 bc	4.20 cd	6.00 cd
V_4I_3	2.00 d	3.60 ef	5.40 de
CV%	15.60	11.52	7.76
LSD (0.05%)	0.48	0.60	0.61

*Here, V_1: SAU Cherry Tomato-1, V_2: Crimson Red, V_3: Australian Cherry, V_4: Sutton Cherry and I_1: Once a day, I_2: Twice a day, I_3: Thrice a day

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

4.3. Days to 50% flowering (visual observation)

Significant variation was recorded among the varieties in respect of days to 50% flowering after transplantation of cherry tomato varieties (Appendix VIII). The longest period was required for 50% flowering in variety V_1 (44.93 days) while the shortest period was in V_4 (38.80 days) (Table 6). The result shows that V_4 is early flowering variety and V_1 is late flowering variety. The data on days to 50 per cent flowering among the cherry tomato genotypes shows that the genotypes are statistically at par with each other because such characters are controlled by genetic make-up and least affected by the changes in micro-climate and optimum light and temperature. These results are in accordance with the findings of Prema *et al*. (2011) in cherry tomato and Singh *et al*. (2013) in greenhouse tomato.

Days to flowering were significantly affected by irrigation frequency on cherry tomato (Appendix VIII). Early 50% flowering was recorded in I_1 (39.95 days) and delayed in I_3 (42.10 days) (Table 7). That might be due to accumulation of maximum photosynthesis favouring fast growth, which triggered early initiation of flowering under I_1 treatment. Similar result was found by Priyanka *et al*., (2005) in tomato.

Combined effect of different cherry tomato varieties and irrigation on days to 50% flowering were significant variation (Appendix VIII). V_4I_2 (36.40 days) required minimum period for 50% flower bud initiation which was statistically similar to V_3I_1 (37.20 days) whereas the maximum from V_1I_3 (47 days) (Table 8). This result is in agreement with the findings of Priyanka *et al*. (2015) who reported that days to early flower initiation was recorded under T_2 (Drip irrigation with 80% of ETc) treatment and most delayed under T_4 (Drip irrigation with 40% of ETc).

4.4. Days to first fruit harvest (visual observation)

Significant variation was found among the varieties in respect of days to first fruit harvesting after transplantation of cherry tomato seedlings (Appendix VIII). The longest period was required for first fruit harvest in V_1 (88.73 days) while the shortest period in V_4 (76.80 days, Table 6). The results indicates that V_4 is early fruit maturity variety whereas V_1 was a late one. Earliness plays important role on fetching higher price and more income. Therefore early varieties are generally preferred for cultivation on commercial scale. Early harvest in this experiment might be due to the varietal response to the congenial growing environment and early flowering. Whereas delayed fruit ripening was due to late flowering. Similar results obtained by Prema *et al*. (2011) in cherry tomato.

Days to first fruit harvest was least significantly affected by irrigation frequency (Appendix VIII). Early fruit maturity was recorded in I_1 (82 days) which was statistically similar to I_2 (82.45 days) and delayed in I_3 (84.45 days) (Table 7). This might be attributed to favourable environmental conditions that prevailed in I_1, leading to the time taken for flower initiation and first harvest as well. This result is in agreement with the findings of Priyanka *et al*. (2015).

Combination of varieties and irrigation frequency at different levels affect significantly on days taken to first fruit harvest (Appendix VIII). Earlier fruit harvesting was observed in V_4I_2 (73.80) while delayed fruit harvesting was observed in V_1I_3 (92.80) (Table 8). The effects of different irrigation treatments were significant on first harvest of plant. Priyanka *et al*. (2015) reported that early first harvesting of tomato was noted with T_2 (Drip irrigation with 80% of ETc) treatment, while the first harvesting was most late under T_4 (Drip irrigation with 40% of ETc) treatment.

4.5. Brix (%)

Significant variation was found among the varieties for their brix percentages (Appendix VIII). The highest percentage (9.07%) was observed in V_4 while the lowest percentage (5.10%) was in V_2 variety (Table 6).

These variation in brix percentage among four varieties might be attributed to the inherent genetic potentiality of the varieties to produce total soluble solids (TSS) at favourable environmental condition. Similar results were obtained by Sucheta *et al*., (2004) in tomato and John *et al*. (2005) in cherry tomato.

Brix percentage was significantly affected by the irrigation frequency; once a day (I_1), twice a day (I_2) and thrice a day (I_3) (Appendix VIII). The highest brix percentage was recorded in I_2 (7.46%) and lowest was recorded from I_3 (6.90%) (Table 7). The increasing TSS could be due to a higher conversion of starch to sugars under water deficit but in extreme water stress condition may reduce the sugar conversion. Ozbahce and Tari (2010) found there was also a negative linear relationship between TSSs and irrigation water amount.

Combined effect of four tomato varieties and irrigation in terms of brix percentage also exposed significant variation (Appendix VIII). Brix percentage was recorded highest in V_4I_2 (9.47%) and lowest was recorded in V_2I_1 (4.90%) (Table 8). In this study, higher irrigation frequency increased the TSS under the same irrigation amount. However, higher irrigation amount reduced the TSS, because low irrigation increased the enzymatic activities of sucrose synthase and sucrose phosphate synthase (Qi *et al*. 2003).

Table 6. Performance of four cherry tomato varieties on days to 50% flowering, days to 1st fruit harvest and brix %**

Variety*	Days to 50% flowering	Days to 1st harvest	Brix %
V_1	44.93 a	88.73 a	7.00 c
V_2	39.67 b	81.40 c	5.10 d
V_3	40.07 b	84.93 b	7.57 b
V_4	38.80 c	76.80 d	9.07 a
CV%	2.28	1.59	2.34
LSD (0.05%)	0.69	0.97	0.12

Here, V_1: SAU Cherry Tomato-1, V_2: Crimson Red, V_3: Australian Cherry, V_4: Sutton Cherry

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

Table 7. Influence of irrigation frequency on days to 50% flowering, days to 1st fruit harvest and brix %**

Irrigation*	Days to 50% flowering	Days to 1st harvest	Brix %
I_1	39.95 c	82.00 b	7.19 b
I_2	40.55 b	82.45 b	7.46 a
I_3	42.10 a	84.45 a	6.90 c
CV%	2.28	1.59	2.34
LSD (0.05%)	0.59	0.84	0.11

Here, I_1: Once a day, I_2: Twice a day, I_3: Thrice a day

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

Table 8. Combined effect of varieties and irrigation frequency on days to 50% flowering, days to 1st fruit harvest, brix %**

Combinations*	Days to 50% flowering	Days to 1st harvest	Brix %
V_1I_1	42.40 c	84.40 d	8.15 d
V_1I_2	45.40 b	89.00 b	6.70 g
V_1I_3	47.00 a	92.80 a	6.14 h
V_2I_1	41.80 c	84.00 d	4.90 j
V_2I_2	39.80 e	81.60 e	5.10 ij
V_2I_3	37.40 fg	78.60 fg	5.30 i
V_3I_1	37.20 g	82.20 e	7.20 e
V_3I_2	40.60 de	85.40 d	8.58 c
V_3I_3	42.40 c	87.20 c	6.92 f
V_4I_1	38.40 f	77.40 g	8.50 c
V_4I_2	36.40 g	73.80 h	9.46 a
V_4I_3	41.60 cd	79.20 f	9.24 b
CV%	2.28	1.59	2.34
LSD (0.05%)	1.19	1.68	0.21

*Here, V_1: SAU Cherry Tomato-1, V_2: Crimson Red, V_3: Australian Cherry, V_4: Sutton Cherry and I_1: Once a day, I_2: Twice a day, I_3: Thrice a day

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

4.6. Number of clusters per plant

Varieties differed significantly among themselves for number of clusters per plant. (Appendix IX). The maximum number of clusters was found in V_4 (18.53) at 90 days after transplanting of cherry tomato and the minimum number of cluster was found in V_1 (13.07) at 90 days after transplanting (Table 9). These significant differences among the varieties might be due to the genetic potentiality of these genotypes responding to the favourable micro climate. These results are in accordance with the findings of Prema *et al*. (2011) in cherry tomato.

Different levels of irrigation frequencies significantly influenced the number of cluster per plant (Appendix IX). The maximum number of cluster per plant was recorded in I_2 (16.70) which was statistically similar to I_1 (16.40) at 90 DAT. The minimum cluster number was found in I_3 (14.20) at 90 days after transplanting (Table 10). Mutava *et al*., (2014) and Mohawesh (2016) reported that water stress treatments significantly reduced the uptake of nitrogen, phosphorus and potassium in tomato plants thus reduce the vegetative growth and yield characteristics where the highest percentage was noticed in case of 100% F.C.

Combined effect of cherry tomato varieties and irrigation frequency exposed statistically significant variation in number of cluster per plant (Appendix IX). Highest number of cluster was found from V_4I_2 (21.60) combination at 90 days after transplanting of cherry tomato varieties but minimum was found from V_1I_3 (11.20) (Table 11). The ability of the cultivars to produce plant growth and yield characteristics under depleted soil moisture regimes might be due to the effect of osmotic adjustment (Richter and Wagner 1983). Nahar and Ullah (2012) reported that flower and fruit characteristics of tomato plants i.e. flowers/cluster, fruits/cluster, clusters/plant, fruit stalk length, fruit length, and diameter and average fruit weight as affected by soil moisture stress. Results showed that all the flower and fruit characteristics were significantly affected by water stresses.

The highest values were obtained at 70%F.C (slight stress) followed by severe stress (40%F.C).

4.7. Number of flowers per cluster

Highly significant variation were found among the varieties in terms of the number of flower per cluster (Appendix IX). The highest number of flower was found at V_1 (75.80) but the lowest number was found at V_2 (8) (Table 9). That variation in number of flowers per cluster production among cherry tomato varieties might be attributed to the inherent genetic potentiality of the varieties to produce flowers at favourable environmental condition. Similar results were obtained by Prema *et al*. (2011) in cherry tomato. Aquirre and Cabrera (2012) and Muthuvel *et al*. (2000) reported that number of inflorescences and stigma exertion are inherent traits.

Significant variation was found in terms of irrigation frequency (Appendix IX). The maximum number of flower was counted at I_1 (27.80) and lowest at I_3 (25.60) (Table 10). Water deficit during flowering stages has been found to lead to flower abortion. As a result, number flowers per cluster was reduced. Similar results were obtained by Pulupol *et al*. (1996) and Zegbe *et al*. (2006).

The combined effect of different varieties and irrigation frequencies in terms of flower number per cluster also exposed significant variation (Appendix IX). Highest number of flower per cluster got found at V_1I_1 (80.20) and lowest number of flower per cluster was found at V_2I_3 (8) which was statistically similar to V_2I_1 (8), V_2I_3 (8) (Table 11). This might be attributed to favourable environmental conditions that prevailed under treatment I_1 , leading to higher vegetative growth contributing to more number of flowers, more number of fruits, higher per cent of fruit set. Similar results were reported by Priyanka *et al*. (2015) in tomato.

4.8. Number of flowers per plant

Highly significant differences were found among the varieties in terms of number of flower per plant (Appendix IX). The maximum number of flower was counted in V_1 (995.20) but the minimum number of flower per plant was counted in V_2 (125.30) (table 9). This variation in number of flowers per plant production among cherry tomato varieties result of genetic variation and increased number of flowers per cluster. These results are in agreement with those obtained Prema *et al*., (2011), Aquirre and Cabrera (2012).

Flower number per plant was significantly affected by irrigation frequency too. (Appendix IX). The highest number of flower per plant was counted in I_1 (430.80) while the lowest number of flower was counted in I_3 (316.90) (Table 10). Water deficit during flowering stages has been found to lead to flower abortion. Similar results were obtained by Pulupol *et al*. (1996) and Zegbe *et al*., (2006).

Flower number per plant had significant inequality among the combination of different varieties and irrigation frequencies (Appendix IX). The highest number of flower was found at V_1I_1 (1186) but the lowest was at V_2I_1 (108.80) which was statistically similar to V_3I_3 (111.60) (Table 11). This result is in agreement with those obtained by Colla *et al*. (1999) affirmed that deficit irrigation reduced the number of flowers. In addition, Farooq *et al*. (2009) indicated that water deficit reduced plant growth and development, leading to the production of smaller organs, and reduction the number of flowers per plant.

4.9. Number of fruit per cluster

Highly significant differences were observed among the cherry tomato varieties with respect to number of fruit per cluster (Appendix IX). It was become clear that the maximum number of fruits per cluster was recorded from variety V_1 (48.73) and the lowest was found from variety V_2 (6.13) (Table 9). The significant variation among genotypes pertaining to number of fruits per cluster in the present study might be due to the genetic potentiality of genotypes responding to the favourable micro climate and similar results were obtained by Prema *et al*. (2011) and Aguirre and Cabrera (2012) in cherry tomato.

Fruit number per cluster was significantly affected by the irrigation frequency (Appendix IX). The maximum number of fruits per cluster was recorded in I_1 (19.55) while the lowest was recorded from I_3 (15.45) (Table 10). This result is in agreement with those obtained by Colla *et al.* (1999) affirmed that deficit irrigation reduced the number of flowers leading to decrease the number of fruits.

Combined effect of four cherry tomato varieties and treatments in terms of number of fruits per cluster also exposed significant variation (Appendix IX). Number of fruit per cluster of different cherry tomato varieties exposed significant inequality among different treatments. The highest number of fruit per cluster was recorded in V_1I_1 (55) but the lowest was recorded in V_3I_3 (5.60) which was statistically similar with V_2I_1 (5.60) (Table 11). Water deficit during flowering stages has been found to lead to flower abortion. As a result, number of fruits per cluster was reduced. Similar results were obtained by Pulupol *et al*. (1996) and Zegbe *et al.* (2006).

4.10. Number of fruits per plant

Highly significant differences among the four cherry tomato varieties were obtained with respect to number of fruit per plant (Appendix IX). The maximum number of fruits per plant was recorded from V_1 (645.50) but the lowest was found from variety V_2 (96.73) which was statistically similar to V_3 (106.30) (Table 9). This increased fruits per plant is due to increased number of flower per plant, high fruit set percentage and maximum number of fruits per plant. These results are in agreement with those obtained Prema *et al*. (2011) and Singh *et al*. (2013).

The fruit number per plant was significantly affected by the irrigation frequency (Appendix IX). The maximum number of fruits per plant was recorded in I_1 (304.40) but the minimum was recorded in I_3 (194.90) (Table 10). The 100% of water at a time (I_1) registered the highest number of fruits per plant followed by I_2, but I_3 gave lowest number of fruits per plant. This may be due to fact that water applied at 100% ETc adequately meets the crop water requirement. This result is in agreement with the findings of Ozbahce and Tari (2010) who reported that plant yield components and yield decreased with increasing water deficit.

Combined effect of four varieties and irrigation for the number of fruits per plant also exposed highly significant variation (Appendix IX). Number of fruit per plant of different cherry tomato varieties exposed significant inequality among different treatments. The highest number of fruits per plant was recorded in V_1I_1 (814) but the lowest was recorded in V_3I_3 (69.60) which was statistically similar to V_2I_1 (76) (Table 11).

Irrigation has a complex effect on plant. One of the main effects was the increased number of marketable fruits per plant. Stronger and healthier plants can produce higher rates of flowering, fruit set, and more fruits as well. The present result correlates with the outcome of Alaoui *et al*. (2014).

Table 9. Performance of four cherry tomato varieties on number of clusters/plant, number of flowers/cluster, number of flowers/plant, number of fruits/cluster, number of fruits/plant**

Variety*	No. of cluster/plant	No. of flower/cluster	No. of flower/plant	No. of fruit/cluster	No. of fruit/plant
V_1	13.07 c	75.80 a	995.20 a	48.73 a	645.50 a
V_2	15.67 b	8.00 d	125.30 c	6.13 d	96.73 c
V_3	15.80 b	9.00 c	142.20 c	6.60 c	106.30 c
V_4	18.53 a	14.13 b	263.30 b	10.00 b	187.90 b
CV%	4.72	2.94	7.03	3.29	8.04
LSD (0.05%)	0.55	0.56	19.73	0.43	15.32

Here, V_1: SAU Cherry Tomato-1, V_2: Crimson Red, V_3: Australian Cherry, V_4: Sutton Cherry

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

Table 10. Influence of irrigation frequency on the number of clusters/plant, number of flowers/cluster, number of flowers/plant, number of fruits /cluster, number of fruits/plant**

Irrigation*	No. of cluster/plant	No. of flower/cluster	No. of flower/plant	No. of fruit/cluster	No. of fruit/plant
I_1	16.40 a	27.80 a	430.80 a	19.55 a	304.40 a
I_2	16.70 a	26.80 b	396.90 b	18.60 b	278.00 b
I_3	14.20 b	25.60 c	316.90 c	15.45 c	194.90 c
CV%	4.72	2.94	7.03	3.29	8.04
LSD (0.05%)	0.47	0.50	17.09	0.37	13.27

Here, I_1: Once a day, I_2: Twice a day, I_3: Thrice a day

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

Table 11. Combined effect of varieties and irrigation frequency on the number of clusters/plant, number of flowers/cluster, number of flowers/plant, number of fruits /cluster, number of fruits/plant**

Combinations*	No. of clusters/plant	No. of flowers/cluster	No. of flowers/plant	No. of fruits/cluster	No. of fruits/plant
V_1I_1	14.80 d	80.20 a	1186.00 a	55.00 a	814.00 a
V_1I_2	13.20 ef	75.40 b	995.20 b	50.40 b	665.40 b
V_1I_3	11.20 g	71.80 c	804.00 c	40.80 c	457.20 c
V_2I_1	13.60 e	8.00 f	108.80 i	5.60 i	76.00 hi
V_2I_2	15.60 cd	8.00 f	124.80 hi	6.20 hi	96.80 gh
V_2I_3	17.80 b	8.00 f	142.40 ghi	6.60 h	117.40 fg
V_3I_1	18.60 b	9.00 f	167.40 g	7.40 g	137.80 f
V_3I_2	16.40 c	9.00 f	147.60 gh	6.80 gh	111.60 fg
V_3I_3	12.40 f	9.00 f	111.60 i	5.60 i	69.60 i
V_4I_1	18.60 b	14.00 de	260.60 e	10.20 e	189.80 e
V_4I_2	21.60 a	14.80 d	319.80 d	11.00 d	238.40 d
V_4I_3	15.40 d	13.60 e	209.40 f	8.80 f	135.60 f
CV%	4.72	2.94	7.03	3.29	8.04
LSD (0.05%)	0.95	1	34.17	0.75	26.54

*Here, V_1: SAU Cherry Tomato-1, V_2: Crimson Red, V_3: Australian Cherry, V_4: Sutton Cherry and I_1: Once a day, I_2: Twice a day, I_3: Thrice a day

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

4.11. Fruit length

Significant variation was observed for fruit length among the four cherry tomato varieties (Appendix X). The longest fruit was recorded from V_2 (34.93 mm) but the shortest was recorded from V_1 (22.44 mm) (Table 12). The longest fruit length of V_2 is probably due to its genetic character and the response to acclimatize to the environment conditions. Similar result was also obtained by Omprasad *et al.* (2018).

Fruit length showed no significant variation with irrigation frequency (Appendix X). The longest fruit was found from I_1 (29.39 mm) which was statistically similar to I_2 (29.34) but the shortest was found from I_3 (28.15) (Table 13). Irrigation frequency had no significant effect on fruit length. Liu *et al*. (2019) was found similar result with the present study.

Combined effect of four cherry tomato varieties and irrigation frequency at different levels in terms of fruit length exposed significant variation (Appendix X). The longest fruit was found from V_2I_3 (36.67 mm) while the shortest was found from V_1I_3 (20.92 mm) which was statistically similar to V_1I_2 (22.11 mm) (Table 14). Fruit weight, diameter and length are determined mainly by the cultivar, but they are also affected by irrigation treatment to some extent (Wang *et al*. 2011).

4.12. Fruit diameter

Significant variation was observed for fruit diameter among the varieties (Appendix X). The maximum fruit diameter was recorded from V_2 (31.47 mm) but the minimum was recorded from V_1 (19.18 mm) (Table 12). The shorter fruit girth may due to character of the *cerasiforme* species. The present result correlates with the outcome of Kumar *et al*. (2014) in cherry tomato.

Fruit diameter showed significant variation among the different levels of irrigations (Appendix X). The fruit diameter recorded The highest from I_2 (27.17 mm)while the minimum was recorded from I_3 (26.63 mm) (Table 13).

Fruit diameter increased steadily with irrigation amount but not with irrigation frequency. The present result correlates with the outcome of Liu, *et al*. (2019).

Combined effect of different varieties and irrigation frequency in terms of fruit diameter exposed significant variation (Appendix X). V_2I_3 (33.07 mm) was recorded as widest whereas V_1I_3 (18.15 mm) which was statistically similar to V_1I_2 (18.98 mm) was recorded as the lowest (Table 14). Fruit weight, diameter and length are mainly determined by the cultivar, but they are also affected by irrigation treatment to some extent (Wang *et al*., 2011).

4.13. Single fruit weight

Significant variation existed among the varieties of cherry tomato in terms of single fruit weight (Appendix X). V_2 (23.05 g) variety exposed the highest single fruit weight while minimum was obtained from V_1 (5.18 g) (Table 12). That variation in single fruit weight might be due to inverse relationship existing between single fruit weight, and number of fruits per cluster. That was accordance with the findings of Prema *et al*. (2011) and Islam *et al*. (2012).

No significant variation was found among the irrigation frequencies (Appendix X). The maximum single fruit weight was recorded in I_2 (15.13 g) but the lowest was recorded from I_1 (14.96 g) (Table 13). Drip irrigation methods and irrigation treatments have no significant effect on the fresh, the dry fruit weight (Hashem *et al*., 2018).

Combined effects of four tomato varieties and irrigation in terms of single fruit weight exposed significant variation (Appendix X). The maximum single fruit weight was recorded in V_2I_3 (24.14 gm) but the lowest was recorded in V_1I_3 (4.95 g) which was statistically similar to V_1I_2 (5.12 g) and V_1I_1 (5.46 g) (Table 14). Fruit weight is mainly determined by the cultivar, but that is also affected by irrigation treatment to some extent (Wang *et al*., 2011).

In this study, irrigation frequency did not affect fruit weight significantly, but irrigation amount affected that one significantly.

4.14. Yield per plant

Yield per plant was significantly affected by cherry tomato varieties (Appendix X). The maximum yield per plant was recorded from V_1 (3.37 kg) but the minimum was recorded from V_3 (1.67 kg) (Table 12). That increased yield per plant is due to increased number of flower per plant, high fruit setting percentage, the maximum number of fruits per cluster and per plant, taller plants which intern increased the photosynthetic activity and ultimately leads to higher yield per plant. These results are in agreement with those obtained by Prema *et al*. (2011) and Singh *et al*. (2013).

Yield per plant was significantly affected by the irrigation frequency (Appendix X). The maximum yield per plant was recorded in I_1 (2.86 kg) which was statistically similar to I_2 (2.84 kg) but the lowest was recorded from I_3 (2.07 kg) (Table 13). The results show that decreasing irrigation water significantly affected on fruit yield characteristics. Where, the highest significant values of fruit yield was obtained by full irrigated treatment at once. Similar finding was obtained by Cetin *et al*. (2002), where the highest fruit yield was noticed with full irrigated treatment.

Combined effect of cherry tomato varieties and treatments in terms of yield per plant also exposed significant variation (Appendix X). Yield per plant was maximum in V_1I_1 (4.44 kg) but the lowest was in V_3I_3 (1.06 kg) (Table 14). Irrigation has a complex effect in increasing yield. One of the main effects was the increased number of marketable fruits per plant. Stronger and healthier plants can produce higher rates of flowering, fruit set, and ripened fruits. This result matches with what was reported earlier by Alaoui *et al*. (2014) in tomato plant.

Table 12. Performance of different varieties on the fruit length, fruit diameter, single fruit weight and yield/plant**

Variety*	Fruit length (mm)		Fruit diameter (mm)		Single fruit weight (gm)		Yield/plant (Kg)	
V_1	22.44	d	19.18	c	5.18	d	3.37	a
V_2	34.93	a	31.47	a	23.05	a	2.24	c
V_3	32.87	b	28.53	b	15.65	c	1.67	d
V_4	25.61	c	28.49	b	16.27	b	3.07	b
CV%	4.27		2.84		3.46		8.18	
LSD (0.05%)	0.91		0.56		0.38		0.16	

Here, V_1: SAU Cherry Tomato-1, V_2: Crimson Red, V_3: Australian Cherry, V_4: Sutton Cherry

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

Table 13. Influence of irrigation frequency on the fruit length, fruit diameter, single fruit weight, yield/plant**

Irrigation*	Fruit length (mm)		Fruit diameter (mm)		Single fruit weight (gm)		Yield/plant (Kg)	
I_1	29.39	a	26.95	ab	14.96	a	2.86	a
I_2	29.34	a	27.17	a	15.13	a	2.84	a
I_3	28.15	b	26.63	b	15.02	a	2.07	b
CV%	4.27		2.84		3.46		8.18	
LSD (0.05%)	0.79		0.49		0.33		0.14	

Here, I_1: Once a day, I_2: Twice a day, I_3: Thrice a day

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

Table 14. Combined effect of varieties and irrigation frequency on the fruit length, fruit diameter, single fruit weight and yield/plant**

Combinations*	Fruit length (mm)		Fruit diameter (mm)		Single fruit weight (gm)		Yield/plant (Kg)	
V_1I_1	24.29	f	20.41	g	5.46	h	4.44	a
V_1I_2	22.11	g	18.98	h	5.12	h	3.41	c
V_1I_3	20.92	g	18.15	h	4.96	h	2.26	e
V_2I_1	33.23	c	29.83	c	21.89	c	1.66	f
V_2I_2	34.87	b	31.52	b	23.11	b	2.23	e
V_2I_3	36.67	a	33.07	a	24.14	a	2.83	d
V_3I_1	34.82	b	29.30	cd	16.17	def	2.23	e
V_3I_2	32.65	cd	28.59	de	15.58	fg	1.74	f
V_3I_3	31.15	d	27.71	ef	15.21	g	1.06	g
V_4I_1	25.23	f	28.27	ef	16.31	de	3.10	d
V_4I_2	27.73	e	29.61	c	16.70	d	3.97	b
V_4I_3	23.86	f	27.60	f	15.78	efg	2.14	e
CV%	4.27		2.84		3.46		8.18	
LSD (0.05%)	1.56		0.97		0.66		0.27	

*Here, V_1: SAU Cherry Tomato-1, V_2: Crimson Red, V_3: Australian Cherry, V_4: Sutton Cherry and I_1: Once a day, I_2: Twice a day, I_3: Thrice a day

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

(a) (b)

(c) (d)

(e) (f)

Plate 2. Pictorial presentation of clusters of cherry tomato varieties. (**a**), (**b**) Single cluster of SAU Cherry Tomato-1 (V_1), (**c**) Cluster of Crimson red (V_2), (**d**) Cluster of Australian Cherry (V_3), (**e**), (**f**) Single cluster of Sutton Cherry (V_4)

V_1I_1 **V_1I_2** **V_1I_3**

V_2I_1 **V_2I_2** **V_2I_3**

V_3I_1 **V_3I_2** **V_3I_3**

V_4I_1 **V_4I_2** **V_4I_3**

Plate 3. Pictorial presentation of varietal performance due to irrigation frequency; Here, SAU Cherry Tomato-1 (V_1), Crimson Red (V_2), Australian Cherry (V_3), Sutton Cherry (V_4). Once a day (I_1), Twice a day (I_2), Thrice a day (I_3)

CHAPTER V

SUMMARY AND CONCLUSIONS

5.1. Summary

To evaluate the effects of irrigation frequency on the four cherry tomato varieties, an experiment was conducted on the rooftop at the Academic Building, Sher-e-Bangla Agricultural University, Dhaka-1207 during November 2019 to March 2020. It was a two factorial experiment with four cherry tomato varieties, i.e. SAU Cherry Tomato-1 (V_1), Crimson Red (V_2), Australian Cherry (V_3), Sutton Cherry (V_4) and three irrigation frequencies i.e. Once a day (I_1), Twice a day (I_2), Thrice a day (I_3). The experiment was outlined in Completely Randomized Design (CRD) with the five replications. Collected data were statistically analysed for the evaluation of treatments for the selection of best tomato varieties and irrigation schedule. Summary of the experiment are described below:

The tallest plant was found at V_1 (153.30 cm) at 90 days while the shortest was found at V_2 (119.30 cm). In case of irrigation frequency, the tallest plant was found from I_1 (145.90 cm) but the shortest one was found from I_3 (128.90 cm). In case of combinations, the tallest plant was obtained from V_1I_1 (173.34 cm) but the shortest was obtained from V_3I_3 (118 cm) at 90 DAT.

In terms of number of branches per plant, the maximum number of branches were found in V_3 (6.67) at 90 days after transplanting but the minimum was found in V_4 (5.73) at 90 days after transplanting. In case of irrigation frequency, the maximum number of branches were found in I_1 (6.60) at 90 days after transplanting while the minimum was found in I_3 (5.58). In case of combinations, the highest number of branches were found at V_3I_1 (7.60) while the lowest at V_1I_3 (5.20).

In case of days to 50% flowering, longest period was required for flowering in V_1 (44.93 DAT) while the shortest period was in V_4 (38.80 DAT). In case of irrigation frequency, early flowering was recorded in I_1 (39.95 DAT) while delayed in I_3 (42.10 DAT). In case of combinations, V_3I_1 (37.20 DAT) required the minimum period for 50% flower bud initiation whereas the maximum from V_1I_3 (47 DAT).

For days to the 1st fruit harvest, the longest period (88.73 days) was required for 1st fruit harvest in V_1 whereas the shortest period (76.80 days) was required from V_4. In case of irrigation frequency, early fruit harvest was recorded in I_2 (82 days) while late harvesting was recorded in I_3 (84.45 days). In case of combinations, the longest period (92.80 days) was found for 1st harvesting in V_1I_3 whereas the shortest period (73.80 days) was recorded from V_4I_2.

In terms of the brix percentage, highest value was found in V_4 (9.07%) while the lowest was from V_2 (5.10%). In case of irrigation frequency, the highest brix percentage was found from I_2 (7.46%) while the lowest was found from I_3 (6.90%). In case of combinations, the highest brix percentage was found from V_4I_2 (9.47%) but the poorest was recorded from V_2I_1 (4.90%).

In link with the number of cluster per plant, the maximum number was found from V_4 (18.53) but the minimum was found from V_1 (13.07). In case of irrigation frequency, the maximum number of cluster per plant was recorded from I_2 (16.70) but the minimum was found from I_3 (14.20). In case of combinations, the highest number of clusters per plant was found from V_4I_2 (21.60) but the minimum was found from V_1I_3 (11.20).

In terms of number of flowers per cluster, the highest number of flower was found at V_1 (75.80) but the lowest was found in V_2 (8). In case of irrigation frequency, the maximum number was counted in I_1 (27.80) but the lowest in I_3 (25.60) treatment. In case of combinations, the highest number of flowers was found in V_1I_1 (80.20) but the lowest number was found in V_2I_3 (8).

In terms of number of flowers per plant, the maximum number was counted in V_1 (995.20) but the minimum number of flower per plant was counted in V_2 (125.30). In case of irrigation frequency, the highest number of flowers per plant was counted in I_1 (430.80) but the lowest was counted in I_3 (316.90).

In case of combinations, the highest number of flower was found in V_1I_1 (1186) but the lowest was found in V_2I_1 (108.80).

In link with the number of fruits per cluster, the maximum number was counted from variety V_1 (48.73) but the lowest was from variety V_2 (6.13). In case of irrigation frequency, the maximum number of fruits per cluster was recorded in I_1 (19.55) but the lowest was recorded from I_3 (15.45). In case of combinations, the highest number of fruits per cluster was obtained from V_1I_1 (55) but the lowest was found at V_3I_3 (5.60) which was statistically similar to V_2I_1 (5.60).

Among the varieties, the maximum number of fruits per plant was recorded from variety V_1 (645.50) but the lowest was from the variety V_2 (96.73). In case of irrigation frequency, the maximum number of fruits per plant was recorded in I_1 (304.40) but the minimum was in I_3 (194.90). In case of combinations, the highest number of fruits per plant was recorded in V_1I_1 (814) and the lowest was in V_3I_3 (69.60).

In case of fruit length, the longest fruit was measured from V_2 (34.93 mm) but the shortest was from V_1 (22.44 mm). In case of irrigation frequency, the longest fruit was found from I_1 (29.39 mm) but the shortest was from I_3 (28.15 mm). In case of combinations, the longest fruit was found from V_2I_3 (36.67 mm) but the shortest was found from V_1I_3 (20.92 mm).

For fruit diameter, the maximum value was recorded from V_2 (31.47 mm) but the minimum was from V_1 (19.18 mm). In case of irrigation frequency, the highest from I_2 (27.17 mm) but the minimum was from I_3 (26.63 mm). In case of combinations, V_2I_3 (33.07 mm) was recorded as the widest whereas V_1I_3 (18.15 mm) was recorded as the lowest.

In terms of single fruit weight, V_2 (23.05 g) had the highest single fruit weight while the minimum was obtained from V_1 (5.18 g). In case of irrigation frequency, the maximum single fruit weight was in I_2 (15.13 g) but the lowest was from I_3 (14.96 g). In case of combinations, the single fruit weight was maximum in V_2I_3 (24.14 g) but the lowest was in V_1I_3 (4.95 g).

The maximum yield per plant was gained from V_1 (3.37 Kg) but the minimum was from V_3 (1.67 Kg). In case of irrigation frequency, the maximum yield per plant was recorded in I_1 (2.86 Kg) while the lowest was from I_3 (2.07 Kg). In case of combinations, the yield per plant was maximum in V_1I_1 (4.44 Kg) but the lowest was recorded in V_3I_3 (1.06 Kg).

5.2. Conclusion

From the above results, it can be concluded that, V_1 was the best in terms of plant height, number of flowers per cluster, number of flowers per plant, number of fruits per cluster, number of fruits per plant, yield per plant but the minimum fruit yield (1.67 kg/plant) was found from V_3 . V_4 exposed early flowering, early fruiting and provide best results in terms of number of clusters per plant and highest brix percentage. In case of irrigation frequency, I_1 provided the best results in terms of growth and yield related parameters but I_3 provide worst results. In case of combinations, V_1I_1 provided better performance in terms of plant height, number of flowers per cluster, number of flowers per plant, number of fruits per cluster, number of fruits per plant, yield per plant over any other combinations. Looking upon the above circumstances, it can be easily enunciated that, V_1 was the most outstanding variety and I_1 (once a day) was the most excellent irrigation frequency for desired growth and yield attributes of cherry tomato.

5.3. Recommendations

Based on the findings of the present research, such two recommendations can be made:

1. SAU Cherry Tomato -1 (Golden purna) could be recommended for production in farmers' field after regional participatory yield trial.
2. Application of drip irrigation with the frequency I_1 (once a day) could be adopted to increase water use efficiency as well as growth and yield of cherry tomato.

5.4. Suggestions for future research

1. Results are presented on the basis of one-year experiment; so, further trials are needed to substantiate the findings.
2. The present study was conducted in pots on rooftop condition. This study could be extended to the farmers’ field level.
3. A critical study may also be conducted on some other parameters of the drip irrigation technology.
4. Similar studies could also be conducted in other locations as well, so that, overall drip irrigation technology in Bangladesh can be projected to draw valid conclusions and suggestions for future extension programmes.

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APPENDICES

Appendix I. Monthly reference evapotranspiration of the crop

Monthly ETo Penman-Monteith - C:\Users\DR.SHAHIDUL\Documents\My_CLIMWAT_Files\DHAKA.pen

Country: Location 8 | Station: DHAKA

Altitude: 9 m. | Latitude: 23.76 °N | Longitude: 90.38 °E

Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	12.3	26.2	87	124	8.3	15.8	2.50
February	15.1	28.9	69	143	8.2	17.7	3.51
March	20.0	33.0	63	223	8.3	20.3	5.21
April	23.5	34.1	74	316	7.7	20.9	5.55
May	24.6	33.3	97	381	6.8	20.2	3.81
June	26.0	32.1	93	324	5.0	17.6	3.65
July	26.2	31.8	88	334	4.9	17.3	3.98
August	26.2	32.0	92	285	4.8	16.8	3.61
September	25.9	32.3	94	288	5.3	16.4	3.43
October	23.7	31.8	92	213	7.1	16.9	3.50
November	18.6	29.9	90	124	8.1	16.0	3.02
December	13.8	26.8	96	134	8.1	15.0	2.34
Average	**21.3**	**31.0**	**86**	**241**	**6.9**	**17.6**	**3.68**

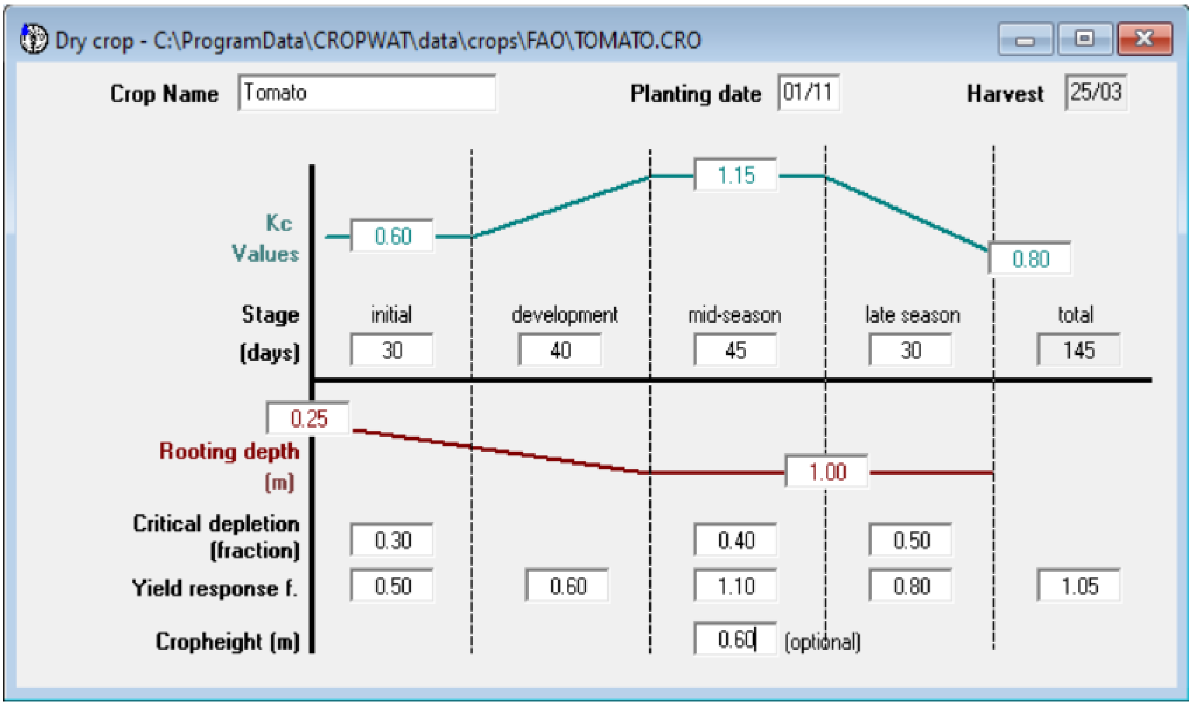
Appendix II. Monthly reference rainfall data used for CROPWAT 8.0

Monthly rain - C:\Users\DR.SHAHIDUL\Documents\DHAKA.crm

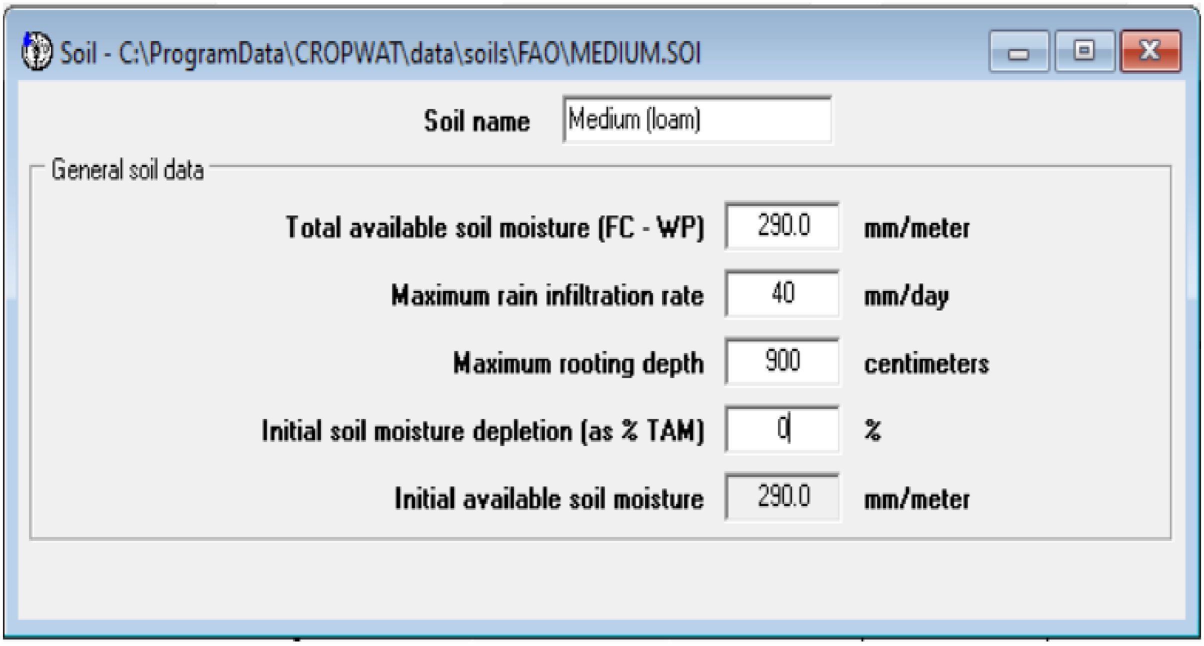
Station: DHAKA | Eff. rain method: USDA S.C. Method

	Rain	Eff rain
	mm	mm
January	4.0	4.0
February	19.0	18.4
March	58.0	52.6
April	149.0	113.5
May	290.0	154.0
June	382.0	163.2
July	385.0	163.5
August	312.0	156.2
September	286.0	153.6
October	165.0	121.4
November	35.0	33.0
December	10.0	9.8
Total	**2095.0**	**1143.3**

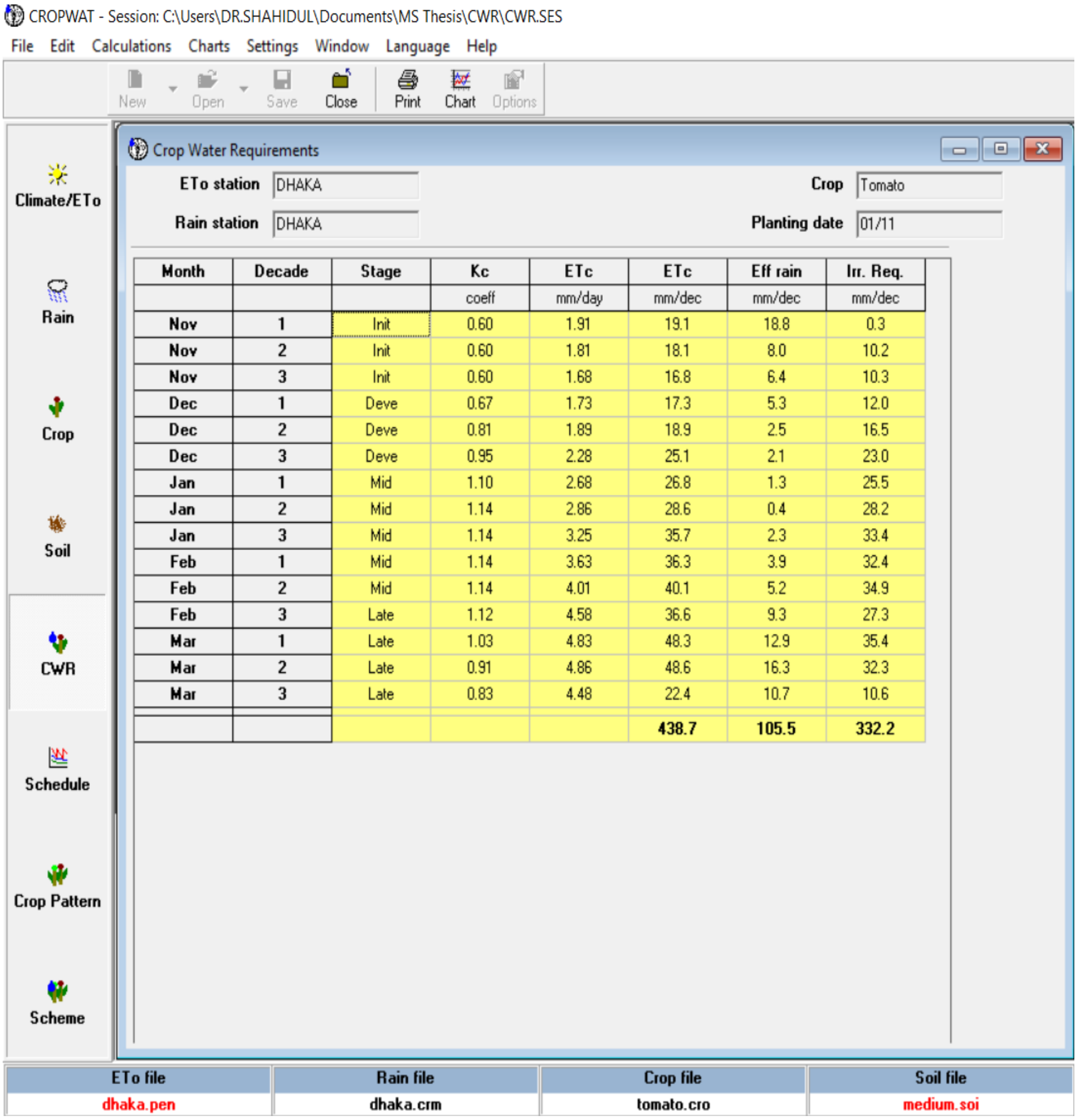
Appendix III. Tomato crop parameters used for CROPWAT 8.0 model



Appendix IV. Reference soil data used for CROPWAT 8.0



Appendix V. Crop water requirement calculated by CROPWAT 8.0



Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Nov	1	Init	0.60	1.91	19.1	18.8	0.3
Nov	2	Init	0.60	1.81	18.1	8.0	10.2
Nov	3	Init	0.60	1.68	16.8	6.4	10.3
Dec	1	Deve	0.67	1.73	17.3	5.3	12.0
Dec	2	Deve	0.81	1.89	18.9	2.5	16.5
Dec	3	Deve	0.95	2.28	25.1	2.1	23.0
Jan	1	Mid	1.10	2.68	26.8	1.3	25.5
Jan	2	Mid	1.14	2.86	28.6	0.4	28.2
Jan	3	Mid	1.14	3.25	35.7	2.3	33.4
Feb	1	Mid	1.14	3.63	36.3	3.9	32.4
Feb	2	Mid	1.14	4.01	40.1	5.2	34.9
Feb	3	Late	1.12	4.58	36.6	9.3	27.3
Mar	1	Late	1.03	4.83	48.3	12.9	35.4
Mar	2	Late	0.91	4.86	48.6	16.3	32.3
Mar	3	Late	0.83	4.48	22.4	10.7	10.6
					438.7	105.5	332.2

Appendix VI. Analysis of variance for plant height at different days after transplanting of cherry tomato					
Source of variation	**Degrees of freedom**	**Mean square for plant height (cm)**			
		30 DAT	**45 DAT**	**60 DAT**	**90 DAT**
Factor A (cherry tomato varieties)	3	48.95*	576.40*	1178.27*	3054.98*
Factor B (irrigation frequency)	2	88.20*	461.52*	1556.27*	1527.22*
Interaction (A×B)	6	68.87*	239.98*	553.47*	914.73*
Error	44	7.07	10.20	19.31	37.79
***: Significant at 0.05 level of probability**					

Appendix VII. Analysis of variance for number of branches/plant at different days after transplanting of cherry tomato				
Source of variation	**Degrees of freedom**	**Mean square for number of branch/plant**		
		30 DAT	**45 DAT**	**60 DAT**
Factor A (cherry tomato varieties)	3	0.58*	1.44*	2.73*
Factor B (irrigation frequency)	2	0.60*	1.27*	2.92*
Interaction (A×B)	6	1.16*	2.22*	1.63*
Error	44	0.14	0.22	0.23
***: Significant at 0.05 level of probability**				

Appendix VIII. Analysis of variance for days to 50% flowering, days to 1st fruit harvest, brix %				
Source of Variation	**Degrees of freedom**	**Mean square of**		
		Days to 50% flowering	**Days to 1st fruit harvest**	**Brix %**
Factor A (Cherry Tomato varieties)	3	114.44*	388.02*	40.35*
Factor B (Irrigation frequency)	2	24.62*	34.02*	1.57*
Interaction (A×B)	6	32.06*	53.64*	3.08*
Error	44	0.88	1.73	0.03
***: Significant at 0.05 level of probability**				

Appendix XI. Analysis of variance for number of clusters/plant, number of flowers/cluster, number of flowers/plant, number of fruits/cluster, number of fruits/plant						
Source of variation	**Degrees of freedom**	**Mean square of**				
		No. of cluster s/plant	**No. of flowers/ cluster**	**No. of flower/plant**	**No. of fruits /cluster**	**No. of fruits/plant**
Factor A (cherry tomato varieties)	3	74.78*	16158.53*	2567463.31*	6396.22*	1020480.00*
Factor B (Irrigation frequency)	2	37.27*	24.27*	68457.35*	92.18*	65264.12*
Interaction (A×B)	6	32.84*	22.13*	45001.79*	60.67*	38877.38*
Error	44	0.55	0.62	714.88	0.35	433.65
***: Significant at 0.05 level of probability**						

Appendix X. Analysis of variance for fruit length, fruit diameter, single fruit weight, yield/plant					
Source of variation	**Degrees of freedom**	**Mean square of**			
		Fruit length (mm)	**Fruit diameter (mm)**	**Single fruit weight (g)**	**Yield/plant (Kg)**
Factor A (cherry tomato varieties)	3	523.47*	428.39*	816.17*	8.99*
Factor B (irrigation frequency)	2	9.84*	1.48	0.14	3.99*
Interaction (A×B)	6	18.58*	8.87*	2.91*	3.19*
Error	44	1.53	0.58	0.27	0.05
***: Significant at 0.05 level of probability**					

CHAPTER I

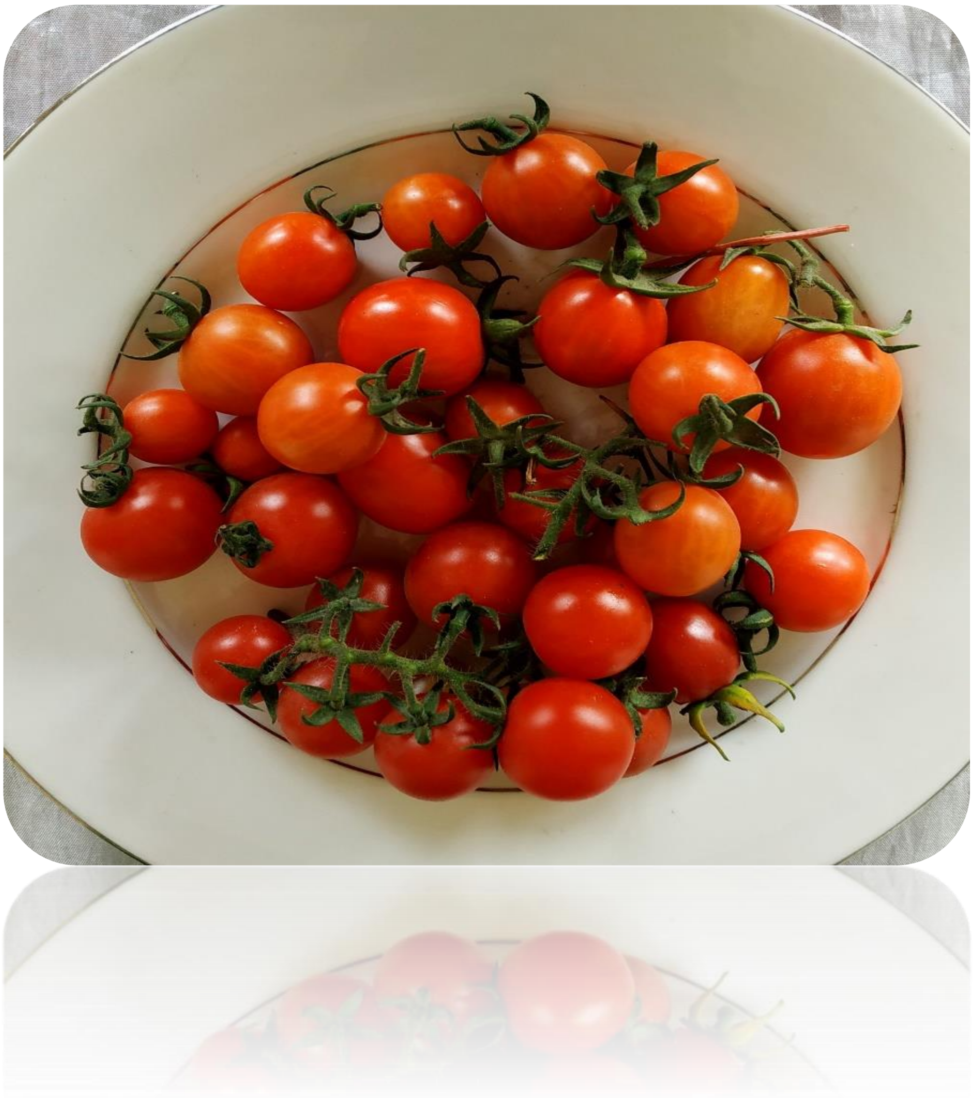
INTRODUCTION

CHAPTER II

REVIEW OF LITERATURE

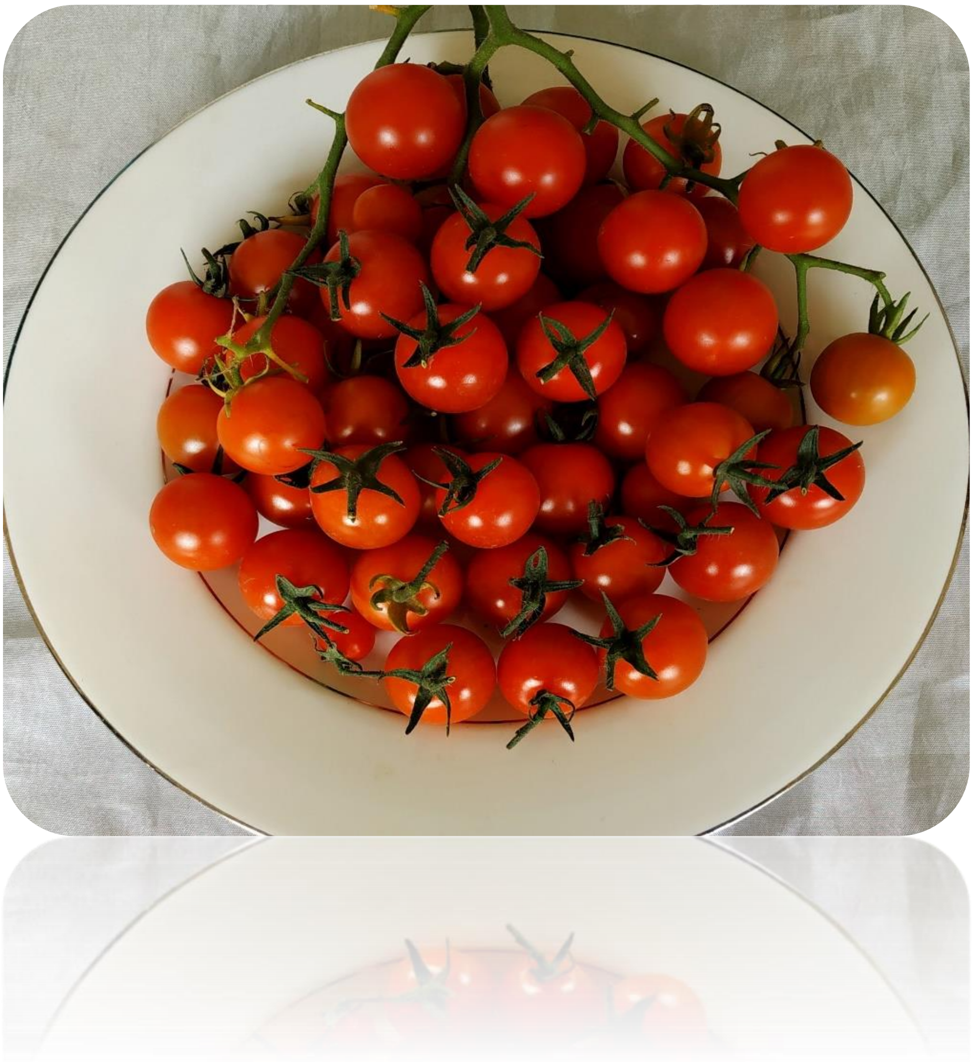
CHAPTER III

MATERIALS AND METHODS



CHAPTER IV

RESULTS AND DISCUSSION



CHAPTER V

SUMMARY AND CONCLUSION

REFERENCES

APPENDICES