EFFECT OF DRIP IRRIGATION OVER CONVENTIONAL METHOD ON THE GROWTH AND YIELD OF TOMATO

A THESIS

BY

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Student No: 1505292

Thesis Semester: July- December, 2017

MASTER OF SCIENCE (M.S)

IN

IRRIGATION AND WATER MANAGEMENT

DEPARTMENT OF AGRICULTURAL AND INDUSTRIAL ENGINEERING

HAJEE MOHAMMAD DANESH SCIENCE AND TECHNOLOGY UNIVERSITY, DINAJAPUR-5200

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DEDICATED TO MY

BELOVED PARENTS

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All praises to Almighty for blessing me with opportunities abound and showering upon me his mercy and guidance all through the life. I pray that He continues the same the rest of my life.

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The Author **June 2017**

ABSTRACT

The experiment was conducted from 27 October, 2016 to 27 February 2017 at Hajee Mohammad Danesh Science and Technology University (HSTU) farm, Dinajpur to determine the effect of drip irrigation over the other conventional methods on the growth and yield of tomato namely BARI tomato-7. There were four irrigation treatments viz. control (T_O), furrow (T_1), border (T_2), and drip irrigation (T_3) having three replication for each. The size of each plot was 1m × 1m. Four plants were transplanted in two rows in each plot. Irrigation water was applied at three growth stages viz. vegetative (0-30), flowering (35-60), and fruit development stages (65-100) based on field capacity. From the experiment it was observed that yield of tomato in drip irrigation 63.8 tha^{-1} and about 184 % water could be saved in drip irrigation compared to other conventional methods. The yield of tomato in drip irrigation was found to be 63.8 tha^{-1} and the water productivity under this irrigation was found to be 0.30$tha^{-1}m^{-3}$ The water productivity under treatments T_1 and T_2 were 0.08, 0.09 tha^{-1} m^{-3} respectively.

ACRONYMS AND ABBREVIATIONS

BARI	: Bangladesh Agricultural Research Institute
BCR	: Benefit Cost Ratio
Cb	: Centi Bar
CV	: Crop Variety
DAT	: Das After Transplanting
ET	: Evapotranspiration
FAO	: Food and Agricultural Organization
GO	: Government Organization
K_C	: Crop Factor
Mha	: Million Hectare
MIE	: Minor Irrigation Equipment
NGO	: Non Government Organization

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CHAPTER-I

INTRODUCTION

Water is one of the most vital factors for crop production. If water is not in adequate quantity and at the exact time for the crops then it will not be appropriately fruitful for the plant production and growth. Irrigation system is the important components, affecting the yield and quality of agricultural farming system. Irrigation water applied to the field such conventional irrigations like furrow, border, and check basin. To obtaining a high efficiency with surface irrigation methods various major problems are appear, like evaporation, percolation, conveyance and seepage losses. The use of drip irrigation saves water, fertilizer and gives better plant yield and quality and overcome many problems that are faced by using other conventional methods.

1.1 Tomato and its importance

Tomato (*Lycopersicon esculentum*) is the family of Solanaceae which are widely used as salad, jam, jelly, pickle, ketchup not only in our country but also the another country. Many developing countries like Bangladesh benefited from the green revolution in cereal production in the past but were not able to substantially reduce poverty and malnutrition. Vegetable production can help farmers to generate income which eventually alleviate poverty. Among the vegetables tomato is one of the most important vegetables in terms of acreage, production, yield, commercial use and consumption. At present 6.10% area is under tomato cultivation both in winter and summer (BBS, 2005). It is the most consumable vegetable crop after potato and sweet potato occupying the top of the list of canned vegetable (Chowdhury, 1979). It is cultivated all over the country due to its adaptability to wide range of soil and climate (Ahmed, 1976).

Tomato plants are extremely sensitive to hot and wet growing conditions, the weather which prevails in the summer to rainy season in Bangladesh. But limited efforts have been given so far to overcome the high temperature barrier preventing fruit set in summer-rainy (hot-humid) season. Its demand for both domestic and foreign markets has increased manifold due to its excellent nutritional and processing qualities (Hossain *et. al.,* 1999).

Considering the growing demand and importance of tomato, Bangladesh Agricultural Research Institute (BARI) has taken initiative to develop off-season summer and rainy season tomatoes. But very little information has been generated about the profitability and adoption of hybrid tomato cultivation technologies by the farmers in the country. Generalization from studies conducted by home and abroad (Mohiuddin *et al.,* 2007; Zaman *et al.,* 2006; Islam, 2005; Rahman *et al.,* 1998; Ali and Gupta, 1978; Gupta and Rao, 1978) regarding the tomato production may not be always applicable due to considerable variation in attributes of the technologies and for various others factors. Fortunately, the farmers of Bagherpara thana under Jessore district started to adopt this technology as a pioneer farmer since 2005. It is nutritious, portable vegetable rich in vitamin A, vitamin C, minerals and it can be eaten both in raw s well as ripe and after cooking. It is originated in South Africa .But most of the researcher or scientist says that Mexico is the origin of Tomato. At present the rank of tomato production is third in the world (FAO, 2002).Since the soil and climate conditions of Bangladesh during the winter season are congenial to proper growth of tomato, it is expected that improved management practices would augment the yield. The leading tomato producing countries of the world are China, Egypt, India, Turkey, Iran, Mexico, and Indonesia (FAO, 2002).

The benefits of consuming fruits and vegetables of all kinds, including tomatoes are impressive. Those are given as follows:

Tomato can help combat the formation of free radicals known to cause cancer. Beta-carotene consumption has been shown to have an inverse association with the development of colon cancer in Japanese population. According to American cancer society, some studies have shown that people who have diets rich in tomatoes may have a lower risk of certain types of cancer, especially cancer of the prostate, lung, and stomach. The fiber, potassium, vitamin c and chlorine content in tomatoes all support heart health. Tomatoes also contain folic acid, which helps to keep homocysteine levels in check, thereby reducing a risk factor of heart disease. Studies have shown that people with type-I diabetes who consume high-fiber diets have lower blood glucose levels, while people with type-II diabetes may have improved blood sugar, lipids and insulin levels. One cup of cherry tomatoes provides about 2 grams of fiber.

Eating foods that are high in water content and fiber like tomatoes can help with hydration and promote regular bowel movements. Fiber adds bulk to stool and is essential for minimizing constipation. Tomatoes are rich source of lutine and powerful antioxidants that protect the eyes against light- induced damage associated with the development of characters and age related macular degeneration (AMD). The Age-Related Eye Disease study (AREDS) recently found that people with high dietary intake of lutein and zeaxanthin had a 35% reduction in the risk of nonvascular AMD·

1.2 Agriculture and irrigation in Bangladesh

Agriculture is the largest employment sector in Bangladesh. As of 2016, it employs 47% of the total labor force and comprises 16% of the country's GDP("The World Factbook",24 February 2016). The performance of this sector has an overwhelming impact on major macroeconomic objectives like employment generation, poverty alleviation, human resources development and food security. A plurality of Bangladeshi earn from agriculture. Due to a number of factors, Bangladesh's labor-intensive agriculture has achieved steady increases in food grain production despite the often unfavorable weather conditions. Unemployment remains a serious problem, and a growing concern for Bangladesh's agricultural sector will be its ability to absorb additional manpower. Irrigation is a artificial water supply for dry agricultural land by means of dams, barrages, channels or other devices. Irrigation has been practiced for thousands of years, chiefly in regions with annual rainfall of less than 500 mm, including many countries of Africa, Asia and America. Estimates of total irrigated land in the world range from 543 to 618 million acres (Irrigation Banglapedia). In modern times, pumps have facilitated the use of underground as well as surface water.

In Bangladesh there has been widespread use of both shallow and deep tube wells for irrigation of agricultural lands, particularly during the dry period (November to March). According to recent survey, water is being lifted in this country through 26,704 deep tube wells, 4,69,226 shallow tubewells,56,829low lift pumps,1,42,132 manual pumps, and more than 5,65,000 indigenous water lifting devices(Banglapedia, 2014). For successful crop production and development of our agriculture based country importance of irrigation is undoubtedly indispensable.

1.3 Drip irrigation

In drip irrigation water is conveyed under pressure through a pipe system to the fields, where it drips slowly into the soil through emitters or drippers which are located close to the plants. Only the immediate root zone of each plant is wetted. It is the most efficient method of irrigation where more than 90% water is used.

1.4 Advantages of drip irrigation

Water is used at maximum level. As water is applied locally and leaching is reduced, fertilizer/nutrient loss is minimized. Yield of crops are maximum here. It is not necessary to level the field. Waste of fertilizer is less. Soil erosion is not taken place. Energy cost is reduced as it is operated in lower pressure than other irrigation.

1.5 Disadvantages of drip irrigation

Expense especially initial cost is high, may cause clogging if water is not filtered correctly. Problems in moisture distribution, Salinity problem, Germination problem, High skills are required.

1.6 Objectives of the study

i. To determine the effectiveness of drip irrigation over the other conventional irrigation methods for tomato cultivation
ii. To find out the productivity of water in tomato cultivation.

CHAPTER-II

REVIEW OF LITERATURE

Response of crops is not anything new and the fact is well established that crops respond positively to irrigation. Tomato is one of the most important vegetables crops grown under field and greenhouse condition, which received much attention to the researchers throughout the world. Scientists and researchers of different parts of the world who are engaged in the noble cause of promoting the sustainable agriculture of the time have reported many of their findings regarding influence of irrigation on the increase of growth, yield attributing components of tomato. Valuable findings from numerous investigations on different aspects of tomato potentialities have been achieved so far. A brief review of relevant important works on irrigation in tomato crop which are relevant to the present study have been reviewed and presented as follows:

Rao *et al.* (1995) conducted a study to determine yield and water use of tomato crop in drip and check basin method of irrigation under climatic conditions of the Nainital Tarai region of India. The percentage increase of yield for drip irrigated tomato over surface-irrigated tomato were 25.33, 18.37, and 26.26 percent for single pair wise ,double pair wise and micro tube irrigation, respectively. The percentage savings of water over surface irrigation were found to be 33.90, 39.74 and 43.12 for double pair wise, single pair wise and micro tube drip irrigated tomato, respectively. The yield and saving of water were found to be maximum for micro tube system of drip irrigation. Doorenbos and Kassam (1979) reported that in case of specific demand for a high soil water content, drip irrigation has been successfully applied.

Biswash *et al.* (2005) conducted a study with different drip irrigation levels viz, irrigation at an alternate ,three and four days interval with and without mulch to determine their effect on yield, economic return and water use efficiency of tomato (BARI tomato-7) during the rabi season at the central research station, BARI, Gazipur. It was found that the yield and yield contributing characters varied significantly under all levels of irrigation over control producing the highest tomato yield of 83.72 tha^{-1} and the highest incremental benefit cost ratio (BCR) of 7.69. The study also showed the highest water efficiency of (494 $kgha^{-1}mm^{-1}$) with 51% water saving over the control.

Dalvi *et al.* (1998) carried out an experiment to evaluate the effect of irrigation level, And frequency of micro irrigation on the yield of tomato and it was observed that micro irrigation saved water to the tune of 21% and increased yield up to 27%.It further reported that considering the advent of mechanically moved portable drip sets and with every second day irrigation, approximately 50% saving on initial investment of drip set could be achieved as the same set would irrigate double the area.

Amayresh *et al.* (2005) conducted a two years field study to develop crop co-efficient for field grown tomato, a major crop in the Jordan valley, under drip irrigation system. It was concluded that the exact updated values of crop co-efficient would enhance future estimation of crop water requirements and hence irrigation management of tomato crop.

Harmanto *et al.* (2005) conducted a study of four different levels of drip fustigated irrigation equivalent to 100, 75, 50 and 25% of crop evapotranspiration (Et_c) based on penman method. The results revealed that the optimum water requirement for the troy 489 variety of tomato was around 75% of the Et_c. Based on this it was assumed that the actual irrigation water for tomato crop in tropical greenhouse could be recommended between 4.1 and 5.6$mmday^{-1}$. Statistically, the effect of depth of water application on the crop growth, yield and irrigation productivity was significant, while the irrigation mode did not show any effect on the crop performance. Drip irrigation at 75% of Et_c provided the maximum crop yields and irrigation water productivity.

Haddadin *et al.* (1985) planted two weeks old tomato seedlings (variety: Orient) in a 5.3 m wide rows, 1.2 m apart in sandy loam soil and mulched. The crop was irrigated at soil moisture tensions of 30 cb. Yields were increased by 16.9 and 16.6% for the two mulches, respectively compared to control and it was observed that the number of fruits differed very little between treatments but the individual fruit weight varied with a great range of weight.

Shrivasta *et al.* (1993) conducted an experiment with tomato (CV rupali) on a soil with 63% clay and 15% available moisture content during 3 successive winter seasons. The highest crop yield was about 51tha^{-1} and 44% saving in irrigation water were obtained using the combination of drip irrigation and 0.4%CPE (Cumulative Pan Evaporation) and mulch of sugarcane trash. This treatment also gave the maximum - water productivity of 163 kg ha^{-1} mm^{-1}.

Raina *et al.* (1999) conducted a field experiment during 1996 and 1997 on loamy sand to investigate the effect of drip irrigation and polyethylene mulch compared with surface irrigation,on fruit yield, quality and water use efficiency of tomato cv. Naveen and it was found that drip irrigation at 80% of crop evaporatranspiration gave significantly higher fruit yield (16.63tha^{-1}) than surface irrigation (11.95tha^{-1}). From the study it was also observed that water use efficiency under drip irrigation and surface irrigation was 0.344 and 0.16t ha^{-1}-cm respectively.

Ortega *et al.* (2001) carried out a study to evaluate the study of different levels of drip irrigation on the yield and quality of tomato. From the result it was revealed that the total yield of tomato decreased with lower quantities of water, whereas fruit size significantly increased with the highest level of irrigation.

Hanson *et al.* (2003) conducted a study to investigate the effect of drip irrigation frequencies on the yield of tomato and from the experiment it was found that irrigation had little effect on yield of tomato and the drip irrigation was appropriate in medium to fine textured soil of the project site.

Zhu *et al.* (2001) conducted a protected cultivation experiment of two tomato cultivars during 1999-2000 in Shanghai, Chaina, to compare the effect of 3 drip irrigation tubes on the growth and yield of tomato. From the experiment it was evident that drip irrigation reduced water use by 15.96-28.53%, decreased soil Salinization and reduced soil hardening.

Pan *et al.* (1999) studied drip irrigation with black plastic mulch and fustigation for assessing its effect on the growth, yield and maturity characterizes of tomato. It was found that the drip irrigation improved plant growth during the first 8 weeks and increased yield. It was further reported that at 112 days after transplanting the number fruits were 76 without drip irrigation and 159 with drip irrigation .Plant with drip irrigation also had a greater weight. From the experiment it was also noticed that highest factory grade and red fruits occurred at 114 days after transplanting, with yields of 79 and 72tha^{-1} for plants with drip irrigation and 54 and 44tha^{-1} for plants without drip irrigation, respectively.

CHAPTER-III

MATERIALS AND METHODS

3.1 Location of the experimental site

The experiment was conducted from 27 October, 2016 to 27 February 2017 at Hajee Mohammad Danesh Science and Technology University (HSTU) farm, Dinajpur. The station is located at $25^{0}37^{'}16^{''}$ N latitude and $88^{0}38^{'}4^{''}$E longitude and 37m above the mean sea level (MSL). Growth and yield of tomato were carried out in research field during Rabi season to compare the effectiveness of drip irrigation over conventional method of irrigation.

3.2 Physical properties of the land

The land was prepared with several plugging. Bulk density of the soil in the field was found to be 1.42gm/cm^3. The texture of the soil measured by hydrometer method was found to be clay loam. The volumetric field capacity was measured as 45%.

3.3 Experimental design and treatments

Total plot was 17.5 sq. meter (5m×3.5m) and each plot was a surface area 1 sq. meter (1m×1m) with effective soil depth of 1.5m and there was a separate arrangement in each plot for irrigation, drainage. RCBD design of tomato shown in following Figure 3.1.

T_1R_1	**T_2 R_1**	**T_0 R_1**	**T_3 R_1**
T_0R_2	**T_3 R_2**	**T_1 R_2**	**T_2 R_2**
T_1R_3	**T_2 R_3**	**T_0 R_3**	**T_3 R_3**

Fig-3.1: RCBD block design of tomato field

There were four treatments for the experiment as given below

T_0 = No irrigation (control)

T_1 = Furrow irrigation up to field capacity at vegetative, flowering and fruit development stages

T_2 = Border irrigation up to field capacity at vegetative, flowering and fruit development stages

T_3 =Drip irrigation using saline bag at vegetative, flowering and fruit development stages.

3.4 Land preparation and transplanting

The land was prepared with several cross ploughing by spade. Before transplanting land was fertilized uniformly with a recommended 500kg N_2 ha^{-1} as urea, 600 kg P_2O_5 ha^{-1} as TSP, 200 kg K_2O ha^{-1} and 10,000 kg ha^{-1} as cow dung. Before land preparation soil samples were collected up to 30 cm to know the moisture content in the soil. Thirty two days old seedlings of tomato variety BARI tomato -7 were transplanted on the 6th November 2016 in two rows. There were four plants in each plot and two plants in each row.

3.5 Intercultural operation

Weddings were done at 30 days after transplanting. Since the stem and branches were elongating, staking were given to each plant by bamboo stick to keep them erect. Each plant was marked with an identifying numbers.

3.6 Application of irrigation water

Irrigation water was applied as per schedule of the irrigation treatments. Soil moisture was calculated at each stage of crop by gravimetric method before irrigation. The depth of irrigation water was calculated by following equation

$$d = (FC – M/100) \times 15$$

Where,

d = irrigation water depth (cm)

FC = field capacity (% vol.)

M = percent moisture content (volume basis)

Fifteen is the detonated soil depth for every 15 cm increment up to 60 cm. This depth (d) was multiplied by the area of each plot to get the volume of water. Measured amount of irrigation was applied to the plot (other than drip irrigated tank) using a calibrated bucket.

3.7 Growth stages of tomato

During the study, the growth stages considered for observation of yield were vegetative (0-30 days), flowering (35-60 days) and fruit development (65-100 days).

3.8 Soil moisture measurement

Soil moisture content in each plot was measured by gravimetric method up to 60cm depth for every 15 cm increment at the time of transplanting, before and after each irrigation and at the end of the growth stages, and at the time of harvest.

Table-3.1: Working date of different activities during the growing season

SI No	Working activities	Date
1.	Land preparation and application of fertilizer	5.11.2016
2.	Transplanting of plant	6.11.2016
3.	Weeding	5.12.2016
4.	Irrigation	
	Vegetative stages	1.12.2016
	Flowering stage	27.01.2017
	Fruit development stage	09.02.2017
5.	Harvesting	From 01.03.2017-20.03.2017
6.	Dry weight of stem	30.03.2017

Photographic representation of tomato Field

Fig-3.2: Land Preparation

Fig-3.3: Cowdung Application

Fig-3.4: Seedlings Transplanting

Fig-3.5: Research field of Tomato

Fig-3.6: Control Irrigation

Fig-3.7: Border Irrigation

Fig-3.8: Furrow Irrigation

Fig-3.9: Drip Irrigation

Fig-3.10: Green Tomato

Fig-3.11: Harvesting of Tomato

Fig-3.12: Ripe Tomato

3.9 Harvesting

Fruits were harvested at 2 to 4 days interval during early ripening stage when they becoming slightly red color. Harvesting was started on the 1 March and continued up to 20 March, 2017.

3.10 Collection of data

Data on the following parameters were recorded from each plant during the course of experiment.

3.11 Plant height

Plant height was measured from the sample plants in centimeter (cm) from the ground level to the tip of the longest stem and mean value was calculated. Plant height was recorded at 15 days interval starting from 20 days of transplanting up to 120 days to observe the growth rate of plants. Lastly the plant height was recorded at final harvesting time, number of primary branch and number of secondary branch were also recorded.

3.12 Days to first flowering

Different dates of flowering were recorded. The observation was recorded from the date of transplanting for all treatments.

3.13 Number and weight of ripe tomatoes per treatment plot

Numbers of fruits were recorded manually and the weight of fruits per treatment plot was taken by using a pan scale balance as shown in fig. The fruit weight of each harvest was recorded separately for a particular plot and all the weights from first to final harvest were combined together to get the total yield for the same plot. The number of harvested tomato, weight of harvested tomato and weight of dry stem were recorded.

3.14 Data analysis

The recorded data were compiled and analyzed by RCBD design to find out the statistical significance of the experimental results. That means for all recorded data, the analyses of variance for all the characters and Least Significance Difference (LSD) test were performed using statistical package program SPSS version -22.0.

CHAPTER-IV

RESULTS AND DISCUSSION

This chapter comprises the presentation and discussion of the results obtained from the effect of drip irrigation over conventional method on the growth and yield of tomato. The results of each parameter studied in the experiment have been presented and discussed bellow.

4.1 Growth stage of tomato plant

No irrigation, furrow irrigation, border irrigation and drip irrigation were used to observe the growth of tomato plant and the plant height was recorded at different days after transplanting (DAT). For all the treatments it was observed that the plant height increased gradually with advancement of time as shown in Fig. 4.1 and Table- 4.1. The impact of different irrigation methods on primary branch, secondary branch and straw yields is shown in Table-4.2. It was observed that the trend of highest primary, secondary branches and straws yields were in treatment T_3.

Table-4.1. Plants height of the selected tomato plants under different s irrigation treatments

Treatments	Plants height **(cm)**				
	20DAT	35DAT	50DAT	65DAT	120DAT
T_0	23	26	30	36	39
T_1	25	32	38	45	73
T_2	30	36	42	55	68
T_3	32	38	44	48	80

Table-4.2. Primary and secondary branch and dry weight of stem

Treatment	Plant No	Primary branch (no)	Secondary branch (no)	Dry weight of stem (gm)
T_0	1	1	3	30
	2	2	4	35
	3	2	3	40
	4	**1**	5	50
T_1	1	2	3	35
	2	2	5	40
	3	2	7	48
	4	3	7	55
T_2	1	2	5	40
	2	2	6	50
	3	1	7	55
	4	2	8	60
T_3	1	2	10	55
	2	2	9	65
	3	2	9	50
	4	4	8	70

The average dry weight of control, furrow, border and drip irrigation were found 38.75gm, 44.5gm, 51.25 gm, 60gm. The dry weight was low at control irrigation and comparatively high at drip irrigation. In drip irrigation method, it may be tomato plant intake much water comparatively others irrigation methods.

4.2 Plant height at different days after transplanting

The variation of tomato plant height under different irrigation method at different DAT are shown in Appendix-A. The plant height varied from 22 to 80.5 cm. The highest plant height was recorded in the treatment T_3 (80.5 cm) under drip irrigation method which was closely followed by T_2 (73 cm) under border irrigation. The highest plant height showed in drip irrigation, this might be due to water application at plant root zones slowly at field capacity and the lowest plant height showed in control irrigation.

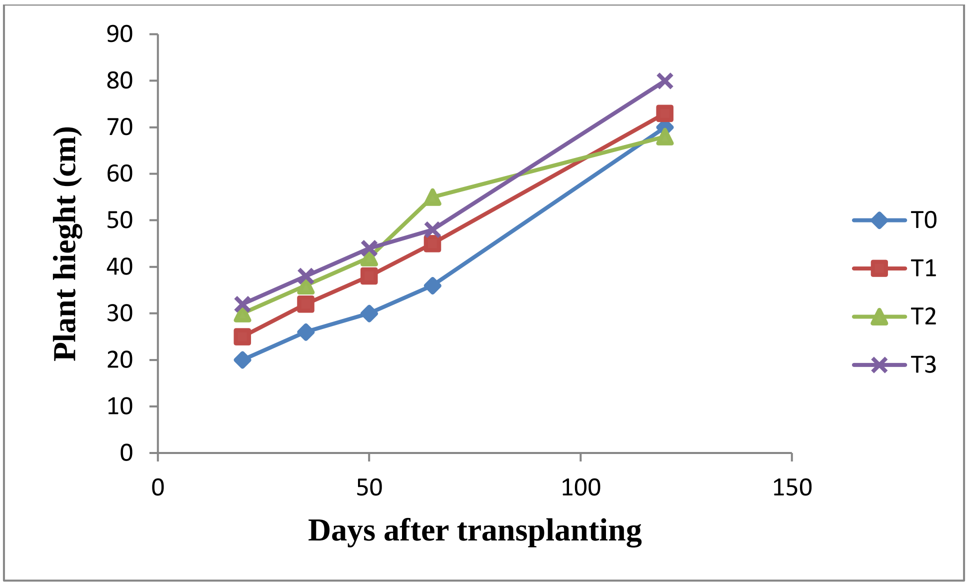

Fig-4.1: Effect of different irrigation treatment on plant height at different DAT for BARI tomato-7

4.3 Yield and water use of tomato

The number of fruits and corresponding weight, yield, number of irrigations, amount of irrigation water applied, irrigation water savings and water productivity for tomato under various treatments are presented in Table-4.3

Table-4.3: Yield and Water Productivity of tomato

Treatments	No of Fruits	Weight (kgm^{-2})	Yield (tha^{-1})	No of irrigation	Irrigation water applied		Excess water needed than T_3 (%)	Water Productivity $tha^{-1}m^{-3}$
					Depth (cm)	Vol^m (m^3ha^{-1})		
T_0	103.33±4.16	5.05±0.1	50.5	0	0	0	-	-
T1	102±3.60	5.17±0.4	51.7	3	5.97	597	184	0.08
T_2	129.66±1.52	6.73±0.4	67.3	3	7.92	792	277	0.09
T_3	125.33±0.57	6.38±0.15	63.8	3	2.1	210	-	0.30

4.4 Yield of tomato

From the Fig 4.2 it is observed that the height yield was produced in border irrigation from treatment T_2 for BARI tomato-7, because of highest irrigation requirement of 792 m^3ha^{-1}.

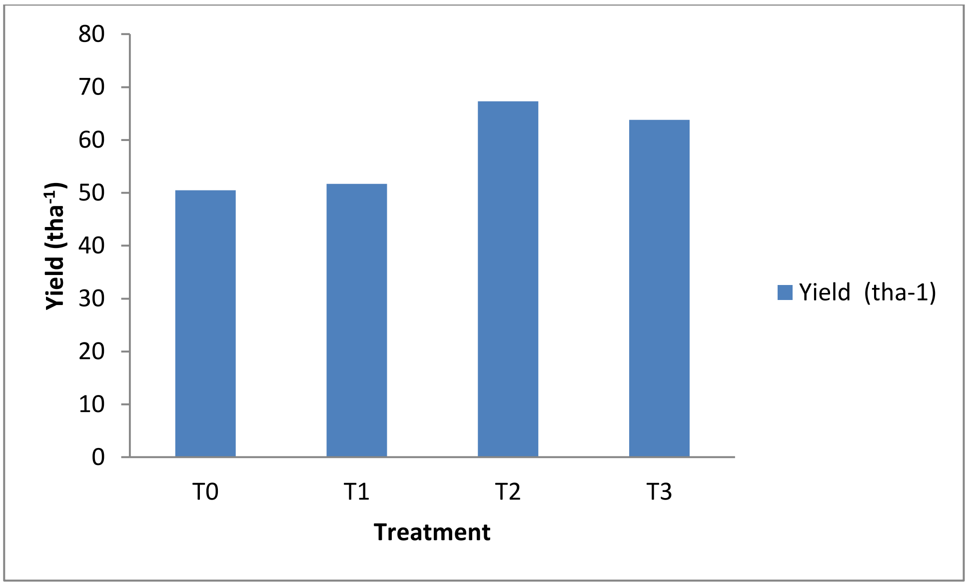

Fig-4.2: Yield of different irrigation treatment

4.5 Water requirement of tomato

It can be seen from table-4.3 and Figure 4.2 that the highest fruit yield of 67.3 $tha^{-1}$was obtained under treatment T_2 (surface or border irrigation) for BARI tomato -7 followed by treatment T_3 (drip irrigation), T_1 (furrow irrigation) and T_0 (no irrigation) in order.

It was evidenced that except no irrigation treatment, irrigation was imposed at the three selected growth stages (vegetative, flowering and fruit development) in other all treatments, but only the approaches were different. The number of irrigation was same for treatments T_1 and T_2. As the depleted soil moisture was fulfilled to the field capacity, varying amount of water was needed for different treatments. From table-4.3 the highest amount of water needed was 7.92 cm in T_2, followed by 5.97 cm in T_1, only 2.1 cm in T_3 (drip irrigation method). Thus, drip method saved about 184% and 277% compared to furrow (T_1), surface (T_2) irrigation method respectively. Hence, compared to drip irrigation method, yields were not increased in other methods in proportion to their water requirement. Thus, drip irrigation method seemed to be the best water saving technique for obtaining reasonably higher yield (Figure 4.3).

Further, converting the applied water to per hectare volumetric content, it can be seen that the minimum water (210m^3/ha) was required in treatment T_3 (drip irrigation) which made the highest water productivity of .30$tha^{-1}m^{-3}$ (Figure -4.3).

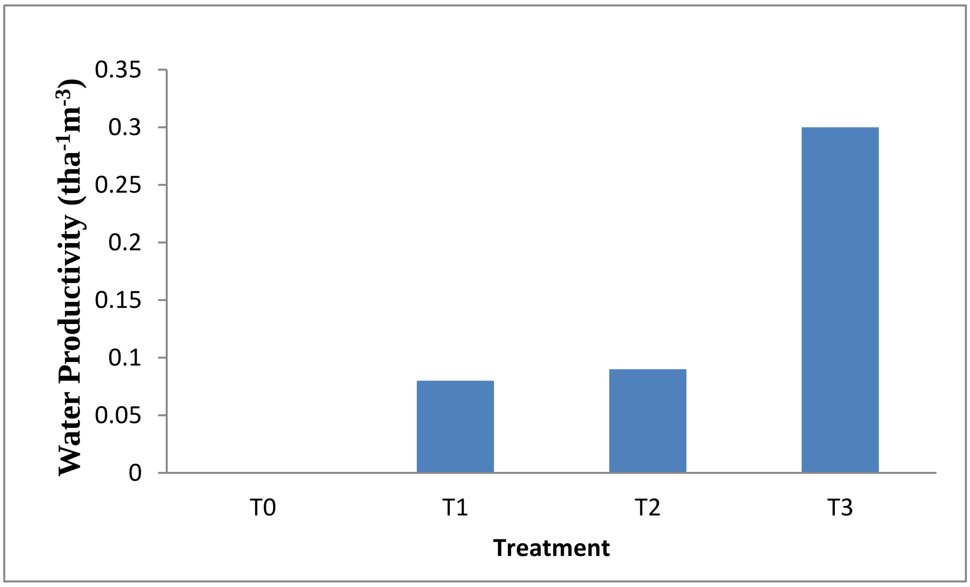

Fig-4.3: Water productivity of different irrigation treatment

CHAPTER-V

CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The experiment was conducted in the Hajee Mohammad Danesh Science & Technology University (HSTU) farm, Dinajpur during October 2016 to February 2017.On the basis of the experimental findings, the following conclusions may be drawn: Tomato can be grown successfully with drip irrigation. A substantial amount of irrigation water can be saved through drip irrigation without hampering the yield of tomato. Drip irrigation required only 210 m^3ha^{-1} for tomato compared to other methods. The water productivity of BARI tomato-7 under drip irrigation was found 0.30 $tha^{-1}m^3$. Tomato can be grown having a reasonable yield under residual soil moisture condition. .The yield of tomato were 50.5, 51.7, 67.3, 63.8 t ha^{-1} for control, furrow, boarder and drip irrigation methods. The yield of tomato in different irrigation methods were $T_0 < T_1 < T_3 < T_2$ in relation. However the yield of tomato was higher at boarder irrigation method but the water productivity of drip irrigation was higher for BARI tomato-7 0.3$tha^{-1}m^{-3}$.

5.2 Recommendations

The following recommendations may be put forward for future research work:

1. The studies should be repeated for several years to confirm the results.
2. Experiments need to be conducted for other variety of tomato to verify the results.

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APPENDIX–A

Soil properties of the experimental sites of the study area during 2016-2017 (Before sowing of tomato)

Soil depth (cm)	**P^H**	**OM (%)**	**Total N (%)**	**P (mg/gm soil)**	**K (mg/100g soil)**	**S (mg/gm soil)**	**Zn (mg/gm soil)**	**B (mg/gm soil)**
0-10	6.2	2.33	0.12	36.47	0.19	10.81	0.88	0.22
10- 20	6.83	1.49	0.08	23.99	0.12	12.16	0.68	0.28
20-30	7	1.60	0.08	13.93	0.14	12.76	0.57	0.23
Avg	6.68	1.81	0.09	24.8	0.15	11.91	0.68	0.25

Plants height at different days after transplanting treatments (T_O)

Treatment	Plant Height (cm)		
	Plant height from each replication	Average	DAT
T_O	22	23	20
	23		
	24		
	25	26	35
	24		
	26		
	29	30	50
	30		
	30		
	35.5	36	65
	36		
	35.5		
	39.5	39	120
	39.5		
	37		

Plants height at different days after transplanting treatments (T_1)

Treatment	Plant Height (cm)		
	Plant height from each replication	Average	DAT
T_1	24	25	20
	25.5		
	24.5		
	31	32	35
	32		
	33		
	39	38	50
	39		
	37		
	44	45	65
	45		
	44		
	70	70	120
	70		
	70		

Plants height at different days after transplanting treatments (T_2)

Treatment	Plant Height (cm)		
	Plant height from each replication	Average	DAT
T_2	29	30	20
	30		
	30		
	36	36	35
	36		
	35		
	42	42	50
	43		
	42		
	54.5	55	65
	54.5		
	55		
	67.5	68	120
	68.5		
	68		

Plants height at different days after transplanting treatments (T_3)

Treatment	Plant Height (cm)		
	Plant height from each replication	Average	DAT
T_3	32	32	20
	31		
	32		
	39	38	35
	38		
	39		
	43	44	50
	44		
	44		
	49	48	65
	48		
	47		
	80.5	80	120
	79.5		
	79		

APPENDIX–B

Harvesting activities at different days (Treatments T_O)

Date	Plot No					
	1		2		3	
	No	Wt (gm)	No	Wt (gm)	No	Wt (gm)
01/03/17	6	192	5	189	10	230
03/03/17	7	371	9	400	11	450
05/03/17	14	740	12	730	13	720
07/03/17	19	1050	18	1040	15	1000
09/03/17	19	1070	21	1090	20	1080
11/03/17	13	670	10	590	11	580
15/03/17	4	130	5	125	8	200
17/03/17	8	450	5	380	9	400
20/03/17	12	400	15	460	11	380
Grand Total	102	5070	100	5004	108	5040

Harvesting activities at different days (Treatments T_1)

Date	Plot No					
	1		2		3	
	No	Wt (gm)	No	Wt (gm)	No	Wt (gm)
01/03/17	-	-	2	140	3	160
03/03/17	3	191	6	210	5	200
05/03/17	10	720	14	830	10	690
07/03/17	24	1270	21	1190	19	1110
09/03/17	25	1210	23	1200	29	1310
11/03/17	8	430	11	460	6	250
15/03/17	5	190	6	200	4	130
17/03/17	12	580	10	430	15	630
20/03/17	12	530	13	540	10	720
Grand Total	99	5121	106	5200	101	5200

Harvesting activities at different days (Treatments T_2)

Date	Plot No					
	1		2		3	
	No	Wt (gm)	No	Wt (gm)	No	Wt (gm)
03/03/17	3	168	2	145	1	51
07/03/17	14	990	16	1050	15	1000
09/03/17	23	1410	21	1350	25	1410
11/03/17	41	2205	43	2300	40	2250
13/03/17	10	320	9	280	10	310
15/03/17	8	305	6	250	9	300
17/03/17	11	56	10	510	13	610
20/03/17	20	830	21	850	18	760
Grand Total	130	6788	128	6735	131	6691

Harvesting activities at different days (Treatments T_3)

Date	Plot No					
	1		2		3	
	No	Wt (gm)	No	Wt (gm)	No	Wt (gm)
03/03/17	3	170	6	280	4	200
07/03/17	11	720	9	580	12	820
09/03/17	18	1090	20	1280	19	1110
11/03/17	19	955	18	850	20	1050
13/03/17	17	770	15	710	16	730
15/03/17	15	785	16	790	16	800
17/03/17	19	850	20	900	19	900
20/03/17	23	950	22	910	20	950
Grand Total	125	6290	126	6300	126	6560