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Effect of Drip Irrigation over Conventional Method on the Growth and Yield of Tomato

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Abstract: Presently the drip irrigation is the most efficient method of irrigation in the smart agriculture farming. The present study has been conducted to determine the effect of drip irrigation over the other conventional methods on the growth and yield of tomato namely BARI tomato-7. 4 different types of irrigation treatments no irrigation (T0), furrow (T1), border (T2), and drip irrigation (T3) has been conducted and 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 as 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 and the water productivity under this irrigation was found to be 0.30 tha^{-1} m^{-3}. The water productivity under treatments T1 and T2 were 0.08 tha^{-1} m^{-3}, 0.09 tha^{-1} m^{-3} respectively.
Keywords: Water Productivity, Furrow Irrigation, Border Irrigation, Check Basin Irrigation, Bulk Density.

I. INTRODUCTION

Irrigation system is one of the significant components for the yield and quality of agricultural farming system. Irrigation water applied to the field such conventional irrigations like furrow, border, and check basin. 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. 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. To obtain a high efficiency with surface irrigation methods various major problem appears 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. 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 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).

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 Eating foods that are high in water content and fibre like tomatoes can help with hydration and promote regular bowel movements. Fibre 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.

Agriculture is the largest employment sector in Bangladesh. As of 2016, it employs 47% of the total labour 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. 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-1mm-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.

A. *Objectives of the Study*

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

II. MATERIALS AND METHODS

A. *Location of the Experimental Site and Physical Properties of The Land*

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 25037'16'' N latitude and 88038'4''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. The land was prepared with several plugging. Bulk density of the soil in the field was found to be 1.42gm/cm3. The texture of the soil measured by hydrometer method was found to be clay loam. The volumetric field capacity was measured as 45%.

B. *Experimental Design and Treatments*

Total plot was 17.5 sq. meter (5m×3.5m) and each plot has 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 Table I.

Table I. RCBD Block Design Of Tomato Field

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	$T_2 R_3$	$T_0 R_3$	$T_3 R_3$

There were four treatments for the experiment as given below

T0 = No irrigation (control)

T1 = Furrow irrigation up to field capacity at vegetative, flowering and fruit development stages

T2 = Border irrigation up to field capacity at vegetative, flowering and fruit development stages

T3 =Drip irrigation using saline bag at vegetative, flowering and fruit development stages.

C. Land Preparation, Transplanting and Intercultural Operation

The land was prepared with several cross ploughing by spade. Before transplanting land was fertilized uniformly with a recommended 500kg N2 ha-1 as urea, 600 kg P2O5 ha-1 as TSP, 200 kg K2O 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. Weddings were done at 30 days after transplanting. Since the stem and branches were elongating, staking was given to each plant by bamboo stick to keep them erect. Each plant was marked with an identifying number.

D. Irrigation Water Application

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.

E. 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).

F. Representation of Different Method of Irrigation

Control Irrigation | Border Irrigation

Furrow Irrigation | Drip Irrigation

Fig. 1 Representation of different methods of irrigation

G. *Harvesting*

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

H. *Collection of data*

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

I. *Plant height*

Plant height was measured from the sample plants in centimetre (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 branches were also recorded.

J. *Days to First Flowering*

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

K. *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 tomatoes, weight of harvested tomato and weight of dry stem were recorded.

L. *Data Analysis*

The recorded data were compiled and analysed 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.

III.RESULTS AND DISCUSSION

The results of each parameter studied in the experiment have been presented and discussed below.

A. *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. 2.

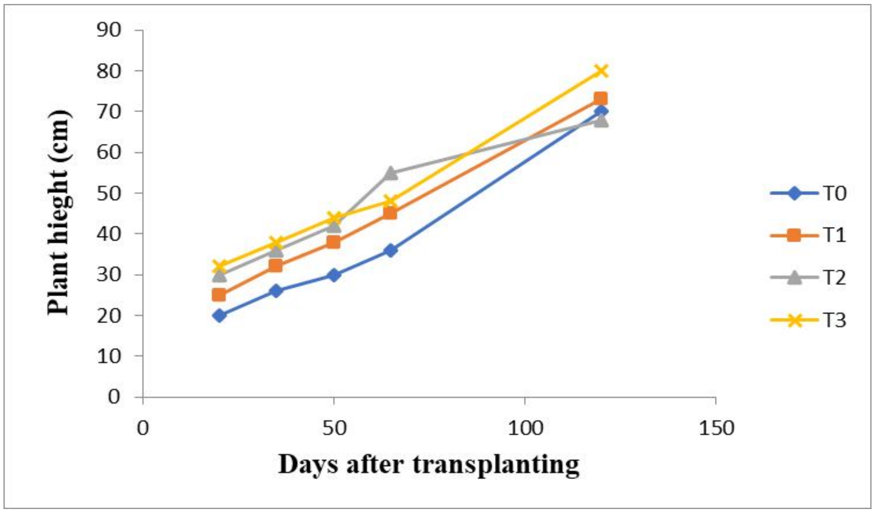

Fig. 2 Effect of different irrigation treatment on plant height at different DAT for BARI tomato-7

B. 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 II.

Table II
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	Water Productivit y
					Depth	Vol^m (m^3ha^-		
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

C. Yield of Tomato

From the Fig 3 it is observed that the height yield was produced in border irrigation from treatment T2 for BARI tomato-7, because of highest irrigation requirement of 792 m3ha-1.

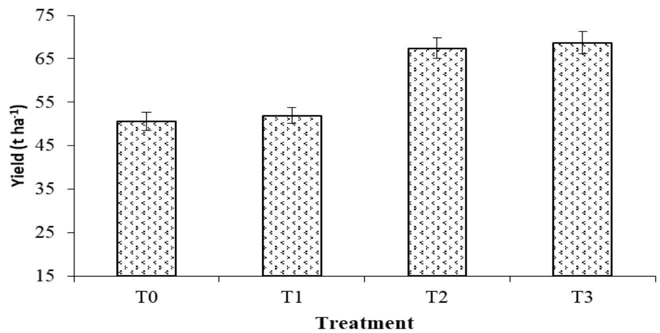

Fig. 3 Yield of different irrigation treatment

D. Water Requirement of Tomato

It can be seen from Table II and Fig. 3 that the highest fruit yield of 67.3 tha-1was obtained under treatment T2 (surface or border irrigation) for BARI tomato -7 followed by treatment T3 (drip irrigation), T1 (furrow irrigation) and T0 (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 irrigations was same for treatments T1 and T2. As the depleted soil moisture was fulfilled to the field capacity, varying amount of water was needed for different treatments. From Table II the highest amount of water needed was 7.92 cm in T2, followed by 5.97 cm in T1, only 2.1 cm in T3 (drip irrigation method). Thus, drip method saved about 184% and 277% compared to furrow (T1), surface (T2) 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 (210m3/ha) was required in treatment T3 (drip irrigation) which made the highest water productivity of .30 tha-1m-3 (Fig. 4).

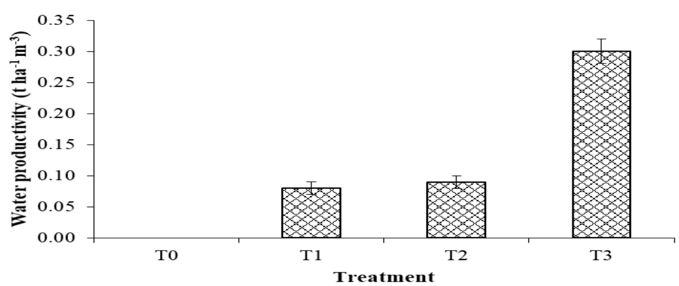

Fig. 4 Water productivity of different irrigation treatment

IV. CONCLUSIONS AND RECOMMENDATIONS

A. 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 m3ha-1 for tomato compared to other methods. The water productivity of BARI tomato-7 under drip irrigation was found 0.30 tha-1m3. Tomato can be grown having a reasonable yield under residual soil moisture condition. The yield of tomato was 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 T0 <T1<T3<T2 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 0.3tha-1m-3.

B. 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.

V. ACKNOWLEDGMENT

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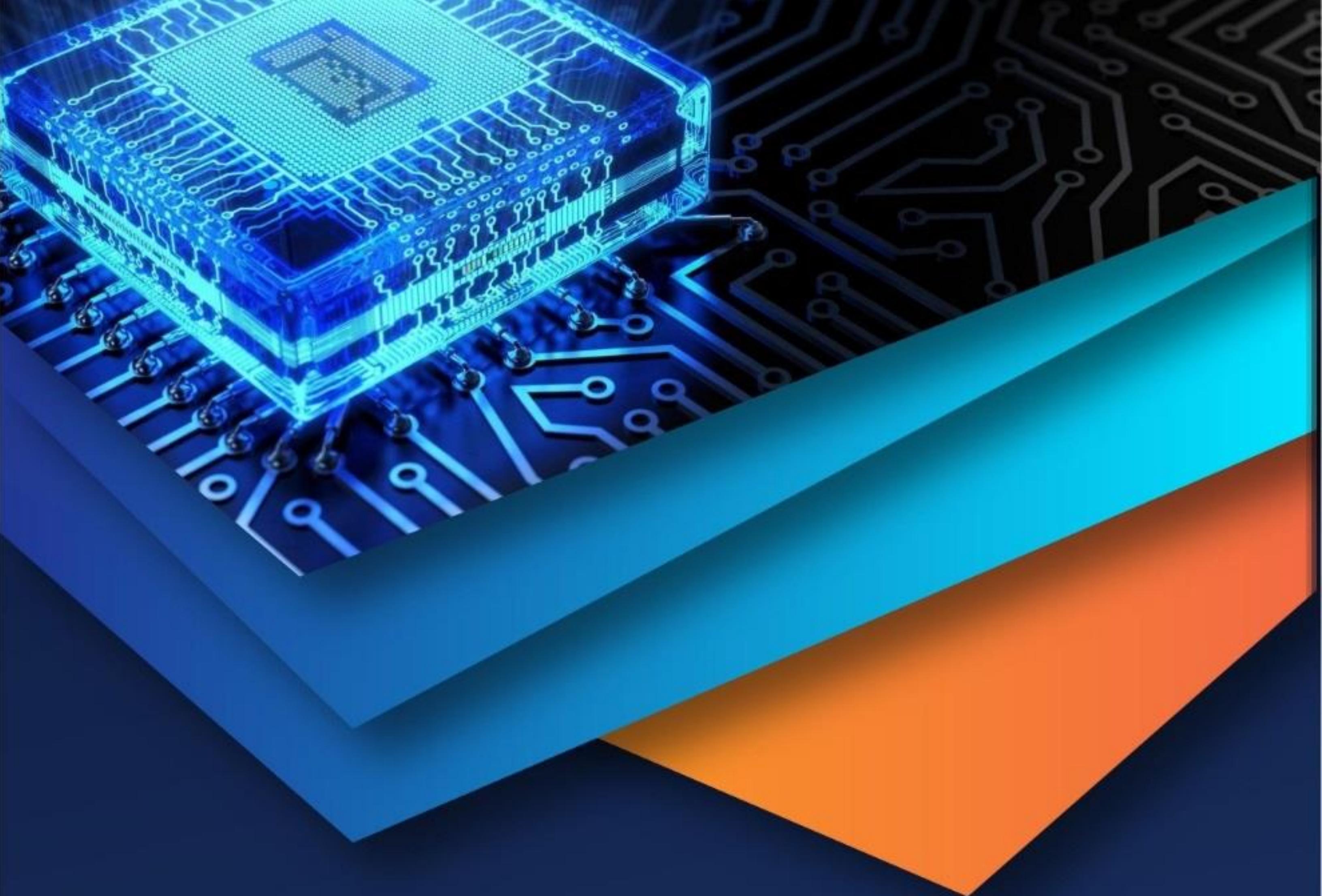

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