Effect of drip irrigation regime on plant height and stem girth of tomato (Lycopersicon esculentum Mill)

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Abstract. Plant height and stem girth are usually a good index of plant vigour, which may contribute towards greater productivity. In this vein, a randomized complete block design (RCBD) experiment was set up to investigate the effect of drip irrigation regime on plant height and stem girth of tomato. In the experimental set-up, irrigation frequency and depth were used as the main and sub-plot respectively in three replicates. Three frequencies (7, 5 and 3 days; designated as F1, F2 and F3, respectively) and three depths (100, 75 and 50% of crop evapotranspiration; designated as D1, D2 and D3, respectively) were used. Plant height and stem girth were recorded weekly. Plant height was measured with the aid of a flexible tape from the base of the plant to the tip while stem girth was measured using a digital Vernier caliper (model GMC – 190, GTK Taiwan). Analysis of Variance was done to determine the relationship between irrigation interval and depth on one hand and plant height and stem girth on the other. The mean was separated using Fisher’s Least Significant Difference (LSD) at 95% confidence level (P <0.05). The results obtained show similar trends for both plant height and stem girth. Higher values were recorded for plant height at F3 and the lowest values observed for F1. Although, higher values were recorded for stem girth at F2, depth of water application at 75% ETc gave better results for both plant height and stem girth.

1. INTRODUCTION

The increase for the demand of water in the world is on the high sides; especially in tropical regions resulting in a search for effective ways to use water resources by farms. It is this light that water conserving practices such as drip irrigation system has become prominent especially in the production of a high water consuming crop like Tomato. Drip irrigation system, whose efficiency has been estimated at about 95%, has been viewed as the most practical solution in vegetable production [1]. Tomato is the leading vegetable crop in the world and they are very rich in vitamin A and vitamin C, proteins, fats and carbohydrates, food energy calories as well as other essential minerals and food elements [2]. It is a prominent vegetable crop in Nigeria vastly cultivated using drip irrigation system. The crop is largely being grown in the semi-arid
region of the country during the cool dry season (harmattan). However, this leads to scarcity of this crop
during off season especially in the southern part of the country where the cultivation is relatively low [3].
Therefore, there is a need to encourage tomato production in the Southern parts of Nigeria, particularly
during the dry season to bridge the production deficit gap.

The knowledge of the relationship among plant characters, growth parameters and yield is
important. This usually points to parameters that affect the yield of the crop. Plant height and stem girth are
usually a good index of plant vigour, which may contribute towards greater productivity. [4] reported that
there is a high significant positive correlation between tomato plant height and fruit diameter. It has also
been discovered that plant height has a significant positive correlation with leaf parameters such as number
of leaves, leaf area, and leaf area index as well as with number of branches [5]. It was reported by [6], that
stem girth at 90 days after transplanting positively and significantly correlated with total yield while they
also observed that early yield per plant was positively and significantly associated with stem girth 90 days
after transplanting and plant height at 60 days after transplanting. Since drip irrigation system is a prominent
component of tomato production in Nigeria, it is expedient that the appropriate water regime with the
optimum effect on growth parameters such as plant height and stem girth which ultimately affects the
overall yield of the plant be investigated.

2. Materials and Methods

2.1 Description of the Study Area

The study was conducted at the teaching and research field of Agricultural Engineering Department, Ladoke
Akintola University of Technology, Ogbomoso. Ogbomoso lies between Latitudes 8° 08' and 8° 10' N of
the Equator and Longitudes 4° 10' and 4° 14' E of the Greenwich Meridian. The climatic condition of
Ogbomoso is mostly influenced by the Northeast and Southwest trade winds with a maximum temperature
of 33°C and a minimum temperature of 28°C [7]. The Northeast trade wind which is cold with drying effect
harmattan normally starts from November to March while the southwest trade wind which is warm and
very moist (rain bearing) blows between the months of April and October [7]. The relative humidity of this
area is high all year round (about 74%) except in the month of December to February where relative
humidity is low when the dry wind blows from the North [8]. The average annual rainfall is about 1000
mm. The soil type is sandy loam. The soil in the field used for the study was fallow for three years before
the experiment.

2.2 Nursery operations

Tomato seeds were planted on a nursery bed. The seedlings were nursed for about four weeks after which
they were transplanted to the field. The seedlings were planted at a spacing of 0.5 m within row and 1 m
between rows. This implies that each 2 m x 2 m sub-plot had 15 stands of tomato.

2.3 Experimental Design, Plot Layout and Management

The experiment was a two factor experiment. The factors were frequency of water application [7 days (F1),
5 days (F2) and 3 days (F3)] as the main plot and depth of application as subplots. The depths of application
were taken as 100, 75 and 50% of the crop evapotranspiration (ETc) water use designated as D1, D2 and D3
respectively. The experimental design is a randomized complete block design (RCBD) with three replicates.
Each sub-plot measures 4 m² as shown in Figure 1 The irrigation scheduling was determined as a function
of ETc.

Each sub-plot is 2 x 2 square meters which contained 15 stands of tomato at 0.5 m spacing within row and
1 m between rows. The three main plots were separated from each other by a space of 1 m. Weeding of the
plots was done manually at four (4) weeks interval. The first weeding was done four weeks after
transplanting (WATP). Fertilizer based application was done according to the standard recommended
dosage for tomato using N.P.K (15-15-15) at the rate of 10 g / 0.26 m² [9] at the crop initial growth stage.
Figure 1. Experimental Field Layout Source: [10]

LEGEND

- $F_1$ = 7 – day irrigation frequency
- $F_2$ = 5 – day irrigation frequency
- $F_3$ = 3 – day irrigation frequency
- $D_1$ = depths of water application (100 % ETc)
- $D_2$ = depths of water application (75 % ETc)
- $D_3$ = depths of water application (50 % ETc)
- ETc = crop evapotranspiration
- $F \times D$ = the interaction between the factors
Plate 1. The tomato drip irrigated project site in LAUTECH, Ogbomoso, Nigeria.  
Source: Google map – www.googleearth.com

2.4 Irrigation Scheduling

The volume of application for the desired depth was determined by multiplying the depth by the crop area as:

\[ a_v = d_l \times a_c \]  

Where:

\[ a_v \] = volume of application (m³)
\[ d_l \] = irrigation depth (m)
\[ a_c \] = crop nutrient area (m²)

The drippers were calibrated to have a discharge 4 l/h. The time required for applying the desired volume was calculated using the relation

\[ t \times d = a_v \]  

Where:

\[ t \] = time required (hr)
\[ a_v \] = volume of application (L)
\[ d \] = discharge (L/hr)

2.5 Determination of Plant height and Stem girth

Plant height was monitored on weekly basis. The plant height was measured with the aid of a flexible tape from the base of the plant to the tip. Stem girth was also measured with the aid of a digital Vernier caliper (model GMC – 190, GTK Taiwan).

2.6 Statistical Analysis

The data collected were subjected to analysis of variance (ANOVA). All the statistical analyses were done using SPSS (SPSS IBM Statistics v. 20). The means were separated using Least Significant Difference (LSD) at 5% probability level.

3. Results and Discussion

3.1 Plant height

The results from Figures 2, 3 and 4 revealed that plant heights mean value for F3 was greater than F2 and F1 and, this was in agreement with [11], who reported that plant height increase with decrease of irrigation interval and vice versa. Among the irrigation regimes there was only a small difference of about 6% between the largest value (154 cm) in the treatment F1 and the smallest value (28 cm) in the treatment F2. Also, from the Figures, the plant height observed from the various treatments show significant differences, 42 days after transplanting. This could be due to availability of moisture required for the initial development at the early stage. However, 65 days after transplanting, there were significant differences in all the treatments, F1 produced the highest value (154 cm) of plant height at D3 with the depth of water application of 50% ETc followed by F3 and F2 with values (148 and 140 cm) at D2 with the depth of water application of 75% ETc. According to [12] water stress results in reduction in growth of most growth parameters in plants.
Figure 2. Effects of 7 – days irrigation frequency on plant height
3.2 Stem girth

The plants that were irrigated every five days accordingly resulted in significantly larger stem girth (diameter) as compared to irrigation frequencies of every three and seven days. The results as shown in the Figures were in agreement with [13], who found a reduction in stem diameter due to increased time of irrigation intervals between successive irrigations. They explained their findings by the fact that plants were under water stress. The results obtained from this experiment with the quality stem girth produced shows that F1 and F2 follow the same trends with the higher value of stem girth which were recorded at depth of water application with 75% ETc. The lowest values were observed at depth of water application with 50% ETc except at the F3 where D1 recorded the higher value between 42 days and 70 days.

The results in the frequency F3 give a clear picture that water application results into the same growth stages of tomato with D1, D2 and D3 from week one to week five. According to [14], it was found in their study that the stem diameter increased with plant growth, and the final stem diameter is larger in treatments with more irrigation water applied. The results of [14] are not in accordance with [15] who reported that the excess water would make the tomato plant too high and thin. The reason of the different results was that the amount of water applied in this study was smaller compared to that which was applied in experiment by [15]. However, differences in stem girth among drip irrigation regimes were not large although, the treatment F3 with three days irrigation interval produced the smallest value. And it was clear that tomatoes reacted positively to the frequency of application of irrigation water.
Figure 5. Effects of 7 – days irrigation frequency on stem girth
Figure 6. Effects of 5 – days irrigation frequency on stem girth

Figure 7. Effects of 3 – days irrigation frequency on stem girth
4. Conclusion

It can be concluded from this study that tomato responds significantly and positively to water stress. Higher values were recorded for plant height at F3 (3-day irrigation regime) and the lowest values observed for F1 (7-day irrigation regime). Although, higher values were recorded for stem girth at F2 (5-day irrigation frequency), depth of water application at 75% ETc gave better results for both plant height and stem girth.

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