ISSN 1819-1894

Asian Journal of Agricultural Research

http://knowledgiascientific.com

Knowledgia SCIENTIFIC
A Place to Publish Outstanding Research

Asian Journal of Agricultural Research 4 (4): 196-203, 2010
ISSN 1819-1894

Effect of Irrigation Interval on Growth and Development of Tomato under Sprinkler

[1]P.O. Boamah, [2]L.K. Sam-Amoah and [2]J.D. Owusu-Sekyere
[1]Department of Ecological Agriculture, Bolgatanga Polytechnic, P.O. Box 767, Bolgatanga, Ghana West Africa
[2]Department of Agricultural Engineering, School of Agriculture, University of Cape Coast, Cape Coast, Ghana West Africa

Abstract: This research was conducted to determine the performance of two sprinkler heads and to use one of them to determine suitable irrigation interval for the optimum growth and yield of tomatoes. Technical evaluation of sprinkler system performance was done using the sprinkler heads, i.e., LEGO and AGROS and Parameters measured and their values for them were, respectively: Coefficient of Uniformity (CU), 98.05±0.21 and 99.20±0.13, Distribution Uniformity (DU) 17.00±3.00 and 57.67±5.51, Scheduling Coefficient (SC), 6.00±1.00 and 1.87±0.23, precipitation rate, 7.87±0.38 and 8.00±0.00, operating pressure, 0.18±0.25 and 0.18±0.01, Radius of throw, 0.53±0.06 and 0.53±0.06, Deep Percolation Ratio (DPR), 0.46±0.01 and 0.61±0.18, Depth of water, 5.69±01.0 and 5.93±0.18. AGROS performed better than LEGO in most parameters determined. Four irrigation intervals; one day (T_1), 3 days (T_2), 5 days (3) and 7 days (T_4) were used. Tomato plants under T_1 had a significantly higher stem diameter (2.85), fruit mass (45.00), fruit length (5.3), flower number (2.781), than those under the other treatments. Irrigation intervals of a day (T_1) lead to the best growth and development of tomatoes.

Key words: AGROS, LEGO, performance, irrigation interval, growth, yield, tomato

INTRODUCTION

Tomato is one of the most popular and widely grown vegetable crops in the world. It belongs to the genus *Lycopersicon* which is grown for its edible fruit (Jones, 1989). The fruit contains high levels of vitamin A, B, C, E and nicotinic acid and is therefore an important source of vitamins. On the average, the fruit contains 8% protein 34% minerals (mainly K^+ Ca^+ and P) 48% total soluble sugars, 9% citric acid and 0.5% vitamin. Tomato has a higher acreage than any vegetable crop in the world and it requires a high water potential for both, optimal vegetative and reproductive development (Jones, 1989).

The crop tolerates fairly acid soil and liming is unnecessary unless the soil pH is below 5. Well drained sandy loam is preferred by the crop. No horticultural crop has received more attention and detailed study than tomato (*Lycopersicon esculentum*). Water deficit decreases tomato growth, yield and quality (Byari and Al-Sayed, 1999) therefore, proper water management is vital for sustainable crop production.

The use of irrigation technology is not widespread but considered to be of great importance in view of the seasonal and incidental occurrence of drought. The main

Corresponding Author: P.O. Boamah, Department of Ecological Agriculture, Bolgatanga Polytechnic, P.O. Box 767, Bolgatanga, Ghana West Africa

consumptive water uses in Ghana are for domestic, industrial and irrigation purposes. According to SRID (2002), in 2000 about 652 million m^3 were withdrawn for irrigation (66%), 235 million m^3 for domestic purposes (24%) and 95 million m^3 for industry (10%), giving a total water withdrawal of 982 million m^3. Sprinkler irrigation is a versatile means of applying water to any crop, soil and topographic condition. It is popular because surface ditches and prior land preparation are not necessary and because pipes are easily transported and provide no obstruction to farm operation when irrigation is not needed. Sprinkling is suitable for sandy soils or any other soil and topographic condition where surface irrigation may be inefficient or expensive or where erosion may be particularly hazardous.

According to Ismail and Ozawa (2009), in the arid and semi arid as well as tropical regions, water shortage is a normal phenomenon and seriously limits the agricultural potential. Therefore, under irrigation or rain-fed conditions, it is important for the available water to be used in the most efficient way. Proper irrigation interval can play a major role in increasing the water use efficiency and the productivity by applying the required amount of water when it is needed. On the other hand, the poor irrigation interval can lead to the development of crop water deficit and result in a reduced yield due to water and nutrient deficiency.

Early in the season when plants are small, it is beneficial to encourage the roots to explore as much of the soil profile as possible. This maximizes nutrient uptake and stress tolerance later in the season (Ismail and Ozawa, 2009).

Jamiez *et al*. (2000) stated that irrigation frequencies or different irrigation frequencies or different irrigation intervals have beneficial effects on water balance fruit quality and fruit production. Irrigation also plays important role in maintaining sustainable growth of every crop especially it reduces the wilting which causes 60-80% crop loss but sometimes excessive water or frequent flooding for longer periods of time affect the yield of the crop (Gajera *et al*., 1998).

In this study two sprinkler heads were evaluated and one of them was used to study the sprinkler irrigation intervals on the growth and yield of tomatoes. It represents an effort to quantify the effect of water application on the growth and yield of tomatoes.

MATERIALS AND METHODS

The Study Area

The study was carried out at the University of Cape Coast (UCC) Teaching and Research Farm from 2006 to 2007. It falls within the Coastal Savanna zone of Ghana between latitude 05^0 03'N and 05^0 15'N, longitude 01° 13 W and 01° 13' W. The area is characterized by a mean annual rainfall, which varies from about 750 to 1200 mm. The area has two seasons, that is, dry season and wet season. The wet season can also be divided into two, the minor one and the major one. The major season is from May to July with a peak in June and the minor season is from September to November with a peak in October. The dry season is from December to February (Ayittah, 1996).

Temperatures are uniformly high throughout the year with an annual average minimum of 30°C. Diurnal variations in temperature are greatest in February and March.

Determination of Etc

The mean daily Eto for the study area was computed using Modified Penman method (Sam-Amoah, 1996). The Etc was then derived from the formulae below:

Etc = KcETo (Doorenbos and Pruitt, 1977)

Where:
Etc = Crop evapotranspiration
Eto = Reference evapotranspiration (Modified Penman Method)
Kc = Crop coefficient

Total volume of water for the growing period was 31.48 m^3.The same amount was used for each of the treatments.

Determination of Sprinkler Head Performance

A rubber hose, stand pipe, flow meter with pressure gauge and a sprinkler head were connected. Forty catch cans were arranged on a 8×8 m field to establish a grid pattern of 2×0.8 m. Two sprinklers were used in the evaluation. The LEGO model sprinkler (Tarjuelo *et al*., 1999) was used for the first three runs and AGROS model sprinkler (Tarjuelo *et al*., 1999) for the last three runs. The cans were initially turned upside down in their positions in order to test run the sprinkler and the sprinkling pattern was observed. The cans were then set up correctly and the sprinklers were turned on. Each run lasted for 1 h and the quantity of water collected in each catch can was measured using the measuring cylinder. This was used to determine the depth of catch. The depth of water in the soil was determined by bringing up soil with the soil auger and measuring the depth of wetness with a ruler. Soil samples were taken to the laboratory to determine the moisture content before and after irrigation. Flow rate, operating pressure before and after irrigation were measured with the flow meter and pressure gauge, respectively.

Nozzle diameters were measured with a caliper.

Sprinkler Head Performance Measures

The sprinkler head performance measures determined included:

- **Distribution uniformity:** Is usually defined as a ratio of the smallest accumulated depths in the distribution to the average depth of the whole distribution. It was determined according to the Irrigation Association (2005) methodology
- **Uniformity coefficient:** The coefficient is computed from field observation of the depths of water caught in open cans placed at regular intervals within a sprinkled area (ASAE, 2001)
- **Scheduling Coefficient (SC):** Determines how big the critical dry area is and the irrigation time required to alleviate this dry area. It was determined according to Wilson and Zoldoske (1997) methodology
- **Precipitation rate:** It is usually expressed as the ratio of average depth readings to test time. Wilson and Zoldoske (1997) method was adopted for the computation
- **Deep Percolation Ratio (DPR):** This refers to the loss of water below the root zone, that is, beyond plant reach. The method used was according to Senzanje *et al*. (2000)

Experimental Design for Sprinkler Interval on Tomato Growth

A Randomized Complete Block Design (RCBD) was used. There were 16 plots and each plot size was 8×8 m. There were eight rows with plant spacing of 1×1 m and plant population per plot was 64.

Seed

The Wosowoso variety of tomato was used. It was obtained from a certified seed company in Cape Coast.

Nursing and Planting

The seeds were nursed and planting was done a month after nursing. Growing duration was 90 days.

Irrigation

There were four treatments with four replications. The treatments were: daily application of water (T_1), every third day (T_2), every fifth day (T_3) and every seventh day (T_4). The treatments were imposed two weeks after transplanting.

Moisture Determination

Soil water contents were measured before and after irrigation in the laboratory by the gravimetric method.

Crop Measurement

Data collected on plant growth included: plant height, number of flowers, fruit weight, fruit length and number of fruits and stem diameter. There were five sampling times and measurements were taken on five plants.

Cultural Practices

The plants were staked and fertilizer application to all treatment was done. Plants were kept free of weed by repeated hand weeding and insects, pest and diseases were controlled with fungicide and insecticide.

Harvesting and Fruit Sampling

The fruits were hand-harvested 90 days after transplanting. Fruit dimensions were determined using a venier caliper.

Method of Analysis

Analysis of Variance (ANOVA) was conducted on the data using MSTATC statistical package. The means were compared by applying Least Significant Difference (LSD) at test 5% probability level.

RESULTS AND DISCUSSION

Sprinkler Head

From Table 1, sprinkler model AGROS had the highest uniformity coefficient (99.20), distribution uniformity (57.67), percolation ratio (0.61), depth of water applied (5.93) but the lowest scheduling coefficient (1.87) as compared to LEGO.

From Table 2, both sprinkler models at the same operating pressure (0.18) had the same radius of throw (0.53).

Table 1: Field test result for the uniformity coefficient, distribution uniformity, percolation ratio, scheduling coefficient and depth of water

Sprinkler model	Scheduling coefficient	Uniformity coefficient	Distribution uniformity	Percolation ratio	Depth of water applied (mmx10^2)
LEGO	6.00	98.05	17.00	0.46	5.69
AGROS	1.87	99.20	57.67	0.61	5.93

Table 2: Field test result for operating pressure and radius of throw

Sprinkler model	Operating pressure (Mpa)	Radius of throw (m)
LEGO	0.18	0.53
AGROS	0.18	0.53

Table 3: Irrigation interval and fruit yield

Treatment	Fruit yield (g)
T_1	45.0a
T_2	27.5b
T_3	25.0bc
T_4	22.5c

Means followed by the same letter within the column are not significantly different at 5 % level of probability

Table 4: Irrigation interval, plant growth and fruit dimensions

Irrigation interval (days)	Plant height (cm)	Stem diameter	Fruit length (mm)	
			Max.	Min.
T_1	54.79a	2.85a	5.55a	5.05a
T_2	34.43c	2.69b	4.20b	4.00b
T_3	55.31b	2.73b	4.00c	3.77c
T_4	55.44a	2.78ab	3.95c	3.62c

Means followed by the same letter within the column are not significantly different at 5 % level of probability

Fruit Yield

Means followed by the same letter are not significantly different at 5% level of probability.

Fruit yield over here is the mean mass of all harvested fruit. From Table 3, T_1 (45.00) had the highest mean fruit yield followed by T_2 (27.50), T_3 (25.00) and T_4 (22.50) in that order. There were significant differences between T_1 (45.00) and the other treatments. There were no significant differences between T_2 (27.50) and T_3 (25.00). There was a significant difference between T_2 (27.50) and T_4 (22.50) but no significant difference between T_3 (27.50) and T_4 (22.50). Irrigation interval significantly affected the fruit yield.

Tomato Growth and Dimensions

From Table 4, T_1 (2.85) had the highest stem diameter followed by T_4 (2.78), T_3 (2.73) and T_2 (2.69). There were no significant differences between T1 (2.85) and T4 (2.78). There were differences between T_1 (2.85) and T_2 (2.69), T_3 (2.73). Irrigation interval significantly affected the fruit lengths. The T_1 (2.85) had the highest fruit length followed by T_2 (2.69), T_3 (2.73) and T_4 (2.78).

From Fig. 1, T_1 had the highest flower number of 2.781 followed by T_3 (2.776), T_2 (2.627) and T_4 (2.301). The lowest flower number was registered by T_4 of 2.301. It was observed that flower number increases as irrigation interval decreases with the exception of T_3 (2.776) which resulted in increased flower number.

The results for flower number for all the treatments were statistically analysed and there were no significant differences among the irrigation intervals.

Deep Percolation Ratio

Comparing the deep percolation ratio for the two sprinkler heads, the AGROS had the highest. The differences could be due to the sprinkler model or the nozzle diameter (Senzanje *et al*., 2000) and subsequently the impact of droplets on the soil surface.

Christiansen's Uniformity Coefficient and Distribution Uniformity

The main difference between Coefficient of Uniformity (CU) and Distribution Uniformity (DU) is that, CU is a measure of the absolute difference from the mean divided by the mean while DU is the ratio of the smallest accumulated depths in the distribution to the average depths of the whole distribution. From the experiment, CU values were very high and this can be attributed to the definition of CU and DU. It was in agreement with Wilson and Zoldoske

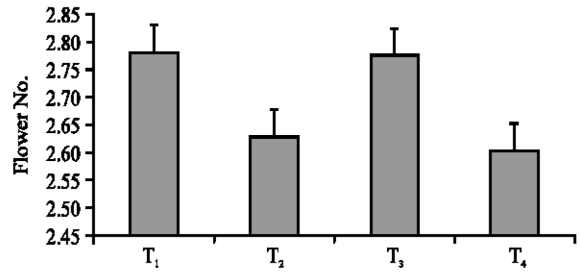

Fig. 1: Flower number and irrigation interval

(1997) who did a research on sprinkler system and their findings were DU value for rotor system was 70% or higher and 50% or above for spray-head system. It should be emphasised that the results obtained during the study were under a particular field and climatic conditions at the time of the test. Since wind has a large impact on the distribution of irrigation water, a test conducted in lesser wind conditions may have shown better results for distribution uniformity.

Irrigation Interval, Growth and Yield Parameters

Fruit Yield

In this present experiment irrigation interval had an influence on fruit yield. This is in agreement with Byari and Al-Sayed (1999) who found a reduction in fruit mean mass due to increased irrigation intervals (1, 2, 3, 5) and their findings were explained by the fact that plants were under water stress because irrigation interval has a major influence on the soil moisture profile. Irrigation interval in this work had a significant effect on yield indicators. Again, Pulupol *et al.* (1996) and Byari and Al-Sayed (1999) ascribed poor plant yield to plants grown under water stress or increased time of irrigation intervals between successive irrigation.

These differences in irrigation interval may be enough to cause water to be a limiting factor for yield of tomatoes. Several researchers have reported that frequency of irrigation and quantity of nutrient in solution provided to plants affect yield (May and Gonzales, 1994; Peet and Willits, 1995; Singandhupe *et al.*, 2002).

Plant Height

Data from this study revealed that plant height mean for T_1 was greater than T_2 and T_3 and this in agreement with Olalla and Valero (1994) who reported that plant height increased with decrease of irrigation interval and vice versa.

Stem Diameter and Fruit Length

Plants that were irrigated every day resulted in significantly larger stem diameter and fruit length as compared to irrigation interval of every third, fifth and seventh day. This was in agreement with Byari and Al-Sayed (1999) who found a reduction in stem diameter and fruit length due to increased time of irrigation intervals between successive irrigation. He explained his findings by the fact that plants were under water stress. However, it was clear that tomatoes reacted, positively to the frequency of application of irrigation water.

Fruit Number

Candido *et al.* (1999) reported that drought reduces fruit growth and size and excessive fluctuations in soil moisture content may induce physiological disorders such as blossom end rot and this was in agreement with the present study. Ponce *et al*. (1996) reported plants under any kind of stressed conditions tends to shortened their life span and try to complete their life cycle in hasten which causes the minimum flowering and fruiting of plants.

CONCLUSION

Sprinkler head AGROS performed better than LEGO. Irrigation interval of one day, using the same amount of irrigation water, had a significantly higher plant height, stem diameter, fruit mass, fruit length, fruit number, flower number than intervals of 3, 5 and 7 days.

ACKNOWLEDGMENTS

Author wish to express my sincere thanks and appreciation to Dr. L.K. Sam-Amoah and Rev. Dr. J.D. Owusu-Sekyere for their encouragement, tireless supervision, valuable advice, assistance and patience throughout this research.

REFERENCES

ASAE, 2001. Test Procedure for Determining the Uniformity of Water Distribution of Center Pivot and Lateral Move Irrigation Machines Equipped With Spray or Sprinkler Nozzles. American Society of Agricultural, St Joseph, MI, USA., pp: 916-926.

Ayittah, F.T., 1996. The effect of three sources of water on tomato crop yield. B.Sc. Thesis, Umpqua Community College, pp: 25.

Byari, S.H. and A.R. Al-Sayed, 1999. The influence of differential irrigation regimes on five greenhouse tomato cultivars. 2.-The influence of differential irrigation regimes on fruit yield. Egyptian J. Horticul. Sci., 26: 127-146.

Candido, V., V. Miccolis and M. Perniola, 1999. Effects of irrigation regime on yield and quality of processing tomato cultivars. Acta Hortic., 537: 779-788.

Doorenbos, J. and W.O. Pruitt, 1977. Guidelines for Predicting Crop Water Requirement. 2nd Edn., FAO, Rome, pp: 144.

Gajera, M.S., R.P.S. Ahlawat and R.B. Ardeshna, 1998. Effect of irrigation schedule, tillage depth and mulch on growth and yield of winter pea. Indian. J. Agronomy., 43: 689-693.

Ismail, M.S. and K. Ozawa, 2009. Effect of irrigation interval on growth characteristics, plant Water stress tolerance and water use efficiency for Chile pepper. Proceeding of the 13th International Water Technology Conference, March 11- 13, Hurghada, Egypt, pp: 545-556.

Jamiez, R.E., F.R. Vielma and N.C. Garcia, 2000. Effect of irrigation frequency on water and carbon relation in three cultivars of sweet pepper. Sci. Horticul., 81: 301-308.

Jones, H.G., 1989. Plant water relations and implications for irrigation scheduling. Acta Horticul., 278: 67-76.

May, D.M. and J. Gonzales, 1994. Irrigation and nitrogen management as they affect fruit quality and yield of processing tomatoes. Acta Hort., 277: 129-134.

Olalla, F. and J.A. Valero, 1994. Growth and production of bell pepper under different irrigation intervals. Res. Ser. Arkansas Agric. Expt. Stat., 466: 929-95.

Peet, M.M. and D.H. Willits, 1995. Role of excess water in tomato fruit cracking. Hort. Sci., 30: 65-68.

Ponce, M.T., S.G. Selles, E.R. Frreyra, J.M. Peralla, A.S. Moyan and A.S. Ainrichsen, 1996. Metabolic indicators of water deficit as a possible criterion for evaluation of irrigation management: The case of sweet pepper (*Capsicum annuum* L.). Agric. Terncia, 56: 57-63.

Pulupol, L.U., M.H. Behboudia and K.J. Fisher, 1996. Growth, yield and postharvest attributes of glasshouse tomatoes produced under deficit irrigation. Hort. Sci., 31: 926-929.

SRID, 2002. Agriculture in Ghana: Facts and Figures. Ministry of Food and Agriculture, Ghana.

Sam-Amoah, L.K., 1996. Comparative analysis of evapotranspiration using climatic factors. Proceedings of the 2nd national Conference on Agricultural Engineering, Sept. 22-26, Kumasi, Ghana, pp: 274-283.

Senzanje, A., I.E.C. Samakende and D. Mugutso, 2000. Field Irrigation practice and the performance of small holder irrigation in zimbabwe-chakohwa case study. Proceedings of the 2nd International Conference on Agricultural Engineering, Sept. 24-28,Kumasi, Ghana.

Singandhupe, R.B., G.G. Rao, N.G. Patil and P.S. Brahman, 2002. Fertigation studies and irrigation scheduling in drip irrigation system in tomato crop (*Lycopersicon esculentum* Mill). Eur. J. Agron., 1: 1-14.

Tarjuelo, J.M., J. Montero, P.A. Carrion, F.T. Hunrubia and M.A. Calvo, 1999. Irrigation uniformity with medium size sprinklers. Part II: Influence of wind and other factors on water distribution. Trans. ASAE., 46: 677-689.

The Irrigation Association, 2005. Landscape Irrigation Scheduling and Water Management. Irrigation Association Water Management Committee, Falls Church, VA., pp: 190.

Wilson, T.P. and D.F. Zoldoske, 1997. Evaluating Sprinkler Uniformity. CATI Publication, California, Washington D.C., pp: 1-6.