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PRELIMINARY TRIAL ON THE RESPONSE OF DIVAFI TOMATO VARIETY TO DIFFERENT IRRIGATION REGIMES IN A CONTROLLED ENVIRONMENT

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Abstract: To ascertain the Response of DIVAF1 variety of Tomato to Different Irrigation Regimes, an experiment was carried out at the screen house of the Department of Crop Science and Technology. Three quantities (50cl (0.5L), 100cl (1L) and 150cl (1.5L)) of pure water were applied in three different frequencies viz; once daily, once in two days and once in three days. The experiment was laid in a Completely Randomized Design (CRD) with four replications. Data were collected on plant height, number of leaves, number of branches, leaf area, number of days to first flowering, numbers of flowers, number of fruits per plant, number of seeds per fruit, fruit weight per plant and fruit weight per hectare. Results revealed that amount of irrigation singly and its interaction with frequency significantly influenced the measured growth and yield parameters. Tomato plants irrigated with 100cl once in 2 days produced the most number of fruits of 11.75 while the least was produced by plants that received 100cl once in 3 days and 150cl once daily respectively. The highest number of seeds was produced by plants irrigated with 50cl. It is therefore recommended that 100cl once in 2 days be subjected to further trials on tomato in a closed environment.

Keywords: Amount, DIVAF1, frequency, irrigation regimes, tomato

Introduction

Tomato (*Lycopersicon esculentum* L.) belongs to the nightshade family known as "*Solanaceae*" together with crops like eggplant and pepper all of which are of commercial and nutritive importance. According to Larry and Joanne (2007), the crop originated from South and Central America. Globally, tomato is considered to be one of the most important vegetables produced in commercial agriculture because of its potentials as an export cash crop. In 2019, the global area cultivated with tomato and the yield were 5, 051, 983 hectares and 190 million tonnes respectively. China being the highest producer of tomato accounts for 34.67% of this total (FAOSTAT, 2020) closely followed by India, the United States, Turkey and Egypt.

Nigeria is the leading producer of tomato in the sub-saharan Africa (Ugonna *et al*., 2015) with a total production of about 3, 575, 968 tonnes representing 1.89% of total world production and 68.4% of West African total production (Ugonna *et al*., 2015). The plant typically grows to 1 – 3 meters in height and have a weak stem that often sprawls over the ground if not staked. Most cultivars produce red fruits but a number of genotypes with yellow, orange, pink, purple, green, black or white fruit are also available. These fruits contain carotenoids, flavonoids, phytosterols, vitamins, and minerals which are essential in human nutrition. The presence of carotenoids such as lycopene, beta-carotene, and gamma-carotene confers anti-carcinogenic properties on the crop (Miller *et al*., 2002; Naika *et al*., 2005).

Tomato is a tender crop and is susceptible to a wide range of pests, diseases and also soil borne pathogens. These cause damages not only to the fruit and stem but also to the root system of the plant leading to reduction in the overall market quality of the fruits.

Problem Statement

Even though Nigeria is the largest producer of tomato in the sub-saharan Africa, its production still falls short of the demand hence her reliance on importation. This is because tomato is consumed all over Nigeria but production is mostly concentrated in the Northern states of Bauchi, Gombe, Jigawa, Kaduna, Kano, Katsina, Sokoto, Zamfara and Taraba. Sunday *et al*. (2018) stated that Nigeria's annual tomato import is valued at US$170 million. Tomato farmers over the years have adopted different production systems chief of which is the open field production system. This is however characterized by high incidence of pests and diseases, excessive and limited supply of water and excessive temperatures, weaker and low survival rate of transplant seedlings leading to low yield (Siam and Abdelhakim, 2018). There is therefore the need to evolve a more sustainable method of tomato fruit production to bridge the gap between demand and supply. Controlled environment systems are being adopted worldwide. In line with the findings of Nicola *et al*. (2009), Greenhouse cultivation is the most effective method of producing high quality and nutritional tomato fruits for both local and international markets.

According to the United Nations in 1997, fresh water suitable for food production constitutes only 3% of the earth's total water. Of this, only 1% in form of lakes and rivers is easily accessible for human use. Inappropriate irrigation leads to water loss either through seepage or evaporation. With increasing human population, pressure on available water for food production has continued to rise and it has become necessary to preserve every drop of water (Li *et al*., 2020). Proper understanding of the physiology of crops in relation to their water need will help not only to conserve water but also to ensure all year round food production in Owerri, Nigeria where crop production is largely rainfed and tomato scarcity is high. This research therefore sets out to determine the amount and frequency of irrigation needed for best yields of tomato in Owerri Southeastern Nigeria.

Materials and Methods

The experiment was carried out in the Screen house of the Department of Crop Science and Technology, School of Agriculture and Agricultural Technology, Federal University of Technology, Owerri, Nigeria. Owerri lies on Latitude 5^0 22´56´´N and Longitude 6^0 59˝26´´ E with altitude of 56m above sea level (Handheld Global Positioning System) in the tropical rainforest region of Nigeria. The minimum and maximum temperature are

20°C and 32°C respectively and with relative humidity of about 83%. Mean annual rainfall is about 2500 mm and is characterized by two rainfall peaks in June and September.

Nursery Preparation and Transplanting.

A flat bed was made at a slightly shaded area within the Teaching and Research farm. 10 tons/ha poultry was applied and thoroughly pulverized and incorporated into the soil to increase fertility. After one week, the seeds which were obtained from East-West Seeds International were planted by broadcasting method.

Three parts of top soil and two parts of poultry manure were collected from the Poultry section of the Teaching and Research farm of the School of Agriculture and Agricultural Technology. One part of River sand was obtained from the Otamiri river bank. These were bulked, sterilized at 60^0C for 30 minutes and bagged. The bags were then transferred into the screen house.

After three weeks, precisely at 4 to 5 leaf stage, the tomato seedlings were transplanted with the "ball of earth" at the rate of 1 seedling per bag into the planting bags.

Treatments and Experimental Design

The experiment assessed two factors; Amount of irrigation (50, 100 and 150cl), and; Frequency of irrigation (once daily, once in 2 days and once in 3 days). Total of nine (9) treatment combinations with four (4) replications giving a total of 36 experimental units laid as 3 x 3 factorial in Completely Randomized Design (CRD).

Data Collection and Analysis

Data on plant height, number of leaves and number of branches were taken by physical counting. Leaf area was calculated using the formula according to Carmassi *et al*. (2007).

Leaf area = Length x Width x 0.5

Other parameters include number of flowers per plant, number of fruits per plant, number of seeds per fruit, fresh fruit weight per plant and per hectare.

Data Analysis

Data collected were subjected to Analysis of Variance (ANOVA) while significant means were separated using the Least Significant Difference (LSD) tool at 5% level of probability.

Results and Discussion

Results

Effect of amount and frequency of irrigation on the plant height of tomato

While the amount of irrigation significantly affected the plant height of tomato at 3 and 4 Weeks After Plating (WAP), the frequency of irrigation had no significant (p<0.05) effect except at 5 and 6 WAT (Table 1). Tomato plants that received 100cl water grew tallest to 32.04 cm and 55.82 cm at 3 and 4 WAT. However, when the amount of irrigation was increased to 150cl, the heights significantly changed to 25.32cm and 46.07 cm representing a 20.97% and 17.40% reduction in plant height. Plants that were irrigated once daily had the highest height of 88.77 cm and 100.9 cm at 5 and 6 WAT respectively. These were significantly (p<0.05) higher than 81.69 cm and 92.0 cm recorded from plants that were irrigated once in three days. The interaction effect of amount and frequency of irrigation was significant at 5 WAT. Plants that were irrigated with 100cl once daily grew to 95.52 cm and this was significantly tallest when compared with other interactions with 150cl applied once in three days recording the lowest height of 77.55 cm.

Table 1: Effect of Amount and Frequency of irrigation on the plant height (cm) of tomato

	Frequency (once in)											
	2 WAT				3WAT				4 WAT			
Amount (cl)	1 day	2 days	3 days	Mean	1 day	2 days	3 days	Mean	1 day	2 days	3 days	Mean
50	14.88	15.45	15.47	15.27	30.83	28.30	30.03	29.72	53.52	49.95	52.37	51.95
100	16.80	16.43	18.10	17.11	32.50	31.28	32.35	32.04	56.67	55.38	55.42	55.82
150	14.42	14.25	15.97	14.88	25.78	25.43	24.75	25.32	48.62	44.05	45.52	46.07
Mean	15.37	15.38	16.52		29.70	28.33	29.04		52.94	49.79	51.11	
LSD $_{(0.05)}$ (Amount)			Ns		3.136				4.248			
LSD $_{(0.05)}$ (Frequency)			Ns		Ns				Ns			
LSD $_{(0.05)}$ (Amount x Frequency)			Ns		Ns				Ns			

	Frequency (once in)							
	5 WAT				6WAT			
Amount (cl)	1 day	2 days	3 days	Mean	1 day	2 days	3 days	Mean
50	84.27	88.92	79.55	84.25	93.6	92.7	87.8	91.4
100	95.52	85.25	87.97	89.58	107.0	93.4	95.5	98.7
150	86.52	84.30	77.55	82.79	102.2	98.3	92.6	97.7
Mean	88.77	86.16	81.69		100.9	94.8	92.0	
LSD $_{(0.05)}$ (Amount)			4.134		Ns			
LSD $_{(0.05)}$ (Frequency)			4.134		6.79			
LSD $_{(0.05)}$ (Amount x Frequency)			7.160		Ns			

Effect of amount and frequency of irrigation on the number of leaves of tomato

Even though, the amount of irrigation significantly affected the number of leaves of tomato at 3, 4, 5 and 6 WAT, the frequency of irrigation as well as the interaction of the amount and frequency has no significant effect on the number of leaves (Table 2). Tomato plants that received 100cl of water produced the most number of leaves (8.92, 11.42, 14.92 and 15.92) at 3, 4, 5 and 6 WAT respectively. When the amount of irrigation was increased to 150cl, the number of leaves significantly changed to 7.58, 9.67, 13.58 and 14.75 representing a 15.02%, 15.34%, 0.89% and 0.73% reduction in the number of leaves.

Table 2: Effect of Amount and Frequency of irrigation on the number of leaves of tomato

	Frequency (once in) ………..2 WAT..…….				………3WAT….....				…………4 WAT………….			
Amount (cl)	1 day	2 days	3 days	Mean	1 day	2 days	3 days	Mean	1 day	2 days	3 days	Mean
50	5.00	4.75	5.25	5.00	8.50	8.50	8.50	8.50	11.25	10.25	10.50	10.67
100	5.25	5.50	5.50	5.42	9.00	9.00	8.75	8.92	11.50	11.25	11.50	11.42
150	5.25	5.00	5.25	5.17	8.25	7.75	6.75	7.58	10.25	9.00	9.75	9.67
Mean	5.17	5.08	5.33		8.58	8.42	8.00		11.00	10.17	10.58	
LSD $_{(0.05)}$ (Amount)			Ns				0.585				0.769	
LSD $_{(0.05)}$ (Frequency)			Ns				Ns				*Ns*	
LSD $_{(0.05)}$ (Amount x Frequency)			Ns				Ns				*Ns*	

	Frequency (once in ….) ………..5 WAT..…….				………6WAT….....			
Amount (cl)	1 day	2 days	3 days	Mean	1 day	2 days	3 days	Mean
50	14.50	15.25	13.25	14.33	15.25	14.75	14.25	14.75
100	15.25	14.00	15.50	14.92	16.25	15.25	16.25	15.92
150	13.75	13.75	13.25	13.58	15.00	15.00	14.25	14.75
Mean	14.50	14.33	14.00		15.50	15.00	14.92	
LSD $_{(0.05)}$ (Amount)			1.081				0.907	
LSD $_{(0.05)}$ (Frequency)			Ns				Ns	
LSD $_{(0.05)}$ (Amount x Frequency)			Ns				Ns	

Effect of amount and frequency of irrigation on the number of branches of tomato

Table 3 shows the effect of amount and frequency of irrigation singly, and their interaction on the number of branches of tomato. Analysis of variance showed that while the amount of irrigation significantly affected the number of branches of tomato, at 3 and 4 WAT except at 5 and 6 WAT where the amount showed no significant effect, the frequency of irrigation and the interaction of amount and frequency of irrigation has no significant effect on the number of branches at 3,4 ,5 and 6 WAT. Tomato plants that received 100cl water had highest number of branches of 3.50 and 4.67 at 3 and 4 WAT. When the amount of irrigation was increased to 150cl, the number of branches dropped significantly to 2.00 and 3.42 representing a 42.85% and 26.7% reduction in the number of branches at 3 and 4 WAT.

Effect of amount and frequency of irrigation on the leaf area (cm^2) of tomato

The differences in the leaf area of tomato as a result of the variations in the amount and frequency of irrigation singly, and their interaction are displayed in Table 4. The Analysis of Variance revealed that while the amount of irrigation significantly affected the leaf area of tomato at 3, 5 and 6 WAT, the frequency of irrigation had no significant effect on the leaf area of tomato across the sampling period. Tomato plants that received 100cl water had the highest leaf area of 219.0 cm^2, 449.6 cm^{2}and 676.0 cm^2 at 3, 5, and 6 WAT. When the amount of irrigation was increased to 150cl, the leaf area changed significantly to 163.3, 363.1 and 58.0 cm^2 representing a 24.43%, 19.23% and 13.75% reduction in the leaf area. The interaction effect of amount and frequency of irrigation was not significant on the leaf area except at 5 WAT, where plants that were irrigated with 100cl once in 2 days had leaf area of 484.7 cm^2 and this was significantly highest when compared with other interactions with 150cl applied once in three days recording the least leaf area of 346.9 cm^2.

Effect of amount and frequency of irrigation on the number of days to first flowering and number flowers of tomato

Table 5 displays the effect of amount and frequency of irrigation on the number of days to first flowering and number of flowers per tomato plant. The Analysis of

Variance showed neither the main effects of amount and frequency nor their interaction had significant effect on the number of days to first flowering. The frequency of irrigation however had significant influence on the number of flowers per plant. Plants irrigated once in 2 days produced the highest number of flowers of 7.83 when compared with plants irrigated once daily and once in 3 days with 6.08 and 5.58 flowers representing a 22.34% and 28.73% reduction in the number of flowers. The main effect of amount of irrigation and its interaction with frequency had no significant influence on the number of flowers per plant.

Table 3: Effect of amount and frequency of irrigation on the number of branches of tomato

	Frequency (once in)											
	………..3 WAT..…….				………4WAT….....				…………5 WAT………….			
Amount (cl)	1 day	2 days	3 days	Mean	1 day	2 days	3 days	Mean	1 day	2 days	3 days	Mean
50	3.25	1.75	1.75	2.25	5.25	3.75	3.75	4.25	7.25	7.50	6.50	7.08
100	4.00	3.50	3.00	3.50	5.00	4.25	4.75	4.67	7.50	7.75	7.50	7.58
150	2.25	2.25	1.50	2.00	3.50	3.50	3.25	3.42	6.00	6.75	7.00	6.58
Mean	3.17	2.50	2.08		4.58	3.83	3.92		6.92	7.33	7.00	
LSD $_{(0.05)}$ (Amount)			0.915				0.867				Ns	
LSD $_{(0.05)}$ (Frequency)			Ns				Ns				Ns	
LSD $_{(0.05)}$ (Amount x Frequency)			Ns				Ns				Ns	

	Frequency (once in….)			
	………..6 WAT..…….			
Amount (cl)	1 day	2 days	3 days	Mean
50	9.00	8.25	8.50	8.58
100	8.00	9.00	9.00	8.67
150	7.50	8.50	8.50	8.17
Mean	8.17	8.58	8.67	
LSD $_{(0.05)}$ (Amount)			Ns	
LSD $_{(0.05)}$ (Frequency)			Ns	
LSD $_{(0.05)}$ (Amount x Frequency)			Ns	

Table 4: Effect of amount and frequency of irrigation on the leaf area of tomato

	Frequency (once in)											
	………..2 WAT..…….				………3WAT….....				…………4 WAT………….			
Amount (cl)	1 day	2 days	3 days	Mean	1 day	2 days	3 days	Mean	1 day	2 days	3 days	Mean
50	48.6	41.9	48.0	46.2	183.8	174.9	183.7	180.8	345.4	282.6	306.1	311.3
100	57.5	56.8	48.6	54.3	220.4	232.4	204.2	219.0	322.1	319.7	334.8	325.5
150	45.0	43.0	46.2	44.7	166.5	162.4	161.0	163.3	306.5	257.2	266.3	276.6
Mean	50.4	47.6	47.2		190.2	189.9	183.0		324.6	286.5	302.4	
LSD $_{(0.05)}$ (Amount)			Ns		28.85				Ns			
LSD $_{(0.05)}$ (Frequency)			Ns		Ns				Ns			
LSD $_{(0.05)}$ (Amount x Frequency)			Ns		Ns				Ns			

	Frequency (once in….)							
	………..5 WAT..…….				………6WAT….....			
Amount (cl)	1 day	2 days	3 days	Mean	1 day	2 days	3 days	Mean
50	477.1	364.5	350.6	397.4	757.0	631.0	581.0	657.0
100	404.4	484.7	459.7	449.6	690.0	666.0	673.0	676.0
150	370.9	371.6	346.9	363.1	602.0	566.0	582.0	583.0
Mean	417.4	406.9	385.7		683.0	621.0	612.0	
LSD $_{(0.05)}$ (Amount)			48.03				69.1	
LSD $_{(0.05)}$ (Frequency)			Ns				Ns	
LSD $_{(0.05)}$ (Amount x Frequency)			83.19				Ns	

Table 5: Effect of amount and frequency of irrigation on some reproductive parameters of tomato

(a)

	Frequency of irrigation (once in…)							
	No of days to first flowering				No of flowers/plant			
Amount (cl)	1 day	2 days	3 days	Mean	1 day	2 days	3 days	Mean
50	56.2	56.2	54.8	55.8	4.75	8.00	6.50	6.42
100	55.0	54.2	54.2	54.5	7.50	9.00	4.00	6.83
150	56.0	58.5	39.3	51.3	6.00	6.50	6.25	6.25
Mean	55.8	56.3	49.4		6.08	7.83	5.58	
LSD $_{(0.05)}$ (Amount)			Ns			Ns		
LSD $_{(0.05)}$ (Frequency)			Ns			1.290		
LSD $_{(0.05)}$ (Amount x Frequency)			Ns			Ns		

(b)

	Frequency of irrigation (once in ….)							
	No of fruits				No of seeds per fruit			
Amount (cl)	1 day	2 days	3 days	Mean	1 day	2 days	3 days	Mean
50	4.75	8.00	6.50	6.42	58.5	74.5	74.0	69.0
100	7.50	11.75	4.00	7.75	53.0	63.0	54.2	56.8
150	6.00	6.50	6.25	6.25	35.0	41.2	45.5	40.6
Mean	6.08	8.75	5.58		48.8	59.6	57.9	
LSD $_{(0.05)}$ (Amount)			Ns			7.87		
LSD $_{(0.05)}$ (Frequency)			1.591			7.87		
LSD $_{(0.05)}$ (Amount x Frequency)			2.756					

Effect of amount and frequency of irrigation on the number of flowers of tomato

Table 5 displays the effect of amount and frequency of irrigation on the number of number of flowers per tomato plant. The Analysis of Variance showed neither the main effects of amount and frequency nor their interaction had significant effect on the number of flowers per plant. The frequency of irrigation however had significant influence on the number of flowers per plant. Plants irrigated once in 2 days produced the highest number of flowers of 7.83 when compared with plants irrigated once daily and once in 3 days with 6.08 and 5.58 flowers representing a 22.34% and 28.73% reduction in the number of flowers. The main effect of amount of irrigation and its interaction with frequency had no significant influence on the number of flowers per plant.

Effect of amount and frequency of irrigation on the number of fruits per plant and number of seeds per tomato fruit.

The effect of amount and frequency of irrigation on the number of fruits per plant and number of seeds per tomato fruit are presented in Table 5b. The ANOVA showed that the frequency of irrigation separately, and its interaction with amount of irrigation all had significant influence on the number fruits per plant. Plants irrigated once in 2 days produced 8.75 fruits and this is the highest when compared with plants irrigated once daily and once in three days which produced 6.08 and 5.58 flowers respectively representing a 30.51% and 36.22% reduction in the number of fruits per plant. For the interaction, plants that received 100cl water once in two days produced 11.75 fruits and this is significantly highest when compared with other interactions. This is closely followed by 8.00 fruits produced plants that received 50cl once in two days while the lowest number of fruits of 4.00 was recorded for plants that received 100cl once in three days.

There was also significant influence of the main effects of amount and frequency of irrigation on the number of seeds of tomato. Plants that received 50cl irrigation produced the significantly ($p<0.05$) highest number of seeds of 69.0 per fruit. This number significantly reduced by 17.68% and 41.15% as the amount of irrigation increased to 100 and 150cl respectively.

For frequency of irrigation, it was observed that plants that were irrigated once in 2 days produced the highest number of seeds of 59.6 closely followed by 57.9 recorded from plants irrigated once in 3days. Plants irrigated once daily produced the significantly lowest number of seeds 48.8 representing a 18.12% reduction in the number of seeds.

Discussion

Oxygen is generally necessary especially for the aeration of the root system. This oxygen passes through the pore spaces in the soil into the plant root. The shortage or complete absence of oxygen in the soil creates an anoxic condition which impairs physiological processes leading to reduction in growth rate. This condition called waterlogging, occurs when the soil moisture level goes above the field capacity. Water logging is detrimental to the growth and development of tomato (Bray *et al*., 2001). The results from this study show that when the amount of irrigation is increased from 100 to 150cl, there was a general reduction in the plant height, number of leaves and number of branches. This could be attributed to the displacement of soil air by the water molecules thereby causing suffocation of the root system. Tareq *et al*. (2020)

similarly reported that morphological characteristics of tomato such as height, number of leaves and branches reduced with increasing exposure to waterlogged conditions.

Leaf area also dropped as the amount of irrigation is increased from 100 to 150cl similar to the findings of Guang *et al*. (2012) on cotton. Soils that were irrigated with 100cl once in 2 days produced highest leaf area. However, when the irrigation regime was increased to 150cl once daily, once in 2 days and once in 3 days, the leaf area reduced significantly by 23.4%, 23.3% and 28.42% respectively. This reduction could have occurred because of the changes in the internal structure of the leaves occasioned by the increased moisture level in the soil. Studies with *Avicennia marina* (Gray Mangrove) show that excessive moisture content is contributory to the decrease in the thickness of mesophyll, parenchyma, hypodermis and overall leaf thickness (Xiao *et al*., 2009). This has deleterious effects on the growth and yield of crops because it impairs nutrient uptake, photosynthetic efficiency and ultimately leads to low yield.

Significantly different number of fruits/plant and number of seeds per fruit were observed when different amount of irrigation were applied at different frequencies. 50cl applied once daily and 150cl applied once in 3 days produced significantly low fruit yield per plant and seed yield per fruit. The both irrigation regimes may have supplied inadequate or excess amount of water to the soil thereby creating a water stress situation like waterlogging and drought, which reduce yield. This is in conformity with the work of Jitsuyama *et al*. (2019).

Result from this research showed that;

1. 50cl and 100cl irrigation produced significantly equal number of leaves across all sampling periods except 6 weeks after planting where 100cl irrigation produced the most number of leaves. Irrigation with 150cl water produced the least number of leaves.
2. Number of branches was not significantly affected by amount, frequency of irrigation and their interactions except at 3 and 4 weeks after planting where plants irrigated with 100cl produced the highest number of branches
3. Plants irrigated with 100cl water once in 2 days produced the highest leaf area.
4. Plants that received 100cl irrigation once in 2 days produced the highest number of fruits while the highest number of seeds per fruit was produced by plants that received 50cl water once in 2 days. However, 150cl irrigation applied once daily produced the least number of fruits per plant and seeds per fruit.

Recommendation

The study has shown that excessive water in the soil hampers the growth and development of tomato plants. It is therefore recommended that farmers should apply 100cl irrigation once in two days for optimum growth and yield of tomato under a controlled environment.

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