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OPTIMIZATION OF WATER REQUIREMENT FOR REDUCED DISEASE SUSCEPTIBIITY OF TOMATO (*Solanum lycopersicum* L.) IN LAFIA, NASARAWA STATE NIGERIA

***[1]Terna, T. P., [1]Umar, A. H., [2]Mohammed, I. A.**

[1]Department of Botany, Federal University Lafia. PMB 146 Lafia, Nasarawa State, Nigeria.
[2]Biology Department, Federal College of Education, Yola, Adamawa State, Nigeria.

*Corresponding Author's Email: ternapaul@yahoo.com; Tel: +2347030350853

ABSTRACT

Study was carried out to evaluate responses of selected tomato varieties to the incidence of various field diseases under the influence of different irrigation regimes in Lafia, Nasarawa State. Seedlings of 4 tomato varieties namely; Roma Savanna (*Dan syria*), Tropimech (*UTC, Jos*), Riogrande (*Dan baka*) and Roma VF (*Teema*) were irrigated under 7 water regimes namely; Morning, Afternoon, Evening, Morning and afternoon, Morning and evening, Afternoon and evening, Morning, afternoon and evening, for a period of 15 weeks, and observed for the onset and progress of disease symptoms for a total duration of 9 weeks after transplanting. Tomato seedlings watered only in the afternoons showed the highest incidences of leaf spots, 9.72%, leaf yellowing, 22.75%, and leaf necrosis, 6.42%. Seedlings watered in the morning, afternoon and evening showed the highest incidence of leaf blight, 8.77% and crown wilt, 4.86%. Stem necrosis, seedling damping-off and insect damage were most observed (5.55%, 14.98% and 3.21% respectively) on tomato seedlings watered in the afternoons and evenings. Roma Savanna was the most susceptible to disease (3.77%), followed by Tropimech (3.66%), Roma VF (3.62%), and lastly Riogrande (3.52%). Differences in mean effect of water regime on disease susceptibility of evaluated tomato varieties were significant ($P \leq 0.05$). Watering of tomato seedlings in the evenings resulted in the least incidence of field diseases and is therefore recommended for improved yield and reduced tomato crop losses in the study area.

Keywords: *Disease Incidence, Lafia, Optimization, Tomato Varieties, Water Regimes*

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) belongs to the family solanaceae (Tindall, 1983) and is regarded as one of the most important fresh vegetables all over the world. It plays a particularly important role in human nutrition in supplying essential minerals, vitamins, and dietary fiber (Salunkhe *et al*., 1991; Salunkhe and Kadam, 1995; Niederwieser, 2001). It is one of the most widely cultivated vegetable crops in Africa and beyond (Peirce, 1987, Opena and Kyomo, 1990). World tomato production in 2001 was about 105 million tons of fresh fruits on an estimated 3.9 million hectares of land. As it is relatively a short duration crop and gives a high yield, it is economically attractive and the area under cultivation is increasing (Naika *et al*., 2005).

Nigeria ranks as the 16th largest tomato producing nation in the world and has the comparative advantage and potential to lead the world in tomato production and exports (FAO, 2010). The production of tomatoes in Nigeria in 2010 was about 1.8 million metric tonnes, which accounted for about 68.4% of West Africa, 10.8% of Africa's total output and 1.28% of world output (FAO, 2010). In 2016 Nigeria had a world share of 1.3% in global tomato production (FAO, 2016).

The yield and quality of tomato is limited by shortage of water with severe economic consequences (Sutton and Merit, 1993; Sen and Sevgican, 1999). It is well known that there is a good correlation between adequate water supply, high yields and good quality in crop production (Sefara, 1994; Byari and Al-Sayed, 1999). Therefore, proper water management is vital for sustainable crop production. In Nasarawa State and other parts of Nigeria, in spite of the economic value of the tomato crop, little is known about the influence of time and frequency of irrigation on disease susceptibility of the tomato plant among commercial growers in communities where the crop is cultivated. This study shall provide much needed answers to the question of how often and how much water is needed for enhanced disease resistance and tomato crop productivity in the study area.

MATERIALS AND METHODS

Source of Tomato Cultivars

Fruits of tomato cultivars used in the study namely; Roma Savanna (*Dan syria*), Tropimech (*UTC, Jos*), Riogrande (*Dan baka*) and Roma VF (*Teema*) were purchased from the Lafia Tomato Market and conveyed in sterile polyethylene bags to the

Botany Laboratory of Federal University Lafia, for further processing.

Seed Preparation

Sampled fruits were cut longitudinally with a clean knife, and seeds extracted by gently scrapping them off from placenta tissues with a knife. Extracted seeds were washed thoroughly with water, air dried and packaged in paper bags prior to planting.

Soil Preparation and Planting

The method reported by Terna *et al.* (2017) was adopted as follows; Garden soil was collected from Triple Zee Farm Lafia, Nasarawa State, and dispensed in sterile polyethylene bags at the rate of 5kg per bag. For the establishment of tomato nurseries, potted soils were further moistened with water and impregnated with healthy tomato seeds at a depth of about 3cm. Seeds were planted at the rate of 10 seeds per pot and 18 pots for each variety. Planted pots were kept under shade and watered separately for the commencement of seedling germination.

Watering

Tomato plants were irrigated under 7 different water regimes which include;

i. Morning
ii. Afternoon
iii. Evening
iv. Morning and afternoon
v. Morning and evening
vi. Afternoon and evening
vii. Morning, afternoon and evening.

Irrigation was done for a total period of 15 weeks.

Transplanting

Five weeks old seedlings were transplanted at the rate of 2 stands per pot, onto fresh potted soil. Prior to transplanting, soils were moistened with water to prevent excessive root and stem breakage. Transplanting was done in the evening to prevent excessive loss of water and wilting due to the desiccating effect of sunlight heat.

Evaluation of Disease Incidence

Plants were observed weekly for the appearance of symptoms such as leaf spots, leaf yellowing, leaf blight, leaf necrosis, stem necrosis, stem rot, damping-off, insect damage, crown wilt and fruit rot, for a total duration of 9 weeks. Tissue damage was estimated by evaluating percentage of diseased tissues in relation to entire tissue area as reported by Okogbaa *et al.* (2017).

Experimental Design

Experimental treatments were laid out in Randomized Complete Block Design (RCBD) with seven treatment replicates.

Data Analysis

Data obtained from the study was subjected to Analysis of Variance (ANOVA) at 5% level of significance. Means were separated using the Duncan Multiple Range Test (DMRT).

RESULTS

The highest incidence of leaf spot (9.72%) was observed on leaves of Tropimech tomato variety watered only in the afternoons. Roma VF, Tropimech and Riogrande tomato varieties watered only in the evenings and those watered in the morning, afternoon and evening, showed absence of leaf spots. Leaf spots were also absent on Roma Savanna watered in the mornings, Roma VF watered in the morning and evening, Tropimech watered in the morning and evening, Tropimech watered in the afternoon and evening, and Riogrande watered in the afternoon and evening. Differences in the incidence of leaf spots among different tomato varieties watered using different water regimes were not significant ($P>0.05$) (Table 1).

Different tomato varieties subjected to different daily water regimes showed variations in the incidence of leaf yellowing on different tomato varieties, 9 weeks after transplanting (Table 2). The highest incidence of leaf yellowing (27.98%) was observed on the leaves of the Roma VF tomato variety watered morning and evening, while leaves of the Riogrande tomato variety watered morning, afternoon and evening, showed the least incidence of yellowing (10.22%). Differences in the incidence of leaf yellowing among tomato varieties watered using different water regimes were significant ($P\leq0.05$).

Leaf blight was highest (8.33%) on leaves of Tropimech watered morning and evening, and the Roma VF tomato variety watered afternoon and evening respectively. Leaf blight was absent on the Riogrande tomato variety watered in the morning; Tropimech, Riogrande and Roma Savanna watered in the afternoon; Roma VF, Tropimech, and Riogrande watered in the evening; Tropimech watered in mornings and afternoons; Riogrande watered in the mornings and afternoons; Tropimech watered afternoon and evening; Roma Savanna watered afternoon and evening; Roma VF watered morning, afternoon, and evening; and Riogrande watered morning, afternoon and evening. Differences in the incidence of leaf blight among the evaluated tomato varieties watered using different water regimes, were not significant ($P>0.05$) (Table 3).

Table 1: Effect of Different Water Regimes on Incidence of Leaf Spot on Different Tomato Varieties 9 Weeks after Transplanting

Tomato Variety	Disease Incidence (%)						
	Morning	Afternoon	Evening	Morning + Afternoon	Morning + Evening	Afternoon + Evening	Morning + Afternoon + Evening
Roma VF	6.34^{ab}	4.25^{ab}	0.00^{a}	0.00^{a}	9.27^{abc}	4.25^{ab}	0.00^{a}
Tropimech	5.55^{ab}	9.72^{abc}	0.00^{a}	2.77^{a}	0.00^{a}	0.00^{a}	0.00^{a}
Riogrande	5.55^{ab}	4.25^{ab}	0.00^{a}	1.47^{a}	1.27^{ab}	0.00^{a}	0.00^{a}
Roma Savanna	0.00^{a}	2.17^{ab}	1.66^{a}	5.55^{ab}	2.77^{a}	5.55^{ab}	1.66^{a}

Means followed by same superscripts within same column are not significantly different (P>0.05)

Table 2: Effect of Different Water Regimes on Incidence of Leaf Yellowing on Different Tomato Varieties 9 Weeks after Transplanting

Tomato Variety	Disease Incidence (%)						
	Morning	Afternoon	Evening	Morning + Afternoon	Morning + Evening	Afternoon + Evening	Morning + Afternoon + Evening
Roma VF	20.36^{ab}	20.62^{ab}	23.33^{b}	13.56^{a}	27.98^{b}	18.75^{a}	22.65^{a}
Tropimech	20.62^{ab}	17.83^{a}	21.94^{b}	20.83^{b}	21.11^{a}	15.41^{a}	26.34^{b}
Riogrande	19.88^{ab}	25.78^{c}	19.46^{b}	17.77^{b}	26.68^{b}	14.30^{a}	10.22^{a}
Roma Savanna	18.77^{a}	26.87^{c}	12.50^{a}	12.22^{a}	18.56^{a}	15.20^{a}	27.43^{b}

Means followed by different superscripts within same column are significantly different (P≤0.05)
Means followed by same superscripts within same column are not significantly different (P>0.05)

Table 3: Effect of Different Water Regimes on Incidence of Leaf Blight on Different Tomato Varieties 9 Weeks after Transplanting

Tomato Variety	Disease Incidence (%)						
	Morning	Afternoon	Evening	Morning + Afternoon	Morning + Evening	Afternoon + Evening	Morning + Afternoon + Evening
Roma VF	5.55^{abc}	1.47^{a}	0.00^{a}	6.94^{abc}	1.94^{abcd}	8.33^{abc}	0.00^{a}
Tropimech	6.94^{abc}	0.00^{a}	0.00^{a}	0.00^{a}	8.33^{abc}	0.00^{a}	1.80^{acd}
Riogrande	0.00^{a}	0.00^{a}	0.00^{a}	1.11^{abcd}	0.00^{a}	1.57^{abcd}	0.00^{a}
Roma Savanna	2.77^{a}	0.00^{a}	5.55^{abc}	5.55^{abc}	1.80^{abcd}	0.00^{a}	1.66^{abcd}

Means followed by same superscripts within same column are not significantly different (P>0.05)

The highest incidence of leaf necrosis (9.67%) was observed on the leaves of the Riogrande tomato variety watered only in the afternoon, while Riogrande seedlings watered in the afternoon and evening showed absence of leaf necrosis. Differences in the incidence of leaf necrosis among tomato varieties watered using different water regimes were significant (P≤0.05) (Table 4).

Incidence of stem necrosis was highest (5.55%) on the stems of the Tropimech tomato variety watered morning and afternoon. Tomato varieties treated with other water regimes showed absence of stem necrosis except Riogrande which showed 2.22% to 4.25% necrosis. Differences in the incidence of stem necrosis among tomato varieties watered using different water regimes were not significant (P>0.05) (Table 5).

Roma Savanna tomato variety watered morning and afternoon had the highest incidence of damping-off (22.43%). Absence of damping-off was observed on the Roma VF tomato variety watered in the mornings and evenings. Differences in the incidence of damping-off among the evaluated tomato varieties watered using different water regimes were significant (P≤0.05) (Table 6).

Table 4: Effect of Different Water Regimes on Incidence of Leaf Necrosis on Different Tomato Varieties 9 Weeks after Transplanting

Tomato Variety	Disease Incidence (%)						
	Morning	Afternoon	Evening	Morning + Afternoon	Morning + Evening	Afternoon + Evening	Morning + Afternoon + Evening
Roma VF	5.36^{a}	4.44^{a}	7.84^{b}	3.88^{a}	7.17^{b}	7.50^{b}	3.28^{a}
Tropimech	6.87^{a}	3.88^{a}	2.17^{a}	6.94^{a}	1.11^{a}	4.67^{ab}	5.14^{a}
Riogrande	5.41^{a}	9.67^{b}	7.70^{b}	3.21^{a}	2.98^{ab}	0.00^{a}	2.65^{a}
Roma Savanna	3.61^{a}	7.77^{b}	2.50^{a}	5.83^{a}	4.86^{ab}	3.95^{ab}	5.43^{a}

Means followed by different superscripts within same column are significantly different (P≤0.05)
Means followed by same superscripts within same column are not significantly different (P>0.05)

Table 5: Effect of Different Water Regimes on Incidence of Stem Necrosis on Different Tomato Varieties 9 Weeks after Transplanting

Tomato Variety	Disease Incidence (%)						
	Morning	Afternoon	Evening	Morning + Afternoon	Morning + Evening	Afternoon + Evening	Morning + Afternoon + Evening
Roma VF	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	1.47^{a}	0.00^{a}	0.00^{a}
Tropimech	1.66^{a}	1.11^{a}	1.11^{a}	5.55^{a}	0.00^{a}	0.00^{a}	2.17^{a}
Riogrande	3.14^{a}	0.00^{a}	0.00^{a}	0.00^{a}	4.25^{a}	2.22^{a}	0.00^{a}
Roma Savanna	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}	0.00^{a}

Means followed by same superscripts within same column are not significantly different (P>0.05)

Table 6: Effect of Different Water Regimes on Incidence of Damping-off on Different Tomato Varieties 9 Weeks after Transplanting

Tomato Variety	Disease Incidence (%)						
	Morning	Afternoon	Evening	Morning + Afternoon	Morning + Evening	Afternoon + Evening	Morning + Afternoon + Evening
Roma VF	11.94^{c}	16.68^{b}	8.88^{b}	7.91^{a}	0.00^{a}	9.51^{a}	3.33^{a}
Tropimech	8.56^{b}	14.44^{b}	5.20^{a}	9.65^{a}	13.40^{c}	13.54^{ab}	9.86^{ab}
Riogrande	2.63^{a}	3.75^{a}	4.11^{a}	12.84^{b}	8.81^{b}	15.41^{ab}	21.94^{c}
Roma Savanna	8.95^{b}	2.98^{a}	12.24^{bc}	22.43^{bc}	12.70^{c}	21.11^{c}	7.38^{ab}

Means followed by different superscripts within same column are significantly different (P≤0.05)
Means followed by same superscripts within same column are not significantly different (P>0.05)

Insect damage was only observed on the Roma VF tomato seedlings. The highest incidence of insect damage (9.27%) was observed on the leaves and stems of the Roma VF tomato variety watered morning, afternoon and evening. Differences in the incidence of insect damage among tomato varieties watered using the morning, afternoon and evening water regime were significant (P≤0.05) (Table 7).

Crown wilt was only observed on the seedlings of the Tropimech tomato variety watered morning, afternoon and evening (1.47%), and did not differ significantly from tomato varieties watered using other water regimes (P>0.05) (Table 8). The highest incidence of leaf spot (5.11%) was observed on the leaves of the Tropimech tomato variety watered with the least daily amount of water (750ml), while daily supply of 2250ml of water per pot resulted in the absence of leaf spots on majority of the studied tomato varieties. Differences in the incidence of leaf spot among tomato varieties watered daily with different amounts of water were not significant (P>0.05).

Table 7: Effect of Different Water Regimes on Incidence of Insect Damage on Different Tomato Varieties 9 Weeks after Transplanting

Tomato Variety	Disease Incidence (%)						
	Morning	Afternoon	Evening	Morning + Afternoon	Morning + Evening	Afternoon + Evening	Morning + Afternoon + Evening
Roma VF	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]	1.34[a]	9.27[b]
Tropimech	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]
Riogrande	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]
Roma Savanna	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]

Means followed by different superscripts within same column are significantly different (P≤0.05)
Means followed by same superscripts within same column are not significantly different (P>0.05)

Table 8: Effect of Different Water Regimes on Incidence of Crown Wilt on Different Tomato Varieties 9 Weeks after Transplanting

Tomato Variety	Disease Incidence (%)						
	Morning	Afternoon	Evening	Morning + Afternoon	Morning + Evening	Afternoon + Evening	Morning + Afternoon + Evening
Roma VF	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]
Tropimech	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]	1.47[a]
Riogrande	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]
Roma Savanna	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]	0.00[a]

Means followed by same superscripts within same column are not significantly different (P>0.05)

Table 9: Effect of Water Quantity on Incidence of Leaf Spot on Different Tomato Varieties 9 Weeks after Transplanting

Tomato Variety	Disease Incidence (%)		
	750ml Daily	1500ml Daily	2250ml Daily
Roma VF	3.56[a]	4.63[a]	0.00[a]
Tropimech	5.11[a]	0.92[a]	0.00[a]
Riogrande	3.33[a]	4.48[a]	0.00[a]
Roma Savanna	1.34[a]	4.63[a]	1.66[a]

Means followed by same superscripts within same column are not significantly different (P>0.05)

The highest incidence of leaf yellowing (27.43%) was observed on the leaves of Roma Savanna tomato variety watered daily with 2250ml of water. Leaf yellowing on the Roma VF, Tropimech, and Roma Savanna tomato varieties were least on seedlings watered daily with 1500ml of water (20.15%, 19.21%, and 15.30% respectively). The least incidence of leaf yellowing on the Riogrande tomato variety (10.22%) was observed on seedlings supplied daily with a total amount of 2250ml of water. Differences in the incidence of leaf yellowing among tomato varieties watered using different water amounts were significant ($P \leq 0.05$) (Table 10).

Variations in the incidence of leaf blight were observed on tomato seedlings watered daily with different amounts of water (Table 11). The highest incidence of leaf blight (7.87%) was observed on the leaves of the Roma Savanna tomato variety supplied daily with 1500ml of water, while Riogrande watered with 750ml of water, Roma VF watered with 2250ml, and Riogrande watered with 2250ml of water showed the absence of leaf blight. Differences in the incidence of leaf blight among tomato varieties supplied with different daily amounts of water were not significant ($P > 0.05$).

Incidence of leaf necrosis was highest (7.65%) on leaves of the Riogrande tomato variety watered daily with 750ml of water. The least incidence of leaf necrosis on the studied tomato varieties was observed on Tropimech (2.21%) supplied daily with 1500ml of water. Differences in the incidence of leaf necrosis among tomato varieties supplied daily with different amounts of water were significant ($P \leq 0.05$) (Table 12).

Table 10: Effect of Water Quantity on Incidence of Leaf Yellowing on Different Tomato Varieties 9 Weeks after Transplanting

	Disease Incidence (%)		
Tomato Variety	750ml Daily	1500ml Daily	2250ml Daily
Roma VF	21.41^{b}	20.15^{b}	22.65^{b}
Tropimech	20.22^{b}	19.21^{b}	26.34^{b}
Riogrande	10.81^{a}	19.65^{b}	10.22^{a}
Roma Savanna	19.44^{b}	15.30^{a}	27.43^{b}

Means followed by different superscripts within same column are significantly different ($P \leq 0.05$)
Means followed by same superscripts within same column are not significantly different ($P > 0.05$)

Table 11: Effect of Water Quantity on Incidence of Leaf Blight on Different Tomato Varieties 9 Weeks after Transplanting

	Disease Incidence (%)		
Tomato Variety	750ml Daily	1500ml Daily	2250ml Daily
Roma VF	2.31^{a}	1.24^{a}	0.00^{a}
Tropimech	2.31^{a}	2.77^{a}	1.80^{a}
Riogrande	0.00^{a}	3.70^{a}	0.00^{a}
Roma Savanna	2.72^{a}	7.87^{ab}	1.66^{a}

Means followed by same superscripts within same column are not significantly different ($P > 0.05$)

Table 12: Effect of Water Quantity on Incidence of Leaf Necrosis on Different Tomato Varieties 9 Weeks after Transplanting

	Disease Incidence (%)		
Tomato Variety	750ml Daily	1500ml Daily	2250ml Daily
Roma VF	5.25^{a}	6.24^{ab}	3.28^{a}
Tropimech	4.37^{a}	2.21^{a}	5.41^{b}
Riogrande	7.65^{a}	2.96^{a}	2.65^{a}
Roma Savanna	4.62^{a}	4.88^{a}	5.43^{b}

Means followed by different superscripts within same column are significantly different ($P \leq 0.05$)
Means followed by same superscripts within same column are not significantly different ($P > 0.05$)

Different tomato varieties supplied with different daily amounts of water showed variations in the incidence of stem necrosis (Table 13). The highest incidence of stem necrosis (8.88%) was observed on the Riogrande tomato variety watered daily with 1500ml of water. Necrotic lesions were absent on stems of Roma VF and Roma Savanna watered with 750ml of water daily, Roma Savanna supplied with 1500ml of water daily, Roma VF and Roma Savanna supplied with 2250ml of water daily. Differences in the incidence of stem necrosis among tomato varieties supplied with different daily amounts of water were significant ($P \leq 0.05$).

The highest incidence of damping-off (22.22%) was observed on the Riogrande tomato variety supplied daily with 2250ml of water. Roma VF supplied daily with 2250ml of water showed

the least incidence of damping-off (3.33%). Differences in the incidence of damping-off among tomato varieties supplied with different daily amounts of water were significant (P≤0.05) (Table 14).

Insect damage was observed only on Roma VF seedlings, and increased with increase in daily quantity of water supply. The highest incidence of insect damage (9.27%) was observed on the Roma VF tomato variety watered daily with 2250ml of water. Differences in the incidence of insect damage among tomato varieties supplied with different daily amounts of water were not significant (P>0.05) (Table 15).

Table 13: Effect of Water Quantity on Incidence of Stem Necrosis on Different Tomato Varieties 9 Weeks after Transplanting

	Disease Incidence (%)		
Tomato Variety	750ml Daily	1500ml Daily	2250ml Daily
Roma VF	0.00[a]	0.55[a]	0.00[a]
Tropimech	1.38[ab]	1.85[a]	2.17[a]
Riogrande	1.10[ab]	8.88[ab]	6.66[b]
Roma Savanna	0.00[a]	0.00[a]	0.00[a]

Means followed by different superscripts within same column are significantly different (P≤0.05)
Means followed by same superscripts within same column are not significantly different (P>0.05)

Table 14: Effect of Water Quantity on Incidence of Damping-off of Different Tomato Varieties 9 Weeks after Transplanting

	Disease Incidence (%)		
Tomato Variety	750ml Daily	1500ml Daily	2250ml Daily
Roma VF	12.56[b]	5.81[a]	3.33[a]
Tropimech	9.46[b]	12.28[b]	9.86[b]
Riogrande	3.56[a]	12.45[b]	22.22[c]
Roma Savanna	8.12[b]	18.75[c]	7.38[b]

Means followed by different superscripts within same column are significantly different (P≤0.05)
Means followed by same superscripts within same column are not significantly different (P>0.05)

Table 15: Effect of Water Quantity on Incidence of Insect Damage on Different Tomato Varieties 9 Weeks after Transplanting

	Disease Incidence (%)		
Tomato Variety	750ml Daily	1500ml Daily	2250ml Daily
Roma VF	1.85[a]	4.25[a]	9.27[ab]
Tropimech	0.00[a]	0.00[a]	0.00[a]
Riogrande	0.00[a]	0.00[a]	0.00[a]
Roma Savanna	0.00[a]	0.00[a]	0.00[a]

Means followed by same superscripts within same column are not significantly different (P>0.05)

Crown wilt was observed only on tomato seedlings watered daily with 2250ml. The highest incidence of crown wilt (5.55%) was observed on the Riogrande tomato variety, followed by Tropimech (1.47%). Differences in the incidence of crown wilt among tomato varieties supplied with different daily amounts of water were not significant (P>0.05) (Table 16).

Tomato seedlings watered using different water regimes showed varying susceptibilities to different disease symptoms (Table 17). Tomato seedlings watered only in the afternoons showed the highest incidences of leaf spots (9.72%), leaf yellowing (22.75%), and leaf necrosis (6.42%). Seedlings watered in the morning, afternoon and evening showed the highest incidence of leaf blight (8.77%) and crown wilt (4.86%). Stem necrosis, seedling damping-off and insect damage were most observed (5.55%, 14.98% and 3.21% respectively) on tomato seedlings watered in the afternoons and evenings. Differences in mean effect of water regime on disease susceptibility of evaluated tomato varieties were significant (P≤0.05).

Tomato seedlings watered only in the afternoons had the highest overall disease incidence (4.00%). The least incidence of tomato diseases (3.36%) was observed on tomato seedlings watered only in the evenings. Differences in the overall responses of tomato varieties watered using different water regimes were significant (P≤0.05) (Table 18).

Roma Savanna was the most susceptible to disease (3.77%), followed by Tropimech (3.66%), Roma VF (3.62%), and lastly Riogrande (3.52%). Differences in the overall disease responses among the evaluated tomato varieties were not significant (P>0.05) (Table 19)

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Table 16: Effect of Water Quantity on Incidence of Crown Wilt on Different Tomato Varieties 9 Weeks after Transplanting

	Disease Incidence (%)		
Tomato Variety	750ml Daily	1500ml Daily	2250ml Daily
Roma VF	0.00[a]	0.00[a]	0.00[a]
Tropimech	0.00[a]	0.00[a]	1.47[a]
Riogrande	0.00[a]	0.00[a]	5.55[a]
Roma Savanna	0.00[a]	0.00[a]	0.00[a]

Means followed by same superscripts within same column are not significantly different (P>0.05)

Table 17: Overall Effect of Different Water Regimes on Disease Susceptibility of Tomato 9 Weeks After Transplanting

Water Regime	LS	LY	LB	LN	SN	DO	ID	CW
Morning	4.43[a]	19.84[ij]	3.81[a]	5.38[bc]	1.27[a]	8.00[de]	0.00[a]	0.00[a]
Afternoon	9.72[a]	22.75[kl]	0.43[a]	6.42[cd]	2.77[a]	9.44[ef]	1.47[a]	0.00[a]
Evening	4.27[a]	19.37[i]	1.47[a]	5.12[bc]	2.77[a]	7.65[de]	0.00[a]	0.00[a]
Morning + Afternoon	2.43[a]	16.16[h]	5.90[a]	3.47[b]	1.47[a]	13.21[g]	0.00[a]	0.00[a]
Morning + Evening	6.16[a]	23.54[l]	1.23[a]	4.10[b]	1.47[a]	8.73[ef]	0.00[a]	0.00[a]
Afternoon + Evening	2.43[a]	15.92[h]	2.17[a]	4.70[bc]	5.55[a]	14.98[gh]	3.21[a]	0.00[a]
Morning + Afternoon + Evening	4.25[a]	21.69[jk]	8.77[a]	4.22[a]	5.20[a]	10.60[f]	2.43[a]	4.86[a]

Means followed by different superscripts within same column are significantly different (P≤0.05)
Means followed by same superscripts within same column are not significantly different (P>0.05)

LS = Leaf spots; LY = Leaf yellowing; LB = Leaf blight; LN = Leaf necrosis; SN = Stem necrosis; DO = Damping off; ID = Insect damage; CW = Crown wilt

Table 18. Overall Effect of Different Water Regimes on Disease Responses of the Studied Tomato Varieties

Water Regime	Mean Total Disease (%)
Morning	3.51[ab]
Afternoon	4.00[b]
Evening	3.36[a]
Morning + Afternoon	3.45[ab]
Morning + Evening	3.81[ab]
Afternoon + Evening	3.77[ab]
Morning + Afternoon + Evening	3.88[ab]

Means followed by different superscripts within same column are significantly different (P≤0.05)
Means followed by same superscripts within same column are not significantly different (P>0.05)

Table 19: Overall Disease Response of Different Tomato Varieties Subjected To Different Water Regimes 9 Weeks After Transplanting

Tomato Variety	Mean Total Disease (%)
Roma VF	3.62[a]
Tropimech	3.66[a]
Riogrande	3.52[a]
Roma Savanna	3.77[a]

Means followed by same superscripts within same columns are not significantly different (P>0.05)

DISCUSSION

Tomato seedlings watered daily using different water regimes showed varying susceptibilities to different disease symptoms. Ambang (2007) and Ambang *et al.* (2016) also noted that plants develop different disease symptoms in response to different irrigation water regimes. Variations in water availability could give rise to plant diseases by either making available a suitable environment for the growth and reproduction of various plant pathogens, or by introducing varying degrees of water stress to irrigated plants, thereby resulting to various disease responses.

Tomato seedlings watered only in the afternoons had the highest overall disease incidence. Similarly, Lobo (2018) stated that watering of tomatoes at midday could result to heating up of the water droplets by the sun which could result to several pathological responses by the plant. This also explains why tomato seedlings watered only in the evenings resulted in the least incidence of disease symptoms compared to other studied water regimes.

Roma Savanna was the most susceptible to disease, followed by Tropimech, Roma VF, and lastly Riogrande. Similarly, Mitsuya *et al.* (2000) reported that stress in plants resulting from either abiotic or biotic influences have potential to trigger various changes in internal structure and functions of plant organs. Variations in responses of the studied tomato varieties to incidence of different disease symptoms under different irrigation regimes could be linked to possible differences in their anatomical, physiological and biochemical compositions.

CONCLUSION

Tomato plants watered using different water regimes showed significant variations with respect to incidence of disease. Watering of tomato seedlings in the evenings resulted in the least incidence of field diseases and is therefore recommended for improved yield and reduced tomato crop losses in the study area.

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