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Tomato (*Solanum lycopersicum*) Growth, Yield, and Taste Components Under Water Stress in Sri Lanka's Dry Zone

K. Yobisuthan
Department of Agriculture
Faculty of Technology
Sri Lanka Technological Campus
Padukka, Sri Lanka
yobisuthank@sltc.ac.lk

D.D.N. Vibodhani
Department of Agriculture
Faculty of Technology
Sri Lanka Technological Campus
Padukka, Sri Lanka
nisansalav@sltc.ac.lk

R.M.P.I. Rajapaksha,
Department of Agriculture
Faculty of Technology
Sri Lanka Technological Campus
Padukka, Sri Lanka
isharar@sltc.ac.lk

R. M. S. M. B. Rathnayaka
Department of Agriculture,
Faculty of Technology,
Sri Lanka Technological Campus,
Padukka, Sri Lanka
sangeethr@sltc.ac.lk

***Abstract*—This study aimed to investigate the effects of water stress on the growth, yield, and taste components of the "Padma" tomato variety, offering valuable insights for farmers contending with limited water resources in the dry zone of Sri Lanka. Employing three treatments—drought stress, control, and excess water stress—the research reveals that drought stress significantly diminishes plant wet weight (169.9±29.7 g) and dry weight (66.7±11 g), impacting parameters like branches, plant height, and leaf count. In the realm of yield and fruit dimensions, excess water stress proves advantageous, yielding larger fruit diameters (3.7±0.25 cm) and higher yield per plant (742±196), while drought stress results in lower values. These findings not only enhance our understanding of water stress effects on tomato cultivation but also offer practical guidance for farmers in water-scarce regions, aiding them in optimizing crop management strategies for sustainable and efficient production**

***Keywords*—Tomato, water stress, plant growth, fruit quality, Brix, pH**

I. Introduction

Tomato fruit is a highly perishable commodity with a limited shelf life under normal temperature conditions. The flavor of tomatoes is influenced by several factors, including their sugar, acid, and volatile chemical content, which can vary depending on the variety and environmental conditions. While genetics governs the flavor profile of tomatoes, environmental elements such as sunlight, soil nutrients, and water availability can also impact these characteristics. Water is a crucial factor in tomato cultivation, as it significantly determines yield and fruit quality. Optimal water supply throughout the growing period is essential for achieving higher yields and optimal fruit quality in tomatoes [1]. However, dry zone areas in Sri Lanka often face water scarcity issues, with drought being a particularly challenging climate event in these regions. Drought stress has been found to limit the growth and yield of tomato plants, leading to reduced plant height, leaf size, stem diameter, and poor fruit and seed quality. Therefore, this study aims to address the yield and taste components of tomatoes cultivated in the dry zone areas of Sri Lanka under water stress conditions.

II. Methodology

The experiment was conducted in a Poly house located on Raja Road, Tirunelveli, East Jaffna, Sri Lanka, from December 2022 to May 2023. The tomato cultivar ‘Padma’ was selected for this experiment and after three weeks seedlings were planted in black-colored poly bags filled with a 2:1 topsoil to cow manure ratio. In this experiment, three water stress conditions were used as treatments: T_1 - drought stress treatment (100 ml water/day), T_2 - control treatment (200 ml/day - determined by analyzing soil field capacity of this area), and T_3 - excess water stress treatment (400 ml/day). Each treatment had 18 replicates. Plant height and number of leaves were measured at weekly intervals and at the end of the growth period number of branches, wet weight, and dry weight of the plants were measured. Yield parameters were measured as wet weight, number of fruits, and fruit diameter. Harvesting was done when fruits reached their full maturity, and harvested samples were prepared for Brix% and pH analysis. Statistical analysis was performed using the ANOVA function of the MINITAB Statistical Package version 19.

III. RESULTS

A. Growth Parameters

a. Wet Weight and Dry Weight

Drought stress treatment had the significantly lowest mean value in plant wet weight (169.9±29.7 g) and had the lowest mean value in plant dry weight (66.7±11 g) (Tab. 1).

b. Number of Branches

The number of branches did not differ significantly between treatments. Drought stress treatment showed a lower mean value (3.61±0.56) than excess water stress treatment (Tab. 1).

c. Plant height

Plant height did not show a significant difference in means between treatments except in the 8th week where drought stress treatment had a lower mean value (113.7±7.9 cm) than excess water stress treatment (Tab. 2).

d. Number of Leaves

Significant differences between the treatments were observed during the 8th week where drought stress treatment displayed significantly lowest mean value (11.7±1.2) (Tab. 3).

B. Yield, Fruit Parameters and Taste Components

a. Fruit Diameter

Excess water stress treatment had the highest mean value (3.7±0.25 cm) than drought stress treatment and control treatment (Tab. 4).

b. Fruit Weight

Drought stress treatment showed a mean value of 33.6±4.3 g which was lower than excess water stress treatment (Tab. 4).

c. Number of Fruits

The number of fruits did not significantly vary between treatments. Drought stress treatment had the lowest mean value which is 20.1±2.7 (Tab. 4).

d. Yield per Plant

Excess water stress treatment showed the highest yield/plant. Compared to the excess water stress treatment drought stress treatment had a lower mean value which is 742±196 (Tab. 4).

e. Brix % and pH

Significantly similar mean brix % and pH values were noted between drought stress treatment and control treatment (Tab. 4).

TABLE I: RESULTS OF GROWTH PARAMETERS

Treatments	Plant Growth Parameters		
	Number of Branches	***Plant Dry weight(g)***	***Plant Wet Weight(g)***
T1	3.61 ± 0.56 a	66.7 ± 11 a	169.9 ± 29.7 b
T2	3.1 ± 0.46 a	96.2 ± 12.5 a	301.9 ± 38.8 a
T3	3.9 ± 0.52 a	90.3 ± 10.3 a	299.2 ± 35.2 a

Values in each column represent the means of 18 replicates ± SE (Standard Error). The mean followed by the same letter within each column is not significantly different at $p<0.05$

TABLE II: RESULTS OF PLANT HEIGHT

Treatments	Plant Height(cm)				
	1st week	***4th week***	***6th week***	***8th week***	***11th week***
T1	92.3 ± 2.3 a	104.6 ± 3.7 a	111.1 ± 3.9 a	113.7 ± 7.9 a	86.6 ± 13.4 a
T2	95.3 ± 1.8 a	108.4 ± 2.5 a	116.5 ± 3.4 a	109.4 ± 10.2a	67.0 ± 14.7 a
T3	90.6 ± 6.5 a	104.4 ± 8.3 a	110.1 ± 8.8 a	121.1 ± 9.5a	81.9 ± 15.2a

Values in each column represent the means of 18 replicates ± SE (Standard Error). The mean followed by the same letter within each column is not significantly different at $p<0.05$.

TABLE III: RESULTS OF THE NUMBER OF LEAVES

Treatments	Number of Leaves				
	1st week	***4th week***	***6th week***	***8th week***	***11th week***
T1	15.3 ± 0.5 a	15.6 ± 0.9 a	14.7 ± 1.2 a	11.7 ± 1.2 b	9.5 ± 1.8 a
T2	15.2 ± 0.4 a	18.5 ± 0.6 a	15.0 ± 0.8 a	13.5 ± 1.5 ab	6.9 ± 1.6 a
T3	15.3 ± 1 a	17.5 ± 1.6 a	15.3 ± 2 a	18.1 ± 2.5 a	10.7 ± 2.5 a

Values in each column represent the means of 18 replicates ± SE (Standard Error). The mean followed by the same letter within each column is not significantly different at $p<0.05$.

TABLE IV: RESULTS OF YIELD AND FRUIT PARAMETERS

Treatments	Fruit and Yield Parameters			
	Fruit Weight (g)	***Yield/ plant***	***Number of Fruits***	***Fruit Diameter (cm)***
T1	33.6 ± 4.3 a	742 ± 196. a	17.2 ± 3.1 a	3.4 ± 0.15 a
T2	33.6 ± 3.9 a	673.5 ± 93.8 a	19.8 ± 1.1 a	3.4 ± 0.12 a
T3	42.9 ± 4.9 a	1011 ± 193.5 a	20.1 ± 2.7 a	3.7 ± 0.25 a

Values in each column represent the means of 18 replicates ± SE (Standard Error). The mean followed by the same letter within each column is not significantly different at $p<0.05$.

TABLE V: RESULTS OF TASTE COMPONENTS

Treatments	Taste Components	
	Brix%	***pH***
T1	5.9 ± 0.48 a	3.4 ± 0.06 a
T2	6.1 ± 0.39 a	3.4 ± 0.07 a
T3	5.0 ± 0.39 a	3.2 ± 0.2 a

Values in each column represent the means of 18 replicates ± SE (Standard Error). The mean followed by the same letter within each column is not significantly different at $p<0.05$

IV. DISCUSSION

Tomato is sensitive to a variety of environmental challenges, particularly excessive temperature, drought, salinity, and insufficient moisture, and has an adverse impact on plant growth, development, and production. Drought conditions are caused by a scarcity of water due to a decrease in rainfall and an increase in the frequency of dry periods. This study examined the effects of various water treatments on various characteristics of fruit and plant growth parameters. In this study, drought stress treatment showed a lower mean value than the excess water stress treatment during the 8th week in terms of plant height. This aligns with prior research reporting drought stress can reduce plant height [1]. Drought stress treatment had significantly the lowest number of leaves during the 8th week suggesting that drought stress reduces leaf growth [2]. Drought stress treatment showed a significantly lower mean value in terms of plant wet weight which implies that drought stress can reduce plant weight. Prior studies investigated how different crops respond to drought stress. For instance, drought stress has significant effects on the chili pepper cultivars' taste components, fruit size, and overall productivity [3] and the stress condition was affected in the taste component synthesis cycles ex. Capsaicinoids synthesis cycle [4]. When considering the other environmental stress conditions present findings were tallied with the findings for the salinity stress conditions [5] of chili pepper cultivars which were in the same family as tomatoes. Along with this, a prior report showed the drought stress treatment had the lowest number of fruits [6] and drought stress treatment showed a lower mean value in terms of Yield/plant when compared to the excess water stress treatment, suggesting drought stress can reduce total yield/plant in tomato plants. Drought stress treatment showed significantly similar pH and Brix% values when compared to the control treatment. This implies that drought stress might not substantially impact sugar content and fruit acidity. This is consistent with studies noting minimal changes in fruit quality attributes under drought stress conditions [7].

V. CONCLUSION

The findings of our study provide valuable insights into the effects of drought stress on tomato cultivation in the dry zone of Sri Lanka. The results suggest that drought stress affects plant growth parameters, fruit characteristics, and yield/plant in tomatoes. These findings can guide future research and assist farmers in making informed decisions to improve tomato production in water-stressed environments. However, further research is needed to fully understand the underlying physiological mechanisms and optimize water stress conditions for tomato cultivation in water-limited environments.

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