Effect of Salinity Stress on Plant Growth, Yield, and Taste Components in Tomato (*Solanum lycopersicum*)

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Abstract—**Tomato cultivation in Sri Lanka faces challenges due to salinity stress, and it affects productivity and quality. This study investigates the impact of salinity stress on tomato growth, yield, and fruit attributes. Three treatments were investigated which are T1: Control- level (0.6 g/l NaCl), T2: Additional - level (3.0 g/l NaCl), and T3: Excess - level (6.5 g/l NaCl). and plant growth, fruit parameters, and yield were analyzed. Plant height and leaf growth were decreased with time by excessive salinity stress, while fruit quality (pH) was increased. Yield per plant was affected, with excess salinity leading to lower yield (264.8 ± 13.6 g) while resulting in the lowest fruit weight (23.2 ± 0.27 g). These findings provide insight into how salinity stress affects tomato cultivation, which is important for sustainable agricultural practices. Notably, excess salinity improved fruit quality, despite adverse effects on growth and yield.**

Keywords—**Salinity stress, growth parameters, yield, fruit length**

I. INTRODUCTION

Tomato (*Solanum lycopersicum*) is a highly valuable and widely cultivated crop across the globe. Environmental factors, especially the temperature, soil water conditions, and salinity have been found to alter the plant chemistry [1]. Especially, the productivity and quality of tomato plants are significantly affected by various abiotic stresses, including salinity stress. Salinity stress occurs when excessive salts accumulate in the soil, leading to hindered water and nutrient uptake by plants [2]. In regions like Sri Lanka, salinity stress is a critical factor that limits plant cultivation in saline-affected lands [1]. Salt tolerance is an important topic in agriculture to study because it causes the loss of plant productivity and land productivity by salinization. However, to our knowledge, findings about the salinity stress and the taste component behavior with the salinity were very limited, and therefore, this study aims to address the yield and taste components of tomatoes cultivated under different salinity stress conditions in Sri Lanka.

II. METHODOLOGY

The experiment was conducted in a poly house in Kadawatha, Sri Lanka, from January 2023 to May 2023. Tomato seedlings from the variety 'Thilina' which were three weeks old were planted in black color polythene bags. Three treatments were executed: T1: Control- level (0.6 g/l NaCl), T2: Additional - level (3.0 g/l NaCl), and T3: Excess - level (6.5 g/l NaCl). Salinity stresses were induced through the irrigation water and water treated with different levels of NaCl was applied to the plants once in two days until the end of the study. Plant Height (cm), and Number of Leaves were measured in weekly intervals and the Wet and Dry weights of the plants were measured at the end of the experiment. Harvesting was done when fruits reached their full maturity. Fruit length (cm), Fruit weight (g), Number of Fruits/Plant, Brix%, and pH were measured in the fruits harvested daily and finally, the Total Yield (g)/Plant was calculated. Each fruit sample was ground and juiced for Brix and pH analysis. Brix% was analyzed by a Refractometer and pH was analyzed by a Digital pH meter. Statistical analysis was carried out employing the ANOVA feature within the MINITAB Statistical Package, version 19. The study utilized a one-factor Factorial design with 18 replicates per treatment.

III. RESULTS

The study investigated the effects of three salinity treatments on various plant growth, fruit, and yield parameters.

A. Growth Parameters

a. Plant Height

There were no significant differences noted among the treatments during the 1st and 6^{th} week. However, control-level treatment plants showed higher values than additional-level treatment and excess-level treatment (Tab. 1).

b. *Number of Leaves*

There were no significant differences observed among treatments, but control-level treatment plants showed higher values than additional-level treatment and excess-level treatment (Tab. 2).

c. *Wet and Dry weight*

There were no significant differences observed among treatments, but excess-level treatment plants showed higher values than control-level treatment and additional-level treatment in terms of dry weight and control-level treatment showed higher values than the other two treatments in terms of wet weight (Tab. 3).

B. *Fruit and Yield Parameters*

a. *Fruit Length*

Significant differences among treatments were observed for fruit length. Control-level treatment plants had significantly wider fruits (12.0 ± 0.10 cm) compared to the other two treatments (Tab. 4).

b. *Fruit Weight*

Fruit weight exhibited significant differences between control-level treatment and additional-level treatment, as well as between control-level treatment and excess-level treatment (Tab. 4).

c. *Number of Fruits/plant*

Significant differences among treatments were observed for the Number of Fruits/plants. Control-level treatment plants had significantly more fruits (14.0 ± 0.9) compared to excess-level treatment (Table V).

d. *Yield/Plant*

Significant differences in yield were observed among treatments. Additional-level treatment had a significantly higher yield compared to excess-level treatment (Tab. 5).

e. *Brix%*

There were no significant differences noted between the treatments (Tab. 4).

f. *pH*

There were significant differences in pH between the treatments. In comparison to control-level treatments and additional-level treatments, excess-level treatments exhibited significantly higher pH values (Tab. 4).

TABLE I. RESULTS OF PLANT HEIGHT

Treatments	**Plant Height (cm)**				
	1st week	***4th week***	***6th week***	***8th week***	***11th week***
T1	71.9 ± 1.0 ^{a}	88.7 ± 1.0 ^{a}	91.0 ± 1.3 ^{a}	97.1 ± 1.2 ^{a}	102.8 ±1.2 ^{a}
T2	60.4 ± 5.2 ^{a}	71.8 ± 6.1 ^{ab}	77.0 ± 6.6 ^{a}	29.1 ± 2.5 ^{c}	86.5 ± 7.4 ^{ab}
T3	60.0 ± 5.2 ^{a}	68.6 ± 5.9 ^{b}	73.1 ± 6.3 ^{a}	77.5 ± 6.6 ^{b}	81 ± 6.9 ^{b}

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 THE NUMBER OF LEAVES

Treatments	**Number of Leaves**				
	1st week	***4th week***	***6th week***	***8th week***	***11th week***
T1	16.0 ± 0.4 ^{a}	25.5 ± 0.8 ^{a}	29.5 ± 1.0 ^{a}	31.3 ± 1.4 ^{a}	31.5 ± 0.7 ^{a}
T2	14.0 ± 1.28 ^{a}	23.10 ± 2.1 ^{a}	26.2 ± 2.4 ^{a}	29.1 ± 2.5 ^{a}	30.5 ± 2.8 ^{a}
T3	12.5 ± 1.22 ^{a}	20.8 ± 1.9 ^{a}	24.2 ± 2.1 ^{a}	27 ± 2.3 ^{a}	26.9 ± 2.4 ^{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 III. RESULTS OF GROWTH PARAMETERS

Treatments	**Plant Growth Parameters**	
	Plant Dry weight (g)	***Plant Wet Weight (g)***
T1	82.2 ± 2.6 ^{a}	184.3 ± 4.1 ^{a}
T2	71.0 ± 5.8 ^{a}	167.9 ± 15.2 ^{a}
T3	93.8 ± 7.6 ^{a}	169.2 ± 15.1 ^{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 FRUIT PARAMETER AND TASTE COMPONENTS

Treatments	**Fruit and Yield Parameters**		
	Fruit Length (cm)	***Brix%***	***pH***
T1	12.0 ± 0.10 ^{a}	4.1 ± 0.02 ^{a}	4.4 ± 0.04 ^{ab}
T2	11.3 ± 0.09 ^{b}	4.1 ± 0.04 ^{a}	4.3 ± 0.02 ^{b}
T3	11.1 ± 0.02 ^{b}	4.2 ± 0.03 ^{a}	4.5 ± 0.05 ^{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 YIELD AND FRUIT PARAMETERS

Treatments	**Fruit and Yield Parameters**		
	Fruit Weight(g)	***Yield/Plant (g)***	***Number of Fruits***
T1	27.6 ± 0.38 ^{a}	386.1 ± 26.8 ^{a}	14.0 ± 0.9 ^{a}
T2	26.4 ± 0.25 ^{b}	342.0 ± 8.4 ^{a}	12.9 ± 0.3 ^{ab}
T3	23.2 ± 0.27 ^{c}	264.8 ± 13.6 ^{b}	11.3 ± 0.5 ^{b}

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

Abiotic stress, which includes conditions like drought, salinity, and high temperatures, has a detrimental effect on the growth, development, and yield of plants. This study examined the effects of various salinity treatments on various characteristics of fruit and plant growth parameters and there were significant differences in terms of plant height during the 4^{th}, 8^{th}, and 11^{th} weeks. In most of the weeks, excess-level treatments showed lower results compared to control and additional-level treatments and this behavior was similar in the Additional-level treatment plants which also showed lower results than control-level treatment. Even though there were no significant differences noted between the treatments, additional-level treatment, and excess-level treatment showed lower values when compared to control treatment in terms of the number of leaves. These findings align with other studies that indicate salinity adversely affects plant growth and development [2]. Excess-level treatment plants showed higher values than additional-level treatment in terms of plant dry weight and wet weight, suggesting excess salinity stress level might increase the moisture and dry matter content of plants. Excess level condition plants' Fruit number and yield per plant were lower than control-level treatment and additional-level treatment. This finding aligns with other studies that indicated decreased yield, and fruit number under saline conditions [3]. However, when comparing the yield per plant, the results of the additional-level condition with the control-level condition, there were only minor differences noted between the values, indicating that yields are only slightly or not at all affected by low salt concentrations [4]; [5]. Salinity, which is defined as an excessive level of salt in the soil, water, and plants, is an issue that can be caused by both natural and anthropogenic activity and gets more acute with time. Prior studies investigated how saline stress affected the development, production, and taste components of different crops [6]. While the Brix% values exhibited no significant differences, the pH values demonstrated variations, with excess salinity levels leading to elevated pH levels compared to the other two conditions. So, it appeared to enhance fruit quality. This aligns with previous observations that salinity stress can lead to improved fruit quality attributes, possibly due to altered metabolic pathways [3]. Along with this, a prior report showed the Fruit's glucose level increased while its total sugar and glutamic acid amounts decreased as the water supply in the fruit of Chili Pepper (*Capsicum annuum* L.) [7].

V. Conclusion

This research provides valuable insights into the effects of different salinity stress levels on various plant growth, yield, and fruit parameters. The results underline the potential negative impacts of salinity on plant height, leaf growth, fruit number, and yield, while also suggesting a potential positive effect on fruit quality. These findings contribute to our understanding of how salinity stress influences plant growth and fruit development and can guide strategies to mitigate its adverse effects on agricultural productivity.

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