The Impact of Foliar Spraying with alpha-Tocopherol and Salicylic Acid on the Quality of Tomato Fruits in Three Hybrids under Protected Agriculture Conditions.

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Abstract

A field experiment was conducted during the 2024-2025 autumn growing season in a protected cultivation system at the College of Agriculture, University of Diyala, to investigate the effect of foliar application of alpha-tocopherol and salicylic acid at a concentration of 100 mg L-1 each, alone and in combination, on some fruit quality attributes of three tomato hybrids (Bobcat, Arwa, and Sandy). The foliar application was performed four times, once before flowering and three times after flowering. The interval between each foliar spray was 20 days. The results showed that the different treatments had a significant and substantial impact on enhancing fruit quality traits, particularly fruit firmness, with the highest value (4.103 kg cm-2) recorded for the combined treatment of alpha-tocopherol and salicylic acid, although it did not differ significantly from the alpha-tocopherol treatment alone. The highest fruit vitamin C content (31 mg 100 mL-1) and total acidity (0.357%) were recorded for the combined treatment, although the latter did not differ significantly from the alpha-tocopherol treatment alone. The highest total soluble solids (TSS) percentage (5.488%) was recorded for the combined treatment. Regarding the hybrids, no significant differences were observed between them in fruit firmness and vitamin C content. However, the hybrid H3 (Sandy) outperformed the other hybrids in total acidity, while the hybrid Bobcat (H1) outperformed the other hybrids in TSS content. Based on these findings, the current study recommends incorporating foliar application of alpha-tocopherol and salicylic acid into technical programs to improve fruit quality of tomato plants grown under protected cultivation systems.

Keywords: alpha-tocopherol, salicylic acid, tomato, protected cultivation.

Introduction

Tomato (Solanum lycopersicum L.) is one of the most important horticultural crops belonging to the Solanaceae family and is a self-pollinating crop. Tomatoes occupy a significant position in global agriculture due to their widespread consumption and high nutritional value, containing essential nutrients required by humans (Islam et al., 2018). Medical studies have shown a significant relationship between consuming tomato fruits and products and reducing the risk of cardiovascular diseases, various types of cancer, and delaying aging (Sesso et al., 2003). Foliar nutrition is a common and crucial method for absorbing nutrients through leaves, contributing to maintaining plant growth and increasing productivity (Gorni et al., 2021). Under recent climate changes and the decline in global vegetable production, the use of antioxidants such as tocopherol has

emerged. Tocopherol is a lipophilic compound that acts as an antioxidant and belongs to the vitamin E family. This compound is naturally produced in green photosynthetic organisms like algae and higher plants (Falk & Munné-Bosch, 2010). Studies have shown that tocopherol is present in leaves and that the rate of leaf production in plants is significantly affected by the cellular tocopherol level, which enhances plant tolerance to various stresses. Moreover, studies have confirmed that foliar spraying with tocopherol during the reproductive stage can improve fruit quality through its positive effects on the antioxidant defense mechanism (Ali et al., 2019). A recent study demonstrated that foliar spraying with alpha-tocopherol at a concentration of 125 mg/L on tomato plants led to improvements in the physical and chemical characteristics of fruits (Ibrahim, 2023). Salicylic acid is one of the essential phenolic acids with antioxidant properties, characterized by unique properties (Pirasteh-Anosheh et al., 2023). Salicylic acid also functions to increase fruit firmness and pericarp thickness (Kanj et al., 2023). Another study showed that foliar spraying with salicylic acid at a concentration of 0.5 mM on tomato plants resulted in an increase in plant yield and total soluble solids (Baek et al., 2021.(

This study aims to evaluate the impact of foliar spraying with tocopherol and salicylic acid and their combination on the quality of tomato fruits under protected agriculture conditions .

Material and Methods

Study Site:

The experiment was conducted in the plastic house belonging to the Department of Horticulture and Landscape Engineering, College of Agriculture, University of Diyala, during the autumn season 2024-2025. The study aimed to evaluate the effect of foliar spraying with alpha-tocopherol and salicylic acid on the vegetative and chemical characteristics of three tomato hybrids under protected agriculture conditions.

Experimental Design:

The experiment was conducted using a Randomized Complete Block Design (RCBD) with a Split Plot arrangement and three replications. The first factor was foliar spray treatments, which included:

A1: Control treatment (water spray only(

A2: Alpha-tocopherol 100 mg/L

A3: Salicylic acid 100 mg/L

A4: Combination of alpha-tocopherol + salicylic acid (100 mg/L each(

The second factor was three tomato hybrids:

H1: Bobcat H2: Arwa H3: Sandy

Plants were sprayed four times: once before flowering and three times after.

Measured Traits:

Readings were taken from five random plants from each experimental unit, and included the following traits:

.1Fruit firmness (kg/cm²): measured using a Pentrometer device from the shoulder area of the fruit at the red ripening stage, and then the average was calculated.

.2Vitamin C content (mg/100 ml): estimated according to the method described by Klein and Perry (1982.(

.3Total acidity (%): estimated by taking a random sample of fruits from each treatment, squeezing them using a manual juicer, filtering the juice, and then titrating it with sodium hydroxide (0.1 N) after adding phenolphthalein indicator.

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.4Total soluble solids (TSS) (%): measured using a Pocket Refractometer device by taking a drop of juice from five fully ripe fruits from each experimental unit.

Statistical Analysis:

Results were analyzed using SAS software, and means were compared using Duncan's Multiple Range Test at a probability level of 0.05.

Results and Discussion:

Fruit Firmness (kg/cm²(

The results in Table 1 showed significant differences between foliar spray treatments ($P < 0.05$), where the combination treatment A4 (alpha-tocopherol and salicylic acid) outperformed the control treatment A1 and treatment A3 (salicylic acid), with a value of 4.103 kg/cm², which did not differ significantly from treatment A2 (alpha-tocopherol), with a value of 3.935 kg/cm². The control treatment had the lowest value, with 3.790 kg/cm². Regarding the hybrids, we did not find any significant differences between them ($P > 0.05$), and hybrid H3 recorded the highest value, with 3.980 kg/cm². As for the interactions, the interaction between treatment A4 (alpha-tocopherol and salicylic acid) and hybrids H1 and H3 gave the highest fruit firmness, with a value of 4.106 kg/cm². The lowest fruit firmness was recorded for the control treatment with hybrid H1, with a value of 3.646 kg/cm².

Table 1 shows the effect of alpha-tocopherol and salicylic acid and their interaction on fruit firmness (kg/cm²) in three tomato hybrids

Average effect of the factor A	Levels of the factor H			Levels of the factor A
	H3	H2	H1	
3.790 B	3.933 ba	3.790 bc	3.646 c	A1
3.935 AB	4.003 ba	3.890 bac	3.913 bac	A2
3.886 B	3.880 bac	3.840 bac	3.940 ba	A3
4.103 A	4.106 a	4.096 a	4.106 a	A4
	3.980 A	3.904 A	3.901 A	Average effect of the factor H

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%

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Vitamin C Content (mg 100ml-1 (

The results in Table 2 showed significant differences between foliar spray treatments (P < 0.05), where the combination treatment A4 (alpha-tocopherol and salicylic acid) outperformed the other treatments, with a value of 31 mg 100 ml-1. Treatment A2 (alpha-tocopherol) outperformed treatments A3 (salicylic acid) and A1 (control), with a value of 26.555 mg 100 ml-1. Treatment A3 (salicylic acid) also outperformed the control treatment, with a value of 23 mg 100 ml-1.

Regarding the hybrids, we did not find any significant differences between them (P > 0.05), and hybrid H3 recorded the highest value, with 24.33 mg 100 ml-1, and the lowest value was 22.833 mg 100 ml-1. As for the interactions, the interaction between treatment A4 (alpha-tocopherol and salicylic acid) and hybrids H1 and H3 gave the highest value of vitamin C, with 32.33 mg 100 ml-1 for both. The lowest value of vitamin C was recorded for the control treatment (A1) with hybrid H1, with 11.667 mg 100 ml-1 .

Table 2 shows the effect of alpha-tocopherol and salicylic acid and their interaction on fruit vitamin C content (mg 100 ml-1) in three tomato hybrids.

Average effect of the factor A	Levels of the factor H			Levels of the factor A
	H3	H2	H1	
13.66 D	14.66 d	14.66 d	11.66 d	A1
26.55 B	27.66 ba	26.66 bc	25.33 bc	A2
23 C	22.33 c	24.66 bc	22 a	A3
31 A	32.66 a	28 ba	32.33 a	A4
	22.83 A	23.50 A	24.33 A	Average effect of the factor H

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5% .

Total Acidity Percentage in Fruits(%)

The results in Table 3 showed significant differences between foliar spray treatments (P < 0.05), where the combination treatment A4 (alpha-tocopherol and salicylic acid) outperformed treatments A1 (control) and A3 (salicylic acid) with a value of 0.357%, but did not differ significantly from treatment A2 (alpha-tocopherol). The lowest value was 0.182% for the control treatment.

Regarding the hybrids, hybrid H3 outperformed the other hybrids significantly with a value of 0.338%, and the lowest value was 0.236% for hybrid H2. As for the interactions, the interaction between treatment A4 (alpha-tocopherol and salicylic acid) and hybrid H3 gave the highest value of 0.434%. The lowest value was 0.153% for the control treatment (A1) with hybrid H1 .

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Table 3 shows the effect of alpha-tocopherol and salicylic acid and their interaction on total acidity percentage in fruits (%) in three tomato hybrids.

Average effect of the factor A	Levels of the factor H			Levels of the factor A
	H3	H2	H1	
0.182 C	0.222 cde	0.170 de	0.153 e	A1
0.285 BA	0.353 b	0.251 cd	0.250 cd	A2
0.270 B	0.345 b	0.221 cde	0.244 cd	A3
0.357 A	0.434 a	0.301 cb	0.336 b	A4
	0.338 A	0.236 B	0.246 B	Average effect of the factor H

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Total soluble solids (TSS :(%) (

The results in Table 4 showed significant differences between foliar spray treatments ($P < 0.05$), where the combination treatment A4 (alpha-tocopherol and salicylic acid) outperformed the other treatments, with a value of 5.488%. The lowest value was 3.455% for the control treatment (A1). There were no significant differences between treatments A2 and A3 (alpha-tocopherol and salicylic acid.(

Regarding the hybrids, hybrid H1 outperformed the other hybrids with a value of 5.066%.

As for the interactions, the interaction between treatment A4 (alpha-tocopherol and salicylic acid) and hybrid H1 gave the highest value, with 6.466%. The lowest value was 3.266% for the control treatment (A1) with hybrid H2.

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Table 4 shows the effect of alpha-tocopherol and salicylic acid and their interaction on total soluble solids (TSS) percentage (%) in three tomato hybrids.

Average effect of the factor A	Levels of the factor H			Levels of the factor A
	H3	H2	H1	
3.455 C	3.333 cd	3.266 d	3.766 cbd	A1
4.255 B	4.366 cb	3.900 cbd	4.500 B	A2
4.711 B	4.333 cb	4.266 cbd	5.533 A	A3
5.488 A	5.566 a	4.433 B	6.466 a	A4
	4.400 B	3.966 B	5.066 A	Average effect of the factor H

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

The results of the study showed that the combination of salicylic acid at a concentration of 100 mg/L and vitamin E at a concentration of 100 mg/L was the most effective in improving the qualitative traits of tomato fruits. This combination contributed to a significant increase in the percentage of total soluble solids (TSS), titratable acidity, vitamin C content, and fruit firmness compared to other treatments and control.

This improvement is attributed to several interrelated factors, including the increase in the content of macronutrients (nitrogen, phosphorus, and potassium) in the fruits, which play a crucial role in the synthesis of phytochemicals that determine fruit quality and marketability. These results are consistent with what was found by (Javaheri et al., 2012) when spraying tomato plants with salicylic acid, which improved the qualitative characteristics of fruits, including vitamin C.

In addition, the antioxidant properties of salicylic acid and vitamin E work to protect fruit cells from oxidative damage caused by free radicals, which contributes to maintaining the stability of vitamin C and thus increasing its firmness. Foliar application of this combination also leads to an improvement in chlorophyll content in leaves, which enhances photosynthetic efficiency and supports sugar accumulation, which positively reflects on increasing TSS percentage in fruits.

Salicylic acid also works to prevent cell wall degradation and maintains the thickness of the fruit pericarp by inhibiting the activity of metabolic enzymes responsible for respiration, which are detrimental to fruit quality, and thus leads to fruit firmness, strength, and thickness of the mesocarp.

This improvement in qualitative traits is essential for improving fruit taste, increasing fruit resistance to

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significant differences between them in some traits, while no significant differences were recorded in other traits, which can be attributed to the difference in chemical composition and qualitative characteristics of the cultivars. spoilage during storage, and enhancing the market value and nutritional quality of fruits. Regarding the hybrids, there were

Conclusions:

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The results showed that the combination of salicylic acid at a concentration of 100 mg/L and vitamin E at a concentration of 100 mg/L was the most effective in improving the qualitative traits of tomato fruits.

.2This combination contributed to a significant increase in the percentage of total soluble solids (TSS), titratable acidity, vitamin C content, and fruit firmness.

.3Hybrid H1 outperformed the other hybrids in some qualitative traits, while no significant differences were recorded in other traits.

.4Salicylic acid and vitamin E can be used as an alternative to chemical fertilizers to improve the quality of tomato fruits.

.5It is recommended to cultivate hybrid H1 and use the combination of salicylic acid and vitamin E to improve the quality of tomato fruits.

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