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Effect of Tryptophan Application Method and Sorbitol Spray on Growth of Mandarian Transplants

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ABSTRACT

Background: Sorbitol (a non-cyclic polyol) and sugar are the major products of photosynthesis and the major components transported through the phloem in some economically important species in the Rosaceae family, especially in apple *Malus pumila*, pear *Pyrus communis*, almond *Prunus dulcis*, cherry *Prunus* spp., peach *Prunuspersica* L. and plum *Prunus* spp.

Methods: A field experiment was conducted in a private orchard in Diyala Governorate to reveal the effect of the tryptophan application method and sorbitol spray on the growth of 2-yrs old mandarin transplants. The study included two factors: tryptophan application method (control, spray 200, 400 mg.L^{-1} and soil application at 500, 1000 mg.L^{-1}) and sorbitol spray (0, 20 and 40 g. L^{-1}).

Result: Sorbitol spray at 20 g.L^{-1} caused a significant increase in stem length and diameter, leaves number, leaf area and leaves P and K content. Tryptophan application at 1000 mg.L^{-1} gave the best increase in stem length and the largest number of leaves per plant, furthermore, this treatment gave the highest carbohydrates, nitrogen and phosphorus content, whereas the largest increase in stem length and leaves chlorophyll content resulted from tryptophan spray at 400 mg. L^{-1}, On the other hand, the highest leaves potassium content in the leaves resulted from tryptophan application at 500 mg.L^{-1} in soil.

Key words: Application method, Mandarin, Sorbitol, Tryptophan.

INTRODUCTION

Citrus is one of fruit crop belonging to Rutaceae family (Rana *et al*., 2020). Its occupies a special place in the global economy in terms of food and trade (Memarne *et al*., 2021). Because of the fruits' economic and nutritional value, citrus trees are considered significant fruit trees (Sohby *et al*., 2023 and Yulianti *et al*., 2021). They are abundant in salts like calcium, potassium, sodium, magnesium, phosphorus and sulfur which are essential for the construction of the human body. They also contain valuable amounts of vitamins like B2, A, C and B1 (Ibrahem, 2015), as well as leaves with oil glands in most parts of the plant, essential oil and perfume (El-Qatrani, 2019). As a result of forest fires brought on by decreased rainfall, global warming, a shortage of water resources and increased greenhouse gas emissions, drought-the most destructive natural disaster-causes enormous losses by seriously harming both the environment and people (Hekimoğlu and Altındeğer, 2008). Among the stressors that arable lands worldwide face, drought stress makes up the biggest percentage (26%), according to Kalefetoğlu and Ekmekçi, (2005).

Sugar alcohols are the primary building blocks of carbohydrates produced by photosynthesis. When added to plants, they increase the products of carbohydrate metabolism, including proteins, peptides, lipids, pectins and organic acids. Affecting the plant's vital processes, including respiration, energy release and ATP production, thus affecting growth by increasing cell division and elongation. This, in turn, will facilitate the absorption processes of elements and water and thus affect the many growth processes of the plant (Mena *et al*., 2022 and Jia *et al*., 2024). Sorbitol is a carbohydrate product that can be transported in many plants (Sankar *et al*., 2013). Sorbitol $C_6H_{14}O_6$, sugar alcohol, the main and final product of photosynthesis, plays a crucial role in plants' ability to withstand abiotic conditions (Al-Dulaimi and Homed, 2024). Sorbitol (a non-cyclic polyol) and sugar are the major products of photosynthesis and the major components transported through the phloem in some economically important species in the Rosaceae family, especially in apple [*Malus pumila* (P.) Mill.], pear [*Pyrus communis*], almond [*Prunus dulcis* (D. A.) Webber], cherry [*Prunus spp*.], peach [*Prunus persic*a (L.) Batsch] and plum [*Prunus spp*.], which collectively rank among the most significant tree fruit crops in the world (Loescher and Everard, 2017). Between 65% and 75% of the transported carbon in mature apricot (Prunus armeniaca) leaves is sorbitol, which is frequently the main result of photosynthesis (Bieleski and Redgwell, 1985). Despite numerous studies investigating the importance of plant growth promoters and regulators in enhancing and improving citrus transplants growth

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(Abobatta *et al.,* 2024; Al-hayany *et al*., 2016; Al-Kayssi, 2017; Al-Marsoumi and Mustafa 2025; Ami and Asmaa, 2012), research on the effects of sorbitol and tryptophan is very limited. Therefore, it is essential to understand the significance of these two compounds in citrus transplants growth is crucial, paving the way for modern approaches to supporting agricultural production.

Found Al-Shammari and Al-Azzawi (2022) in their experiment on Capsicum frutescens L. When sprayed with two concentrations of sorbitol, 0 and 10 g L^{-1}, spraying with sorbitol led to an increase in plant height, number of branches and total leaf area in a balanced manner.

Hekmet and Alalaf (2025) found that the foliar spraying with sorbitol at 50 g^{-1} on *Ziziphus jujuba* Mill recorded a significant increase in the leaf content of nitrogen, potassium, carbohydrates and chlorophyll, which recorded the lowest values of these characteristics.

According to Tegeder and Rentsch (2010), some amino acids are precursors of several plant hormones that are essential for several biological functions in plants, including stress tolerance, protein synthesis, pollination, photosynthesis and fruit development. Tryptophan is a crucial amino acid that is essential for the formation of auxins (IAA) in certain plant tissues and one of the structural components and building blocks of enzymes and proteins. Tryptophan is utilized in place of direct auxin to increase crop productivity and growth (Ahmad *et al.*, 1999). Conversely, glycine is essential for protecting plants from environmental stressors like drought, heat and salinity (Ashraf and Harris, 2004). It also inhibits photorespiration and activates the formation of chlorophyll (Hendry and Stobart, 1977). Al-Hadethi *et al.* (2025) conducted an experiment on peach plants by spraying them with different concentrations of tryptophan (0, 50, 100 and 200 mg L^{-1}). It was observed that the highest increase was obtained at a concentration of 200 mg L^{-1}, as the height of the plant increased, as well as an increase in its longitudinal part. The leaf area, number of leaves of the plant and its content of chlorophyll and carbohydrates, as well as its content of nitrogen and potassium, also increased.

MATERIALS AND METHODS

A factorial experiment was conducted in a private orchard in Diyala Governorate, to reveal the effect of the tryptophan application method and sorbitol spray on the growth of mandarin transplants on two years old. The study included two factors: tryptophan application method (control, spray 200, 400 mg.L^{-1} and soil application at 500,1000 mg.L^{-1}) and sorbitol spray (0, 20 and 40 g.L^{-1}). The spray treatments of previous materials were conducted four times (20 March, 10 April, 5 and 30 May), whereas soil application of tryptophan was done three times (20 March, 20 April and 20 May). A factorial experiment was conducted according to a randomized complete block design with three replicates and two transplants in the experimental unit and the data were analyzed with the use of a ready-made SAS program (SAS, 2003).

Studied traits:

1- The increase in main stem length (cm).
2- The increase in the main stem diameter (mm).
3- Leaves number (leaf per transplant).
4- Leaf area (cm^2): Measured according to Dvronic (1965) method.
5- Leaves chlorophyll content: Determined by spectrophotometer (Mg.g^{-1} fresh weight).
6- Leaves carbohydrate contents (%).
7- The leaves N content(%): determined by spectrophotometer according to Novozamsky (1974) method.
8- The leaves P content: Determined using Van Schouwenberg and Walinga (1967) method.
9- The leaves' K content (%): Determined using a flame photometer (Tendon, 2005). The means were compared using the least significant degree (LSD) at a 0.05 probability level (Al-Rawi and Khalaf, 1980).

RESULTS AND DISCUSSION

Stem length increase (cm)

The result are shown in (Table 1) that Sorbitol sprays at 20 g.L^{-1} gave the major stem length increase (26.78 cm), whereas untreated transplants gave the lowest increase (20.88 cm). Tryptophan, soil application at 1000 mg.L^{-1} gave a higher stem length increase (27.42 cm), whereas untreated plants gave the lowest increase (18.38 cm). Sorbitol spray at 20 g.L^{-1} interacted with the Soil application of Tryptophan at even 500 or 1000 mg.L^{-1} giving a higher increase in stem length (32 cm for each), compared with 17.25 cm for the untreated control treatment.

Stem diameter increase (mm)

A significant difference in stem diameter increase (Table 1), when Sorbitol was sprayed at 20 g.L^{-1} (2.65 mm), compared to 2.08 mm for untreated plants. Tryptophan application had different effects, whereas spraying at 400 mg.L^{-1} gave the highest increase (2.56 mm), compared with 1.96 mm for untreated plants. The interaction between the two factors gave significant differences, where the treatment of Tryptophan spray at 400 mg.L^{-1} with Sorbitol at 20 g.L^{-1} gave the highest increase in stem diameter (2.967 mm). In contrast, the lowest increase was 1.168 mm for the untreated control treatment.

Number of leaves

Sorbitol spray at 20 g.L^{-1} was significantly superior in the number of leaves per plant, whereas untreated plants had the lowest number of leaves (Table 1). Tryptophan application at 400 mg.L^{-1} was superior by giving the largest number of leaves, whereas untreated plants had the lowest number of leaves. As for the effect of the interaction between Tryptophan spray at 400 mg.L^{-1} interacted with Sorbitol at 20 g.L^{-1} gave the largest number of leaves (133 leaves), whereas untreated control treatment gave the least number (84.50 leaves).

Leaf area (cm^2)

Sorbitol spray at 20 g.L^{-1} differs significantly from the rest treatments where the mean leaf area reached 15.834 cm^2

compared to 13.89 cm^2 for untreated plants (Table1). Tryptophan treatment at 500 $mg.L^{-1}$ gave the best leaf area (15.67 cm^2), whereas the lowest one reached 13.71 cm^2 for untreated plants. The interaction of Tryptophan application at 500 $mg.L^{-1}$ with Sorbitol spray 20 $g.L^{-1}$ gave the largest leaf area (17.00 cm^2), whereas untreated control gave the lowest leaf area (13.29 cm^2).

Leaves chlorophyll content ($mg.g^{-1}$ fresh weight)

No significant differences were noted between Sorbitol treatments in leaves chlorophyll content, in contrast with Tryptophan spray where 400 $mg.L^{-1}$ treatment was significantly superior by recording the highest value of chlorophyll (16.65 $mg.g^{-1}$), whereas the lowest chlorophyll content was obtained in the untreated plants (14.50 $mg.g^{-1}$). The interaction treatments Tryptophan application at 1000 mg l^{-1} interacting with Sorbitol spray at 20 $g.L^{-1}$ was significantly superior by giving the highest chlorophyll content (16.86 $mg.g^{-1}$), spraying with Sorbitol at 20 $g.L^{-1}$ alone gave the lowest value (13.99 $mg.g^{-1}$).

Carbohydrates content (%)

A non-significant difference was noted between Sorbitol spray treatments in the leaves' carbohydrate content (Table 2). Tryptophan application treatment revealed that 1000 $mg.L^{-1}$ treatment gave the highest content (7.968%), whereas untreated plants gave the lowest value (7.105%). The interaction between the studied factors treatments didn't differ significantly from each other.

It may be attributed to the important role of sugar alcohols to transport the major and minor nutrients, especially the slow-moving elements such as calcium and boron through the xylem, they move freely and easily within the plant and as we known Sorbitol and Mannitol one of the forms that facilitate the transfer of Boron element inside the xylem on a complex image dis- (Sorbitol) borate ester (Silke, 2011). The transfer of boron and the major and minor nutrients from the source to the sink may improve physiological and biochemical processes (Mosleh and Rasool, 2019). These elements are important in the process of photosynthesis and respiration as they enter the synthesis of DNA and RNA which they are necessary for cell division in addition to its role in the synthesis of hormones including auxins, which leading to cell division and elongation thus increasing vegetative traits (Ali *et al*., 2014).

This indicates that the plants treated Tryptophan invested their ability to support the plant and provide it with the necessary nutrients to activate metabolic processes, especially the photosynthesis process, which led to the formation of a good vegetative group and thus increased the accumulation of nutrients such as carbohydrates and proteins in the seeds, which led to increased vegetative growth (Mahdi and Mustafa, 2024).

Nitrogen (%)

Results in Table 2 revealed a non statistical differences were noted between Sorbitol spray treatments, the same

Table 1: Effect of Sorbitol and Tryptophan application on vegetative traits of mandarin transplants.

Treatments \ Traits		Length of stem	Diameter of stem	Number of leaves	Leaf area	Chlorophyll
				Sorbitol ($gm.L^{-1}$)		
0		20.88B	2.083B	113.6B	13.89B	15.62A
20		26.78A	2.652A	130.1A	15.84A	15.83A
				Tryptophane ($mg.L^{-1}$)		
0		18.38C	1.962B	107.8B	13.71B	14.50B
200		22.33BC	2.423AB	120.8AB	14.53AB	15.42AB
400		23.79AB	2.560A	129.9A	15.17A	16.65A
500		27.25A	2.447AB	123.0AB	15.67A	16.05AB
1000		27.42A	2.447AB	127.6A	15.24A	16.01AB
				Sorbitol * Tryptophane		
	0	17.25c	1.677c	84.50b	13.29d	15.01ab
	200	19.50bc	2.163bc	109.5a	13.85cd	15.20ab
0	400	22.33bc	2.153bc	126.8a	14.24cd	16.63a
	500	22.50bc	2.297abc	123.3a	14.33cd	16.10ab
	1000	22.83bc	2.127bc	123.6a	13.74cd	15.15ab
	0	19.50bc	2.247abc	131.2a	14.13cd	13.99b
	200	25.17b	2.683ab	132.0a	15.20bc	15.63ab
20	400	25.25b	2.967a	133.0a	16.11ab	16.68a
	500	32.0a	2.597ab	122.7a	17.00a	15.99ab
	1000	32.0a	2.767ab	131.5a	16.73ab	16.86a

Table 2: Effect of Sorbitol and Tryptophane on chemical contents of mandarin leaves.

Treatments \ Traits		Carbohydrate	N	P	K
Sorbitol (gm.L^{-1})					
0		7.510A	1.781A	0.148B	1.126B
20		7.752A	1.887A	0.172A	1.322A
Tryptophane (mg.L^{-1})					
0		7.105B	1.738A	0.147C	1.171B
200		7.532AB	1.812A	0.155BC	1.199AB
400		7.893AB	1.890A	0.164AB	1.203AB
500		7.647AB	1.807A	0.159ABC	1.317A
1000		7.968A	1.923A	0.174A	1.230AB
Sorbitol *Tryptophane					
	0	7.247a	1.650c	0.130d	1.048c
	200	6.953a	1.790abc	0.149cd	1.069c
0	400	8.110a	1.743 bc	0.152cd	1.127bc
	500	7.393a	1.810abc	0.151cd	1.253ab
	1000	7.827a	1.910abc	0.160bc	1.134bc
	0	6.963a	1.827abc	0.164bc	1.293ab
	200	8.110a	1.833abc	0.162bc	1.330a
20	400	7.677a	2.037a	0.177ab	1.280ab
	500	7.900a	1.803abc	0.168abc	1.380a
	1000	8.110a	1.937ab	0.189a	1.327a

results were noted for Tryptophan treatments. As for the effect of the interaction between these two factors, it is noted that there are significant differences between them, where Tryptophan spray at 400 mg.L^{-1} interacted with sorbitol at 20 g.L^{-1} treatment gave the highest nitrogen content in the leaves (2.037%), whereas untreated control treatment gave the lowest value (1.650%).

Phosphorus (%)

Results in Table 2 indicated significant differences resulting from sorbitol spray at 20 g.L^{-1} reached 1.72%, versus 0.148% for untreated plants. Tryptophan application significantly affected leaves P content, where the highest content reached 0.174% for Tryptophan application at 1000 mg.L^{-1}, whereas it decreased for the rest treatments reaching its lowest in the control treatment, (0.147%). The interaction between sorbitol spray at 20 g.L^{-1}, with Tryptophan application at 1000 mg.L^{-1} gave the highest content (0.189%), whereas untreated control plants had the lowest content (1.65%).

Potassium (%)

Sorbitol spray at 20 g.L^{-1} showed that the highest K content (1.322%) compared to 1.126% for untreated plants (Table 2). As for Tryptophan treatments, the results showed that 500 mg.L^{-1} application gave the best leaves content (1.317%), compared to 1.171% for untreated plants. Interaction between Tryptophan application at 500 mg.L^{-1} with Sorbitol spray at 20 g.L^{-1} gave the best K content (1.380%), on the other hand the lowest content reached 1.048% for untreated control treatment.

CONCLUSION

The study concludes that Tryptoph an application at 1000 mg.L^{-1} gave the best increase in stem length and the largest number of leaves per plant, furthermore, this treatment gave the highest carbohydrates, nitrogen and phosphorus content, whereas the largest increase in stem length and leaves chlorophyll content resulted from tryptophan spray at 400 mg. L^{-1}, On the other hand, the highest leaves potassium content in the leaves resulted from tryptophan application at 500 mg.L^{-1} in soil.

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Disclaimers

The views and conclusions expressed in this article are solely those of the authors and do not necessarily represent the views of their affiliated institutions. The authors are responsible for the accuracy and completeness of the information provided, but do not accept any liability for any direct or indirect losses resulting from the use of this content.

Informed consent

The study was conducted exclusively on plant transplants , animal subjects were involved. Therefore, informed consent is not applicable to this research.

Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or

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