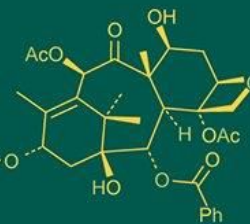
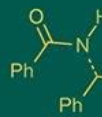
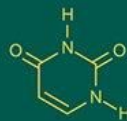
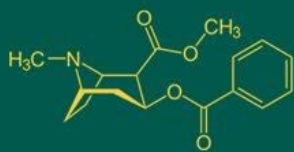


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Effect of rootstock and foliar application of some treatments on certain growth traits of grapefruit scion cv. Dancan

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Abstract

The experiment was conducted in one of the nurseries of Babylon Province during the period from October 10, 2024, to June 1, 2025, to study the effect of two *Citrus* rootstocks and foliar application of some treatments on the vegetative traits of grapefruit scions (cv. Dancan). Grafted seedlings were obtained from the Horticultural Station in Al-Hindiya District. The experiment included two factors with three replications. The first factor (A) was the rootstock type, which included Volkameriana (A1) and Rangpur (A2). The second factor (T) was the foliar treatments, which included: control (T₀), Nano NPK fertilizer at 1 g L⁻¹ (T₁), tryptophan at 200 mg L⁻¹ (T₂), Humic acid at 2 ml L⁻¹ (T₃), and vitamin C at 250 mg L⁻¹ (T₄).

The results showed that foliar application significantly affected some of the studied traits. Vitamin C application gave the highest mean leaf area (2124.86 cm²), while Humic acid resulted in the highest fresh shoot weight (51.035 g) and the highest fresh root weight (52.82 g).

The interaction between rootstock and foliar treatments also had a significant effect on most traits. The treatment combination A2T₃ recorded the highest fresh shoot weight (62.34 g), dry shoot weight (26.49 g), fresh root weight (64.48 g), and dry root weight (25.47 g). On the other hand, treatment A1T₄ gave the highest dry matter percentage in leaves (34.04%).

Keywords: Nano fertilizer, Humic acid, Ascorbic acid

Introduction

Citrus (*Citrus* sp.) belongs to the family Rutaceae, which is characterized by the presence of oil glands in most plant parts, giving them a distinctive aromatic scent. This family includes three genera, the most economically important of which is *Citrus*. Due to the diversity of species within this genus, it has been classified into five groups: mandarins, sweet oranges, hybrids, acidic group, and grapefruit (Ladanyia, 2008) [17].

Grapefruit (*Citrus paradisi*) is considered either a hybrid of pummelo (shaddock) or a result of a genetic mutation. Grapefruit cultivars are generally grouped into those with white pulp and those with colored pulp, and both groups include seeded and seedless varieties. The Dancan cultivar is a seeded white-pulp variety that has proven successful in Iraq under open-field cultivation. It is characterized by early fruiting, good fruit quality, and suitability for canning (Al-Khafaji *et al.*, 1990) [2].

Several rootstocks are used in *Citrus* propagation. Volkameriana rootstock is known for its resistance to quick decline, gummosis, and *Citrus* psorosis, and it is compatible with many *Citrus* species. Trees grafted on it produce high yields, excellent fruits, and show vigorous growth (Hussain, 2000; Nemeth, 2012) [13, 18].

Rangpur is a hybrid between rough lemon and lime, and it has recently gained attention as a promising rootstock due to its desirable traits, which made it widely adopted in *Citrus* propagation. It has been extensively used in many countries, including Asian countries and Brazil, one of the world's largest *Citrus* producers (Allan *et al.*, 2021) [9].

Despite the importance of soil-applied fertilizers and their impact on plant growth and development, their availability is often limited due to processes such as precipitation and adsorption. Therefore, alternative fertilization practices such as foliar feeding are necessary. Foliar application allows nutrients to be absorbed directly through the leaves and aerial parts,

especially under unfavorable soil conditions such as drought or temperature fluctuations (Lovatt, 2013) [16].

The use of nanotechnology in fertilizer formulation has opened new perspectives in agricultural and biotechnological applications. Nano-fertilizers are innovative agricultural inputs that help reduce the environmental risks associated with conventional fertilizers, while enhancing plant growth and yield both quantitatively and qualitatively (Janmohammadi *et al.*, 2016) [14]. Compared to traditional fertilizers, nano-fertilizers are more soluble, rapidly penetrate plant tissues, and are more efficiently metabolized.

The use of nano-fertilizers, either in solution or solid form, has proven superior in enhancing the growth and productivity of various crops. They represent one of the important strategies for supplying plants with essential nutrients while simultaneously reducing the negative environmental impacts of high concentrations of conventional fertilizers, thus contributing effectively to minimizing pollution (Singh *et al.*, 2017) [21].

Al-Awadi (2024) [3] demonstrated that the application of nano NPK fertilizer at concentrations of 1 and 2 g L⁻¹ to orange seedlings grafted on Rangpur rootstock resulted in a significant increase in most vegetative and chemical traits.

Organic fertilization is considered one of the important approaches to supply plants with nutrients without causing harmful effects on the environment, whether applied through soil or foliar application (Nardi *et al.*, 2016) [20]. Numerous researchers have confirmed the role of humic acid in promoting plant growth by enhancing photosynthesis, facilitating nutrient transport within the plant, improving nutrient absorption, and increasing plant dry matter. Furthermore, it plays a vital role in soil structure improvement, serving as a reserve source of nutrients, particularly nitrogen (Al-Zurfi, 2012) [5].

Similarly, Hethal (2014) reported that the application of humic acid at a concentration of 1.5 g L⁻¹ improved most vegetative growth parameters of *Citrus* seedlings grafted onto different rootstocks.

Vitamins are also essential for plant metabolism as enzymatic cofactors, and they possess strong antioxidant activity. These include water-soluble compounds such as vitamins C and B, and fat-soluble compounds such as vitamins A, D, and E (Pogson and DellaPenna, 2006) [11]. Vitamin C, a vital amino sugar with the chemical structure CHO, plays multiple physiological roles in plants, including

its participation in respiration, photosynthesis, stimulation of nucleic acid and protein synthesis, and other metabolic processes (Wheeler *et al.*, 1998; Smirnov, 2000) [22].

Due to the limited number of studies on the application of these compounds and their influence on the growth of Duncan grapefruit scions grafted onto Volkameriana and Rangpur rootstocks, the present study was conducted.

Studied Traits

- 1. Fresh shoot weight (g seedling⁻¹):** The fresh weight of the shoot system (stem, leaves, and branches) was measured using a sensitive balance after carefully removing the seedlings from the soil, washing them thoroughly with running water to remove adhered particles, and separating the root system.
- 2. Dry shoot weight (g seedling⁻¹):** The shoot parts were cut into small pieces and placed in perforated bags for air-drying in an oven at 70 °C until a constant weight was obtained, after which they were weighed using a sensitive balance.
- 3. Fresh root weight (g seedling⁻¹):** Fresh root weight was measured by extracting the plant from the soil, washing it thoroughly with running water, separating the shoot system, and weighing the root system with a sensitive balance.
- 4. Dry root weight (g seedling⁻¹):** This was determined in the same manner as dry shoot weight.
- 5. Leaf dry matter percentage (%):** After oven-drying, the dry matter percentage of leaves was calculated according to the following equation (Al-Sahaf, 1989) [4]:

$$\text{Dry matter\%} = \frac{\text{Dry weight of leaves}}{\text{Fresh weight of leaves}} \times 100$$

Results and Discussion

Fresh shoot weight (g): Table (1) shows a significant effect of foliar application on fresh shoot weight. The treatment with humic acid recorded the highest mean value (51.035 g), while the control treatment gave the lowest mean (37.47 g). The rootstock factor did not show significant differences for this trait. However, the interaction between rootstocks and foliar treatments was significant. The treatment A2T₃ (Rangpur × humic acid) achieved the highest mean fresh shoot weight (62.34 g), whereas A2T₀ (Rangpur × control) recorded the lowest mean (37.42 g).

Table 1: Effect of two *Citrus* rootstocks, foliar application of some treatments, and their interaction on fresh shoot weight (g)

A Average	Transactions T					The Origins N
	Vitamin C T ₄	Humic acid T ₃	Tryptophan T ₂	NPK nano T ₁	Comparison T ₀	
42.28	47.53	39.73	46.28	40.34	37.52	Volcamariana A1
48.46	43.80	62.34	48.41	50.37	37.42	Rangpur A2
	45.66	51.03	47.34	45.35	37.47	T Average
18.97 Interaction				T 13.42	A N.S	L.S.D 0.05

Dry shoot weight (g): Table (2) shows that both Rangpur and Volkameriana rootstocks did not exhibit any significant effect on dry shoot weight. Similarly, foliar application treatments, including water (control), nano NPK, humic acid, vitamin C, and tryptophan, did not result in significant differences in this trait.

However, the interaction between rootstocks and foliar treatments was significant. The treatment A2T₃ (Rangpur × humic acid) recorded the highest mean dry shoot weight (26.49 g), while A1T₀ (Volkameriana × control) gave the lowest mean value (15.43 g).

Table 2: Effect of two *Citrus* rootstocks, foliar application of some treatments, and their interaction on dry shoot weight (g)

A Average	Transactions T					The Origins N
	Vitamin C T ₄	Humic acid T ₃	Tryptophan T ₂	NPK nano T ₁	Comparison T ₀	
19.32	22.09	20.77	19.90	18.45	15.43	Volcamariana A1
22.56	19.43	26.49	23.87	23.41	19.62	Rangpur A2
	20.76	23.63	21.85	20.93	17.52	T Average
Interaction 10.92				T N.S	A N.S	L.S.D

3. Fresh root weight (g)

Table (3) indicates that foliar application treatments had a significant effect on fresh root weight. The treatment with humic acid recorded the highest mean value (52.82 g), whereas the control treatment gave the lowest mean (38.79 g).

In contrast, the rootstock factor did not show any significant effect on this trait.

However, the interaction between rootstocks and foliar treatments was significant. The treatment A2T₃ (Rangpur × humic acid) recorded the highest mean fresh root weight (64.48 g), while the treatment A2T₀ (Rangpur × control) gave the lowest mean (32.13 g).

Table 3: Effect of two *Citrus* rootstocks, foliar application of some treatments, and their interaction on fresh root weight (g).

A Average	Transactions T					The Origins N
	Vitamin C T ₄	Humic acid T ₃	Tryptophan T ₂	NPK nano T ₁	Comparison T ₀	
47.36	53.03	41.17	45.84	51.31	45.46	Volcamariana A1
48.59	43.29	64.48	51.73	51.35	32.13	Rangpur A2
	48.16	52.82	48.78	51.33	38.79	T Average
Interaction 20.33				T 12.03	A N.S	L.S.D

Dry root weight (g)

Table (4) shows that the two rootstocks, Rangpur and Volkameriana, did not have a significant effect on dry root weight. Similarly, foliar treatments with water, nano NPK, humic acid, vitamin C, and tryptophan did not produce significant differences for this trait.

However, the interaction between rootstocks and foliar treatments was significant. The treatment A2T₃ (Rangpur × humic acid) recorded the highest mean dry root weight (25.47 g), while A2T₄ (Rangpur × Vitamin C) gave the lowest mean (12.1 g).

Table 4: Effect of two *Citrus* rootstocks, foliar application of some treatments, and their interaction on dry root weight (g)

A Average	Transactions T					The Origins N
	Vitamin C T ₄	Humic acid T ₃	Tryptophan T ₂	NPK nano T ₁	Comparison T ₀	
15.67	17.55	14.53	15.50	18.31	12.48	Volcamariana A1
17.92	12.18	25.47	19.22	18.70	14.04	Rangpur A2
	14.86	20.00	17.36	18.50	13.26	T Average
Interaction 11.97				T N.S	A N.S	L.S.D

Leaf dry matter percentage (%)

Table (5) shows that the two rootstocks, Rangpur and Volkameriana, did not have a significant effect on leaf dry matter percentage. Similarly, foliar treatments with water, nano NPK, humic acid, vitamin C, and tryptophan did not produce significant differences for this trait.

However, the interaction between rootstocks and foliar treatments was significant. The treatment A1T₄ (Volkameriana × Vitamin C) recorded the highest mean leaf dry matter percentage (34.04%), while A2T₂ (Rangpur × Tryptophan) recorded the lowest mean (29.34%).

Table 5: Effect of two *Citrus* rootstocks, foliar application of some treatments, and their interaction on leaf dry matter percentage (%)

A Average	Transactions T					The Origins N
	Vitamin C T ₄	Humic acid T ₃	Tryptophan T ₂	NPK nano T ₁	Comparison T ₀	
30.78	34.04	29.35	30.48	30.52	29.52	Volcamariana A1
30.27	30.15	30.91	29.34	29.89	31.05	Rangpur A2
	32.10	30.13	29.91	30.20	30.29	T Average
Interaction 4.612				T N.S	A N.S	L.S.D

The results presented in the previous tables indicate slight increases in the vegetative traits of Dancan grapefruit scions grafted onto the Rangpur rootstock compared to the

Volkameriana rootstock; however, these increases were not statistically significant. Regarding the effect of foliar spraying with different treatments, nano-fertilizer showed

superior performance. This significant increase in traits such as fresh weight of the vegetative shoot, dry weight of the vegetative shoot, and leaf potassium percentage can be attributed to the presence of growth hormones, particularly auxins, in organic fertilizers, which enhance cell division, as well as vitamins and amino acids that influence vegetative growth. Moreover, applying organic fertilizers to the soil improves its quantitative properties and increases carbon content, while also enhancing the availability of N, P, and K, thereby promoting their uptake by roots and leading to significant increases in vegetative and root growth indicators (Vajranabhiah & Krishnamoorthy, 1986) ^[15]. These findings are consistent with those reported by Abd El-Naby *et al.* (2017) ^[10] in their study on fig trees.

The observed increase in fresh root weight (Table 3) following foliar application of humic acid is due to its content of essential mineral elements in suitable amounts, which are easily absorbed by the plant. This promotes activation of vital physiological processes and the synthesis of metabolites required for cell division and formation of new cells, leading to enhanced nutrient accumulation and transport to roots, thereby increasing root growth and fresh root weight. These results are in agreement with Huthal (2014) ^[8] and Abdel-Wahab & Al-Mushari (2017) ^[6].

The positive effect is also reflected in the increase in dry root weight (Table 4), which results indirectly from improved root growth due to enhanced vegetative growth, ultimately leading to a larger root system and an increase in the percentage of dry matter in roots. These findings are consistent with those of Baha *et al.* (2018) and Ghani *et al.* (2009).

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