The Future of Horticulture

FSA

Article

Enhancing Productivity and Quality Attributes of Some Orange Cultivars Grown Under North Sinai Condition via Some Nutrients

Haleem. A.Y.

Pomology Unit, Department of Plant Production, Desert Research Center, Cairo, Egypt.

***Corresponding author:** dratef.haleem@gmail.com

https://doi.org/10.37229/fsa.fjh.2026.05.20

CrossMark

Future Science Association

Available online free at
www.futurejournals.org

Print ISSN: 2692-5826

Online ISSN: 2692-5834

Received: 10 March 2026
Accepted: 30 April 2026
Published: 20 May 2026

Publisher's Note: FA stays neutral with regard to jurisdictional claims in published maps and institutional affiliations.

Abstract: The study was carried out on three orange cultivars: Sweet, Olinda, and Valencia, grown at Balouza Research Station, North Sinai Governorate, Egypt, during 2024 and 2025 seasons. The objective was to evaluate the effect of nutrients on productivity and fruit quality of cultivars grown under North Sinai conditions. Seven spray treatments were tested: T1, control (water only); T2, Ca at 1.5 cm/L; T3, Ca at 3 ml/L; T4, K at 1.5 ml/L; T5, K at 3 ml/L; T6, Mo +B at 0.5 ml/L; and T7, Mo +B at 1 ml/L. The experiment was arranged in a split-plot design with three replications, where cultivars were assigned to the main plots and nutrient treatments to the sub-plots. The results revealed that nutrition significantly improved productivity and fruit quality compared with the control. Overall, spraying K at 3 cm/L generally gave the highest values for fruit yield per tree, fruit weight, fruit dimension, juice volume, and juice density. In addition, Mo +B at 1 ml/L and K at 3 ml/L were also the most effective treatments for improving juice percentage, properties, highest maturity index, and reducing juice acidity. Among the cultivars, Olinda exhibited the best performance in terms of yield and external fruit quality, whereas Valencia showed superior internal fruit quality, including properties. Sweet cultivar matured earlier than the other cultivars. Therefore, foliar spraying with K at 3 ml/L, Mo +B at 1 ml/L, or Ca at 1.5 ml/L is recommended for improving productivity, juice characteristics, and chemical quality under North Sinai conditions.

Key words: Foliar spraying, Nutrients, Productivity, Fruit quality, Orange cultivars.

1. Introduction

Citrus (*Citrus spp*.) is among the world's most important fruit crops, grown in more than 140 countries and marketed mainly as fresh fruit, juice, or concentrate. Its sensory quality and perceived health value are strongly associated with a rich phytochemical profile, including vitamins, carotenoids, minerals, flavonoids, phenolic acids, limonoids, volatiles, and sugars**. (Saini *et al*., 2022 and Fabela-Morón, 2024).** In 2023, global orange production exceeded 77 million tons, with Brazil ranking first, followed by China and India, while Egypt was among the leading producers and one of the major exporters of fresh oranges worldwide **(FAO, 2024).**

In Egypt, Citrus trees are considered one of the main fruit crops cultivated. In recent years, the area of citrus cultivation has rapidly increased, reaching approximately 529405 feddans, with a total production of around 5142829 tons. Orange orchards represent nearly t 350290 feddans, producing 3471806 tons. Valencia oranges, specifically, covered around 144419 feddans, with an annual production of 1510545 tons, according to the Egyptian Ministry of Agriculture and Land Reclamation. **(MALR, 2023).**

Balanced plant nutrition is a key factor in improving citrus growth, yield, and fruit quality, as citrus trees require a continuous supply of macro- and micronutrients throughout the season. Since citrus trees remain evergreen and produce flushes of growth several times a year, their nutrient demand is constant, and balanced fertilization is essential for achieving high productivity and superior fruit quality. In addition, foliar fertilization is considered an efficient strategy to enhance nutrient uptake and reduce nutrient losses when soil availability is limited, making it particularly useful for sustaining productivity under challenging growing conditions **(Cao *et al.*, 2022 and Krug *et al.*, 2023).**

Fertilization in fruit trees has become an indispensable tool for intensive crop production, as the soil lacks the capacity to meet the optimal nutritional requirements demanded by such commercial agricultural operations**.** The absence of adequate fertilization leads to nutritional imbalances in plants, resulting in physiological disorders that can impact fruit yield and quality **(Kumar and Kumar, 2016 and Srivastava and Malhotra, 2017)).**

Potassium plays a crucial role in the loading and translocation of assimilates within the phloem, facilitating the movement of nutrients and energy throughout the plant. It also contributes to maintaining phloem turgor pressure, which is essential for the efficient transport of nutrients and signalling compounds**.** In citrus, potassium application has been associated with several beneficial effects, including enhanced sugar accumulation, improved sucrose metabolism and transport, activation of key enzymes, increased photosynthetic efficiency, and better regulation of carbohydrate distribution within the plant **(Wu *et al.*, 2021 and Babst *et al.*, 2022).**

Calcium (Ca) plays a vital role as a macronutrient in the growth and development of plants. it is an essential macronutrient in plants, which is involved in several biochemical and physiological processes needed for growth and development as both a structural component and an intracellular second messenger in a variety of processes. The important role of calcium is to connect pectin polymers in the middle layer, which has the function of maintaining the stability of cell wall structure. **(Hocking *et al.*, 2016**; **Thor 2019 and Morales *et al.*, 2023).**

Boron has a structural role and is critical for the architecture of fruit walls and membranes. Thus, its deficiency weakens cell walls by limiting the formation of dRG-II-B complexes (rhamnogalacturonan II-borate dimers), leading to cracking, deformities, reduced mechanical resistance, and faster deterioration, which decreases post-harvest storage. From a physiological standpoint, B deficiency causes conditions such as corky spots (abnormal suberization), internal rot (activation of enzymes that degrade the cell wall), blossom end rot (involvement in calcium mobility), and segment drying in citrus fruits (dehydrated vesicles) **(Thakur *et al.*, 2023 and Vera-Maldonado *et al.*, 2024).** Additionally, metabolically, the absence of B reduces sugar transport, alters acidity and pH, raises respiration rates, accelerates the degradation of ascorbic acid, and diminishes fruit colour intensity. It also results in decreased fruit mass, size, and overall yield due to its role in pollen germination and pollen tube extension **(Hapuarachchi *et al.*, 2022 and Haleema *et al.*,2024).**

Molybdenum is a crucial micronutrient for plant growth, particularly in nitrogen metabolism. It exists in molybdate form and is essential for over 50 enzymes involved in significant processes such as nitrogen acclimatization, phytohormone synthesis, purine degradation, and sulfite detoxification. Molybdenum plays a unique role in the synthesis of abscisic acid (ABA), influencing stress responses and stomatal control, which are vital for transpiration rates and water relations. Its direct or indirect impact on phytohormones and nitrogen metabolism is critical for effective plant functioning and development. **(Rana *et al.*, 2020 and Zahedi *et al.*, 2024).**

Therefore, the aim of the present study is to investigate the effect of foliar application of some nutrients, calcium, potassium, molybdenum and boron, on the productivity and fruit quality attributes of three orange cultivars, Sweet, Olinda, and Valencia, grown under North Sinai conditions.

2. Martials and Methods

The experiment was carried out during two successive seasons, 2024 and 2025, at Balouza Research Station, North Sinai Governorate, Egypt, on three sweet orange cultivars (*Citrus sinensis* L.), namely Sweet, Olinda, and Valencia, grown under the environmental conditions of the station. The trees were grafted onto Volkamer lemon (*C. volkamerina* L.) rootstock and spaced at 6 × 4 m in silty clay soil. Laboratory analyses were conducted at both Balouza Research Station, North Sinai Governorate, Egypt, and the Faculty of Agriculture, Cairo University, Egypt. Orchard management practices were standardized, with particular emphasis on fertilization and phytosanitary control through the application of the recommended agricultural chemicals. The experiment was arranged in a split-plot design, where the main plots were assigned to orange cultivars, while the sub-plots were devoted to nutrient treatments. Seven treatments were evaluated, each replicated three times, with one tree per replicate. Foliar spraying was applied twice: the first spray was carried out two weeks after fruit set, and the second spray was repeated one month later. Spraying was performed using a 25-L backpack sprayer, and the trees were sprayed until runoff.

The experiment included two factors:

- Main factors (A): cultivars

A1: Sweet A2: Olindat A3: Valencia

- Sub-factors (B): spraying treatments

The seven different treatments were as follows:

T1: Control

T2: Spraying Ca 1.5 ml/L

T3: Spraying Ca 3 ml/L

T4: Spraying K 1.5 ml/L

T5: Spraying K 3 ml/L

T6: Spraying Mo +B 0.5 ml/L

T7: Spraying Mo +B 1 ml/L

To evaluate the effect of these treatments on yield and fruit quality, the following parameters were studied.

1-yield per tree: The yield per tree (kg) was calculated by multiplying the average fruit weight (g) by the total number of fruits on each tree after the fruits were harvested and their weight (g) was noted.

2-Fruit quality parameters: To determine the physical and chemical characteristics, ten mature fruits were randomly selected from each tree at harvest time.

a- Fruit physical characteristics: fruit weight (g), fruit dimensions, juice volume was determined by measuring the extracted juice from each fruit, while juice percentage was calculated as the ratio of juice weight to fruit weight × 100. Juice density was determined by dividing juice volume by juice weight, whereas maturity index was calculated as the ratio between total soluble solids (TSS) and titratable acidity.

b–Fruit chemical characteristics: According to **A.O.A.C. (2000**), the percentages of juice, ascorbic acid (Vitamin C) content (mg/100 ml Juice), and the percentage of Juice acidity (g citric acid /100 g F.Wt.) were determined. Total soluble solids (T.S.S.) was measured using a hand refractometer.

Statistical analysis

The experiment was arranged in a split-plot design with three replicationswith one tree per replicate. All data were recorded and analyzed according to **Gomez and Gomez (1984).** Data were statistically analyzed using SAS software (2006). Mean comparisons were performed using Duncan's multiple range test **(Duncan, 1955)** at a 5% significance level to determine significant differences among treatments.

3. Results

3.1. Yield components and fruit characters

The data presented in figures (1 to 4) show the effect of foliar application of certain nutrients on fruit yield per tree, fruit weight and fruit dimensions of Sweet, Olindat and Valencia orange cultivars during both seasons. In general, the results showed the same trend during two seasons, where the nutrient sprays consistently improved all studied fruit characteristics compared with the control treatment.

Fruit yield per tree, fruit weight, fruit length, and fruit diameter were significantly influenced by the different nutrient treatments and the three cultivars throughout two studied seasons.

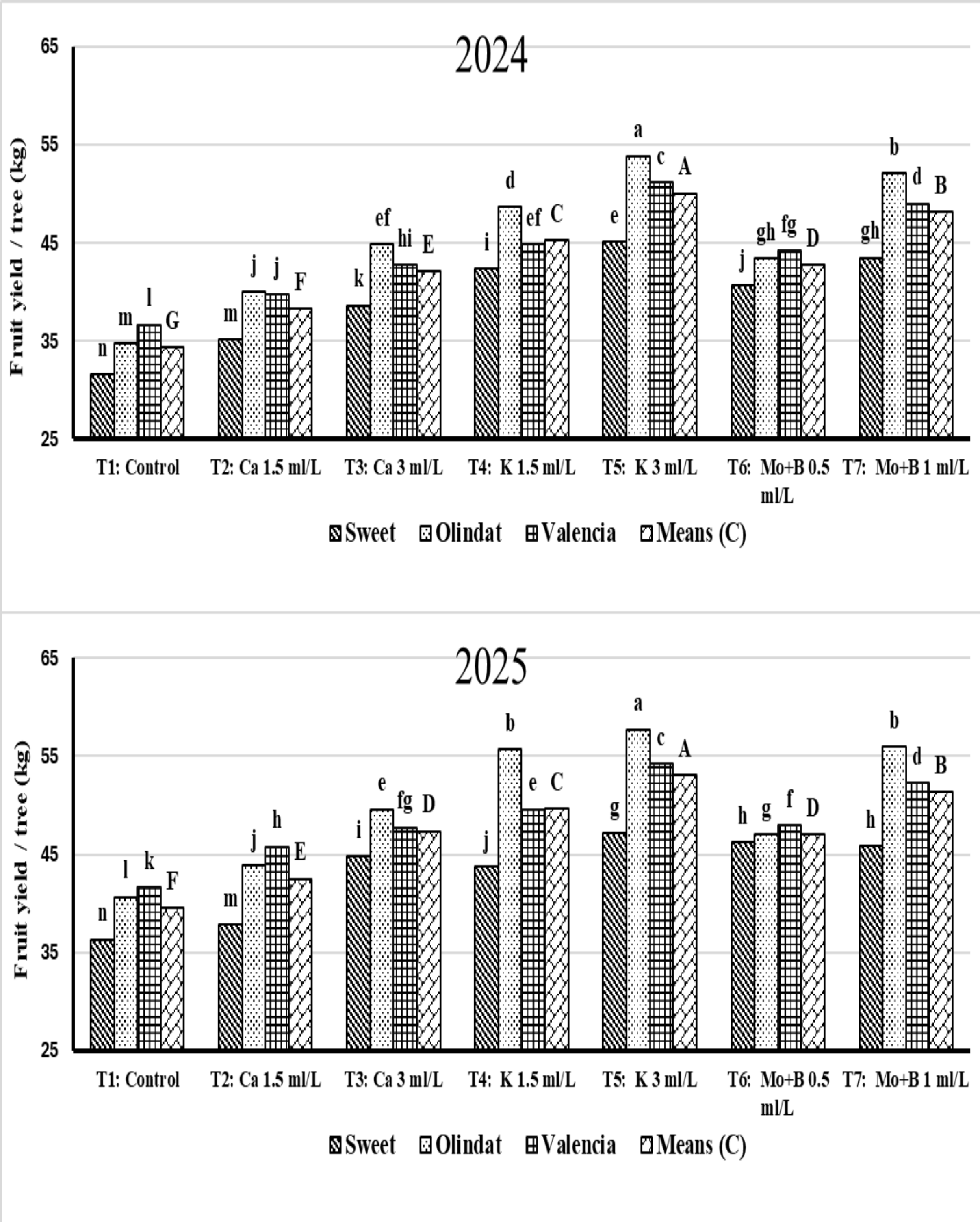
Among the evaluated treatments, spraying trees with K at 3 ml/L (T5) consistently produced the highest values for all measured traits, followed by Mo +B at 1 ml/L (T7) and Ca at 3 ml/L (T3), whereas control recorded the lowest values. Spraying K at 3 ml/L (T5) resulted in the highest Fruit yield per tree which giving (50.03 and 53.04 kg/tree), fruit weight (240.67 and 249.94 g), fruit length (7.33 and 7.67 cm), and fruit diameter (7.58 and 7.65 cm), while control treatment recorded the lowest corresponding values 34.33 and 39.55 kg/tree &165.00 and 174.60 g & 6.60 and 6.58 cm, and 6.75 and 6.95 cm, respectively.

The corresponding increments in fruit yield per tree over the control were 45.73 % and 34.11 %, while fruit weight were 45.86 % and 43.15% during the two seasons, respectively.

The recorded value of fruit yield per tree was (34.33, 38.31, 42.08, 45.28, 50.03, 42.75 and 48.17 & 39.55, 42.50, 47.37, 49.65, 53.04, 47.07 and 51.35 (kg) and fruit weight was (165.00, 194.89, 223.56, 206.11, 240.67, 189.11 and 212.33 & 174.60, 192.84, 230.60, 212.60, 249.94, 187.03 and 218.94 %, as an av. of the two studied seasons, respectively) due to spray water (Control) (T1), spraying Ca 1.5 ml/L (T2), spraying Ca 3 ml/L (T3), spraying K 1.5 ml/L (T4), spraying K 3 ml/L (T5), spraying Mo +B 0.5 ml/L (T6) and spraying Mo +B 1 ml/L (T7), respectively.

Concerning cultivar performance, Olinda generally showed the highest mean values for fruit yield, fruit weight, fruit length, and fruit diameter, followed by Valencia, whereas Sweet recorded the lowest means in most cases. Olinda fruit yield per tree gave (45.37 and 50.07 kg/tree), fruit weight (216.10 and 221.05 g), fruit length (7.28 and 7.39 cm) and fruit diameter values were (7.30 and 7.37 cm) in 2024 and 2025, respectively, followed by Valencia, fruit yield per tree was (44.04 and 48.45 kg/tree), fruit weight (200.10 and 209.62 g), fruit length (7.16 and 7.33 cm) and fruit diameter values were (7.10 and 7.25 cm) while Sweet showed the lowest values, fruit yield per tree was (39.56 and 43.13 kg/tree), fruit weight (197.38 and 197.86 g, fruit length (6.67 and 6.55 cm) and fruit diameter values were (7.15 and 7.21 cm) during the two studied seasons respectively.

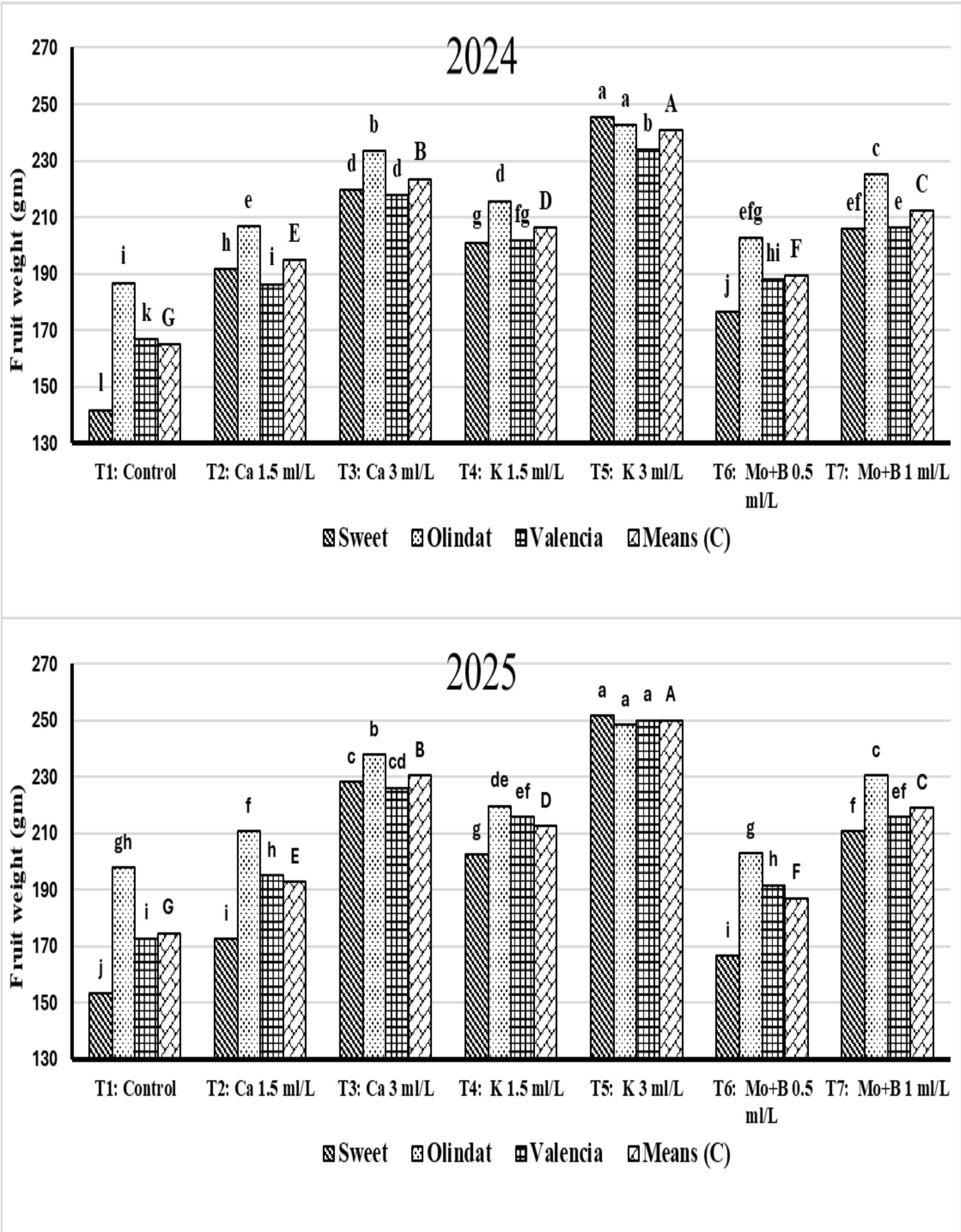
Overall, Olinda was the best cultivar under North Sinai conditions, and spraying K at 3 cm/L was the most effective treatment for improving yield and fruit quality.



Means in the same column followed by the same letter (s) are not significantly ($p \geq 0.05$) different.

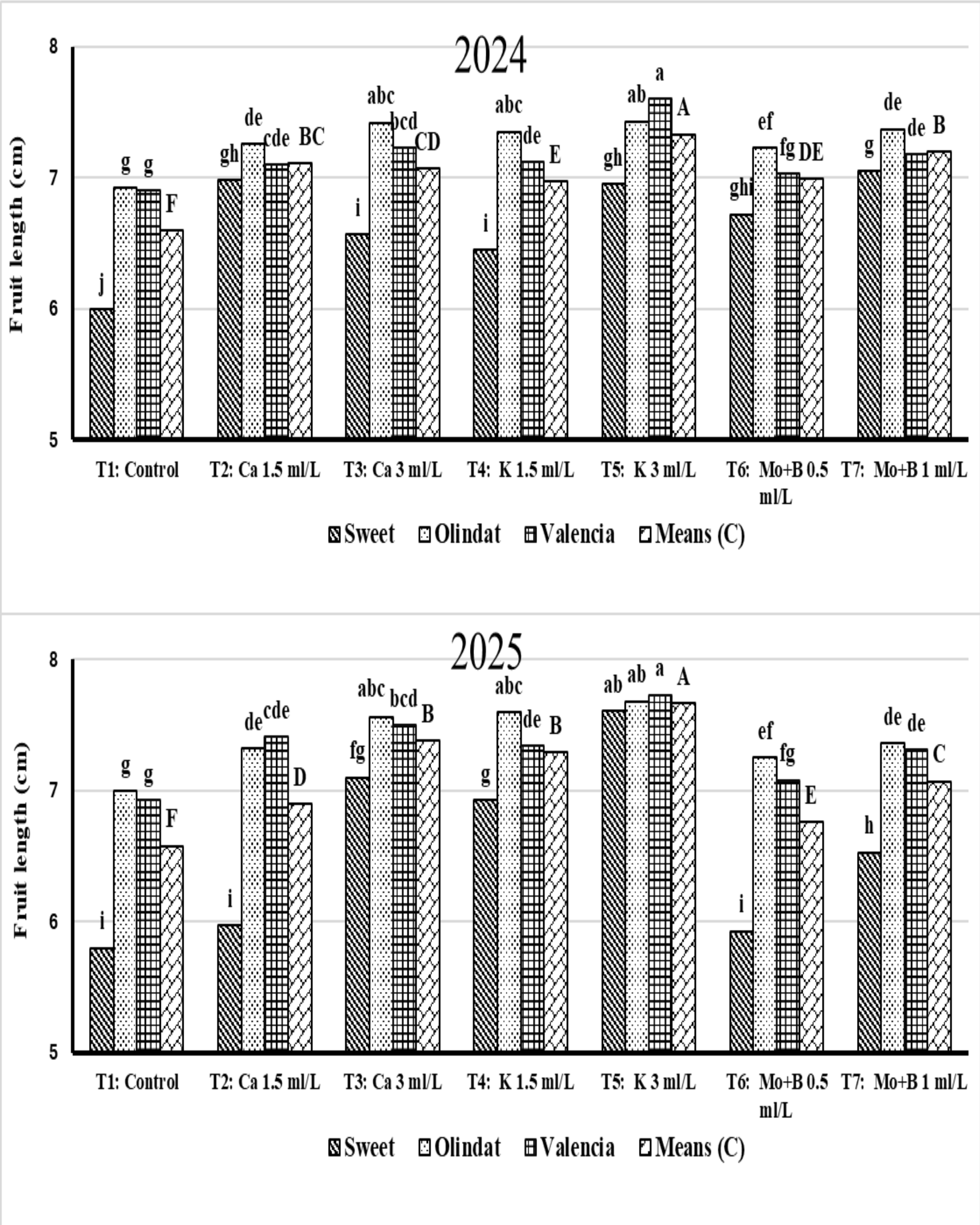
T_1: Control T_2: Spraying Ca 1.5 ml/L T_3: Spraying Ca 3 ml/L T_4: Spraying K 1.5 ml/L
T_5: Spraying K 3 ml/L T_6: Spraying Mo +B 0.5 cm/L T_7: Spraying Mo +B 1 ml/L

Fig (1). Effect of foliar application of certain nutrients on fruit yield per tree of three orange cultivars during the 2024–2025 seasons



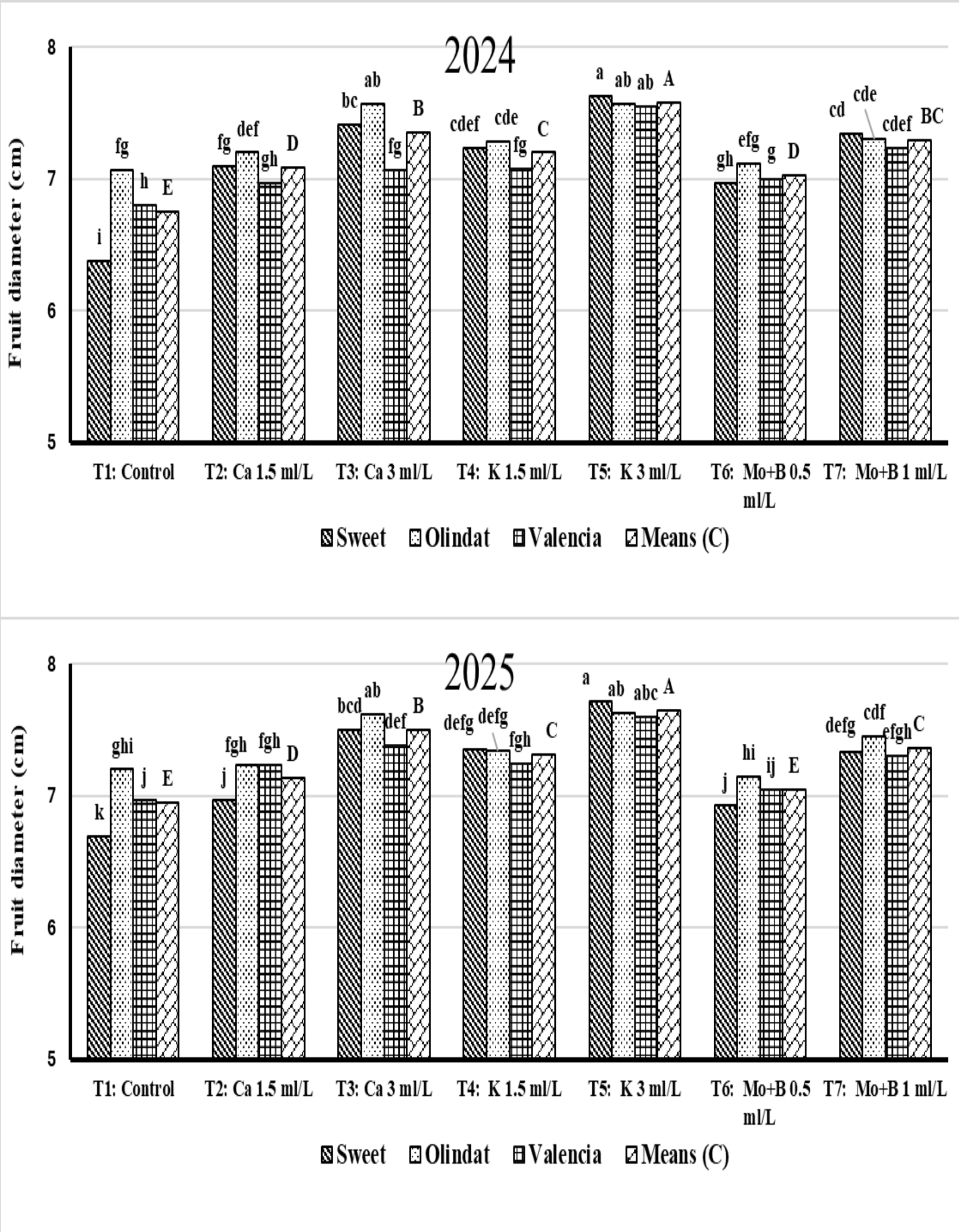
Means in the same column followed by the same letter (s) are not significantly ($p \geq 0.05$) different.

Fig (2). Effect of foliar application of certain nutrients on fruit weight of three orange cultivars during the 2024–2025 seasons



Means in the same column followed by the same letter (s) are not significantly ($p \geq 0.05$) different.

Fig (3). Effect of foliar application of certain nutrients on fruit length of three orange cultivars during the 2024–2025 seasons



Means in the same column followed by the same letter (s) are not significantly ($p \geq 0.05$) different.

Fig (4). Effect of foliar application of certain nutrients on fruit diameter of three orange cultivars during the 2024–2025 seasons

3.2. Fruit juice

The data presented in Tables 1 to 4 indicate that foliar application of the tested nutrients significantly affected juice volume, juice percentage, juice density, and juice acidity of Sweet, Olinda, and Valencia orange cultivars during the two studied seasons. In general, the same trend was observed in both seasons, as nutrient sprays consistently improved the studied juice characteristics compared with the control treatment. The results revealed that juice volume, juice percentage, and juice density were significantly enhanced, while juice acidity was significantly reduced by the different nutrient treatments and the three cultivars during the two studied seasons.

Among the evaluated treatments, spraying K at 3 ml/L (T5) recorded the highest juice volume (103.50 and 112.07), the highest juice density (1.058 and 1.060), and the lowest juice acidity (0.918 and 0.913) in during two study seasons, respectively, whereas spraying Mo +B at 0.5 cm/L (T6) gave the highest juice percentage (48.12 and 49.47), followed by spraying K at 1.5 cm/L (T4) and spraying Mo +B at 1 cm/L (T7). On the other hand, control treatment recorded the lowest juice volume (74.33 and 77.94) and juice density (1.031 and 1.033), while it showed the highest juice acidity (1.061 and 1.039), compared with the nutrient-sprayed trees.

The corresponding increments in juice volume over the control were 39.24 % and 43.79 %, while juice percentage were 4.20 % and 7.59 % during the two seasons, respectively.

The recorded values of juice volume were (74.33, 83.39, 101.94, 92.71, 103.50, 86.44 and 92.22)& (77.94, 84.66, 105.61, 98.42, 112.07, 87.58 and 100.72 as an av. of the two studied seasons, respectively, due to spraying water (Control) (T1), Ca at 1.5 ml/L (T2), Ca at 3 ml/L (T3), K at 1.5 ml/L (T4), K at 3 ml/L (T5), Mo +B at 0.5 ml/L (T6), and Mo +B at 1 ml/L (T7), respectively. Similarly, the recorded values of juice percentage were (46.18, 44.53, 47.90, 47.52, 45.51, 48.12 and 45.76), & (45.98, 45.71, 48.24, 48.97, 47.56, 49.47 and 48.80 as an av. of the two studied seasons, respectively.

Concerning cultivar performance, Olinda generally recorded the highest mean juice volume was (102.13 and 99.41), juice percentage was (49.59 and 50.45 %), whereas Sweet recorded the lowest juice volume values which was (79.94 and 86.86) and juice percentage was (42.27 and 45.73). In addition, Valencia gave the highest juice density (1.060 and 1.062) and juice acidity (1.092 and 1.070) in both seasons, whereas Sweet recorded the lowest values for juice density (1.043 and 1.044) and juice acidity (0.854 and 0.838). Overall, Olinda and Valencia appeared to be the most promising cultivars under North Sinai conditions, while spraying K at 3 cm/L was the most effective treatment for improving juice volume, density, percentage, and acidity.

Table (1). Effect of foliar application of certain nutrients on juice volume of three orange cultivars during the 2024–2025 seasons

Treatments	Juice volume							
	Frist Season (2024)				**Second season (2025)**			
	Sweet	***Olindat***	***Valencia***	**Means (C)**	***Sweet***	***Olindat***	***Valencia***	**Means (C)**
T1	59.67 m	90.50 gh	72.83 l	74.33 E	62.17 m	88.00 ij	83.67 j	77.94 F
T2	74.33 kl	93.00 fg	82.83 i	83.39 D	73.17 l	96.17 efg	84.63 j	84.66 E
T3	97.17 cde	110.33 a	98.33 cd	101.94 A	100.33 df	108.00 bc	108.50 bc	105.61 B
T4	78.67 j	104.47 b	95.00 def	92.71 B	88.50 ij	98.77 ef	108.00 bc	98.42 C
T5	98.83 cd	112.00 a	99.67 c	103.50 A	112.30 b	106.33 c	117.57 a	112.07 A
T6	72.67 l	99.67 c	87.00 h	86.44 C	77.90 k	94.43 fgh	90.40 hi	87.58 D
T7	78.23 jk	104.93 b	93.50 efg	92.22 B	93.67 gh	104.20 cd	104.30 cd	100.72 C
Means (T)	79.94 *C*	102.13 *A*	89.88 *B*		86.86 *B*	99.41 *A*	99.58 *A*	

Means in the same column followed by the same letter (s) are not significantly ($p \geq 0.05$) different.

T_1: Control T_2: Spraying Ca 1.5 ml/L T_3: Spraying Ca 3 ml/L T_4: Spraying K 1.5 ml/L
T_5: Spraying K 3 ml/L T_6: Spraying Mo +B 0.5 cm/L T_7: Spraying Mo +B 1 ml/L

Table (2). Effect of foliar application of certain nutrients on juice percentage of three orange cultivars during the 2024–2025 seasons

Treatments	Juice percentage							
	Frist Season (2024)				Second season (2025)			
	Sweet	*Olindat*	*Valencia*	Means (C)	*Sweet*	*Olindat*	*Valencia*	Means (C)
T1	42.94 ij	49.99 bc	45.60 h	46.18 B	41.31 l	50.61 cd	46.04 gj	45.98 D
T2	39.89 k	46.93 e-h	46.76 fgh	44.53 C	43.73 k	45.64 ij	47.77 ef	45.71 D
T3	46.33 gh	49.59 bcd	47.79 d-g	47.90 A	46.17 f-j	50.80 bc	47.75 efg	48.24 BC
T4	41.06 jk	51.25 ab	50.24 bc	47.52 A	45.97 hij	53.29 a	47.65 e-h	48.97 AB
T5	42.45 ij	48.49 c-f	45.60 h	45.51 BC	47.19 f-i	50.54 cd	44.95 jk	47.56 C
T6	43.21 i	52.29 a	48.84 cde	48.12 A	48.96 de	49.91 cd	49.54 cd	49.47 A
T7	39.99 k	48.59 c-f	48.69 c-f	45.76 B	46.79 f-i	52.34 ab	47.27 e-i	48.80 AB
Means (T)	42.27 *C*	49.59 *A*	47.65 *B*		45.73 **C**	50.45 *A*	47.28 *B*	

Means in the same column followed by the same letter (s) are not significantly (p ≥ 0.05) different.

Table (3). Effect of foliar application of certain nutrients on juice density of three orange cultivars during the 2024–2025 seasons

Treatments	Juice density							
	Frist Season (2024)				Second season (2025)			
	Sweet	*Olindat*	*Valencia*	Means (C)	*Sweet*	*Olindat*	*Valencia*	Means (C)
T1	1.020 h	1.030 g	1.043 ef	1.031 D	0.023 g	1.030 g	1.047 ef	1.033 C
T2	1.030 g	1.040 ef	1.050 def	1.040 C	1.030 g	1.047 ef	1.050 def	1.042 B
T3	1.050 def	1.050 def	1.060 cd	1.053 B	1.050 def	1.053 def	1.060 cd	1.054 A
T4	1.047 ef	1.057 cd	1.067 bc	1.057 AB	1.050 def	1.060 cd	1.067 bc	1.059 A
T5	1.053 de	1.050 def	1.070 ab	1.058 A	1.057 cde	1.050 def	1.073 ab	1.060 A
T6	1.050 def	1.063 bc	1.057 cd	1.057 AB	1.047 ef	1.067 bc	1.060 cd	1.058 A
T7	1.050 def	1.040 e	1.073 a	1.054 AB	1.053 def	1.043 f	1.080 a	1.059 A
Means (T)	1.043 *B*	1.047 *B*	1.060 *A*		1.044 *C*	1.050 *B*	1.062 *A*	

Means in the same column followed by the same letter (s) are not significantly (p ≥ 0.05) different.

Table (4). Effect of foliar application of certain nutrients on juice acidity of three orange cultivars during the 2024–2025 seasons

Treatments	Juice acidity							
	Frist Season (2024)				Second season (2025)			
	Sweet	*Olindat*	*Valencia*	Means (C)	*Sweet*	*Olindat*	*Valencia*	Means (C)
T1	0.923 l	1.067 e	1.193 a	1.061 A	0.903 k	1.057 d	1.157 a	1.039 A
T2	0.893 m	1.023 gh	1.157 b	1.024 B	0.880 l	1.010 f	1.130 b	1.007 B
T3	0.863 n	0.990 i	1.113 c	0.989 C	0.847 m	0.977 g	1.080 c	0.968 C
T4	0.843 o	0.973 j	1.080 d	0.966 D	0.830 n	0.957 h	1.053 d	0.947 D
T5	0.817 p	0.923 l	1.013 h	0.918 F	0.813 o	0.913 j	1.013 f	0.913 F
T6	0.843 o	0.953 k	1.053 f	0.950 E	0.823 n	0.943 i	1.030 e	0.932 E
T7	0.797 q	0.897 m	1.033 g	0.909 G	0.767 p	0.880 l	1.023 e	0.890 G
Means (T)	0.854 *C*	0.975 *B*	1.092 *A*		0.838 *C*	0.962 *B*	1.070 *A*	

Means in the same column followed by the same letter (s) are not significantly (p ≥ 0.05) different.

3.3. Fruit chemical quality

The data presented in Tables 5 to 8 indicate the effect of foliar application of certain nutrients on TSS, total sugars, Vitamin C, and maturity index of Sweet, Olindat and Valencia orange cultivars during 2024 and 2025 seasons. In general, a consistent trend was observed across both seasons, where nutrient sprays substantially improved all studied chemical fruit characteristics compared to the control treatment. The results revealed that TSS, total sugars, and Vitamin C concentrations, as well as the maturity index, were significantly enhanced by the various nutrient treatments across the three cultivars.

Among the evaluated treatments, spraying Mo + B at 1 ml/L (T7) produced the highest TSS (12.60 and 12.91%), the highest total sugars (9.03 and 9.36%), and the highest Vitamin C content (61.73 and 63.52 mg/100 ml) and the highest maturity index (13.97 and 14.66) during the two studied seasons, respectively, followed by spraying K at 3 ml/L (T5). Conversely, control treatment (spraying with water) consistently recorded the lowest values for TSS (11.25 and 11.40%), total sugars (7.76 and 7.93%), Vitamin C (50.31 and 51.38 mg/100ml), and maturity index (10.70 and 11.07) during both seasons. The corresponding increments in TSS over the control were 12.00 % and 13.24 %, while maturity index was 30.56 % and 32.43 % during the two seasons, respectively.

The recorded mean values for TSS were (11.25, 11.56, 11.95, 12.09, 12.60, 12.19, and 12.60 &11.40, 11.79, 12.19, 12.37, 12.84, 12.44, and 12.91) and total sugars were (7.76, 8.04, 8.49, 8.59, 9.03, 8.71, and 9.03 &7.93, 8.29, 8.70, 8.88, 9.37, 9.11, and 9.36) due to treat with spraying water (Control) (T1), Ca at 1.5 ml/L (T2), Ca at 3 ml/L (T3), K at 1.5 ml/L (T4), K at 3 ml/L (T5), Mo +B at 0.5 ml/L (T6), and Mo +B at 1 ml/L (T7), respectively.

Concerning cultivar performance, Valencia generally recorded the highest mean values for TSS (12.59 and 12.82%), total sugars (9.03 and 9.31 %), and vitamin C (62.03 and 63.12 mg/100ml) during both seasons. Olinda followed in the second rank, while sweet orange recorded the lowest values for these chemical parameters. Interestingly, for maturity index, the trend was reversed as sweet orange recorded the highest means (13.60 and 14.12), followed by Olinda (12.33 and 12.79), while Valencia showed the lowest maturity index values (11.57 and 12.04) in both seasons.

Overall, Valencia appeared to be the most superior cultivar in terms of internal fruit quality (TSS, total sugars, and vitamin C), while sweet orange reached maturity earlier. Furthermore, the application of Mo + B at 1 ml/L (T7) or K at 3 ml/L (T5) proved to be the most effective treatments for enhancing the chemical quality profile of the studied orange cultivars under the experimental conditions.

Table (5). Effect of foliar application of certain nutrients on TSS of three orange cultivars during the 2024–2025 seasons

Treatments	TSS							
	Frist Season (2024)				Second season (2025)			
	Sweet	*Olindat*	*Valencia*	Means (C)	*Sweet*	*Olindat*	*Valencia*	Means (C)
T1	11.02 m	11.19 l	11.53 k	11.25 F	11.15 p	11.32 o	11.74 lm	11.40 G
T2	11.24 l	11.52 k	11.91 h	11.56 E	11.37 o	11.73 m	12.26 i	11.79 F
T3	11.52 k	11.91 h	12.42 e	11.95 D	11.66 n	12.14 j	12.77 f	12.19 E
T4	11.64 j	12.02 g	12.62 d	12.09 C	11.79 l	12.40 g	12.92 e	12.37 D
T5	11.91 h	12.43 e	13.44 a	12.60 A	12.19 j	12.78 f	13.55 a	12.84 B
T6	11.70 i	12.09 f	12.79 c	12.19 B	11.98 k	12.25 i	13.10 c	12.44 C
T7	11.99 g	12.61 d	13.20 b	12.60 A	12.32 h	13.03 d	13.39 b	12.91 A
Means (T)	11.58 *C*	11.97 *B*	12.56 *A*		11.780 *C*	12.24 *B*	12.82 *A*	

Means in the same column followed by the same letter (s) are not significantly (p ≥ 0.05) different.

Table (6). Effect of foliar application of certain nutrients on total sugars of three orange cultivars during the 2024–2025 seasons

Treatments	Total Sugars							
	Frist Season (2024)				Second season (2025)			
	Sweet	***Olindat***	***Valencia***	**Means (C)**	***Sweet***	***Olindat***	***Valencia***	**Means (C)**
T1	7.470 o	7.787 m	8.037 l	7.764 F	7.640 q	7.897 p	8.263 o	7.933 F
T2	7.707 n	7.997 l	8.403 i	8.036 E	7.860 p	8.297 o	8.723 kl	8.293 E
T3	7.993 l	8.370 i	8.950 e	8.438 D	8.253 o	8.693 l	9.160 g	8.702 D
T4	8.103 k	8.537 h	9.127 d	8.589 C	8.373 n	8.790 ij	9.490 d	8.884 C
T5	8.397 i	8.880 f	9.800 a	9.026 A	8.760 jk	9.297 f	10.047 a	9.368 A
T6	8.203 j	8.623 g	9.307 c	8.711 B	8.603 m	9.087 h	9.627 c	9.106 B
T7	8.490 h	8.987 e	9.600 b	9.026 A	8.853 i	9.393 e	9.847 b	9.364 A
Means (T)	8.052 *C*	8.454 *B*	9.032 *A*		8.335 *C*	8.779 *B*	9.308 *A*	

Means in the same column followed by the same letter (s) are not significantly ($p \geq 0.05$) different.

Table (7). Effect of foliar application of certain nutrients on vitamin C of three orange cultivars during the 2024–2025 seasons

Treatments	Vitamin C							
	Frist Season (2024)				Second season (2025)			
	Sweet	***Olindat***	***Valencia***	**Means (C)**	***Sweet***	***Olindat***	***Valencia***	**Means (C)**
T1	45.800 q	50.063 o	55.053 k	50.306 G	47.213 u	50.997 s	55.917 n	51.376 G
T2	48.093 p	52.997 l	57.990 h	53.027 F	48.943 t	53.700 p	59.080 i	53.908 F
T3	50.987 n	56.073 j	61.060 f	56.040 E	52.027 r	57.253 l	62.227 f	57.172 E
T4	52.037 m	57.050 i	62.990 d	57.359 D	53.000 q	58.810 j	63.493 e	58.434 D
T5	54.983 k	59.980 g	67.113 a	60.692 B	56.613 m	61.770 g	68.630 a	62.338 B
T6	53.023 l	58.000 h	63.907 c	58.310 C	54.693 o	58.590 k	65.143 c	59.476 C
T7	57.057 i	62.023 e	66.097 b	61.726 A	59.397 h	63.797 d	67.377 b	63.523 A
Means (T)	51.711 *C*	56.598 *B*	62.030 *A*		53.127 *C*	57.847 *B*	63.124 *A*	

Means in the same column followed by the same letter (s) are not significantly ($p \geq 0.05$) different.

Table (8). Effect of foliar application of certain nutrients on maturity index of three orange cultivars during the 2024–2025 seasons

Treatments	Maturity Index							
	Frist Season (2024)				Second season (2025)			
	Sweet	***Olindat***	***Valencia***	**Means (C)**	***Sweet***	***Olindat***	***Valencia***	**Means (C)**
T1	11.94 k	10.50 n	9.66 p	10.70 G	12.35 lm	10.72 p	10.15 q	11.07 G
T2	12.59 h	11.25 m	10.29 o	11.38 F	12.92 j	11.61 o	10.85 p	11.79 F
T3	13.35 ef	12.03 jk	11.16 m	12.18 E	13.77 g	12.43 l	11.83 n	12.68 E
T4	13.81 d	12.35 i	11.68 l	12.61 D	14.20 e	12.96 ij	12.27 m	13.14 D
T5	14.59 b	13.46 e	13.27 f	13.77 B	14.98 b	13.99 f	13.38 h	14.12 B
T6	13.88 d	12.68 gh	12.14 j	12.90 C	14.55 d	12.99 ij	12.72 k	13.42 C
T7	15.06 a	14.07 c	12.77 g	13.97 A	16.07 a	14.81 c	13.09 i	14.66 A
Means (T)	13.60 *A*	12.33 *B*	11.57 *C*		14.12 *A*	12.79 *B*	12.04 *C*	

Means in the same column followed by the same letter (s) are not significantly ($p \geq 0.05$) different.

4. Discussion

Foliar nutrition has become an important tool in citrus production because it allows rapid nutrient uptake, especially when soil conditions limit availability. Recent studies have shown that foliar fertilizers can efficiently enhance nutrient utilization and improve fruit quality, particularly when applied during active flush growth stages, which makes this approach highly valuable in citrus orchards under stress-prone environments**. (Shrestha *et al.,* 2025 and Zekri *et al.,* 2025**).

Potassium is one of the most influential nutrients in citrus fruit development because it supports assimilate translocation, sugar accumulation, and sink strength, all of which directly affect fruit size, weight, and internal quality. Recent citrus studies reported that foliar potassium sulfate application significantly improved fruit weight, soluble solids, and sugar accumulation, while reducing titratable acidity, confirming the positive role of K in enhancing both yield and eating quality. (**Thu *et al.,* 2024**).

Spraying Washington navel orange trees grown under similar environmental conditions and horticulture practices adopted in present experiment with 0.20% potassium silicate x 200 ppm salicylic acid is a beneficial mean in order to improve productivity, fruit quality and nutritional status of such favorite sweet orange cultivar**. (El-Gioushy, 2016)**

Foliar spraying of Valencia orange trees with Chelated calcium, Chelated zinc and boron significantly increased fruit quality in comparison to control and other treatments**. (Baghdady *et al.,* 2014).** Foliar application of calcium chloride, zinc sulphate, and potassium sulphate significantly improved yield and fruit quality of Washington navel orange trees compared with the control. They reported increases in average fruit weight, volume, diameter, length, vitamin C content, and TSS, accompanied by a reduction in juice acidity, with the best results obtained from potassium sulphate at 2 and 3%. **(Aly *et al.,* 2015).**

The increased levels of vitamin C seen in Valencia orange juice fruits due to calcium and boron application may be attributable to increased nucleic acid synthesis from a maximum availability of Valencia orange tree metabolism **(Sajid *et al.,* 2012).** The results of this study highlighted the significant role of CaCl2 treatments on fruit quality properties. Similarly, **Samaan *et al.* (2001)** showed that pre-harvest CaCl2 treatments significantly increased TSS, TSS/acid ratio, and vitamin C content, and decreased juice acidity in both Navel and Succary oranges compared with untreated trees. Similar results were found by **Baghdady *et al.* (2014)** who indicated that spraying Valencia orange trees with 300 ppm chelated calcium and boric acid significantly increased fruit quality compared to control trees.

Spraying Valencia orange trees with 10 g/L of seaweed at flower bud differentiation and after 21 days the first treatment followed by CaCl2 at 1g/L + H3BO3 at 0.5 g/L at full bloom (80% flowering) and after 21 days the first treatment is recommended to increase the final yield, and enhanced the physico-chemical properties of the fruit. (**Alebidi and Abdel-Sattar, 2024**).

Foliar application of Navel orange trees at 70 % flowering with 6 % ammonium molybdate and 4 % boric acid led to obtaining the best quantitative and qualitative production compared to other treatments and control. **(Abobatta *et al.,* 2024).** Foliar Mo application, combined with the appropriate nitrogen source, enhances fruit quality and juice yield in “Pêra” oranges, optimizing commercial orchard production**. (Silva *et al.,* 2025).**

5. Conclusion

Therefore, based on the study’s findings, foliar spraying of Olinda and Valencia orange trees with potassium at 3 ml/L, Mo + B at 1 ml/L, or calcium at 1.5 ml/L can be recommended to improve productivity, juice characteristics, and fruit chemical quality under North Sinai conditions. In addition, Sweet cultivar can be considered for earlier maturity.

References

Abobatta, W. F., El-Enin, M. M. S. A., El, H. M. A. E. M., and Saif, M. I. (2024). Effect of foliar application of boric acid and ammonium molybdate on the productivity and fruit quality of Navel orange. Scientia Horticulturae, 334, 113290.

Alebidi, A. and Abdel-Sattar, M. (2024). Synergistic effect of seaweed extract and boric acid and/or calcium chloride on productivity and physico-chemical properties of Valencia orange. Peer. J., 12, e17378.

Aly, M. A., Harhash, M. M., Awad, R. M. and El-Kelawy, H. R. (2015). Effect of foliar application with calcium, potassium and zinc treatments on yield and fruit quality of Washington navel orange trees. Middle East Journal of Agriculture Research, 4(3), 564–568.

A.O.A.C. (2000). Official methods of analysis (17th ed., pp. 490–520). Washington, DC, USA.

Babst, B. A., Braun, D. M., Karve, A. A., Frank Baker, R., Tran, T. M., Kenny, D. J. and Jensen, K. H. (2022). Sugar loading is not required for phloem sap flow in maize plants. Nature Plants, 8(2), 171–180.

Baghdady, G. A., Abdelrazik, A. M., Abdrabboh, G. A. and Abo-Elghit, A. A. (2014). Effect of foliar application of GA3 and some nutrients on yield and fruit quality of Valencia orange trees. Nature and Science, 12, 93–100.

Cao, S., Yang, S., Zhou, X. and Gong, B. (2022). Nutrient diagnosis and modeling of fruit quality and leaf mineral contents of sweet orange *[Citrus sinensis (L.) Osbeck]*. SSRN 4062732.

Duncan, D. B. (1955). Multiple range and multiple F tests. Biometrics, 11, 1–42.

El-Gioushy, S. F. (2016). Productivity, fruit quality and nutritional status of Washington navel orange trees as influenced by foliar application with salicylic acid and potassium silicate combinations. Journal of Horticultural Science and Ornamental Plants, 8(2), 98–107.

Fabela-Morón, M. F. (2024). Bioactive compounds, sensory attributes, and flavor perceptions involved in taste-active molecules in fruits and vegetables. Frontiers in Nutrition, 11, 1427857.

FAO. (2024). FAOSTAT Statistical Database. Food and Agriculture Organization of the United Nations. Available at: https://www.fao.org/faostat.

Gomez, K. A. and Gomez, A. A. (1984). Statistical procedures for agricultural research. John Wiley and Sons.

Haleema, B., Shah, S. T., Basit, A., Hikal, W. M., Arif, M., Khan, W., Said-Al Ahl, H.A.H. and Fhatuwani, M. (2024). Comparative effects of calcium, boron, and zinc inhibiting physiological disorders, improving yield and quality of *Solanum lycopersicum*. Biology, 13(10), 766 :1-33.

Hapuarachchi, N. S., Kämper, W., Wallace, H. M., Hosseini Bai, S., Ogbourne, S. M., Nichols, J. and Trueman, S. J. (2022). Boron effects on fruit set, yield, quality and paternity of Hass avocado. Agronomy, 12(6), 1479.

Hocking, B., Tyerman, S. D., Burton, R. A. and Gilliham, M. (2016). Fruit calcium: transport and physiology. Frontiers in Plant Science, 7, 569.

Krug, A. V., Papalia, D. G., de Lima Marques, A. L., Hindersmann, J., Soares, V. M., Grando, D. L., Moura-Bueno J M, Trapp T, Rozane D E, Natale W. and Brunetto, G. (2023). Proposition of critical levels of nutrients in citrus leaves, grown in a subtropical climate, for fresh market fruit production. Scientia Horticulturae, 317, 112047.

Kumar, R., and Kumar, V. (2016). Physiological disorders in perennial woody tropical and subtropical fruit crops: A review. The Indian Journal of Agricultural Sciences, 86(6), 703–717.

M.A.L.R. (2023). Bulletin of agricultural statistics, Part (2): Summer and Nili crops. Ministry of Agriculture and Land Reclamation. Egypt.

Morales, J., Martínez-Alcántara, B., Bermejo, A., Millos, J., Legaz, F. and Quiñones, A. (2023). Effect of calcium fertilization on calcium uptake and its partitioning in citrus trees. Agronomy, 13(12), 2971.

Rana, M. S., Bhantana, P., Imran, M., Saleem, M. H., Moussa, M. G., Khan, Z., Khan, I., Alam, M., Abbas, M., Binyamin, R., Afzal, J., Syaifudin, M., Din, I. U., Younas, M., Ahmad, I., Shah, M. A. and Hu, C. (2020). Molybdenum potential vital role in plants metabolism for optimizing the growth and development. Annals of Environmental Science and Toxicology, 4(1), 32–44.

Saini, R. K., Ranjit, A., Sharma, K., Prasad, P., Shang, X., Gowda, K. G. M. and Keum, Y. S. (2022). Bioactive compounds of citrus fruits: A review of composition and health benefits of carotenoids, flavonoids, limonoids, and terpenes. Antioxidants, 11(2), 239.

Sajid, M., Rab, A., Tanveer, S., Iqbal, A., Zamin, M. and Shakur, M. (2012). Pre-harvest treatment of Zn and B affects the fruit quality and storability of sweet orange. Journal of Agriculture Science and Technology, 2, 1224–1233.

Samaan, L. G., El-Boray, M. S. S., Guirguis, F. G. and Helal, M. E. (2001). Calcium pre-harvest applied to control fruit-set, fruiting, pre-harvest dropping and fruit physico-chemical characteristics in citrus trees. Journal of Agricultural Sciences Mansoura University, 26, 1595–1605.

Shrestha, S., Waldo, L., and Schumann, A. (2025). Foliar spray of macronutrient influences fruit quality of Sugar Belle® mandarin grown in Florida sandy soil. Agronomy, 15(6), 1483.

Silva, G. A. D., Vasconcelos, A. D. A., Dias, L. L. C., Silva, F. C., Souza, W. G., Lima, N. L. D. S., Silva, M. A. D. Chiachia, T. R. de S.; Nascimento, V. L. and Rufini, J. C. M. (2025). Foliar application of molybdenum and soil nitrogen sources in the physiology, nutrition, and fruit quality of "Pêra" sweet oranges. Journal of Plant Nutrition, 48(17), 2960–2975.

Srivastava, A. K. and Malhotra, S. K. (2017). Nutrient use efficiency in perennial fruit crops – A review. Journal of Plant Nutrition, 40(13), 1928–1953.

Thakur, S., Sinha, A. and Ghosh Bag, A. (2023). Boron-a critical element for fruit nutrition. Communications in Soil Science and Plant Analysis, 54(21), 2899–2914.

Thor, K. (2019). Calcium—nutrient and messenger. Frontiers in Plant Science, 10, 440.

Thu, A. M., Alam, S. M., Khan, M. A., Han, H., Liu, D. H., Tahir, R., Ateeq, M. and Liu, Y. Z. (2024). Foliar spraying of potassium sulfate during fruit development comprehensively improves the quality of citrus fruits. Scientia Horticulturae, 338, 113696.

Vera-Maldonado, P., Aquea, F., Reyes-Díaz, M., Cárcamo-Fincheira, P., Soto-Cerda, B., Nunes-Nesi, A. and Inostroza-Blancheteau, C. (2024). Role of boron and its interaction with other elements in plants. Frontiers in Plant Science, 15, 1332459.

Wu, S., Zhang, C., Li, M., Tan, Q., Sun, X., Pan, Z., Deng, X. and Hu, C. (2021). Effects of potassium on fruit soluble sugar and citrate accumulations in Cara Cara navel orange (*Citrus sinensis* L. Osbeck). Scientia Horticulturae, 283, 110057.

Zahedi, S. M., Marjani, M., Ahmadvandi, H. R., Alemian, M., Ikram, M., Gholami, R. and Carillo, P. (2024). Molybdenum amelioration of drought stress in agricultural crops: A detailed overview of mechanistic actions and future perspectives. South African Journal of Botany, 174, 1017-1029.

Zekri, M., Schumann, A. W., Vashisth, T., Kadyampakeni, D. M., Morgan, K. T., Boman, B., Shahid M.A. and Obreza, T. A. (2025). 2025–2026 Florida Citrus Production Guide: Fertilizer application methods*:* CPG ch. 16, CG092/CMG14, rev. 8/2025. EDIS.

تحسين الانتاجيه و خصائص الجوده لبعض أصناف البرتقال المنزرعه تحت ظروف شمال سيناء باستخدام بعض المغذيات

عاطف يعقوب حليم

قسم الإنتاج النباتي ، مركز بحوث الصحراء، القاهرة ، مصر

أُجريت هذه الدراسة خلال موسمي 2024 و2025 على ثلاثة أصناف من البرتقال هي Sweet و Olinda وValencia، المنزرعة بمحطة بحوث بالوظة بمحافظة شمال سيناء – مصر، بهدف دراسة تأثير الرش الورقي ببعض العناصر الغذائية على إنتاجية الأشجار وخصائص الثمار تحت الظروف البيئية للمحطة. اشتملت الدراسة على سبع معاملات هي: الرش بالماء كمعاملة مقارنة، والرش بالكالسيوم بتركيزين 1.5 و3 سم/لتر، والبوتاسيوم بتركيزين 1.5 و3 سم/لتر، والموليبدنيم + البورون بتركيزين 0.5 و1 سم/لتر. وقد صممت التجربة بنظام القطاعات المنشقة مرة واحدة**.**

ويمكن تلخيص النتائج كالتالي:

- أدى الرش الورقي بالبوتاسيوم بتركيز 3 سم/لتر على صنف أوليندا إلى تحقيق أعلى إنتاجية للأشجار وتحسين صفات الثمار تحت ظروف شمال سيناء مقارنة بباقي معاملات الرش الورقي والأصناف الأخرى.

- سبب الرش الورقي بالبوتاسيوم بتركيز 3 سم/لتر على صنفي أوليندا وفالنشيا إلى زيادة معنوية في صفات العصير، حيث زاد حجم العصير ونسبته وكثافته مع خفض نسبة الحموضة مقارنة بمعاملة الكنترول .

- أدى الرش الورقي بالموليبدنيم + البورون بتركيز 1 سم/لتر أو البوتاسيوم بتركيز 3 سم/لتر على صنف فالنشيا إلى زيادة معنوية في الصفات الكيميائية للثمار مثل المواد الصلبة الذائبة الكلية والسكريات وفيتامين C.

- أظهرت النتائج أن صنف Sweet يتميز بصفة التبكير في النضج مقارنة بباقي الأصناف تحت ظروف الدراسة.

ومن نتائج هذه الدراسة يمكن التوصية برش أشجار البرتقال صنفي أوليندا وفالنشيا بالبوتاسيوم بتركيز 3 سم/لتر أو الموليبدنيم + البورون بتركيز 1 سم/لتر أو الكالسيوم بتركيز 1.5 سم / لتر، وذلك لتحسين الإنتاجية وصفات العصير والصفات الكيميائية للثمار تحت ظروف شمال سيناء، مع إمكانية الاعتماد على صنف سويت للتبكير في النضج.

الكلمات الدالة :الرش الورقي – العناصر الغذائية – جودة الثمار – المحصول – البرتقال