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Impact of Zn, Yeast and Naa Foliar Spray on Fruiting Aspects and Fruit Attributes of Washington Navel Orange Trees.

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Abstract

This study was conducted in 2022 and 2023 on 7-year-old Washington navel orange trees budded on Sour orange rootstock and grown in clay loamy soil in Qaliobiya Governorate. The study aimed to improve fruiting aspects and fruit attributes through foliar feeding with Zn in two forms (sulfate at 6.0 g/L and Zn-NPs at 6.0 ml/L), yeast at 2.0 % and NAA at 100 ppm. The trees were foliar sprayed 6 times starting from mid-Feb., after fruit set (mid-April) and every month till August. The results reflected that all treatments significantly enhanced the studied parameters than the control. Furthermore, fruit aspect values including (fruit set %, fruit retention %, the number of fruits/tree, fruit weight and yield) were maximized when the trees were sprayed with Zn-NPs at 6.0 m/L + Yeast at 2.0 %. Unlike, such treatment minimized fruit drop %. Regarding fruit attributes, it was clear that Zn-NPs at 6.0 m/L + Yeast at 2.0 % treatment caused a high increment in fruit length, diameter, fruit shape index, fruit volume, fruit juice volume, fruit juice %, TSS, TSS/acid ratio and vitamin C. Unlike, such treatment reduced fruit juice acidity % to the lowest value.

Keywords: Foliar application; **Fruiting aspects , Fruit attributes** , Washington navel orange; Zinc sulfate, Nano-Nps , yeast and NAA

Introduction

Citrus fruits represent one of the most economically and nutritionally important horticultural crops worldwide. These fruits are valued not only for their refreshing taste and high vitamin C content but also for their significant contribution to international trade and national economies, especially in tropical and subtropical regions. In Egypt, citrus is the most important fruit crop in terms of both cultivated area and production(In Egypt, [529405 faddans) (more than 39% of total fruit area) are planted with citrus trees. The production of citrus in Egypt increased to 5142829 tonnes in 2023 **Ministry of Agriculture and Reclamation, Egypt (2023).** Thus, Egypt is considered to be one of the ten largest producers of citrus in the world. Therefore, strenuous efforts have always been exerted to increase the production of citrus through a better understanding of its reaction to the environment and mineral nutrition.

Zinc functions as a cofactor for over 300 enzymes and is essential for processes such as carbohydrate metabolism, hormone regulation (especially indole-3-acetic acid - IAA), and protection against oxidative stress. Inadequate zinc availability can lead to stunted growth, reduced leaf expansion, chlorosis, and poor fruit set **(Broadley et al., 2007; Alloway, 2008)**. In citrus, zinc deficiency is typically manifested as mottled leaves, rosetting, and small, hard fruits with low juice content.

Zinc (Zn) is an essential micronutrient for plants, playing vital roles in enzyme activation, auxin metabolism, photosynthesis, and cell membrane integrity. Zinc deficiency is particularly problematic in fruit orchards located in alkaline or calcareous soils, where zinc becomes less bioavailable. Conventional zinc fertilizers often suffer from poor solubility and mobility in soil. In contrast, zinc nanoparticles (ZnNPs) have demonstrated significantly higher bioavailability and mobility, leading to better absorption by plant tissues and improved physiological performance **(Dimkpa et al., 2012; Raliya et al., 2016).**

Numerous studies have reported the positive effects of foliar-applied ZnNPs on various fruit tree species, including citrus, mango, apple, and grapevine. ZnNPs have been shown to: Improve leaf chlorophyll content, photosynthetic rate, and nutrient translocation. Enhance fruit size, weight, and sugar-acid balance. Boost antioxidant enzyme activity, contributing to stress tolerance. Reduce premature fruit drop and increase yield **(El-Tohamy et al., 2021; Alsaeedi et al., 2019)** Because foliar application delivers nutrients directly to the leaves, nano-zinc fertilizers provide a rapid and efficient method for correcting zinc deficiencies in fruit trees. Additionally, their low application rates reduce the

risk of environmental contamination compared to traditional fertilizers.

Yeasts, particularly *Saccharomyces cerevisiae*, are rich in proteins, amino acids, vitamins (especially B-complex), enzymes, and phytohormones such as auxins, gibberellins, and cytokinins **(El-Tanany et al., 2011; El-Khawaga, 2013)**. They also contain nucleotides, carbohydrates, and various trace elements that enhance their bioactivity when applied to plants. Yeasts are known for their rapid multiplication, high metabolic activity, and ability to colonize plant surfaces or root zones, making them effective in promoting plant growth.

Naphthalene Acetic Acid (NAA) is a synthetic auxin, structurally analogous to the naturally occurring indole-3-acetic acid (IAA), and functions primarily by mimicking the action of endogenous auxins in plant systems. Naphthalene Acetic Acid (NAA) has received considerable attention due to its diverse roles in modulating plant growth and development. NAA is known for its efficacy in reducing pre-harvest fruit drop, enhancing fruit set, stimulating rooting, and regulating vegetative growth. Its application has been extensively studied in various fruit crops, with citrus being one of the most responsive genera **(Davies, 2010; Youssef & Roberto, 2020**).

The main goal of that study is to throw light on some foliar feeding amendments (Zinc, yeast and NAA), hopping enhancement Fruit aspects and fruit attributes of Washington navel orange trees grown in Qaliobia Governorate.

Materials and Methods

Location and plant materials:

The present study was accomplished during two successive seasons (2022 and 2023) on 7-year-old Washington navel orange trees budded on sour orange and grown in a private orchard at Gezera Belee, Benha, Qalubiya Governorate, Egypt.

21 healthy fruitful trees were carefully selected to carry out the investigation.

The chosen trees were nearly as uniform as possible as we could in their size, and shape, grown in clay loamy soil, planted at 5 m apart, irrigated through a flood surface irrigation system and the trees were subjected to the annual regular horticulture management which was adopted in the area according to the Ministry of Agriculture recommendations.

Zinc in two forms (Zn-sulphate and Zn-Nano) and NAA besides bio-activator micro-organisms (yeast), were selected to build up the skeleton of such study.

The 7 Treatments involved in this study were as follows.

T**T1-Control (tap water spray).**
T2 ZnSO4 (6.0 g/L)
T3- Zno-NPs(6.0cm /L
T4- ZnSO4 (6.0g/L) + yeast (0.2%).
T5- Zno-NPs (6.0cm /L)+ yeast (0.2%).
T6- ZnSO4(6.0g/L)+NAA(100 ppm).
T7-Zno-NPs(6.0cm/L)+NAA(100 ppm).

Experiments layout

The treatments were arranged in a complete randomized block design. Each treatment was replicated three times and each replicate was represented by one tree.

Application time

Taking into consideration that spray treatments were applied covering the whole foliage of each tree canopy, 5 liters were found to be sufficient in this concern. The trees were sprayed four times starting from the first week of February, after the fruit set (mid-April), and at one-month intervals till August.

The methodology has been reported in this study to evaluate the response of growth nutritional status and fruiting of to the various investigated treatments being carried out determined changes in different measurements of the following examined characteristics :

1. Fruiting aspects and productivity:

At full bloom during each experimental season the number of perfect flowers per each tagged limb were counted. After 75% of petal fall fruit set as a percentage of perfect flowers was estimated According to the following equation used by **Fouad et al., (1992).**

$$\text{Fruit set })\%\ (= \frac{\text{Total number of set fruitless}}{\text{Total No.of flowers at full bloom}} \times 100$$

Fruit retention percentage and fruit drop (%) were estimated according to the following equation:

$$\text{Fruit retention })\%\ (= \frac{\text{No.of presented (remained) fruits at a given date}}{\text{No. of set fruitlets}} \times 100$$

$$\text{Fruit drop })\%\ (= \frac{\text{No.of set fruitlets} - \text{presently retained fruitlets}}{\text{Total No. of set fruitlets}} \times 100$$

B- Productivity (Yield):

The fruits of each tree were separately harvested, then counted and weighed. Tree productivity (yield) was estimated either as a number or weight (kg) of harvested fruits per tree. Besides, yield per each tree (Kg) as well as yield per feddan (ton).

2-.Fruit quality traits:

Samples of five fruits were randomly collected at harvesting time from each tree (replicate) and the following characteristics of both physical and chemical properties were determined as follows:

A- Fruit physical properties:

The average values of average fruit weight (g), fruit polar, fruit equatorial (mm), fruit shape index, peel thickness (mm), juice volume (g) and juice (%) were the investigated physical properties of Washington navel orange during both seasons of study.

B-Fruit chemical characteristics:

The following fruit juice chemical properties were determined according to **(A.O.A.C, 2005).**

- **Total soluble solids percentage (TSS %)** was determined by using a Zeiss hand refractometer.
- T**otal titratable acidity** percentage was determined in fruit juice as a percentage of anhydrous citric acid by titration with 0.1 N Sodium hydroxide using phenolphthalein as an indicator.
- **Total soluble solids/total acidity (TSS/acid ratio)** was calculated by dividing the total soluble solids percentage by the total acidity percentage.
- **Fruit juice ascorbic acid (Vitamin C)** content as mg/100 ml juice was determined using 2,6 dichlorophenol indol phenol dye as an indicator.
- **Total sugars (%) i**n fruit juice were determined after the method described by **Smith *et al.*, (1956).**

• Statistical analysis:

All the obtained data in the two seasons of the study were statistically analyzed using the analysis of variance method according to **Snedecor and Cochran (1990).** Meanwhile, differences among means were distinguished by Duncan`s multiple range tested at the probability of 5 % level **(Duncan, 1955).**

Results

3.1fruit aspects

3.1.1Fruit set percentage (%).

Concerning fruit set % of Washington Navel orange tree as affected by spraying with the two forms of Zn and the combination between each form and either yeast extract or NAA

, **data in Table (1)**indicates that all investigated treatments were able to improve fruit set % than the water sprayed trees (control) during both seasons of study. Furthermore, the trees that were sprayed with Zn-Nano + yeast (T5) were the best treatment, as it achieved the highest. Values(24.55 and 27.23%) of the tested parameter during the 1st and the 2nd season, respectively. Meanwhile, when yeast extract was added to\$ZnSo_4$ +yeast(T4) or Zn-Nano + NAA (T7) x improved fruit set % but a little bit less than (T5). It was clear that the addition of either $ZnSo_4$ alone(T2) or Zn-Nano alone(T3) failed to increase the fruit set % to an acceptable value. On the other way around, the reverse was true with control trees which exhibited the lowest values (12.22 and 14.28%) of fruit set % during the 1st and the 2nd seasons, respectively.

3.1.2 Fruit retention percentage (%).

Data presented **in Table (1)** indicate that fruit retention % was enhanced with all studied treatments but at varying levels. It was noticed that maximum fruit retention % (17.65 and 19.86%) were associated with Zn-Nano + yeast (T5) during the 1st and the 2nd season, respectively, followed by $ZnSo_4$ + yeast (T4) as it achieved (16.09% and 18.36%) during the 1st and the 2nd season, respectively.

Spraying NAA with both Zn forms (T6, T7) ranked thirdly in such respect. In contrast, the minimum values (10.19% and 8.0%) of fruit retention % were noted with control trees during both seasons of study.

3.1.3Fruit drop percentage (%)

Fruit drop % data of Washington navel orange trees as affected by the different investigated treatments are tabulated in Table (1). It is clear from the data that such a parameter has taken an opposite direction to the earlier mentioned parameter (fruit retention %). The highest fruit drop % was recorded with control trees (89.81% and 92.00%) in the first and the second seasons as well as $ZnSO_4$ (T2) (89.15% and 88.56%) during both seasons of study, followed by in descending order by Zn-Nano (T3) (86.40% and 84.75%), $ZnSO_4$ + NAA (T6) (85.45% and 84.00%), Zn-Nano + NAA (T7) (84.37% and 84.32%), and $ZnSO_4$ + yeast (T4) (83.91% and 81.64%) during the 1st and the 2nd season values, respectively. The lowest fruit drop % was noticed with the trees which were sprayed with Zn-Nano + yeast (T5) (82.35% and 80.14%) during the 1st and the 2nd season, respectively.

Table 1. Fruit set (%), fruit retention (%), and fruit drop (%) of Washington navel orange trees as impacted by foliar spray with zinc (sulfate and nano), yeast, and NAA treatment T during the 2022 and 2023 experimental seasons.

Parameters / Treatments	Fruit set (%)		Fruit retention (%)		Fruit drop(%)	
	2022	2023	2022	2023	2022	2023
T_1-Control (tap waters pray).	12.22 E	14.28 E	10.19 F	8.0 F	84.81 A	92.0 A
T2 ZnSO4 (6 g/L)	15.28 D	18.02 D	10.85 F	11.44 E	84.15 A	88.56 A
T_3- Zno-NPs (.6cm /L	18.34 C	18.95 D	13.60 E	15.25 D	86.40 B	84.75 B
T_4- ZnSO4 (6g/L) + yeast (.4%).	22.95 B	26.01 B	16.09 B	18.36 B	83.91 E	81.64 E
T_5- Zno-NPs (.6cm /L)+ yeast (.4%).	24.55 A	27.23 A	17.65 A	19.86 A	82.35 F	80.14 F
T_6- ZnSO4(6g/L)+NAA(100 ppm).	19.88 C	22.78 C	14.55 D	16.00 C	85.45 C	84.0 C
T_7- Zno-NPs(.6cm/L)+NAA(100 ppm).	22.01 B	25.70 B	15.63 C	15.68 D	84.37 D	84.32 D

values followed by the same letters in the same column are not significantly different of the 0.5 level.

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3.1.5. Productivity (Yield):

.4- No. of fruits/tree

Regarding No. of fruits/trees of Washington navel orange trees as impacted by the tested treatments, data presented in **Table (2)** indicate that there are significant differences among the investigated treatments. Hence, Zn-Nano + Yeast (T5) was the superior treatment in such a concept, as it gave the highest No. of fruit/tree (180.00 and 188.98) during the 1st and the 2nd season, respectively, followed in descending order by $ZnSO_4$ + Yeast (T4) (175.33 and 183.22); both $ZnSO_4$ + NAA (T6)and (T3)non-significant differences(160.38 and 163.66) (155.0 and 163) besides, $ZnSO_4$ + NAA (T6) (145.26 and 140.0), during the 1st and the 2nd season, respectively.

The opposite trend was true with water-sprayed trees (control), as such parameter was minimized to the least values (100 and 108.0) during the 1st and the 2nd season, respectively

3.1.6 -Fruit weight (g):

With regard to the fruit weight of Washington navel orange as affected by the different investigated treatments, obtained data, in Table (2) indicate that all tested treatments improved fruit weight as compared with the control.

Table 2. number of fruits/tree, (average) fruit weight (g) yield/tree (kg), and yield / feddan (tons) of Washington navel orange trees as impacted by foliar spray with zinc (sulfate and nano), yeast and NAA treatment during the 2022 and 2023 experimental seasons during the 2022 and 2023 experimental seasons.

Parameters / Treatments	No. of fruit/tree		Average fruit weight (g)		Yield/tree (Kg)		Yield / Feddan (Tons)	
	2022	2023	2022	2023	2022	2023	2022	2023
T_1-Control (tap waters pray).	100.0 G	108.0 F	209.11 D	213.31 D	20.91 F	23.02 F	3.51 F	3.87 F
T2 ZnSO4 (6 g/L)	115.88 F	123.42 E	220.16 C	225.2 C	25.51 E	27.79 E	4.29 E	4.67 E
T_3- Zno-NPs (.6cm /L	155.5 D	163.0 C	249.22 B	253.11 B	38.63 C	41.26 C	6.49 C	6.93 C
T_4- ZnSO4 (6g/L) + yeast (.4%).	175.33 B	183.22 B	253.18 B	257.17 B	44.31 B	47.07 B	7.44 B	7.91 B
T_5- Zno-NPs (.6cm /L)+ yeast (.4%).	180.00 A	188.98 A	262.06 A	265.22 A	47.17 A	50.12 A	7.92 A	8.42 A
T_6- ZnSO4(6g/L)+NAA(100 ppm).	145.26 E	140.0 D	245.08 B	249.31 B	35.62 D	34.90 D	5.98 D	5.86 D
T_7- Zno-NPs(.6cm/L)+NAA(100 ppm).	160.38 C	163.66 C	249.10 B	253.35 B	39.95 C	41.46 C	6.71 C	6.97 C

Values followed by the same letters in the same column are not significantly different of the 0.5 level.

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Meanwhile, fruit weight values(262.06 and 265.22g) were maximized when the trees were sprayed with Zn-Nano + Yeast (T5) during the 1st and the 2nd seasons of study.

Hence, Zn-Nano alone (T3), ZnSO4 + yeast (T4))and Zn-Nano + NAA (T7) improved fruit weight value but less than (T5). Consequently, The four treatments came in the second rank when fruit weight is considered. In contrast, Control trees showed the minimum values of fruit weight (209.1 g and 213.31g) during the 1st and the 2nd seasons of the study.

3.1.7. Yield/tree ; yield/feddan

Concerning the yield of Washington navel orange trees expressed either as kg/tree or ton/feddan as a reflection of the impact of the studied treatments, data presented in Table (2) indicate that there were significant differences among the studied treatments.

Furthermore, the values of each tested parameter were harmonious with the other one. The values of both parameters were paralleled to each other.

Based on this, yield enhancement of both parameters was more pronounced when the trees were sprayed with Zn-Nano coupled with Yeast extract (T5), where Yield/tree as kg was achieved (47.17 kg and 50.12 kg), while yield/feddan as ton achieved (7.92 and 8.42 tons) during the 1st and the 2nd season, respectively.

When $ZnSO_4$ was replaced by Zn-Nano and conjoint with Yeast extract (T4), it reduced both parameters during both seasons of study. Zn-Nano alone (T3)arranged the third in such respect, and joint with Zn-Nano coupled with NAA (T7), i.e. NAA Addition to Zn-Nano (T7) did not step up or improve the yield parameter.

On the other way around, the opposite was true, with the water-sprayed trees (control), which reflected the least values of yield/tree (20.91 kg and 23.02 kg) and yield/feddan (3.51 tons and 3.87 tons) during the 1st and the 2nd season of study.

3.2.fruit quality

Fruit physical properties.

In this regard, fruit dimensions (equatorial and fruit polar diameters), fruit shape index (L/D), fruit peel thickness (mm), average fruit volume (cm^3), fruit juice volume (cm^3), and fruit juice percentage (%) were the evaluated fruit physical properties of Washington Navel orange in response to different applied treatments. Data obtained during both the 2022 and 2023 experimental seasons are presented **in tables (3.4)and (5)**

3.2.1.1 Fruit polar diameter (cm):

Concerning the effect of different tested treatments on Navel orange fruit polar diameter, data presented in **Table (3)** clear that Zn-Nano + yeast extract treatment (T5) was able to strengthen or elongate fruit polar diameter to the maximum length (9.04 and 8.40 cm) as compared with the other tested treatments during the 1st and the 2nd season, respectively.

Table (3): fruit dimensions (cm) and fruit shape indexes of Washington navel orange trees as impacted by foliar spray with zinc (sulfate and nano), yeast and NAA treatment during the 2022 and 2023 experimental seasons.

Parameters / Treatments	Polar diameter (cm)		Equatorial diameter (cm)		Fruit shape index	
	2022	2023	2022	2023	2022	2023
T_1-Control (tap waters pray).	7.00 C	6.76 D	6.73 D	6.37 E	0.9 B	1.06 B
T2 ZnSO4 (6 g/L)	7.46 C	7.46 C	7.17 C	7.09 D	1.04 A	1.05 B
T_3- Zno-NPs (.6cm /L	7.87 C	8.86 A	7.33 C	7.22 D	1.07 A	1.23 A
T_4- ZnSO4 (6g/L) + yeast (.4%).	8.63 B	8.46 A	7.90 B	7.86 B	1.09 A	1.08 B
T_5- Zno-NPs (.6cm /L)+ yeast (.4%).	9.04 A	8.40 A	8.31 A	8.03 A	1.09 A	1.05 B
T_6- ZnSO4(6g/L)+NAA(100 ppm).	7.83 C	7.46 C	7.40 C	7.18 D	1.06 A	1.03 B
T_7- Zno-NPs(.6cm/L)+NAA(100 ppm).	8.42 B	8.27 B	8.12 A	7.50 C	1.04 A	1.10 B

values followed by the same letters in the same column are not significantly different of the 0.5 level.

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When NAA was replaced by yeast in (T7), it improved the tested parameter and ordered after (T5) to reach (8.42 and 8.27 cm), during both seasons of study.

The other tested treatments caused a little bit of fruit polar diameter increment.

3.2.1.2Fruit equatorial diameter (cm):

Data tabulated in **Table (3)** shows that such parameter was maximized when the trees were sprayed with Zn-Nano associated with yeast extract (T5) (8.31 and 8.03) as compared with the other tested treatments during the 1st and the 2nd season respectively.

Meanwhile, $ZnSO_4$ + yeast treatment (T4) came after (T5) and achieved (7.90 and 7.86 cm) in the 1st and the 2nd season.

The least values of the tested studied parameter were noticed with control trees (6.73 and 6.37 cm) during both seasons of study.

3.2.1.3 Fruit shape index:

It is quite clear from the data presented i**n Table (3)** that Zn-Nano alone treatment (T3) increased the fruit shape index to the optimum value (1.07 and 1.23) during the 1st and the 2nd season respectively. That means such treatment (T3) produced more elongated fruits. It was remarked that there are no significant differences among the tested treatments in both seasons except the control in the 1st season and the Zn-Nano alone treatment (T3) in the 2nd season.

3.2.1.4 Fruit peel thickness (mm):

.Dealing with the impact of sprayingWashington navel orange with two forms of Zn and their combination with either yeast or NAA on fruit peel thickness, obtained data in **Table (4) in**dicate that spraying with Zn-Nano coupled with yeast extract (T5) decreased fruit peel thickness to the minimum values (3.67 and 4.00 mm) during the 1st and the 2nd season respectively.

On the other way around, the other five treatments plus control were divided into two categories. The first one included control, Zinc-Nano (T3), and $ZnSO_4$ + yeast (T4), those three treatments maximized fruit peel thickness to the highest value during both seasons of study. The second category included $ZnSO_4$ + yeast(T4). ZnSo4 + NAA (T6) and Zn. Nano + NAA (T7), those three treatments increased fruit peel thickness but such increment values were a little less than the values achieved with the first category during both seasons of study.

3.2.1.5 Average fruit volume (cm^3):

Concerning fruit volume as impacted by different investigated treatments, data presented in **Table (4)** indicate that all treatments enhanced fruit volume as compared with control.

Meanwhile, it was clear that zn.Nano +yeast (T5) was the most effective treatment in this respect, as it was at the top of such concern. It gave the highest fruit volume values (264.0 and 270.4 cm^3) during the 1st and the 2nd season, respectively.

The other studied treatments came after (T5) and in descending order as follows, ZnSo4 + Yeast (T4), Zn. Nano (T3), Zn. Nano + NAA (T7), Zn-So4 + NAA (T6) and Zn-So4 (T2).

In contrast, the reverse was true with water-sprayed trees (control) which reflected the least fruit volume values (221.3 and 225.5 cm^3) during both seasons of study.

Table (4) Peel thickness (mm)Fruit volume (cm^3)Fruit juice volume (cm^3)Fruit juice percentage (%of Washington navel orange trees impacted by foliar spray with zinc (sulfate and nano), yeast and NAA treatment during the 2022 and 2023 experimental seasons

Parameters / Treatments	Peel thickness (mm)		Fruit volume (cm^3)		Fruit juice volume (cm^3)		Fruit juice percentage (%)	
	2022	2023	2022	2023	2022	2023	2022	2023
T_1-Control (tap waters pray).	5.33 A	5.67 A	221.3 F	225.5 F	91.17 C	93.2 C	41.20 D	41.39 D
T2 ZnSO4 (6 g/L)	4.67 B	4.33 B	230.4 E	236.1 E	100.0 B	102.3 B	43.40 D	43.30 C
T_3- Zno-NPs (.6cm /L	5.00 A	5.00 A	252.4 C	255.2 C	107.5 B	110.4 B	42.60 D	43.26 C
T_4- ZnSO4 (6g/L) + yeast (.4%).	5.33 A	5.33 A	259.3 B	263.3 B	119.0 B	122.1 B	45.90 C	46.37 B
T_5- Zno-NPs (.6cm /L)+ yeast (.4%).	3.67 C	4.00 C	264.0 A	270.4 A	132.5 A	133.5 A	50.20 A	49.37 A
T_6- ZnSO4(6g/L)+NAA(100 ppm).	4.33 B	4.67 B	240.3 D	245.6 D	110.3 B	112.6 B	45.90 C	45.85 B
T_7-Zno-NPs(6cm/L)+NAA(100 ppm).	4.67 B	4.67 B	251.4 C	254.7 C	120.2 B	120.3 B	47.80 B	47.23 B

values followed by the same letters in the same column are not significantly different of the 0.5 level.

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3.2.1.4Fruit Juice Volume (cm³)

It is clear from the data presented i**n Table (4)** that the highest values of fruit juice volume were detected with Zn-Nano + yeast treatment, as such treatment maximized such parameters (132.5 and 133.5 cm³) as compared with the other studied treatments, during the 1st and the 2nd season, respectively.

On the other hand, the other tested treatments failed to access the control one

3.2.1.5 Fruit juice percentage (%):

Dealing with the fruit juice % of Washington navel orange as impacted by different studied treatments, data presented in Table (**4)** indicate that fruit juice % was increased to reach to maximum value (50.20 and 49.37%) in the 1st and the 2nd season, respectively, when the trees were sprayed with Zn Nano combined with yeast extract (T5) as compared with the other studied treatments which came later in such respect.

In contrast, the least values(41.2 and 42.39%). Were obtained with unsprayed trees with any of the studied compounds (control) during both seasons of study.

3.2.2 Fruit chemical characteristics.

In this regard, fruit juice content, i.e., total soluble solids (TSS) %, total acidity %, TSS/Acid ratio and ascorbic acid (VC) contents, were evaluated as fruit chemical characteristics of Washington Navel orange

3.2.2.1 TSS%, fruit juice acidity %, TSS/acid ratio and vitamin C content)

Regarding chemical fruit quality (TSS%, fruit juice acidity %, TSS/acid ratio and vitamin C content) of Washington Navel orange fruits as influenced by different investigated treatments, data tabulated i**n Table (5)** clear that all studied treatments improved all chemical fruit quality as compared with control during both seasons of study.

Furthermore, Zn Nano + yeast extract (T5) was the most promising one in enhancing all chemical fruit qualities, as such treatment was at the top of such challenge, it maximized TSS% values (12.33 and 12.67%), TSS/acid ratio (12.78 and 13.67%)
and juice vitamin C content (50.20 and 49.37mg/ml juice) Meanwhile, such treatment minimized fruit juice acidity % to the lower values (0.96 and 0.91%) during the 1st and the 2nd seasons respectively.

It was clear that spraying either ZnSo4 (T2) or Zn Nano alone(T3) caused a little bit of increment in TSS%, TSS/acid ratio and V.C content besides a little bit of decrease in fruit juice acidity during both seasons of study.

On the other way around, the reverse was true with water-sprayed trees (control) which reflected the lowest values of TSS%, TSS/acid ratio and fruit juice V.C content (9.33 and 9.33%)
(7.54 and 7.35) and (35.5 and 35.3),
meanwhile, it achieved the highest values of fruit juice acidity % (1.23 and 1.27%) during the 1st and the 2nd seasons, respectively

Table 5. TSS %, Total acidity %, and TSS/acid ratio of Washington navel orange trees impacted by foliar spray with zinc (sulfate and nano), yeast and NAA treatment during the 2022 and 2023 experimental seasons.

Parameters Treatments	Fruit juice TSS (%)		Fruit juice acidity (%)		TSS /Acid ratio		Vitamin C (mg/100ml) fruit juice	
	2022	2023	2022	2023	2022	2023	2022	2023
T_1-Control (tap waters pray).	9.33 E	9.33 E	1.23 A	1.27 A	7.59 E	7.35 E	35.05 E	35.3 E
T2 ZnSO4 (6 g/L)	10.0 D	10.67 D	1.44 B	1.15 B	8.77 D	9.28 D	36.4 D	36.2 D
T_3- Zno-NPs (.6cm /L	11.0 C	11.33 C	1.02 C	1.05 C	10.78 C	10.79 C	38.1 C	37.9 C
T_4- ZnSO4 (6g/L) + yeast (.4%).	11.33 A	11.67 B	1.03 C	1.07 C	11.00 B	10.91 C	43.0 B	42.8 B
T_5- Zno-NPs (.6cm /L)+ yeast (.4%).	12.33 A	12.67 A	0.96 D	0.91 D	12.78 A	13.67 A	46.9 A	46.3 A
T_6- ZnSO4(6g/L)+NAA(100 ppm).	11.33 B	11.67 B	1.02 C	1.00 C	11.11 B	11.67 B	39.3 C	39.10 C
T_7- Zno-NPs(.6cm/L)+NAA(100 ppm).	11.33 B	11.33 C	1.04 C	1.07 C	10.89 C	10.59 C	42.1 B	41.80 B

values followed by the same letters in the same column are not significantly different of the 0.5 level.

- Nps -Nanoparticles

Discussion

Zn is an important microelement for human beings, animals as well as crops. Zn is an important component of different enzymes catalyzing metabolic reactions in plants. Zn also plays a significant role in plant resistance against diseases, photosynthesis, and cell membrane integrity within plant tissues **(Azhdar, Hussain et al., 2015).**

Treated guava trees with ZnSO4 at 0.2% caused an increment in tree height, shoot length and diameter, leaf size and area. Such an increase might be due to the active involvement of Zn in the synthesis of tryptophan which is a precursor of IAA synthesis, subsequently, it increased tissue and development **(Haider et al. 2014).**

El-Gioushy et al., (2021) examined the effect of foliar application of ZnSO4(300 and 600 mg/L) on Washington Navel orange trees. They reported that the level of ZnSO4 reflected the highest values of the various vegetative growth parameters including shoot length and diameter, number of leaves/shoot, leaf area and total assimilation area per shoot.

Our results are true to that reported by **Zekri, M. (2024),** who reported that foliar Zn is a key factor in stimulating the growth of citrus trees. Similar results were obtained by **Marcelo et al. (2021)** on orange, **Hussein et al. (2021)** on c limon, **Abed-Hak et al. (2019)** on flame seedless grapes **and Singh et al. (2018)** on sweet orange cv. Mosambi.

Regarding leaf mineral content as affected by Zn foliar spray, the results are supported by which was mentioned by **Singh et al. (2023)** who mentioned that spraying Kinnow mandarin trees with Zn NPs led to an increase in N, P, K and Z elements in the leaves, while **El-Gioushy et al. (2021)** mentioned that spraying Washington navel orange with ZnSO4 increased leaf chlorophyll and mineral contents. **Also, Awess et al. (2020)** on C. limon and **Basar and Gurel (2016)** on olive trees.

Yeast acts as a natural, safe bio-fertilizer and rich source of phytohormones, especially cytokinins, sugars, vitamins, enzymes, amino acids and minerals. It has stimulatory effects on cell division and enlargement, synthesis of protein and nucleic acid as well as chlorophyll formation and that may improve the growth and productivity of different plant species **(Abou El-Yazid and Mahdy Mady (2012))**

The results are confirmed by **AbdulKareem and Hussein (2022)** who reported that treatments of lemon with logic yeast gave the highest values **(1.57, 0.24, 1.48, 7.74 and 0.53%)** and (19.31, 114 .63 and 28.42 ppm)for N, P, K, Carbohydrates, Mg, Mn, Fe and Zn.

Also, Al-Mharib et al. (2022) reported that foliar spray with yeast improved all vegetative growth characteristics of spinach and lettuce respectively. and **Abd El-Galil et al. (2021)** and **Mady (2019).** Meanwhile, **Ahmed et al. (2023**) indicate that jujube-sprayed trees with yeast at 1 and 2% increased leaf total chlorophyll content.

Also, the result goes in line with **Faissal et al. (2018)** on Balady mandarin, **thana et al. (2015)** on olive, **Mustafa and El-Shazly (2013)** on Washington navel orange, and **Mohamed, Karima and Omaima Hafez (2004)** on Valencia orange trees.

Many studies declared that sprayed fruit trees with NAA at pre or post-bloom decreases fruit drop, increases fruit set, and fruit retention, and improves fruit quality and yield as well as vegetative growth **(Abd-El-Rahman, 2005).**

Analogous results were obtained by **Singh et al. (2023)** reported that spraying Kinnow mandarin trees with NAA at 150 ppm and 250 ppm had a significant effect on various vegetative growth parameters (maximum height increment 31.7 cm, annual shoot growth 24.41cm, tree canopy 35.73cm). **Also, Das et al. (2021)** on Eureka lemon; **Abd-El-Naby et al. (2019)** on Canino apricot; **Hamady (2017) and** on Washington navel orange**; Hindy et al., (2017).**

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Effect of Foliar Application of Bio-Regulators (GA3 and NAA) on Vegetative Growth

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تاثير الرش الورقى بالزنك والخميره وNAA على المحصول وصفات جودة ثمار البرتقال ابو سرة

اجريت هذة الدراسة خلال موسمى 2022، 2023 على اشجار البرتقال ابو سرة مطعومة على اصل النارنج وعمرها 7 سنوات ونامين فى ارض طينية بمحافظة القليوبية .

وتهدف هذة الدراسة الى تحسين المحصول وصفات الجودة الثمار وذلك باستخدام عنصر الزنك فى صورتين (سلفات الزنك بمعدل 6جم/لتر او الزنك فى صورة نانو بمعدل 6سم /لتر–مستخلص الخميرة بمعدل 2% وNAA بمعدل 100جزء فى المليون – كل على صورة حرة او متداخلة رشا على الاشجار 6دفعات (مرات) ابتداء من منتصف فبراير ،ومنتصف ابريل (بعد العقد) ثم كل شهر حتى شهر اغسطس .

اوضحت النتائج ان جميع المعاملات ادت الى تحسين الصفات (المعايير المدروسة) مقارنة بالكنترول الا ان رش الاشجار بالزنك النانو بتركيز 6سم/لتر مع مستخلص الخميرة بتركيز 2% ادى الى تعظيم قيم مفردات المحصول وصفاات جودة الثمار الطبعية والكيماوية مع تقليل النسبة المئوية لتساقط الثمار وحموضة العصير .

الكلمات الإسترشادية: برتقال ابو سره سلفات زنك– زنك نانو– الخميره– نفثالين اسيتك اسيد