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ORIGINAL ARTICLE

THE EFFECT OF FOLIAR SPRAYING WITH NANO IRON OXIDE AND TRYPTOPHAN ACID IN SOME INDICATORS OF THE FRUIT GROWTH OF BARHEE TISSUE CULTURE DATE PALM

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Abstract: The experiment was conducted during the 2021 growing season in a local orchard in the Shatt al-Arab district of the katiban area of Basrah to know the effect of spraying with nano iron fertilizer and tryptophan amino acid at 0, 100, 200 mg l^{-1} on some the physical and chemical qualities of *phoenix dactylifera* L. fruits, Barhee cultivar at the age of 8 and during khalal stage, the experiment included nine factorial treatments and a randomized complete block design was used. The results showed that treatments of interaction between nano-fertilizer and tryptophan increased all the physical parameters of the fruits. The treatment of nano-iron 200 mg l^{-1} with tryptophan 200 mg l^{-1} increased all the physical parameters of the fruits, including the fruit's weight, weighing the fruit flesh, the length, and the diameter of the fruit. The same treatment increased all the fruits' chemical properties, such as the total soluble solids, total sugars, and soluble protein. As well as, the same treatment increased the iron and nitrogen content of the leaf compared with other treatments. The success of date palm cultivation depends on the economic productivity obtained from foliar spraying treatments, especially the interaction treatment between nano iron and tryptophan acid at high concentrations of 200 mg l^{-1}.

***Key words*:** Date palm, Nano iron, Tryptophan acid, Fruit flesh, Yield.

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1. Introduction

The date palm (*Phoenix dactyifera* L.) belongs to the family Arecaceae. It is an essential perennial fruit tree that grows in dry and semi-arid areas between the 39-10 north and south latitudes [Al-hajjaj and Ayad (2018)]. Iraq is considered one of the oldest date palm cultivation areas and has many varieties reaching more than 600 varieties [Chao and Krueger (2007)]. Barhee cultivar is one of the most widespread varieties in the Middle East. It is picked and consumed in the Khalal stage but soon enters the Rutab stage during 3-5 weeks [Ismail *et al*. (2006)].

Foliar fertilization is a necessary method for continuing date palm cultivation, to obtain the best results for growth and production, and reducing the damage caused by abiotic stress [Jubeir and Ahmed (2019), Zyarah and Al-jabir (2021)]. Although the date palm is subjected to the annual fertilization program, it faces some challenges, including the lack of availability of soil elements as nutrients, drying of the soil surface, low root activity during the propagation period, soil alkalinity, water scarcity in the cultivation areas, and symptoms of deficiency of some elements [Shareef *et al*. (2021)].

The use of nano-fertilizers in fertilizer programs is an alternative to traditional fertilizers, achieving many advantages, including their use in small quantities, thus increasing profits by 20-30% [Zulfiqar *et al*. (2019)]. In addition to its high stability and speed of absorption in different environmental conditions [Adisa *et al*. 2019)]. Iron is a necessary element of the plant as it

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plays a crucial role in the system of many enzymes that enter the respiration process and are granted Cytochrome, Catalase Oxidase, and the participation of iron element in these compounds is particularly important in the reactions of oxidation and amortization as well as its essential role in cell metabolism [Li *et al*. (2016), Neamah *et al*. (2021)]. Abou El-Nasr *et al*. (2015) noted that the foliar sprays of nano iron fertilizer with three concentrations (25, 125, 250 mg l^{-1}) on pear saplings (*Pyrus serotina* L. X *Pyrus communis* L.) Le-Conte cv. increased carbohydrate and chlorophyll, Fe, and N content.

Amino acids are natural compounds that help the plant grow well balanced and increase its response to fertilization and resistance to diseases, provide part of its nitrogen needs, and prevent internal poisoning with ammonia for the plant [Al-Juthery *et al*. (2019), Kadim *et al*. (2021)]. Amino acids increase the activity of various vesicles within the plant directly or indirectly. They are essential components of proteins, and other necessary compound building materials such as nucleotides, auxiliary enzymes, and plant hormones are necessary.

Tryptophan is an organic and essential compound for the formation of indole acetic acid (IAA), whose composition is concentrated in the peripheral peaks of initiatives and plants, ensuring that leafy plants have the vital capacity to convert tryptophan into this auxin within plant organs, especially those containing anchor cells for construction. It is one of the most critical indicators of endogenous development as it affects many developmental processes such as cell division, elongation, and vascular tissue development [Hussein *et al*. (2014)]. However, when environmental growth conditions are inadequate, the plant cannot sufficiently produce these hormones to maintain growth and productivity within optimal limits [Kudoyarova *et al*. (2019)]. So external additions to these hormones or the addition of substances needed for synthesis improve plant growth and productivity by modifying internal hormone levels [Mustafa *et al*. (2018)]. Hassan *et al*. (2019) found that tryptophan spraying at 200 mg l^{-1} to five times one spray each month at the Hababok stage on the date palm Ashrassi cultivar gave the highest fruit weight, length, and total sugar percent values. The spraying of amino acid tryptophan with a concentration (0.05, 0.1, 0.2)% on palm trees caused an increase in the leaf content of the nutrients Fe, Zn, K, and P compared with the control [Ahmed *et al*. (2014)].

Due to the lack of studies on the use of nano iron oxide fertilizer and tryptophan amino acid on date palm trees, this study was conducted to know the impact of these two compounds on indicators of fruit growth and chemical qualities and the product of the date palm Barhee cultivar.

2. Materials and Methods

The experiment was conducted during the 2021 growing season in a local orchard in the katiban area of Basrah province, and 27 palms were selected from the tissue culture based on symmetry in the strength of vegetable growth and the absence of pathological injuries and at the age of 8 years and planted in the soil of the clay loam and surface irrigated and conducted all the usual agricultural service operations of fertilization and pruning. The trees were pollinated with the Ghannami Akhdar male on 1/3/2021, splitting the number of inflorescences to seven and eight leaves per inflorescence. Foliar spray of nano iron oxide at 0, 100, and 200 mgl^{-1} concentration and amino acid (tryptophan) at 0, 100, and 200 mg l^{-1}. 0.1% of tween 20 solutions were prepared to reduce the surface tension of water and increase the fertilizer adhesion on the leaves; the control treatment spray distilled water and the diffuser material only. Samples were taken in the khalal stage to be used in experimentation measurements.

2.1 Fruit weight and fruit flesh (g)

The weight of the fruit by taking fifty random fruits per repeater using the electric balance and extracting the rate of one fruit from the division of the weight of the total fruits on the number of fruits and the weight of the meat was calculated by the difference between the weight of the fruit and the weight of the seed.

2.2 The length and diameter of the fruit (cm)

The length and diameter of the fruit were measured in fifty randomly taken fruits. The length and diameter of the fruit are measured by the Verner (cm), and then calculation of the length and diameter of the fruit is by dividing the **total of fruits by the number of fruits**.

2.3 Total soluble solids

15 g of fresh fruit pulp was grounded with 15 ml of distilled water and filtered. Put drops of the filtrate into the manual refractometer to measure the percentage of total soluble solids. The results were adjusted according to the dilutions.

Table 1: Physical and chemical properties of soil at a depth of (0-60) cm.

Adjective	Value
Electrical conductivity (EC) (dS m^{-1})	9.76
pH	8.13
Total nitrogen (g kg^{-1})	4.58
Ready phosphorus (g kg^{-1})	0.711
Ready potassium (g kg^{-1})	1.407
Organic matter (g kg^{-1})	13.63
Soil separators %	
Sand	4.50
Silt	63.00
Clay	32.50
Soil texture	clay loam

2.4 Total sugars %

Total sugars in fruit meat were estimated during the khalal stage using lane and Eyaon method based on dry weight according to Zerban *et al*. (1946) and the following dependents:

Total sugars % = reduced sugars % + sucrose

2.5 Soluble protein

Estimate the melted protein in the fruits in the wet phase as Bradford *et al*. (1976) described. 0.2 g of the soft sample and crushed in 15 ml of water distilled in a ceramic mortar, placed in a water bath at a temperature of 50 m for half an hour, and then placed in the centrifuge for 15 min and took the filter for use in the following steps. Standard protein solution prepared with 0.04 g serum Albumin (B.S.A) in a specific volume of distilled water and complete the size with distilled water to 100 ml.

2.6 Nitrogen and iron concentrations in leaves %

According to the method described by [Klute (1986)], estimate nitrogen using a Micro Kjeldahl device. Iron in fruits was estimated by atomic absorption and the method described in [AOAC (2005)].

Table 2: Irrigation water properties of the study site

Adjective	Value
Electrical conductivity (EC) (dS m^{-1})	7.93
pH	7.76
Chloride (mmol l^{-1})	34.57
Calcium (mmol l^{-1})	13.32
Potassium (mmol l^{-1})	0.43
Sodium (mmol l^{-1})	9.08

2.7 Statistical Analysis

The experiment was carried out using the factorial experiment and designing randomized complete block R.C.B.D with three blocks where the one palm tree is one experimental unit.

3. Results and Discussion

3.1 Physical parameters of the fruits

The results in Table 3 indicate the effect of the treatment of sprays with nano iron oxide and tryptophan acid on some of the physical properties of the fruit and the interaction between the treatments for the Barhee cultivar at the khalal stage despite the high salinity of soil and water (Tables 1 & 2). Treatment of spraying with the nano iron fertilizer led to an increase in most of the physical parameters of the fruits (the weight of the fruit, weighed the fruit flesh, the length of the fruit, and the diameter of the fruit) and the concentration of 200 mg l^{-1} increased the weight of the fruit, weighed the fruit flesh, the length of the fruit, and the diameter of the fruit compared with other concentrations, and recorded 9.79 g, 8.99g, 3.22 cm, 2.46 cm respectively. In contrast, 100 mg l^{-1} was recorded the 9.05 g, 8.24 g,

Table 3: The effect of the treatment of sprays with nano iron oxide and tryptophan acid on some of the physical properties of the fruit and the interaction between them for the Barhee cultivar at the khalal stage.

Nano Iron mg l^{-1}	Trypt-ophan mg l^{-1}	Weight of the fruit g	Fruit flesh g	Length of the fruit g	Diameter of the fruitg
0	0	8.40	7.28	2.55	2.07
	100	8.71	7.92	2.96	2.28
	200	9.46	8.64	2.94	2.40
100	0	8.91	8.12	2.62	2.20
	100	9.01	8.20	2.86	2.18
	200	9.23	8.39	3.24	2.46
200	0	8.95	8.12	3.09	2.37
	100	10.01	9.28	3.14	2.51
	200	10.42	9.58	3.43	2.52
R.L.S.D. 0.05		0.53	0.57	0.48	0.18
Average effect Iron	0	8.85	7.94	2.82	2.25
	100	9.05	8.24	2.91	2.28
	200	9.79	8.99	3.22	2.46
R.L.S.D. 0.05		0.30	0.33	0.27	0.10
Average effect Tryptophan	0	8.75	7.84	2.75	2.21
	100	9.24	8.47	2.99	2.32
	200	9.70	8.87	3.20	2.46
R.L.S.D. 0.05		0.30	0.33	0.27	0.10

Table 4: The effect of the treatment of sprays with nano iron oxide and tryptophan acid on some of the chemical properties of the fruit and the interaction between them for the Barhee cultivar at the khalal stage.

Nano Iron mg l^{-1}	Tryptophan mg l^{-1}	Total soluble solids %	Total sugars %	Soluble protein g kg^{-1}
0	0	8.40	7.28	2.55
	100	8.71	7.92	2.96
	200	9.46	8.64	2.94
100	0	8.91	8.12	2.62
	100	9.01	8.20	2.86
	200	9.23	8.39	3.24
200	0	8.95	8.12	3.09
	100	10.01	9.28	3.14
	200	10.42	9.58	3.43
R.L.S.D. 0.05		0.53	0.57	0.48
Average effect Iron	0	8.85	7.94	2.82
	100	9.05	8.24	2.91
	200	9.79	8.99	3.22
R.L.S.D. 0.05		0.30	0.33	0.27
Average effect Tryptophan	0	8.75	7.84	2.75
	100	9.24	8.47	2.99
	200	9.70	8.87	3.20
R.L.S.D. 0.05		0.30	0.33	0.27

2.91 cm, and 2.28 cm, respectively.

Amino acid spraying (tryptophan) at 200 mg l^{-1} increased most of the physical parameters compared with other concentrations, was recorded the 9.70 g, 8.87 g, 3.20 cm, and 2.46 cm, respectively. In contrast, the concentration of 100 mg l^{-1} (control) was recorded; the lowest results were 8.75 g, 7.84 g, 3.20 cm, and 2.46 cm.

Treatments of interaction between nano-fertilizer and tryptophan increased all the physical parameters of the fruits. The treatment of nano-iron 200 mg l^{-1} with tryptophan 200 mg l^{-1} increased all the physical parameters of the fruits and recorded 10.42 g, 9.548 g, 3.43 cm, and 2.52 cm to the weight of the fruit, weighed the fruit flesh, the length of the fruit, and the diameter of the fruit respectively. While the interaction treatment (0 mg l^{-1} nano-iron with 0 mg l^{-1} tryptophan acid) recorded the lowest results for the fruit weight, fruit flesh weight, fruit length, and fruit diameter, which reached 8.40 g, 7.28 g, 2.55 cm, and 2.07 cm, respectively.

3.2 The chemical properties of the fruits

The results in Table 4 indicate the effect of the treatment of sprays with nano iron oxide and tryptophan acid on some of the chemical properties of the fruit and the interaction between the treatments for the Barhee cultivar at the khalal stage. Treatment of spraying with the nano iron fertilizer led to an increase in most of the chemical properties of the fruits (total soluble solids, total sugars, and soluble protein), and the concentration of 200 mg l^{-1} increased the total soluble solids, total sugars, and soluble protein compared with other concentrations, and recorded 42.29% 43.78%, and 39.93 g kg respectively. In contrast, the control treatment was recorded with the lowest values of the total soluble solids, total sugars, and soluble protein were 35.07%, 40.27%, and 32.33 g kg, respectively.

Table 5: The effect of the treatment of sprays with nano iron oxide and tryptophan acid on the iron and nitrogen content of the leaves and the interaction between them for the Barhee cultivar at the khalal stage.

Nano Iron mg l^{-1}	Tryptophan mg l^{-1}	Iron mg kg^{-1}	Nitrogen g kg^{-1}
0	0	41.73	4.44
	100	43.62	5.12
	200	46.44	5.96
100	0	42.50	5.34
	100	44.42	5.94
	200	47.91	6.37
200	0	44.32	5.75
	100	45.11	6.35
	200	51.20	7.06
R.L.S.D. 0.05		1.76	0.85
Average effect Iron	0	43.93	5.17
	100	44.94	5.88
	200	46.87	6.38
R.L.S.D. 0.05		1.01	0.49
Average effect Tryptophan	0	42.85	5.17
	100	44.38	5.80
	200	48.51	6.46
R.L.S.D. 0.05		1.01	0.49

Amino acid spraying (tryptophan) at 200 mg l^{-1} increased the total soluble solids, total sugars, and soluble protein compared with other concentrations, was recorded the 41.30%, 43.00%, and 40.4 g kg, respectively. In contrast, the control treatment recorded the lowest values were 35.93%, 40.59%, and 32.36 g kg.

Treatments of interaction between nano-fertilizer and tryptophan increased all the chemical properties of the fruits. The treatment of nano-iron 200 mg l^{-1} with

tryptophan 200 mg l^{-1} increased all the total soluble solids, total sugars, and soluble protein of the fruits and recorded 43.48%, 44.43%, and 44.14 g kg, respectively. While the interaction treatment (0 mg l^{-1} nano-iron with 0 mg l^{-1} tryptophan acid) recorded the lowest values for the total soluble solids, total sugars, and soluble protein, which reached 30.86%, 39.24%, and 27.75 g kg, respectively.

3.3 The mineral content of iron and nitrogen in the leaves

The results in Table 5 indicate the effect of the treatment of sprays with nano iron oxide and tryptophan acid on the iron and nitrogen content of the leaf and the interaction between the treatments for the Barhee cultivar at the khalal stage. Treatment of spraying with the nano iron fertilizer led to an increase in iron and nitrogen content. The concentration of 200 mg l^{-1} increased the iron and nitrogen content compared with other concentrations and recorded 46.87 mg kg^{-1} and 6.38 g kg^{-1}, respectively. In contrast, the control treatment recorded the lowest iron and nitrogen content values of 43.93mg kg^{-1} and 5.17 g kg^{-1}, respectively.

Amino acid spraying (tryptophan) at 200 mg l^{-1} increased the iron and nitrogen content compared with other concentrations recorded at 48.51 mg kg^{-1} and 6.46 g kg^{-1}, respectively. In contrast, the control treatment recorded the lowest iron and nitrogen content values were 42.85 mg kg^{-1} and 5.17g kg^{-1}.

Treatments of interaction between nano-fertilizer and tryptophan increased the iron and nitrogen content of the leaves. The treatment of nano-iron 200 mg l^{-1} with tryptophan 200 mg l^{-1} increased iron and nitrogen content and recorded 51.20 mg kg^{-1} and 7.06 g kg^{-1}, respectively. At the same time, the interaction treatment (0 mg l^{-1} nano-iron with 0 mg l^{-1} tryptophan acid) recorded the lowest values for the iron and nitrogen content, which reached 41.73 mg kg^{-1} and 4.44 g kg^{-1}, respectively.

4. Discussion

Due to the environmental conditions experienced by the date palm, quick and practical fertilization methods can lead to continuity of production and improve the properties of marketable fruits. Most of the physical and chemical properties of fruits increased, especially when spraying palm trees with nano iron fertilizer, the iron element is essential and necessary for plant growth and plays a significant role in activating enzymatic processes within the plant, as the iron element enters a catalyst for green pigments formation reactions through a series of interactions that end with the formation of the chlorophyll molecule [de Bang *et al*. (2021)]. In addition, iron has an essential role in reducing $NADP^+$ to $NHDPH+H^+$ to produce the energy needed for the photosynthesis process [Cruz *et al*. (2005)]. Our results are similar to those by Abass *et al*. (2012) in the date palm study Hellawi cv., which showed that treatment with chelated iron led to an increase in chemical, physical and productive properties of fruits. Our results are similar to Al-mayahi (2012) findings that the treatment of palm trees vegetables with chelated iron on flowers caused an increase in the weight rate of the fruit and yield.

Previous studies [Ahmed *et al*. (2014), Al-Juthery *et al*. (2019)] indicate that the use of amino acids in improving plant growth depends on the type of amino acid and the plant variety. In the current study, we used the amino acid tryptophan for its ability to regulate the content of auxin and plant nutrients that contribute to growth. However, tryptophan is one molecule that transforms the signal for many physiological processes [Richard *et al*. (2009)]. The results showed that the use of the concentration of 200 mg l^{-1} tryptophan gave an increase in the weight and size of the fruit, and this may be attributed to that tryptophan, which is the initiator of the formation of IAA, one of the most critical indicators of internal development and affects many development processes such as cell division and elongation, as well as the development of vascular tissues and the emergence of roots [Zhao (2012)]. Many studies show that the spraying this amino acid has led to increased vegetative and fruit growth [Al-Juthery *et al*. (2019)].

The positive effect of iron nanoparticles attributed to the suitability of iron and nitrogen on metabolism and stimulation of the activity of photosynthetic pigments and enzymes promotes plant growth [Tawfik *et al*. (2021)]. However, the higher concentrations of iron and nitrogen in the leaves are due to the iron nanoparticles that contribute to the plant's metabolism by building and increasing the potency of several enzymes [Rastogi *et al*. (2017)].

5. Conclusions

Nano-fertilizers and amino acids helped date palm grow and increased fruit weight and total yield. The success of date palm cultivation depends on the

economic productivity obtained from foliar spraying treatments, especially the interaction treatment between nano iron and tryptophan acid at high concentrations of 200 mg l^{-1}.

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