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Effect of the treatment method and spraying with nano-algae extract on productivity and quality of palm trees in new reclaimed areas

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ABSTRACT

This study was conducted during two successive seasons of 2022 and 2023 on Hayany date palm trees cultivar (*Phoenix dactylifera* L.) 12year old grown at the Desert Research Center station, Southeast Al Qantara, Sinai, Egypt, grown in silty clay soil at 7 x 7 m apart under drip irrigation system. Arranged in a randomized complete block design with three replicates. The aim of this research was to investigate the effect of nano fertilizers with algae extract and application method on leaf minerals content, fruit quality and yield of Hayany date palm trees. Two fertilization methods Spraying and trunk injection were used to rationalization chemical fertilizers. The experiment included two application methods foliar Application and Injection with trunk used by three levels at 50,100 and 200ppm / palm tree from nano-algae extract and unsprayed trees (control). All treatments were applied twice, after pollination in 1st April of each season and one month later. The results indicated that the highest of the parameters, including leaf mineral contents, fruit yield parameters, fruit physical properties, and fruit chemical properties were found from trunk injection method at200 ppm with nano-algae extract of Hayany date palm trees were studied compared to other treatments in two studied seasons. Thus, fertilization Hayany date palm trees using trunk injection by 200 ppm /palm from nano-algae extract is recommended starting from twice, after pollination in 1st week of April of each season and one month later to improve leaf mineral contents, and productivity of date palm.

Keywords: Date palm, Foliar application fertilizer, injection fertilizer, Nano algae extract.

1. Introduction

Date palms *(Phoenix dactylifera*) are the most common fruit tree grown in arid and semiarid of the Middle East and North Africa regions. In Egypt, the total cultivated areas of dates attained about 333901 ha with total production of 1603762 tons (FAO, 2019). Date palm is one of the oldest cultivated trees in arid and semi-arid areas, where it is important for both socioeconomic and ecological reasons (Al-Alawi *et al.,* 2017). Date is the most popular fruit consumed, and contains considerable amounts of essential nutrients, vitamins and minerals, high in carbohydrates, and dietary fibers, antioxidants, and high levels of phenolic compounds (Al-Shwyeh, 2019 and Al-Mssallem *et al.,* 2020). From 1.25 million hectares of land, 9.61 million tons of dates are produced globally (FAO 2023).

Fertilization is the important tools to balance productivity with high fruit quality for orchard management successful practices in the date palm trees orchards. One of the main problems that farmers face the cost of fertilizers, chemical fertilizers increased the salinity of the soil. Minimizing mineral fertilization the main goals of many orchard management. Therefore, using natural compounds Injection or spraying of fertilization with nano-algae extract class of bio stimulants (Rouphael and Colla, 2020), that are only somewhat harmful to the environment, people, and animals. algal extracts extract a key for sustainable agriculture, it is a natural source of organic matter and it contains macronutrients such as P, K, Ca, and Mg, micronutrients such as Cu, Fe, Mn, and Zn, some a wide variety of auxins and cytokinins, gibberellins, and polyamines, proteins, and also contains vitamins, polysaccharides, sterols, polyphenols, antioxidants, pigments, and antimicrobial agents, is

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essential for plant metabolism, productivity, and improving plant development, harvest, and fruiting (Bulgari, and Ferrante 2019,Cataldo *et al.,* 2022). Additionally, spraying leaves or injecting the trunk with some plant extracts improved the quantity and quality of date palm Zahdi cultivar Hashim and Thamer (2019).

Injection nutrient solution save 90-95% of nutrients and keep a clean environment Mahmud, (2009). Also, the method of fertilization by injection is an important method because it leads to the material inside the tree as well as to prevent pollution of air and water and that this method is used control the pests and diseases (Drwesh,2015). it reduces nutrient loss and solve the problem of fixation and leaching for some macro and micronutrients (Jahanshah *et al.* 2016). Also, that Nutrient solution trunk injection is an important technique in improving nutritional status of date palm.

Nanoparticles can be reducing the amount of chemicals needed, furthermore is one of the important processes that provide these trees with nutrients directly, thus the plant benefits from the nutrients injected in the highest amount Zaen El-Daen (2019). Using fertilizers via a nano-system was succeeded in improving yield and fruit characteristics of Zaghloul date palm grown under sandy soil (Hussein *et al.,* 2023).

Nowadays, nanotechnology is environmentally friendly fertilizers application has become common in date palm nutrient management by reducing nutrient loss, controlling the way in the soil or directly on the plant (Shareef 2020). The dynamics of nano-fertilizers rapidly penetrate cell membranes to be available in the cytosol. Which effect provides the necessary elements, such as K and Mg, to build new specific proteins and increase secondary metabolites, to reduce the oxidative stress (Naser *et al.,* 2016). Nanomaterials are used in many agricultural plant growth promotion activity and nano-fertilizers (Choudhary *et al.,* 2017 and Abdel-Aziz *et al.,* 2018).

Nanotechnology is increasingly used in agriculture, especially in fertilization programs, as nano fertilizers are an effective alternative to traditional fertilizers, advantages due to their use with lower chemicals, speed of absorption and has given a rapid response to the growth of crops. The use of nanoscale fertilizers are the materials with reduced size, large surface area, excellent solubility in water and absorbed rapidly, it completely in the plant correcting the nutritional deficiencies (Chhipa, (2017), it is characterized as necessary or helpful nutrient nanomaterials or nanoparticles that may be applied to crops at the nanoscale (1–100 nm) to increasing crop production, improving their quality and and reduce environmental pollution and sustainable agriculture Al-Hchami and Alrawi (2020) and Sembada and Enggoro (2024).

The main, goal of this study aims to the effect of the methods of adding fertilizer with Nano algae extract fertilizer technology on growth, yield physical and chemical properties of Hayany date palm trees grown in sandy soil.

2. Material and Method

The present investigation was carried out during the two successive 2022 and 2023 seasons on fruitful Hayany date palm trees (*Phoenix dactylifera* L.), 12 year old grown at the Desert Research Center station, Southeast Al Qantara, Sinai, Egypt. grown in Silty clay soil under drip irrigation system. The selected trees were planted at 7 x 7 m, were almost uniform in growth and free from insect damage and diseases were selected and subjected to the same management and practices and the fertilizing program was applied using a fertigation system and performed to maintain leaf / bunch ratio at 8:1 and 9 bunches were maintained. Soil farm was analyzed according to A.O.A.C. (2005) and reported in Tables (1).

2.1. Experimental work

The experiment included six application treatments were compared with the control and were arranged in a randomized complete block design with two replicates which arranged as the following:

1 Control treatment
2 Spraying of nano-algae extract at 50 ppm
3 Spraying of nano-algae extract at 100ppm.
4 Spraying of nano-algae extract at 200ppm.
5 Injection of nano-algae extract at 50ppm
6 Injection of nano-algae extract at 100ppm.
7 Injection of nano-algae extract at 200ppm.

Table 1: Analysis of the tested soil.

Constituents	Values
Particle size distribution:	
Sand %	5.0
Silt %	53.0
Clay %	42.0
Texture%	Silty clay
pH (1:2.5 extract)	7.88
E.C (1:2.5 extract) mmhos/ cm/ 25°C	1.70
O.M. %	1.43
$CaCO_3$ %	2.22
Total N %	0.10
Available P (ppm, Olsen)	5.4
Available K (ppm, ammonium acetate)	410.2

Trunk injection method: in January tree trunk diameter was measured; A 6 mm-diameter hole was drilled to radius of the tree trunk where xylem was found, the injector was hammered into the hole, the hole around the injector was fallen by silicon, the end of the tube was opened, tied to the injector and the extract solution was fallen in the tube then it tied in any leaf above the hole.

Algae extract formulation: Algae extract was obtained from the Arabian Group for Agricultural Service (AGAS) was produced by Nano Lab Desert Research Center with the following composition, as described in Table, 2

Table 2: The physicochemical properties of Algae

Content	Concentration (%)
Minerals	
Nitrogen	1%
Phosphorus (P_2O_5)	0.5%
Potassium (K_2O)	12%
Manganese	0. 2%
Iron	0.2 %
zinc	0.03%
Natural growth regulators	
Oligosaccharide	3%
Alginic acid	5 %
Phytin	0.003 %
Menthol	0.001%
Cytokinin	0.001%
Indol Acetic acid	0.0002%

All treatments were applied twice, after pollination (First week of April of each season) and one month later. Sprays were applied with a small handgun sprayer until run-off occurred. A wetting agent (Tween 20 at 1%) was applied with the spraying solution.

2.2. The following parameters were measured during the two growth seasons

Leaf chemical composition

Leaf mineral content: Leaf samples were collected for chemical analysis at the 1st week of September. Each sample consisted of 10 leaflet / tree. Leaves were washed several times with tap water, rinsed with distilled water, and then dried at 70 c^{o} until a constant weight, ground and digested according (Chapman, 1978). Nitrogen was estimated by semi-micro kieldahl method of Plummer (1974). Phosphorus was determined by the method outlined by Jackson (1973). Potassium was

determined using atomic absorption spectrophotometer "Perkin Elmer 1100B" after samples digested according to Chapman, (1978). Iron, Manganese and Zinc were determined as ppm using atomic absorption according to (Carter, 1993).

Yield and physical fruit characteristics

- Fifty fruits at tamer stage per palm were taken randomly selected from each tree and then yield /palm(kg) at harvesting time (mid-September in both seasons), yield of the experimental palms was determined as Kg/palm.
- Fruit physical properties i.e. (fruit weight, % flesh weight, % seed weight, fruit length and fruit width were determined and recorded to determine fruit chemical characteristics.

Chemical Fruit Characteristics

- Fifty gram from fruit flesh were blended in 100 ml distilled water using special electric mixer, then filtered and the filtrate was taken for analysis) according to A.O.A.C. (2005). Total soluble solids (T.S.S.) in fruit juice were determined using Carl Zeiss hand refractometer. Total sugars percentage was determined according to Miller (1959).Titratable acidity percentage in fruit juice was determined according to Vogel, (1968).

2.3. Statistical Analysis

The data were subjected to analysis of variance and Duncan's multiple range test were used to study the differentiate between means as described by Duncan (1955).

3. Results and Discussion

3.1. Effect fertilizers and application methods on leaves mineral content

3.1.1. Nitrogen, Phosphorus, Potassium Iron, Zinc and Manganese.

Data concerning the show that all extract treatments were significantly affected on leaves mineral content in Hayany date palm trees in Table (3). However, nano-algae extract injection at 200ppm significantly increased leaves nitrogen content of 1.52- 1.56 %, leaves phosphor content of 0.25 - 0.26 %, leaves potassium content of 1.25 - 1.27 % followed by nano-algae extract spray at 200ppm leaves nitrogen content of 1.46 -1.48%, leaves phosphor content of 0.22 – 0.24%, leaves potassium content of 1.23 – 1.24 % in both seasons as compared with other treatment which gave the lowest value for these studied traits.

Table 3: Effect of spraying and injection with nano-algae extract on leaf mineral content of N, P and K of Hayany date palm.

Treatments	N%		P %		K %	
	2022	2023	2022	2023	2022	2023
Control (untreated)	1.32g	1.34e	0.16e	0.17e	1.16e	1.17d
Spray 50ppm	1.41f	1.34e	0.18de	0.17e	1.17e	1.18d
Spray 100ppm	1.42e	1.45d	0.20cd	0.21cd	1.20cd	1.22c
Spray 200ppm	1.46b	1.48c	0.22b	0.24ab	1.23b	1.24b
Injection 50ppm	1.43d	1.44d	0.20cd	0.20d	1.20d	1.22c
Injection 100ppm	1.44c	1.52b	0.21bc	0.23bc	1.22bc	1.23bc
Injection 200ppm	1.52a	1.56a	0.25a	0.26a	1.25a	1.27a

Means followed by the same letter(s) in each column are not significantly different at 5% level.

It is evident from table (4) shows that Fe, Zn and Mn content were significantly affected by nano-algae extract treatments on Hayany date palm trees. However, the nano-algae seaweed extract injection at levels 200ppm significantly superiority of the control treatment and gave the highest leaves Fe content of 131-130ppm, leaves Mn content of 54-57ppm but gave the highest leaves Zn content of 45-42ppm at levels 200ppm with spray nano-algae seaweed extract in the first and second seasons as compared with other treatment.

Table 4: Effect of spraying and injection with nano-algae extract on leaf mineral content Fe, Zn and Mn of Hayany date palm..

Treatments	Fe(ppm)		Zn (ppm)		Mn(ppm)	
	2022	2023	2022	2023	2022	2023
Control (untreated)	125b	127b	36d	35c	44c	41d
Spray 50ppm	116e	109f	36.d	38b	40d	39e
Spray 100ppm	121d	123d	35d	37b	46c	44c
Spray 200ppm	123c	125c	45a	42a	43cd	45c
Injection 50ppm	120d	117e	40c	38b	50b	48b
Injection 100ppm	125b	127b	36d	35c	52ab	49b
Injection 200ppm	131a	130a	43b	32d	54a	57a

Means followed by the same letter(s) in each column are not significantly different at 5% level.

3.2. Effect fertilizers and application methods on total yield and fruit physical characteristics:

3.2.1. Total yield (kg/tree), fruit weight, pulp weight, seed weight (g), fruit length and fruit width(cm).

Data in Table (5) showed that, total yield (kg/tree) of Hayany date palm trees was increased by all treatments comparing with control in both seasons. The results were showed that application methods had an effect on increasing the yield, especially the treatment of 200ppm nano algae extract with injection method significantly improved the yield. Nano algae extract at 200ppm per palm with injection reached yield (122.8 and 124.3 kg) during the two experimental seasons, respectively

It is clear from table (5) that there was significant increase in all studied fruit physical properties of Hayany date palm fruits obtained from all nano-algae extract spray and trunk injection treatments in both studied seasons. In this respect, we found noticed the highest fruit weight (25.76 &25.03g) obtained from nano-algae extract trunk injection by100 ppm /palm compared with the control treatment which gave the lowest value (14.56 & 14.39g) this led to an improvement in flesh weight which gave the highest values (22.96a &22.40a g) compared to the control treatments recorded the lowest values Flesh weight (12.46 & 13.00g). Moreover, recorded the lowest values seed weight (1.86g) from nano-algae extract spray by100 ppm /palm in the first season while, in the second season recorded (1.50) from nano-algae extract trunk injection by 50 ppm /palm compared to the other treatments.

Table 5: Effect of injection and spraying with nano-algae extract on yield, fruit weight, pulp weight and seed weight of Hayany date palm.

Treatments	Yield (kg/tree)		Fruit weight (g)		Flesh weight (g)		Seed weight (g)	
	2022	2023	2022	2023	2022	2023	2022	2023
Control (untreated)	25.79 D	26.27 D	14.56d	14.93d	12.46f	13.00c	2.20a	2.40a
Spray 50ppm	65.63 BC	65.27 C	19.33c	19.26c	16.33e	17.10b	2.04ab	2.40a
Spray 100ppm	87.12 B	90.81 B	20.50c	19.73c	18.36cd	17.63b	1.86b	2.26a
Spray 200ppm	53.36 C	67.30 C	23.13b	23.00b	20.20b	21.23a	2.20a	2.46a
Injection 50ppm	76.15 BC	65.40 C	19.46c	19.36c	17.93d	17.96b	2.13ab	1.50b
Injection 100ppm	80.81 B	76.23 BC	23.73b	23.56 b	19.63bc	21.16a	2.23a	2.10a
Injection 200ppm	122.8 A	124.3 A	25.76a	25.03a	22.96a	22.40a	2.30a	2.30a

Means followed by the same letter(s) in each column are not significantly different at 5% level.

3.2.3. Fruit length (cm) and fruit width (cm).

As shown in Table (6) insignificant differences among treatments in the second season but in the first season treatments, control and spray at 50ppm had lower significant fruit length compared with all other treatments.

Regarding fruit width, the palms injection with nano algae extract at 200ppm recorded the highest values (2.93 - 2.93 cm) followed by spray with nano algae extract at 200ppm (2.90 - 2.76 cm) in both seasons compared to the other treatments.

Table 6: Effect of spraying and injection with nano-algae extract on fruit length, and fruit width of Hayany date palm.

Treatments	Fruit length (cm)		Fruit width (cm)	
	2022	2023	2022	2023
Control (untreated)	4.53b	5.43a	2.33d	2.26d
Spray 50ppm	4.76b	5.33a	2.46cd	2.56bc
Spray 100ppm	5.20a	5.20a	2.66abc	2.63bc
Spray 200ppm	5.26a	4.83b	2.90ab	2.76ab
Injection 50ppm	5.13a	5.16a	2.60bcd	2.36cd
Injection 100ppm	5.16a	5.16a	2.66abc	2.70ab
Injection 200ppm	5.23a	5.20 a	2.93a	2.93a

Means followed by the same letter(s) in each column are not significantly different at 5% level.

3.3. Effect of fertilizers and application methods on fruit chemical characteristics:

3.3.1. Total soluble solids, total sugar and percentage of total acidity

The results presented in Table (7) clearly indicate that all treatments of nano algae extract used had a significant effect on TSS, Total sugar and acidity in the fruits when compared to the untreated palms in both seasons. Furthermore, it is clear that TSS% significantly increased with the treatment of injection at 100ppm nano algae extract, which were recorded as 29.30 and 30.33% followed by 28.50 and 29.36% with spray at 200ppm nano algae extract in both seasons. In this respect, spraying at 200 ppm nano algae extract gave the highest values of total sugars (23.46 & 24.36%) in the first and second seasons, respectively compared to control and other treatments. Meanwhile, juice total acidity decreased (0.27 & 0.22%) were obtained from spraying at 200 ppm nano algae extract in both seasons as compared with control and other treatment.

Table 7: Effect of spraying and injection with nano-algae extract on total soluble solids, total sugar and total acidity of Hayany date palm.

Treatments	TSS (%)		Total sugar (%)		Acidity (%)	
	2022	2023	2022	2023	2022	2023
Control (untreated)	25.30 c	25.63 c	20.36cd	20.66cd	0.32ab	0.31a
Spray 50ppm	24.33 c	26.16 c	19.40d	19.66d	0.32a	0.27b
Spray 100ppm	27.36 b	28.26 b	21.50bc	22.50b	0.28bc	0.26b
Spray 200ppm	28.50 ab	29.36 ab	23.46a	24.36a	0.27cd	0.22d
Injection 50ppm	24.53c	26.23 c	20.66cd	22.20bc	0.33a	0.31a
Injection 100ppm	29.30 a	30.33 a	21.73bc	19.56d	0.28bc	0.27b
Injection 200ppm	27.70b	28.63 b	22.60b	25.50a	0.24d	0.23c

Means followed by the same letter(s) in each column are not significantly different at 5% level.

4. Discussion

The enhanced effect of algae on leaf chemical constituents of Hayany date palm might be attributed to algae's a rich source of many different compounds, including mineral elements and of amino acids, vitamins and antioxidants and includes natural plant hormones, such as auxins, gibberellins, cytokinins, ethylene, and polyamines (Cataldo *et al.,* 2022; Alebidi and Abdel-Sattar 2024), Seaweed plays a crucial role in improving the photosynthesis rate and enhancing plant uptake of mineral elements that are directly linked to chlorophyll formation in tree leaves, also contains magnesium, which is a crucial element for chlorophyll synthesis (Al-Saif *et al*., 2023).

The obtained results regarding the positive effect of algae extract injecting on yield and fruiting characteristics of Hayany date palm may be due to the fact that the mechanisms effect of algae on cell metabolism which contains plant growth regulators such as cytokinin, auxins, gibberellins, and mineral nutrients might have resulted in a higher photo-assimilate supply to the fruits leading to enhance the yield and its characteristics Omar (2017). Similar results of algae extract on enhancing fruit yield are in harmony with those mentioned by Salama (2015) on Valencia orange reported that algae extract at 2% induced high positive effect on yield and fruit quality. Also, using two types of algae extracts enhancing physical and chemical characteristics of sour orange fruit under clay soil Al-Musawi (2018), On the other hand, the same trend of these results of algae extract on date palm trees was observed by Malaka *et al.* (2016) on Medjool date palm, El-Mahdy *et al.,* (2017) on Sewy date palm, Murad and Al-Dulaimy (2021) on Zahdi date palms.

About the positive effect of fertilization by injection enhancement fruiting characteristics and yield, it may be due to the transfer of elements directly to the parts of the plant with the rising water and not losses in the amount of fertilizers, which lead to improving fruit quality and yield in palm. These results are in agreement with findings by Elsayd *et al.,* (2018) and Jubeir, and Ahmed (2019) who conducted that trunk injection is a more efficient fertilization method that increased vegetative growth and increase yield of date palm. Also, Whereas, injecting the nutrient solution gave the best results in the content of nutrients in the leaves and fruits of Date Palm Cv. Zahdi, Alaa and Rasmi (2023).

Roshdy and Refaai (2016), reached in the best treatments improving growth, yield and fruit quality of Zaghloul date palms when using nanotechnology system as compared with conventional . As a result of observed an increase in the indicators of the studied characteristics due to use in Nano-fertilizer, which was reflected in the characteristics of vegetative growth and yield, importance of nano fertilizer that nano particles as unique in behavior and characteristics, such as the small size,enabled the plant to deliver the elements and availability elements in the leaves contribute rapid transfer photoassimilates to the fruit, which leads to an increase in the weight of the fruits and yield (Altemimy *et al.,* 2019). The use of nano-fertilizers with lower concentrations can lead to a faster growth process by increasing the metabolic activity in fruits, which it Early ripening of fruit and highest prices for dates (Shareef *et al.,* 2020).

Nano-fertilizers are causing increase in fruit flesh weight, fruit bunch weight length and weight of fruits date palm Hakeem *et al.* (2023) and Altemimy (2019). The fruits of date palm were affected by the treatment with nano-fertilizers Jubeir and Ahmed (2019), El-Salhy *et al.* (2021) and Hussein *et al.* (2023) who worked on nanotechnology fertilizers.

4. Conclusion

From the results of this study it could be used biostimulants as nano- fertizer eco-friendly fertilization Hayany date palm trees using trunk injection by 200 p.p.m / palm from nano-algae extract is recommended starting from twice, after pollination in 1st April of each season and one month later to improve leaf mineral contents, fruit quality and yield of date palm to alleviate the side effects of chemical fertilization under for food safety and sustainability.

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