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Effect of nano NPK fertilizer, EM1 fertilizer and seaweed extract on some growth and yield characteristics of date palm CV Khastawi.

Murad Malik Ibrahim Al-Mohammadi[1] **Rasmi Mohammed Hamad[2]**
[1]*Directorate of Seed Testing and Certification, Anbar, IRAQ.*
[2]*Department of Horticulture and Landscaping, College of Agriculture, University of Anbar, IRAQ.*
*Corresponding Author: mur21g5009@uoanbar.edu.iq

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ABSTRACT
This study was conducted in one of the private orchards in Al-Anbar Governorate / Republic of Iraq during the 2024 season, where 54 homogeneous date palm trees were selected, planted systematically at a distance of 9×9 meters. The experiment was designed as a complete randomized block design (RCBD) with three replications. The study included three factors: the addition of nano NPK fertilizer at concentrations of 0, 50, and 100 g palm^{-1}, a biostimulant at a concentration of 0 and 20mL^{-1}, and spraying with seaweed extract at concentrations of 0, 1, and 2 mL^{-1}. Statistical analysis results showed that the study factors achieved good results in vegetative growth and yield characteristics for the treated trees. The treatment with the biostimulant at a concentration of 20 mL^{-1}outperformed all treatments in terms of leaf chlorophyll content, which was 44.47 mg 100 g of fresh weight, and the dry matter percentage in leaves, which was 56.78%. The average fruit weight was 10.81 g, and the total yield was 103.82 kg palm^{-1}. Meanwhile, the treatment with seaweed extract excelled in leaf area, measuring 3.116 m², and the percentage of carbohydrates, which was 18.47%. As for the bilateral interaction between the study factors, the interaction treatment between nano-fertilizer and seaweed extract at a concentration of 100 gm + 2 ml L-1 outperformed the rest of the treatments in both the leaf area trait, which reached 3.254 m2 and the carbohydrate percentage, which reached 19.12%, while the treatment of nano-fertilizer and bio-fertilizer 100 gm + 20 ml L-1 outperformed in both the fruit weight trait, which reached 11.27 gm and the palm yield, which reached 108.05 kg palm tree-1. The interaction treatment between bio-fertilizer and growth stimulant 20 ml L-1 + 2 ml L-1 also achieved the highest values in both the leaf content trait of chlorophyll, which reached 45.50 mg/100 gm fresh weight, and the percentage of dry matter, which reached 57.98%.The results of the three-way interaction showed significant differences among the treatments ,with the interaction treatment of nano fertilizer (100 g),the biostimulant (20 mL^{-1}), and seaweed extract (2 mL^{-1}) outperforming all other treatments for the studied traits.

***Keywords*:** Date palm, Nano NPK, Biofertilizers, EM1, Seaweed extracts.

INTRODUCTION

The date palm tree *Phoenix dactylifera L.* belongs to the family Arecaceae and the order *Palmae*. Date palms are cultivated in arid and semi-arid regions worldwide. It is believed that this tree originated in southern Iraq and the Arabian Gulf, from where it spread to many other countries. Over time, date palm cultivation expanded throughout Iraq, reaching 650 cultivars [1]. The date palm is one of the most important evergreen fruit trees, with a history dating back to the dawn of human civilization. Due to its significant economic value, this blessed tree has held a special place in the cultures of Mesopotamia. Its fruits are nutritionally, medicinally, and therapeutically beneficial. Dates are among the richest fruits in sugar content, which is easily absorbed and digested by the body. Additionally, dates are an excellent source of vitamins, nutrients, and minerals. A 100-gram serving provides the body energy equivalent to 353 calories [2]. The number of palm trees in Iraq reached 17,348,741 palm trees, and the average date production reached approximately 750,225 thousand tons [3]. Since fertilisation is essential for enhancing tree growth vigour and improving both the quality and quantity of the yield, it is crucial to distinguish between the tree's ability to withstand neglect and its capacity to achieve high productivity with well-developed fruit. Given the relatively high nutrient requirements of date palms, symptoms of nutrient deficiencies may become evident if fertilization is neglected, ultimately affecting the growth and productivity of the trees [4]. Due to population growth, limited arable land, and scarce water resources, it has become essential to explore alternative methods to address the causes behind the decline of date palm orchards, reduced yields, and poor fruit quality. One of these techniques is using nanofertilizers, which could serve as an alternative to traditional chemical fertilizers. Nanofertilizers are designed for the efficient use of nutrients, releasing them gradually into the soil, thereby minimizing losses and reducing water and environmental pollution [5]. These environmentally friendly fertilizers are highly efficient, reducing the risk of soil organism toxicity and damage. Compared to traditional fertilizers, nanofertilizers enhance nutrient uptake, allowing plants to absorb nutrients quickly and uniformly based on their needs, while using a relatively small amount of nutrients [6]. Chemical fertilization can also be replaced by biofertilization, which is considered one of the most important contemporary agricultural techniques. Biofertilizers are applied to the plant's growing environment in the form of biological inoculants, notably the biofertilizer EM1 (Effective Microorganisms), which contains more than 60 different beneficial microorganisms, including lactic acid bacteria, photosynthetic bacteria, yeasts, and various fungi, These organisms can provide the plant with the necessary nutrients and vitamins and secrete many growth regulators that work to create a hormonal balance within the plant and increase its supply of nutrients, which is reflected in the plant's growth and increased yield. [7]. Additionally, seaweed extracts can be used as an organic fertilizer source instead of chemical fertilizers in fruit orchards. These extracts are crucial for stimulating growth as they contain essential nutrients, amino acids, organic acids, and growth-promoting substances such as cytokinins, auxins, gibberellins, and vitamins [8]. The study aimed to evaluate the efficiency of nanofertilizers, biofertilizers, and seaweed extracts and to determine the optimal concentration for enhancing vegetative growth vigor and increasing the yield of Khastawi date palm trees.

Materials and Methods

The study was conducted during the 2024 season in Al-Anbar Governorate / Republic of Iraq at the geographical coordinates 33°25'15.9"N 43°45'18.7"E on Khastawi date palm trees. A total of 54 trees, approximately 16 years old, were selected and planted systematically from March to September. All necessary management practices, including pruning, pollination, and disease control, were completed. Eight fruit bunches were selected from each date palm tree to study yield characteristics. The study was conducted as a factorial experiment with three factors using a Randomized Complete Block Design (RCBD), comprising 18 treatments with three replicates. The first factor involved the soil application of nanofertilizer NPK (20:20:20) at concentrations of 0, 50, and 100 g palm, denoted as F0, F1, and F2, applied in four doses from early March (5/3) to August (5/8). The second factor included the soil application of the biofertilizer EM1 (Effective Microorganisms) at two levels: 0 and 20 mL^{-1}, at a rate of 400 ml $palm^{-1}$, represented as E0 and E1, applied twice on March 15 and June 15. The first and second factors were applied by creating basins around the tree trunks with a 1.5-meter diameter (Table 1) and incorporating the respective materials. The third factor consisted of foliar spraying of seaweed extract on the fronds and fruit bunches at concentrations of 0, 1, and 2 mL^{-1}, represented as A0, A1, and A2. Three sprays were conducted in March, May, and July, with the spraying performed early in the morning to maximise absorption efficiency.

Table 1. Physical and chemical properties of the field soil (60 cm).

Type of Analysis	Analysis Result	Unit of Measurement
Nitrogen	235	$mg.g^{-1}$
Phosphorus	11	$mg.g^{-1}$
Potassium	1.2	$mg.g^{-1}$
Electrical Conductivity (EC)	3.54	$dS.m^{-1}$
Soil pH	7.8	
Total Dissolved Solids (TDS)	1511	$g.L^{-1}$
Organic Matter	0.63	$g.kg^{-1}$
Texture	Sandy Loam	
Clay	28	%
Silt	35	%
Sand	37	%

Studied Traits:

1. **Leaf Area (m^2):** This trait was measured by selecting two fully physiologically developed leaves (fronds) from near the growing apex, specifically from the second base, at the growth stage for each treatment, following the calculation method described by Ahmed and Morsy [9].

$$\text{Leaf Area} = \frac{0.37\,(\text{Width} \times \text{Length}) + 10.29 \text{ x NumberofLeaflets}}{1000}$$

2. **Total Chlorophyll Content ($mg.100g^{-1}$ fresh weight):** This was estimated by taking 0.2 g of fresh leaflets and grinding them in a ceramic mortar with 10 ml of 80% acetone. The mixture was then centrifuged, filtered, and the

volume was adjusted to 20 ml with acetone. Readings were taken using a spectrophotometer at wavelengths of 663 and 645 nanometers, following the method by Mackinney [10], modified by Arnon [11]. The total chlorophyll content was calculated using the following equation:

Total Chlorophyll= 20.2D (645) + 8.02D(663)
× (V/W x 1000)
W=Fresh weight of sample (0.2 g)
V= Final volume of filtrate (20 ml)
D=Reading the device according to the wavelength

3. **Percentage of Dry Matter in Leaves (%):** This was determined according to the method by Al-Ani [12] by taking 20 g of fresh weight per sample. The sample was placed in an electric oven at 70°C until a constant weight was achieved. The dry weight of the samples was then measured using a precision balance. The percentage of dry matter was calculated using the following equation:

$$\text{Percentage of Dry Matter} = \frac{\text{Dry Weight of Sample}}{\text{Fresh Weight of Sample}} \times 100$$

4. **Carbohydrate Content in Leaves (%):** The carbohydrate percentage was determined using the method described by Joslyn [13] with a spectrophotometer at a wavelength of 490 nanometers.
5. Average Fruit Weight (g): This was measured by weighing 10 randomly selected fruits at the ripening stage from each experimental unit. The average fruit weight was calculated by dividing the total weight of the fruits by the total number of fruits using the following equation:

$$\text{Average Fruit Weight}(g) = \frac{\text{Total Weight of Fruits}(g)}{\text{Total Number of Fruits}}$$

6. **Yield (kg palm^{-1}):** The total yield per palm was studied by collecting the weight of the eight bunches, then calculating the average total weight for each palm.

Statistical Analysis:

Data were statistically analyzed using the Genstat software, and means were compared using the Least Significant Difference (LSD) test at a significance level of 0.05 [14].

Results and discussions

Leaf Area(m²)

The results presented in Table 2 indicates The application of nanofertilizer significantly increased the leaf area. The highest leaf area was observed with the 100 g concentration in treatment F2, reaching 2.912 m², while the lowest area was recorded at 0 g in treatment F0, and measuring 2.542 m². Additionally, applying the biofertilizer at a level of 20 ml L^{-1} had a significant effect on leaf area, with treatment E1 achieving the highest area of 2.866 m², compared to the lowest area of 2.571 m² at 0 ml L^{-1} in treatment E0. Furthermore, spraying seaweed extract at 2 ml L^{-1} in treatment A2 resulted in the highest leaf area of 3.116 m², compared to the lowest area of 2.339 m² at 0 ml L^{-1} in treatment A0. Regarding the interaction effects, the combined effect of nanofertilizer and biofertilizer in treatment F2E1 produced the highest leaf area of 3.036 m², whereas treatment F0E0 recorded the lowest value of 2.419 m². The interaction between nanofertilizer and seaweed extract in treatment F2A2 achieved the highest area of 3.254 m², compared to the lowest area of 2.238 m² in treatment F0A0. Additionally, the interaction between biofertilizer and seaweed extract in treatment E1A2 resulted in an area of 3.201 m², compared to the lowest area of 2.297 m² in treatment E0A0. The three-way interaction effect of nanofertilizer, biofertilizer, and seaweed extract in treatment F2E1A2 recorded the highest leaf area of 3.305 m², whereas treatment F0E0A0 showed the lowest area of 2.145 m².

Table 2. Effect of nanofertilizer, biofertilizer, and seaweed extract and their interactions on leaf area (m²)

Factor E	Factor A	Factor F			E*A
		F_0	F_1	F_2	
E_0	A_0	2.145	2.252	2.495	2.297
	A_1	2.211	2.275	2.670	2.385
	A_2	2.899	2.988	3.202	3.030
E_1	A_0	2.330	2.270	2.543	2.381
	A_1	2.632	3.152	3.261	3.015
	A_2	3.032	3.267	3.305	3.201
					Mean E

F*E	E_0	2.419	2.505	2.789	2.571
	E_1	2.665	2.896	3.036	2.866
					Mean A
F*A	A_0	2.238	2.261	2.519	2.339
	A_1	2.422	2.713	2.965	2.700
	A_2	2.966	3.127	3.254	3.116
Mean F		2.542	2.701	2.912	

LSD 5%

F*E*A	E*A	F*A	F*E	A	E	F
0.147	0.085	0.104	0.085	0.060	0.049	0.060

Leaf Chlorophyll Content (mg. 100g⁻¹ fresh weight):

The results shown in Table 3 indicate that the application of nanofertilizer had a significant effect on leaf chlorophyll content. The highest chlorophyll content was observed with the 100 g concentration in treatment F2, reaching 42.41 mg.100g⁻¹ fresh weight, while the lowest content was recorded at 0 g in treatment F0, with 41.09 mg.100g⁻¹ fresh weight. The 50 g concentration in treatment F1 did not differ significantly from the 100 g concentration in treatment F2, with a chlorophyll content of 42.01 mg.100g⁻¹ fresh weight. Additionally, applying the biofertilizer at 20 mL L⁻¹ had a positive effect on chlorophyll content, with treatment E1 showing the highest content of 44.47 mg.100g⁻¹ fresh weight, compared to 39.21 mg.100g⁻¹ fresh weight at 0 mL L⁻¹ in treatment E0. Spraying seaweed extract at 2 mL L⁻¹ in treatment A2 resulted in the highest chlorophyll content of 43.55%, compared to the lowest content of 39.88 mg.100g⁻¹ fresh weight at 0 mL L⁻¹ in treatment A0. Regarding the interaction effects, the combination of nanofertilizer and biofertilizer in treatment F2E1 produced the highest chlorophyll content of 45.07 mg.100g⁻¹ fresh weight, whereas treatment F0E0 recorded the lowest value of 38.76 mg.100g⁻¹ fresh weight. The interaction between nanofertilizer and seaweed extract did not show any significant differences in the studied trait. However, the interaction between biofertilizer and seaweed extract in treatment E1A2 resulted in a content of 45.50 mg.100g⁻¹ fresh weight, compared to the lowest content of 36.92 mg.100g⁻¹ fresh weight in treatment E0A0. The three-way interaction of nanofertilizer, biofertilizer, and seaweed extract in treatment F2E1A2 did not yield any statistically significant effects for the studied trait

Table 3. Effect of nanofertilizer, biofertilizer, and seaweed extract and their interactions on leaf chlorophyll content (mg.100g⁻¹ fresh weight).

Factor E	Factor A	Factor F: F_0	F_1	F_2	E*A
E_0	A_0	36.23	37.00	37.52	36.92
	A_1	38.65	38.67	40.03	39.12
	A_2	41.41	41.66	41.69	41.59
E_1	A_0	42.27	43.11	43.13	42.84
	A_1	43.93	45.48	45.78	45.07
	A_2	44.04	46.16	46.30	45.50
					Mean E
F*E	E_0	38.76	39.11	39.75	39.21
	E_1	43.42	44.92	45.07	44.47
					Mean A
F*A	A_0	39.25	40.05	40.33	39.88
	A_1	41.29	42.08	42.91	42.09
	A_2	42.73	43.91	44.00	43.55
Mean F		41.09	42.01	42.41	

LSD 5%

F*E*A	E*A	F*A	F*E	A	E	F
N.S	0.62	N.S	0.62	0.44	0.36	0.44

Percentage of dry matter in leaves (%):

The data presented in Table 4 show that the application of nanofertilizer significantly affected the percentage of dry matter in leaves. The highest percentage was observed with the application of nanofertilizer at 100 g in treatment F2, reaching 55.47%, while the lowest percentage was recorded in the control treatment F0, which had 54.15%. The biofertilizer also played a significant role in increasing the percentage, particularly at the 20 mL L⁻¹ level in treatment E1, which achieved the highest percentage of 56.78%, whereas the non-application treatment E0 recorded the lowest percentage of 52.82%. The results further indicate that spraying seaweed extract at 2 mL L⁻¹ in treatment A2 significantly outperformed the other treatments in dry matter percentage, achieving the highest value of 56.28% compared to the lowest value of 53.42% in the control treatment A0.

The two-way interaction between the studied factors resulted in a significant increase in dry matter percentage. The interaction between nanofertilizer and biofertilizer in treatment F2E1 achieved the highest percentage of 57.73%, compared to the lowest percentage of 52.34% in the non-application treatment F0E0. The interaction between nanofertilizer and seaweed extract in treatment F2A2 recorded the highest percentage of 56.84%, compared to the lowest percentage of 52.71% in the control treatment F0A0. Additionally, the interaction between biofertilizer and seaweed extract in treatment E1A2 achieved the highest percentage of 57.98%, compared to the lowest percentage of 51.40% in treatment E0A0. Statistical analysis results indicate significant differences among the treatments for the three-way interaction between nanofertilizer, biofertilizer, and seaweed extract, with treatment F2E1A2 achieving the highest percentage of 59.11%, compared to the lowest percentage of 50.70% in treatment F0E0A0.

Table 4. Effect of nanofertilizer, biofertilizer, and seaweed extract and their interactions on percentage of dry matter in leaves (%).

Factor E	Factor A	Factor F F_0	 F_1	 F_2	E*A
E_0	A_0	50.70	51.79	51.72	51.40
	A_1	51.78	52.31	53.32	52.47
	A_2	54.54	54.61	54.57	54.58
E_1	A_0	54.72	55.37	56.24	55.45
	A_1	56.86	56.01	57.83	56.90
	A_2	56.27	58.58	59.11	57.98
					Mean E
F*E	E_0	52.34	52.90	53.20	52.82
	E_1	55.95	56.65	57.73	56.78
					Mean A
F*A	A_0	52.71	53.58	53.98	53.42
	A_1	54.32	54.16	55.58	54.69
	A_2	55.41	56.60	56.84	56.28
Mean F		54.15	54.78	55.47	

LSD 5%						
F*E*A	E*A	F*A	F*E	A	E	F
0.92	0.53	0.65	0.53	0.38	0.31	0.38

Carbohydrate content in leaves (%):

The results shown in Table 5 indicate that the application of nanofertilizer had a significant effect on the carbohydrate content in the leaves. Treatment F2, with a nanofertilizer concentration of 100 g, recorded the highest percentage of 16.49%, while the lowest percentage was observed in the control treatment F0, at 14.93%. The biofertilizer also had a substantial impact on carbohydrate content, with treatment E1 at 20 mL L^{-1} achieving the highest value of 16.31%, compared to the lowest value of 15.26% in the non-application treatment E0. The results also show that spraying seaweed extract at 2 mL L^{-1} significantly increased the carbohydrate content, with treatment A2 recording the highest percentage of 18.47%, while the lowest value of 12.46% was observed in the control treatment A0.

For the two-way interaction effects, the combination of 100 g nanofertilizer and 20 mL L^{-1} biofertilizer in treatment F2E1 resulted in the highest percentage of 16.98%, compared to the lowest percentage of 14.07% in treatment F0E0. The interaction between 100 g nanofertilizer and 2 mL L^{-1} seaweed extract in treatment F2A2 recorded a percentage of 19.12%, compared to the lowest value of 12.02% in the control treatment F0A0. Additionally, the interaction between 20 mL L^{-1} biofertilizer and 2 mL L^{-1} seaweed extract in treatment E1A2 achieved the highest value of 18.95%, compared to the lowest value of 12.37% in treatment E0A0.

Regarding the three-way interaction, the combination of nanofertilizer, biofertilizer, and seaweed extract in treatment F2E1A2 outperformed all other treatments, achieving the highest carbohydrate percentage of 19.96%, compared to the lowest percentage of 11.66% in the control treatment F0E0A0.

Table 5. Effect of nanofertilizer, biofertilizer, and seaweed extract and their interactions on carbohydrate content in leaves (%)

Factor E	Factor A	Factor F F_0	 F_1	 F_2	E*A

E_0	A_0	11.66	12.57	12.89	12.37
	A_1	13.06	16.37	16.80	15.41
	A_2	17.50	18.16	18.29	17.98
E_1	A_0	12.39	12.40	12.85	12.55
	A_1	16.81	17.31	18.14	17.42
	A_2	18.16	18.74	19.96	18.95
					Mean E
F*E	E_0	14.07	15.70	15.99	15.26
	E_1	15.79	16.15	16.98	16.31
					Mean A
F*A	A_0	12.02	12.48	12.87	12.46
	A_1	14.94	16.84	17.47	16.42
	A_2	17.83	18.45	19.12	18.47
Mean F		14.93	15.92	16.49	

LSD 5%

F*E*A	E*A	F*A	F*E	A	E	F
1.15	0.67	0.81	0.67	0.47	0.38	0.38

Average fruit weight (g):

The results in Table 6 indicate that the application of nanofertilizer significantly affected fruit weight. Treatment F2, with 100 g of nanofertilizer, recorded the highest fruit weight of 10.28 g, while the lowest weight was observed in the control treatment F0, at 9.60 g. The biofertilizer also had a clear impact, with treatment E1 at 20 mL^{-1} achieving the highest weight of 10.81 g, compared to the lowest weight of 9.00 g in the control treatment E0. Additionally, the data show that spraying seaweed extract at 2 mL^{-1} in treatment A2 resulted in the highest fruit weight of 10.37 g, while the lowest weight was recorded in treatment A0 at 9.45 g.

Regarding the two-way interaction effects, the combination of 100 g nanofertilizer and 20 mL^{-1} biofertilizer in treatment F2E1 yielded the highest fruit weight of 11.27 g, compared to the lowest weight of 8.79 g in treatment F0E0. The interaction between 100 g nanofertilizer and 2 mL^{-1} seaweed extract in treatment F2A2 achieved a weight of 10.83 g, compared to 9.00 g in the control treatment F0A0. The interaction between 20 mL^{-1} biofertilizer and 2 mL^{-1} seaweed extract in treatment E1A2 produced the highest fruit weight of 11.20 g, statistically outperforming all other treatments, while the lowest weight of 8.70 g was recorded in treatment E0A0.

For the three-way interaction, the combination of nanofertilizer, biofertilizer, and seaweed extract in treatment F2E1A2 significantly outperformed all other treatments, with the highest fruit weight of 11.52 g, compared to the lowest weight of 8.60 g in treatment F0E0A0.

Table 6. Effect of nanofertilizer, biofertilizer, and seaweed extract and their interactions on Average fruit weight (g)

Factor E	Factor A	Factor F F_0	F_1	F_2	E*A
E_0	A_0	8.60	8.68	8.81	8.70
	A_1	8.63	8.74	8.89	8.75
	A_2	9.13	9.37	10.13	9.54
E_1	A_0	9.39	10.23	11.01	10.21
	A_1	10.87	10.89	11.29	11.02
	A_2	10.95	11.13	11.52	11.20
					Mean E
F*E	E_0	8.79	8.93	9.28	9.00
	E_1	10.41	10.75	11.27	10.81
					Mean A
F*A	A_0	9.00	9.45	9.91	9.45
	A_1	9.75	9.82	10.09	9.89
	A_2	10.04	10.25	10.83	10.37
Mean F		9.60	9.84	10.28	

LSD 5%

F*E*A	E*A	F*A	F*E	A	E	F
0.33	0.19	0.23	0.19	0.14	0.11	0.14

Yield (kg palm^{-1})

The data analysis results in Table 7 show that the application of nanofertilizer at a concentration of 100 g had a significant effect on palm yield. Treatment F2 significantly outperformed the other treatments, recording the highest yield of 100.41 kg palm^{-1}, compared to 94.26 kg palm^{-1} in the control treatment F0, which used 0 g. The addition of biofertilizer at 20 mL^{-1} also had a significant effect on yield, with treatment E1 achieving a yield of 103.82 kg palm^{-1}, while the lowest yield of 90.74 kg palm^{-1} was recorded in the control treatment E0, which used 0 mL^{-1}. Spraying seaweed extract at 2 mL^{-1} in treatment A2 produced the highest yield of 100.04 kg palm^{-1}, compared to 93.29 kg palm^{-1} in the control treatment A0, which used 0 mL^{-1}.

Regarding the two-way interaction between the studied factors, the combination of 100 g nanofertilizer and 20 mL^{-1} biofertilizer in treatment F2E1 resulted in the highest yield of 108.05 kg palm^{-1}, compared to the lowest value of 88.91 kg palm^{-1} in treatment F0E0. The interaction between nanofertilizer and seaweed extract in treatment F2A2 significantly outperformed all other treatments, yielding 102.57 kg palm^{-1}, compared to 87.90 kg palm^{-1} in the control treatment F0A0. The interaction between biofertilizer and seaweed extract in treatment E1A2 also showed a significant difference in yield, with the highest yield of 107.47 kg palm^{-1}, compared to the lowest value of 88.96 kg palm^{-1} in treatment E0A0. The three-way interaction between nanofertilizer, biofertilizer, and seaweed extract in treatment F2E1A2 produced the highest yield of 108.50 kg palm^{-1}, significantly outperforming the control treatment F0E0A0, which recorded the lowest yield of 87.87 kg palm^{-1}.

Table 7. Effect of nanofertilizer, biofertilizer, and seaweed extract and their interactions on Yield (kg palm^{-1})

Factor E	Factor A	Factor F: F_0	F_1	F_2	E*A
E_0	A_0	87.87	89.33	89.66	88.96
	A_1	88.86	91.19	91.98	90.68
	A_2	90.02	91.15	96.64	92.60
E_1	A_0	87.92	97.62	107.32	97.62
	A_1	105.03	105.78	108.34	106.38
	A_2	105.90	108.03	108.50	107.47
					Mean E
F*E	E_0	88.91	90.56	92.76	90.74
	E_1	99.62	103.81	108.05	103.82
					Mean A
F*A	A_0	87.90	93.47	98.49	93.29
	A_1	96.94	98.49	100.16	98.53
	A_2	97.96	99.59	102.57	100.04
Mean F		94.26	97.18	100.41	

LSD 5%						
F*E*A	E*A	F*A	F*E	A	E	F
4.39	2.54	3.11	2.54	1.79	1.46	1.79

Discussion

The superior growth and yield traits observed in Tables 2-7 due to the application of nanofertilizer NPK may be attributed to the unique properties and structure of the nanofertilizer, which allow it to deliver nutrients into plant tissues even under stressful conditions efficiently. The small size and high surface area of nanofertilizer particles facilitate their penetration through cell walls and easy access to vascular bundles, enhancing nutrient absorption by the plant. This increases nutrient concentration within plant tissues, thereby expanding leaf area. Nitrogen plays a role in boosting the levels of growth-promoting substances, amino acids, and nucleic acids in plant cells, which enhances root volume, increases cell division and elongation, and improves nutrient uptake efficiency. Consequently, this accelerates vegetative growth. The increase in leaf area may also be linked to potassium's role in enhancing nutrient absorption and maintaining turgor pressure, which improves water and nutrient uptake efficiency, thus expanding leaf area [15]. The rise in leaf chlorophyll content can be attributed to nitrogen's influence, as 78% of the nitrogen in plants is found in plastids, which is fundamental in chlorophyll synthesis. This enhances sunlight absorption due to the larger leaf area and increases photosynthetic efficiency because of the higher chlorophyll content. As a result, there is an increase in dry matter content and carbohydrate accumulation, which ultimately boosts yield, The reason for the increase in leaf area may be due to the role of potassium in increasing absorption and the occurrence of the turgor pressure process, which increases the absorption of water and nutrients, which is reflected in the increase in leaf area, which is positively reflected in the chlorophyll content of the leaves, and thus increases the yield. [16]. These findings are consistent with those reported by Abd et al. [17], Al-Jubouri [18], and Al-Mohammadi and Al-Dolaimi [19]. The increase resulting from applying the biofertilizer EM1 can be attributed to the fact that the microorganisms present in the fertilizer secrete chemical substances known as siderophores. These compounds chelate essential nutrients—particularly potassium, phosphorus, and nitrogen—making them more readily available to the plant. This enhances nutrient absorption and accumulation within plant tissues, thereby improving the plant's nutritional status. Consequently, vegetative growth is promoted through increased leaf area and chlorophyll content, which enhances the plant's photosynthetic capacity, leading to carbohydrate accumulation and a higher percentage of dry matter. Ultimately, this results in a greater yield [20]. These findings align with those of Hasaballah et al. [21] and Murugesh & Hanmugam [22].

The increase in growth and yield traits due to applying seaweed extract can be attributed to the enhanced nutrient content in palm trees. Spraying seaweed extracts led to improved nutrient uptake by the vegetative parts, compensating for deficiencies in plant tissues. This process activates auxins, which promote cell division and elongation, ultimately enhancing vegetative growth and increasing leaf area. As a result, there is an increase in chlorophyll content, improved photosynthesis, and the accumulation of synthesized nutrients in plant tissues. This contributes to greater fruit weight and, consequently, a higher overall yield [23]. These findings are consistent with those of Murad and Al-Dulaimy [24], Thajil and Blackt [25], Hashim [26], and Kurdy and Al-Dulaimy (27)

Conclusion:

The addition of nano fertilizer at a concentration of 100 gm palm^{-1} had a positive effect on all studied traits. Date palm trees of Khastawi variety showed a response to the addition of biofertilizer at a concentration of 20 mL^{-1}, as there was a clear improvement in vegetative growth and yield. Spraying with algae extract at a concentration of 2 mL^{-1} affected the growth strength of trees, fruit weight and yield.

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تأثير السماد النانوي NPK والسماد EM1 ومستخلص الأعشاب البحرية على بعض صفات النمو والحاصل لنخيل التمر صنف خستاوي.

مراد مالك إبراهيم المحمدي[1]   رسمي محمد حمد[2]

[1]دائرة فحص وتصديق البذور، الانبار، العراق.

[2]قسم البستنة وهندسة الحدائق، كلية الزراعة، جامعة الانبار، العراق.

الخلاصة

أجريت هذه الدراسة في أحد البساتين الخاصة في محافظة الانبار جمهورية العراق للموسم 2024 على أشجار نخيل التمر صنف خستاوي البالغة من العمر 16 سنة والتي أجريت عليها جميع عمليات الخدمة بشكل متماثل حيث تم اختيار 54 شجرة متجانسة مزروعة بطريقة نظامية على مسافة 9×9 نفذت كتجربة عامليه وفق تَصميم القِطاعات العشوائية الكاملة *RCBD* وبثلاث مكررات شملت الدراسة ثلاث عوامل تمثلت بإضافة ارضية للسماد النانوي *NPK* بتراكيز 0 و 50 و 100غم نخلة-1 والمُخصب الحَيوي بتَركيز 20 مل لتر-1 والرش بمستخلص الطحالب البحرية بتَركيز 0و1و2 مل لتر-1. اظهرت نتائج التَحليل الاحصائي ان عوامل الدراسة حققت نَتائج جيدة في صفات النمو الخضري والحَاصل للأشجار التي تم معاملتها حيث تفوقت معاملة المخصب الحيوي بتَركيز 20 مل لتر-1 على جميع المعاملات في صفة ومُحتوى الأوراق من الكلوروفيل44.47ملغم. 100غم-1 وزن طري ونسبة المادة الجافة في الأوراق56.78% ووزن الثمرة 10.81غم والحاصل الكلي103.82كغم نخلة، في حين تفوقت معاملة مستخلص الطحالب البحرية في صفة مساحة الورقة بقيمة بلغت 3.116م2 والنسبة المئوية للكربوهيدرات بقيمة بلغت 18.47%. اما عن التداخل الثنائي بين عوامل الدراسة فقد تفوقت معاملة التداخل بين السماد النانوي ومستخلص الطحالب البحرية بتركيز 100 غم+2 مل لتر-1 على باقي المعاملات في كل من صفة مساحة الورقة والتي بلغت 3.254م2 ونسبة الكربوهيدرات بلغت 19.12%، في حين تفوقت معاملة السماد النانوي والمخصب الحيوي 100غم+20مل لتر-1 في كل من صفة وزن الثمرة بلغ 11.27غم وحاصل النخلة 108.05 كغم نخلة-1 كما حققت معاملة التداخل بين المخصب الحيوي ومحفز النمو 20مل لتر-1+2مل لتر-1 اعلى القيم في كل من صفة محتوى الأوراق من الكلوروفيل والذي بلغ 45.50 ملغم100غم وزن طري ونسبة المادة الجافة التي بلغت 57.98% .وأظهرت نتائج التَداخل الثلاثي بين عوامل الدراسة وجود فُروق مَعنوية بين المعاملات حيث تفوقت معاملة التَداخل بين السماد النانوي (100غم) والمخصب الحيوي20مل لتر-1 ومستخلص الطحالب 2مل لتر-1 على جميع المعاملات للصفات المدروسة.

الكَلِمات المفتاحية: نخيل التمر، *NPK* نانوي، مخصبات حيوية،*EM1*، مستخلصات طحالب بحرية.