# Effect of Foliar Application of Methionine and Moringa oleifera Leaf Extract on some Growth and Yield Characteristics Date palm (*Phoenix dactylifera* L.) cv. Zahdi

Eman Hekmet Hassan[1*] Ahmed thamer homed[2*] And Abdul Kareem A.J. Mohammad Saeed [3*]

Department of Horticulture and Landscape ,College of Agriculture, University of [1].Diyala ,Iraq

Department of Horticulture and Landscape ,College of Agriculture, University of .[2]Diyala ,Iraq

Department of Horticulture and Landscape ,College of Agriculture, University of .[3]Diyala ,Iraq

*Corresponding authors email : emanhekmet @ uodiyala.edu.iq

## Abstract

The study was conducted in a private orchard located in Al-Huwaider district, Baqubah district, Diyala Governorate, during 2024, growing season to investigating the effect of spraying methionine and moringa leaf extract on some growth characteristics and yield of date palm cv. Zahdi. The experiment consisted of two factors. The first factor was foliar application of the amino acid methionine at three concentrations (0, 50, and 100 mg $L^{-1}$), while the second factor was foliar application of moringa leaf extract at three concentrations (0, 4%, and 8%). A Randomized Complete Block Design (R.C.B.D.) was used with three replicates. Thus, the total number of experimental units was 27, with one palm tree representing each experimental unit ،The results showed that the interaction between the studied factors resulted in significant differences in most of the studied traits compared with the control. The interaction between spraying methionine at 100 mg $L^{-1}$ and moringa leaf extract at 8% resulted in significant increases in leaf chlorophyll content and mineral nutrient concentrations (nitrogen, phosphorus, and potassium). It also improved the physical fruit characteristics, including fruit weight, length, and diameter, with values of (12.98 mg $g^{-1}$, 1.91%, 1.95%, 9.15 g, 34.39 mm, and 25.34 mm), respectively, compared with the control, which recorded the lowest values of (10.43 mg $g^{-1}$, 1.52%, 0.43%, 6.42 g, 30.18 mm, and 19.69 mm), respectively.

**Keywords**: Methionine, Moringa, Zahdi, chlorophyll, mineral elements.

ISSN 2072-3857

## Introduction

positively affect both the quantity and quality of yield when applied as foliar sprays at different growth stages, especially during critical periods such as the beginning of growth, flowering, or under stress conditions such as drought, high temperature, salinity, and frost. Consequently, amino acids contribute to reducing stress effects caused by drought or salinity through modifying the osmotic potential of plant tissues. They also significantly reduce damage caused by biotic stresses, stimulate physiological and biochemical processes, participate in carbohydrate synthesis, contribute to cell division, and promote the production of several natural growth hormones such as IAA and $GA_3$ , thereby increasing productivity (7). Methionine is considered one of the essential amino acids that is safe, inexpensive, and easy to use (20). It possesses a wide range of biological activities within the plant, including systemic resistance against diseases (8, 10). Moringa is considered one of the most important plant species currently used, as it represents a cheap and environmentally friendly organic source with effects similar to growth regulators due to its content of certain growth-promoting substances such as purine adenine and zeatin. Zeatin enhances antioxidant enzymes and protects cells from aging effects caused by reactive oxygen species. In addition, moringa leaves contain many mineral

Date palm is considered one of the most important trees of the Arecaceae family, occupying an important economic position in the agricultural sector from an economic perspective. It is also one of the oldest cultivated trees in Arab countries. Its importance is due to the high nutritional value of its fruits, which are rich in carbohydrates, minerals, and certain vitamins. Date fruits are regarded as foods with high caloric value (11). Iraq possesses more than 600 cultivars distributed throughout the central and southern regions. Some cultivars are more widespread in certain areas than in others, and some cultivars have been transferred from their original cultivation regions to other areas while retaining the same names or renamed in some regions. The Zahdi cultivar ranks first in terms of the number of cultivated palms and production quantity and is considered one of the most famous Iraqi cultivars (2). Dates are considered one of Iraq's national resources; however, date palm productivity has declined significantly due to several factors, including lack of attention and governmental support, infection of many palms with diseases, increased production costs disproportionate to market prices, and farmers' reluctance to care for palm orchards, all of which have led to reduced productivity (12). In this context, many studies have demonstrated that amino acids

ISSN 2072-3857

investigate the effect of using different concentrations of the amino acid methionine and moringa leaf extract, and to determine the optimum concentrations for improving certain growth characteristics and yield of the Zahdi cultivar

elements such as iron, magnesium, copper, potassium, zinc, and calcium, as well as vitamins A, B, C, and D (14, 17).

Due to the increasing recent interest in food quality and safety, reducing production costs, and adopting more sustainable agricultural systems to improve date palm production in Iraq, this study was conducted to

## Materials and Methods

metaxenia effects. Each palm was adjusted to six fruit bunches (thinning to six bunches per tree) to ensure uniform crop load across experimental units.

### Experimental Design and Treatments

The experiment was arranged as a 3 × 3 factorial experiment in a Randomized Complete Block Design (RCBD) with three replicates. Each experimental unit consisted of one palm tree (27 trees in total). Factor A consisted of methionine concentrations (0, 50, and 100 mg $L^{-1}$), while Factor B consisted of moringa leaf extract concentrations (0, 4, and 8%). Moringa extract was prepared by soaking 100 g of dried leaf powder in 1 L distilled water for 24 h (w/v), followed by filtration. The 4% and 8% concentrations were prepared by diluting the stock extract at 40 and 80 $mLL^{-1}$,respectively.

**FoliarApplication**

The experiment was conducted during the 2024 growing season (1 March–15 October 2024) in a private date palm orchard located in Al-Huwaider District, Baqubah, Diyala Governorate, Iraq (33.75° N, 44.64° E). The study aimed to evaluate the effect of foliar application of methionine and moringa (*Moringa oleifera* L.) leaf extract on growth and yield characteristics of date palm (*Phoenix dactylifera* L.) cv. Zahdi. Twenty-seven healthy, bearing, and regularly productive date palm trees of uniform vigor were selected from an established orchard. Soil characteristics are presented in Table (1). Standard horticultural practices were uniformly applied throughout the experimental period, and irrigation was conducted using river water via surface channels. Manual pollination was performed on 1 April 2024 using pollen from the Red Ghanami male cultivar (Ghanami Ahmar), which served as the sole pollen source for all trees to ensure uniform pollination and minimize

ISSN 2072-3857

and 663 nm. Leaf mineral nutrients (N, P, K) were determined from oven-dried samples (65–70°C) using wet digestion (Cresser and Parsons, 1979). Nitrogen was analyzed by the Micro-Kjeldahl method (Al-Sahaf, 1989), phosphorus by spectrophotometry at 620 nm (John, 1970), and potassium using a flame photometer(A.O.A.C., 1980). At the Tamar stage, fruit weight (g) was determined from 25 randomly selected fruits per bunch. Fruit length and diameter (mm) were measured on the same fruits using a vernier caliper

**StatisticalAnalysis**

Data were analyzed using SAS software based on ANOVA for factorial experiments in RCBD. Treatment means were compared using Duncan's Multiple Range Test at $P \leq 0.05$.

Foliar sprays were applied using a hand sprayer until complete wetting. All fruit bunches per tree and the leaves were treated. A non-ionic surfactant was added to all spray solutions at 0.1%. Moringa extract was applied three times at one-month intervals starting in April. Methionine was also applied three times, with the first application conducted three days after the initial moringa spray, followed by two subsequent sprays at monthly intervals.

**Biochemical and Fruit Measurements**

Total chlorophyll content (mg $g^{-1}$ fresh weight) was determined according to Goodwin (1976) using 80% acetone extraction and spectrophotometric readings at 645

**Table 1 shows some physical and chemical properties of the orchard soil.**

| Value | Measured property | N |
|---|---|---|
| **C.L clay loam** | Soil texture: clay loam mixture. | 1 |
| **29.2** | Sand (%) | 2 |
| **35.1** | Clay (%) | 3 |
| **35.7** | | 4 |
| **7.68** | pH (saturated paste extract) | 5 |
| **5.57** | E.C. (saturated paste extract) dS/m | 6 |

ISSN 2072-3857

| | | | |
|---|---|---|---|
| **51** | Available nitrogen (mg/kg or ppm) | | 7 |
| **8.2** | Available phosphorus (mg/kg or ppm) | | 8 |
| **128** | Available potassium (mg/kg or ppm) | | 9 |
| **1.10** | Organic matter (%) | | 10 |
| **28.0** | Calcium carbonate (lime) $CaCO_3$ (%) | | 11 |
| **342** | Calcium $Ca^{2+}$ (mg/L or ppm) | Dissolved positive and negative ions. | 12 |
| **156** | Magnesium $Mg^{2+}$ (mg/L or ppm | | 13 |
| **401** | Sodium $Na^{+}$ (mg/L or ppm) | | 14 |
| **39** | Potassium $K^{+}$ (mg/L or ppm) | | 15 |
| **774** | Chlorides $Cl^{-}$ (mg/L or ppm) | | 16 |
| **708** | Sulfates $SO_4^{2-}$ (mg/L or ppm) | | 17 |
| **355** | Bicarbonates $HCO_3^{-}$ (mg/L or ppm) | | 18 |
| **41** | Nitrates $NO_3^{-}$ (mg/L or ppm) | | 19 |
| **0.52** | Phosphates $PO_4^{3-}$ (mg/L or ppm) | | 20 |

ISSN 2072-3857

## Results

### 1- Chlorophyll Content in Leaves (mg $g^{-1}$ Fresh Weight)

mg $g^{-1}$ fresh weight, whereas the treatment sprayed with 4% extract, which recorded 8.51 mg $g^{-1}$ fresh weight, did not differ significantly from the control treatment, which gave the lowest value of 7.91 mg $g^{-1}$ fresh weight. The interaction between spraying with moringa leaf extract and the amino acid methionine had a significant effect on chlorophyll content. The interaction treatment between spraying moringa leaf extract at 8% and methionine at 100 mg $L^{-1}$ recorded the highest value of 12.98 mg $g^{-1}$ fresh weight. In contrast, the interaction treatment between methionine spraying at 50 mg $L^{-1}$ and moringa leaf extract spraying at 4% recorded the lowest value of 6.48 mg $g^{-1}$ fresh weight

The results presented in Table (2) showed significant effects among methionine amino acid spray treatments on leaf chlorophyll content. The spraying treatment with methionine at a concentration of 100 mg $L^{-1}$ recorded the highest value, reaching 10.42 mg $g^{-1}$ fresh weight. In contrast, the treatment sprayed with 50 mg $L^{-1}$, which recorded 8.15 mg $g^{-1}$ fresh weight, did not differ significantly from the control treatment, which recorded the lowest value of 8.13 mg $g^{-1}$ fresh weight. The treatments of spraying moringa leaf extract also showed significant effects on leaf chlorophyll content compared with the control treatment. The spraying treatment with moringa leaf extract at a concentration of 8% recorded the highest value of 11.21

ISSN 2072-3857

**Table (2)** Effect of spraying the amino acid methionine, moringa leaf extract, and their interaction on leaf chlorophyll content of the Zahdi cultivar (mg $g^{-1}$ fresh weight).

| Moringa leaf extract | Methionine amino acid | | | Moringa leaf extract Average |
|---|---|---|---|---|
| | 0 mg $L^{-1}$ | 50 mg $L^{-1}$ | 100 mg $L^{-1}$ | |
| 0 | 7.91 bc | 7.60 bc | 8.21 bc | 7.91 B |
| 4% | 8.99 bc | 6.48 c | 10.07 b | 8.51 B |
| 8% | 10.28 bc | 10.30 ab | 12.98 a | 11.19 A |
| | 8.13 B | 8.15 B | 10.42 A | Methionine amino acid Average |

**Means with the same letters are not significantly different at the 5% probability level**

## Nitrogen Concentration in Leaves (%)

treatment with moringa leaf extract at a concentration of 8% recorded the highest value of 1.79%, followed by the treatment sprayed with 4%, which recorded 1.64%, compared with the control treatment, which gave the lowest value of 1.33%. The interaction between spraying with moringa leaf extract and the amino acid methionine had a significant effect compared with the control treatment. The interaction treatment between spraying moringa leaf extract at 8% and methionine at 100 mg $L^{-1}$ recorded the highest value of 1.91%, compared with the control treatment, which recorded the lowest value of 1.27%.

The results presented in Table (3) showed significant effects among methionine amino acid spray treatments on nitrogen concentration in the leaves. The spraying treatment with methionine at a concentration of 100 mg $L^{-1}$ recorded the highest value of 1.66%, whereas the treatment sprayed with 50 mg $L^{-1}$, which recorded 1.56%, did not differ significantly from the control treatment, which recorded the lowest value of 1.53%. The treatments of spraying moringa leaf extract also showed significant differences in leaf nitrogen concentration compared with the control treatment. The spraying

ISSN 2072-3857

**Table (3) shows the effect of spraying the amino acid methionine, moringa leaf extract, and their interaction on nitrogen concentration in the leaves of the Zahdi cultivar (%).**

| Moringa leaf extract | Methionine amino acid | | | Moringa leaf extract Average |
|---|---|---|---|---|
| | 0 mg $L^{-1}$ | 50 mg $L^{-1}$ | 100 mg $L^{-1}$ | |
| 0 | 1.27 f | 1.33 ef | 1.40 e | 1.33 C |
| %4 | 1.63 cd | 1.60 d | 1.68 bcd | 1.64 B |
| %8 | 1.71 bc | 1.76 b | 1.91 a | 1.79 A |
| | 1.53 B | 1.56 B | 1.53 A | Methionine amino acid Average |

**Means with the same letters are not significantly different at the 5% probability level**

## Phosphorus Concentration in Leaves (%)

a concentration of 8% recorded the highest value of 0.38%, followed by the treatment sprayed with 4%, which recorded 0.27%, compared with the control treatment, which gave the lowest value of 0.22%. The interaction between spraying with moringa leaf extract and the amino acid methionine had a significant effect compared with the control treatment. The interaction treatment between spraying moringa leaf extract at 8% and methionine at 100 mg $L^{-1}$ recorded the highest value of 0.43%, compared with the control treatment, which recorded the lowest value of 0.20%.

The results presented in Table (4) showed significant effects among methionine amino acid spray treatments on phosphorus concentration in the leaves. The spraying treatment with methionine at a concentration of 100 mg $L^{-1}$ recorded the highest value of 0.32%, followed by the treatment sprayed with 50 mg $L^{-1}$, which recorded 0.28%, whereas the control treatment recorded the lowest value of 0.27%. The treatments of spraying moringa leaf extract also showed significant effects on phosphorus concentration in the leaves compared with the control treatment. The spraying treatment with moringa leaf extract at

ISSN 2072-3857

**Table (4) shows the effect of spraying the amino acid methionine, moringa leaf extract, and their interaction on phosphorus concentration in the leaves of the Zahdi cultivar (%).**

| Moringa leaf extract | Methionine amino acid | | | Moringa leaf extract Average |
|---|---|---|---|---|
| | 0 mg $L^{-1}$ | 50 mg $L^{-1}$ | 100 mg $L^{-1}$ | |
| 0 | 0.20 f | 0.23 e | 0.24 de | 0.22 C |
| %4 | 0.25 cd | 0.27 c | 0.28 c | 0.27 B |
| %8 | 0.35 b | 0.36 b | 0.43 a | 0.38 A |
| | 0.27 C | 0.28 B | 0.32 A | Methionine amino acid Average |

**Means with the same letters are not significantly different at the 5% probability level**

## Potassium Concentration in Leaves (%)

extract at a concentration of 8% recorded the highest value of 1.87%, followed by the treatment sprayed with 4%, which recorded 1.74%, compared with the control treatment, which gave the lowest value of 1.54%.

The interaction between spraying with moringa leaf extract and the amino acid methionine had a significant effect compared with the control treatment. The interaction treatment between spraying moringa leaf extract at 8% and methionine at 100 mg $L^{-1}$ recorded the highest value of 1.95%, compared with the control treatment, which recorded the lowest value of 1.52%.

The results presented in Table (5) showed significant effects among methionine amino acid spray treatments on potassium concentration in the leaves. The spraying treatment with methionine at a concentration of 100 mg $L^{-1}$ recorded the highest value of 1.77%, followed by the treatment sprayed with 50 mg $L^{-1}$, which recorded 1.70%, whereas the control treatment recorded the lowest value of 1.66%. The treatments of spraying moringa leaf extract also showed significant differences in potassium concentration in the leaves compared with the control treatment. The spraying treatment with moringa leaf

ISSN 2072-3857

**Table (5) shows the effect of spraying the amino acid methionine, moringa leaf extract, and their interaction on potassium concentration in the leaves of the Zahdi cultivar (%).**

| Moringa leaf extract | Methionine amino acid | | | Moringa leaf extract Average |
|---|---|---|---|---|
| | 0 mg $L^{-1}$ | 50 mg $L^{-1}$ | 100 mg $L^{-1}$ | |
| 0 | 1.52 f | 1.52 f | 1.57 e | 1.54 C |
| %4 | 1.65 d | 1.76 c | 1.81 b | 1.74 B |
| %8 | 1.82 b | 1.83 b | 1.95 a | 1.87 A |
| | 1.66 C | 1.70 B | 1.77 A | Methionine amino acid Average |

**Means with the same letters are not significantly different at the 5% probability level**

## Fruit Weight (g)

followed by the treatment sprayed with 4%, which recorded 7.18 g, compared with the control treatment, which gave the lowest value of 6.50 g. The interaction between spraying with moringa leaf extract and the amino acid methionine had a significant effect compared with the control treatment. The interaction treatment between spraying moringa leaf extract at 8% and methionine at 100 mg $L^{-1}$ recorded the highest value of 9.15 g, compared with the control treatment, which recorded the lowest value of 6.42 g

.

The results presented in Table (6) showed significant effects among methionine amino acid spray treatments on fruit weight. The spraying treatment with methionine at a concentration of 100 mg $L^{-1}$ recorded the highest value of 7.67 g, followed by the treatment sprayed with 50 mg $L^{-1}$, which recorded 7.48 g, whereas the control treatment recorded the lowest value of 7.37 g. The treatments of spraying moringa leaf extract also showed significant differences in fruit weight, where the spraying treatment with moringa leaf extract at a concentration of 8% recorded the highest value of 8.93 g,

ISSN 2072-3857

**Table (6) shows the effect of spraying the amino acid methionine, moringa leaf extract, and their interaction on fruit weight of the Zahdi cultivar (g).**

| Moringa leaf extract | Methionine amino acid | | | Moringa leaf extract Average |
|---|---|---|---|---|
| | 0 mg $L^{-1}$ | 50 mg $L^{-1}$ | 100 mg $L^{-1}$ | |
| 0 | 6.42 h | 6.42 h | 6.67 g | 6.50 C |
| %4 | 6.93 f | 7.14 e | 7.47 d | 7.18 B |
| %8 | 8.77 c | 8.89 b | 9.15 a | 8.93 A |
| | 7.37 C | 7.48 B | 7.67 A | Methionine amino acid Average |

**Means with the same letters are not significantly different at the 5% probability level**

## Fruit Length (mm)

a concentration of 8% recorded the highest value of 33.64 mm, followed by the treatment sprayed with 4%, which recorded 32.87 mm, compared with the control treatment, which gave the lowest value of 31.11 mm. The interaction between spraying with moringa leaf extract and the amino acid methionine had a significant effect compared with the control treatment. The interaction treatment between spraying moringa leaf extract at 8% and methionine at 100 mg $L^{-1}$ recorded the highest value of 34.39 mm, compared with the control treatment, which recorded the lowest value of 30.18 mm.

The results presented in Table (7) showed significant effects among methionine amino acid spray treatments on fruit length. The spraying treatment with methionine at a concentration of 100 mg $L^{-1}$ recorded the highest value of 33.10 mm, followed by the treatment sprayed with 50 mg $L^{-1}$, which recorded 32.49 mm, whereas the control treatment recorded the lowest value of 32.03 mm. The treatments of spraying moringa leaf extract also showed significant differences in fruit length compared with the control treatment. The spraying treatment with moringa leaf extract at

ISSN 2072-3857

**Table (7) shows the effect of spraying the amino acid methionine, moringa leaf extract, and their interaction on fruit length of the Zahdi cultivar (mm).**

| Moringa leaf extract | Methionine amino acid | | | Moringa leaf extract Average |
|---|---|---|---|---|
| | 0 mg $L^{-1}$ | 50 mg $L^{-1}$ | 100 mg $L^{-1}$ | |
| 0 | 30.18 h | 31.21 g | 31.94 f | 31.11 C |
| %4 | 32.80 e | 32.85 e | 32.97 d | 32.87 B |
| %8 | 33.10 c | 33.42 b | 34.39 a | 33.64 A |
| | 32.03 C | 32.49 B | 33.10 A | Methionine amino acid Average |

**Means with the same letters are not significantly different at the 5% .probability level**

**Fruit Diameter (mm)**

recorded the highest value of 24.14 mm, followed by the treatment sprayed with 4%, which recorded 20.52 mm, compared with the control treatment which gave the lowest value of 19.80 mm.
The interaction between spraying with moringa leaf extract and the amino acid methionine had a significant effect compared with the control treatment. The interaction treatment between spraying moringa leaf extract at 8% and methionine at 100 mg $L^{-1}$ recorded the highest value of 25.34 mm, compared with the control treatment which recorded the lowest value of 19.69 mm.

The results presented in Table (8) showed significant effects among methionine amino acid spray treatments on fruit diameter. The spraying treatment with methionine at a concentration of 100 mg $L^{-1}$ recorded the highest value of 22.16 mm, followed by the treatment sprayed with 50 mg $L^{-1}$, which recorded 21.36 mm, whereas the control treatment recorded the lowest value of 20.94 mm.
The treatments of spraying moringa leaf extract also showed significant differences in fruit diameter compared with the control treatment. The spraying treatment with moringa leaf extract at a concentration of 8%

ISSN 2072-3857

**Table (8) shows the effect of spraying the amino acid methionine, moringa leaf extract, and their interaction on fruit Diameter of the Zahdi cultivar (mm).**

| Moringa leaf extract | Methionine amino acid | | | Moringa leaf extract Average |
|---|---|---|---|---|
| | 0 mg $L^{-1}$ | 50 mg $L^{-1}$ | 100 mg $L^{-1}$ | |
| 0 | 19.69 f | 19.79 f | 19.92 fe | 19.80 C |
| %4 | 20.08 fe | 20.25 e | 21.22 d | 20.52 B |
| %8 | 23.04 c | 24.03 b | 25.34 a | 24.14 A |
| | 20.94 C | 21.36 B | 22.16 A | Methionine amino acid Average |

**Means with the same letters are not significantly different at the 5% .probability level**

## Discussion

plant is reflected in improved fruit weight and size. The improvement may also be attributed to the contribution of methionine in indirectly enhancing photosynthetic efficiency through the regulation of hormonal balance and increasing chlorophyll formation (Table (2)), which leads to higher carbohydrate production and translocation to the fruits. Alternatively, the effect of methionine spraying may be related to its role in promoting plant growth through its involvement as a primary precursor in the synthesis of polyamines within plant cells, as methionine is converted into S-adenosylmethionine, which directly enters the polyamine biosynthesis

The significant differences recorded in most of the studied physical characteristics (fruit weight, length, and diameter) following spraying fruit bunches and the apical growing point with the amino acid methionine may be attributed to its role in enhancing protein and enzyme synthesis. Being a sulfur-containing amino acid and a source of nitrogen and sulfur, methionine participates in the formation of many vital biological compounds. This role leads to increased enzymatic activity associated with cell division and cell elongation, resulting in improved fruit dimensions. Therefore, the enhancement in the efficiency of physiological processes within the

ISSN 2072-3857

plant's nutritional status and metabolic activity. Methionine is an important source of nitrogen and sulfur, both of which are essential elements in the formation of chlorophyll and its associated proteins. In addition, methionine stimulates growth processes and increases the content of mineral elements in leaves, which enhances photosynthetic efficiency and leads to higher chlorophyll accumulation. These results are consistent with those reported by (15). The results of the study also showed that spraying fruit bunches and the apical growing point with moringa leaf extract caused significant differences in most physical fruit characteristics compared with the control treatment, with responses varying according to the concentrations used. This improvement may be explained by the fact that moringa extract contains plant hormones, particularly cytokinins, most notably zeatin, which is one of the most common cytokinin compounds. Cytokinins play an important role in cell division and elongation, as well as in regulating and redistributing photosynthetic products and directing nutrient translocation toward the fruits, which act as strong sinks. This contributes significantly to increasing fruit and seed weight (22, 5). These findings are consistent with those reported by (18) on date palm cultivar Salimi, and (16) on Khadrawi date palms

pathway (19). Polyamine levels are closely associated with rates of cell division; thus, their increase leads to enhanced tissue growth and increased biomass (9).

The increase in the leaf content of mineral elements (nitrogen, phosphorus, and potassium) may be explained by the improvement in the plant's physiological status, the reduction of oxidative stress, and the enhancement of metabolic processes, which in turn lead to improved absorption and translocation of nutrients within the plant. Al Saif et al. (2024) reported that foliar spraying with amino acids, including methionine, resulted in a clear improvement in the mineral content of peach leaves, where treatments showed a significant increase in the concentration of (N, P, and K). Different amino acid treatments also showed superiority in the content of these elements, particularly at higher concentrations and when using combinations of amino acids, reflecting the positive effect of these treatments on the nutritional status of the plant. These results are consistent with those reported by( 1) on mango trees, and with those reported by (15) on grapevines.

The increase in leaf chlorophyll content following spraying with the amino acid methionine may be attributed to its role in improving the

ISSN 2072-3857

uptake and translocation within the plant, resulting in their accumulation in leaf tissues (4).
The increase in leaf chlorophyll content (Table (2)) after spraying with moringa leaf extract may also be explained by its role as a biostimulant rich in nutrients and plant hormones, including nitrogen, magnesium, and iron. These components are directly involved in chlorophyll biosynthesis or stimulate its formation, leading to increased chlorophyll content in leaves. Furthermore, the extract contains antioxidants that reduce oxidative stress within cells and protect chlorophyll from degradation (13)

The increase in leaf mineral content of nitrogen, phosphorus, and potassium (Table (3-4-5)) following foliar application of moringa leaf extract may be attributed to the fact that the extract acts as a direct source of these nutrients when applied as a foliar spray, due to its relatively high content of essential mineral elements and its ease of absorption through leaf surfaces, leading to increased concentrations within plant tissues (21). In addition, the moringa extract contains bioactive compounds such as amino acids and growth regulators that contribute to improving membrane permeability and enhancing the efficiency of nutrient

## References

nano-potassium on the yield and fruit quality of date palm. Horticulturae, 9(10), 1137.

**4-Al‑ Saif, A. M., Sas‑ Paszt, L., Saad, R. M., and Mosa, W. F. A. (2024).** Amino acids as safe biostimulants to improve the vegetative growth, yield, and fruit quality of peach. BioResources, 19(3), 5978–5993.

**5-Anwar, F., Latif, S., Ashraf, M., and Gilani, A. H. (2007).** Moringa oleifera: a food plant with multiple medicinal uses. Phytotherapy Research: An International Journal Devoted to Pharmacological and Toxicological Evaluation

**1-Abd-Elall, E. H. (2022**). Amino acids application improves Mango Ewaise (Mangifera indica L.) trees growth and fruit quality. Journal of Sohag Agriscience (JSAS), 7(2), 239–248

**2Al-Bakr, Abd Al-Jabbar (1972).** Date Palm: Its Past, Present, and the New Developments in Its Cultivation, Industry, and Trade. Al-Aani Press, Baghdad, Iraq.

**3-Al-Saif, A. M., Sas-Paszt, L., Saad, R. M., Abada, H. S., Ayoub, A., and Mosa, W. F. A. (2023).** Biostimulants and

ISSN 2072-3857

of Natural Product Derivatives, 21(1), 17-25

**6-Bakhsh, A. ،Javaad, H. W., Hussain ،F., Akhtar ،A., and Raza, M. K. (2020).** Application of Moringa oleifera leaf extract improves quality and yield of peach (Prunus persica). Journal of Pure and Applied Agriculture, 5(2), 42-51.

**7-Baqir, H. A., Zeboon, N. H., and Al-Behadili, A. A. J. (2019).** The role and importance of amino acids within plants: A review. Plant Archives, 19(2), 1402

**8-Boubakri, H., Wahab, M. A., Chong, J., Gertz, C., Gandoura, S., Mliki, A., ... and Soustre-Gacougnolle, I. (2013).** Methionine elicits H2O2 generation and defense gene expression in grapevine and reduces Plasmopara viticola infection. Journal of Plant Physiology, 170(18), 1561-1568.

**9-Galston, A. W., and Sawhney, R. K. (1990).** Polyamines in plant physiology. Plant Physiology, 94(2), 406–410.

**10-Hasabi V, Askari H, Alavi S, Zamanizadeh H. (2014)**. Effect of amino acid application on induced resistance against citrus canker disease in lime plants. Journal of Plant Protection Research, 54, 144–149.

**11-Ibrahim, Abd Al-Basit Ouda (2008).** Date Palm: The Tree of Life. Arab Center for the Studies of Arid and Dry Lands, Damascus, Syria, 390 pp.

**12-Khalil, Mahmoud Hameed, and Al-Tamimi, Raja Latif Jassim. (2023).** The reality of date palm cultivation in Iraq for the period 2010–2020: An analytical study. Al-Ghary Journal of Economic and Administrative Sciences, 19(4), 26–40.

**13-Mashamaite, C. V., Ngcobo, B. L., Manyevere, A., Bertling, I., and Fawole, O. A. (2022).** Assessing the usefulness of Moringa oleifera leaf extract as a biostimulant to supplement synthetic fertilizers: A review. Plants, 11(17), 2214.

**14-Mbikay, M. (2012).** Therapeutic potential of Moringa oleifera leaves in chronic hyperglycemia and dyslipidemia: a review. Frontiers in pharmacology, 3, 24.

**15-Mekawy, A.Y. (2019).** 'Response of Superior Seedless Grapevines to Foliar Application with Selenium, Tryptophan and Methionine',

ISSN 2072-3857

**Sauter, M., and Geeraerd, A. H. (2013).** S-adenosyl-L-methionine usage during climacteric ripening of tomato in relation to ethylene and polyamine biosynthesis and transmethylation capacity. Physiologia Plantarum, 148(2), 176–188.

**20-Willke T.( 2014) .** Methionine production -A critical review Applied Microbiology and Biotechnology , 98, 9893–9914

**21-Yasmeen, A., Basra, S. M. A., Farooq, M., Rehman, H. U., Hussain, N., and Athar, H. U. R. (2013).** Exogenous application of moringa leaf extract modulates the antioxidant enzyme system to improve wheat performance under saline conditions. Plant Growth Regulation, 69(3), 225–233

**22-Zhang, X., and Ervin, E. (2004).** Cytokinin-containing seaweed and humic acid extracts associated with creeping bentgrass leaf cytokinins and drought resistance. Crop science, 44(5), 1737-1745

Journal of Plant Production, 10(12), pp. 967–972.

**16-Moustafa, A., Abdel-Hamid, N. A., Abd El-Hamid, A. A., El-Sonbaty, M. R., and Abd El-Naby, S. K. M. (2018).** Improving fruit set, yield and fruit quality of khadrawi date palm cultivar. Arab Universities Journal of Agricultural Sciences, 26(Special issue (2B)), 1461-1470.

**17-Oladeji, O. A., Taiwo, K. A., Gbadamosi, S. O., Oladeji, B. S., and Ishola, M. M. (2017).** Studies on Chemical Constituents and Nutrients Bioavailability in Moringa oleifera Leaf and Seed. Journal of Scientific Research and Reports, 14(1), 1–12..

**18-Thabet, A.Y.I., Abdel-Hak, R.S., Ashour, N.E., and Hassan, H.S.A. (2022).** Influence of foliar application with moringa (*Moringa oleifera* L.) aqueous leaf extract on fruit set, yield and fruit quality of Selmy date palms. Egyptian Journal of Chemistry, 65(9), 119–126

**19-Van de Poel, B., Bulens, I., Oppermann, Y., Hertog, M. L. A. T. M., Nicolai, B. M.,**