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Response of Apple Trees Performance to Moringa Extract, Humic Acid, and Liquid Organic Fertilizers (Vit-Org)

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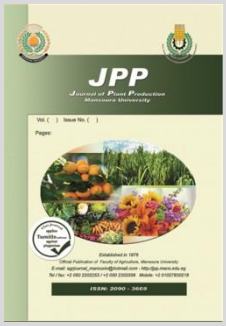

ABSTRACT

To explore the potential synergistic effects of combining bio-stimulants and organic fertilizers on the growth performance of five-year-old Ibrahimi apple trees grafted on Quince rootstock, a research study was conducted aiming to examine the effects of moringa leaf extract applied through the foliar application, along with liquid organic fertilizer applied to the soil, and soil addition of humic acid at different doses. The moringa leaf extract was applied at doses of 0.0, 10.0, and 20.0 g/L, while the liquid organic fertilizer was applied at doses of 0.0 and 10.0 ml/tree. Additionally, humic acid was applied to the soil at doses of 0.0, 5.0, and 10.0 g/tree. The primary focus of this research was to assess the combined impact of these treatments on the growth performance of the Ibrahimi apple cultivar trees. The growth performance of the apple trees was evaluated using various parameters, including leaf area, leaf chlorophyll contents, leaf dry weight, and shoot length. The results indicated that increasing the rate of moringa leaf extract led to an increase in these parameters, while the control treatment showing the lowest values. Similarly, the application of liquid organic fertilizer resulted in increased values for all the studied parameters. Additionally, as the rate of humic acid increased, the values of the parameters also increased, while the control treatment exhibited the lowest values. Moreover, the interactions between the study factors, both twice and triple had a significant impact on all the studied aspects of vegetative growth.

Keywords: Moringa extract, humic acid, organic fertilizers, apple tree.

INTRODUCTION

Apple tree (*Malus domestica* Borkh) holds great importance as a member of the Rosaceae family and is widely grown across the globe. It is believed to have originated in the southern Caucasus region and has been cultivated in East Asia for thousands of years (Bhusal *et al.* 2018). In Iraq, there is an estimated population of 2,632,229 apple trees, which collectively yield a production of around 79,413 tons of apples. On average, each tree produces approximately 30.17 kg of fruit (FAO, 2021). Apples play a vital role in Iraq's economy as they provide employment opportunities in rural areas and contribute to both domestic consumption and export revenue. By adhering to quality standards and employing efficient post-harvest practices, Iraqi apple producers can access international markets, thereby increasing foreign exchange earnings. Furthermore, apple cultivation allows farmers to diversify their agricultural activities, reducing dependence on a single crop and spreading income sources. This diversification promotes agricultural sustainability and mitigates risks associated with market fluctuations and crop-specific challenges (Al-Hadethi *et al.* 2016).

The overutilization of chemical fertilizers in fruit orchards can have detrimental effects on tree growth and the environment. Exceeding the recommended limits of these fertilizers can result in groundwater pollution and the escalation of soil salinity, posing negative consequences for both the economy and overall growth and production (Liu and Wu, 2022). Consequently, there has been a shift towards the adoption of bio stimulants like moringa extract, humate substances, and organic fertilizers as a more sustainable alternative (Pylak *et al.* 2019).

Moringa extract, derived from the leaves of the *Moringa oleifera* tree, has potential effects on plant growth and development, including apple trees. Its nutrient-rich composition, including nitrogen, phosphorus, potassium, and micronutrients, can supplement the nutritional needs of apple trees and facilitate improved nutrient uptake for enhanced growth. Additionally, moringa extract stimulates root growth in apple trees, leading to better nutrient absorption and overall plant vitality. The extract's abundance of bioactive compounds, such as antioxidants and phytochemicals, contributes to strengthening the tree's natural defense mechanisms against pests and diseases, safeguarding the apple trees from various pathogens that may pose a threat (Rani *et al.* 2018; and Meireles *et al.* 2020).

Humic acid is a type of organic compound derived from humus, which is the organic component of soil and offers numerous benefits to apple trees. It enhances nutrient availability and uptake by facilitating the chelation of essential nutrients, leading to improved overall nutrient status and growth. Furthermore, Humic acid stimulates root growth, increasing the surface area for nutrient absorption through the proliferation of root hairs. This results in stronger root systems, enabling better water and nutrient extraction from the soil. Humic acid also improves the tolerance of apple trees to abiotic stresses like drought, high temperatures, and salinity by enhancing soil water-

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holding capacity and mitigating negative environmental effects. Additionally, it improves soil structure and nutrient availability, further supporting the trees' health and productivity (Hidayatullah *et al.* 2018; Al-Marsoumi and Al-Hadethi, 2020; and Zydlik *et al.* 2021).

Organic fertilizers in liquid form offer several advantages and are convenient to prepare. They are free from weed seeds, fungi, and pathogens, ensuring a safer application. These fertilizers can be easily applied to vegetative crops, incorporated into the soil, or mixed with irrigation water. The simplicity of their usage contributes to their importance and provides various benefits (Al-Aareji and Al-Barwari, 2017; El Shawish, 2018; El-Shamy *et al.* 2022; Elsherpiny *et al.* 2023).

Therefore, the objective of this study was to evaluate the response of apple tree performance to moringa extract, humic acid, and liquid organic fertilizers (Vit-Org).

MATERIALS AND METHODS

The objective of this current trail was to assess the impact of applying Moringa leaf extract (MLE) through spraying, as well as the application of humic acid and liquid organic fertilizer (Vit-Org) to the soil, on the growth performance of "Ibrahimi" apple trees.

1.Experimental site and nature of the studied trees

For the 2021 growing season, this research was conducted on "Ibrahimi" apple trees (*Malus domestica* Borkh). The trees, which were around 5 years old and grafted onto quince rootstock, were planted in a private apple orchard located in Youssoufia city, situated in the south-west of Baghdad Governorate. The soil in this area is predominantly clay. All the trees selected for the study were healthy and exhibited similar vigor and size.

2.Soil sampling

The soil samples were analyzed using the standard procedures outlined by Sparks *et al.* (2020) and Dane and Topp (2020), as the physical and chemical properties of tested orchard soil are shown in Table 1.

3.Experimental design and treatments

The moringa leaf extract was applied at doses of 0.0 (control, M_0), 10.0 (M_{10}), and 20.0 (M_{20}) g/L, while the liquid organic fertilizer was applied at doses of 0.0 (V_0) and 10.0 (V_{10}) ml/tree. Additionally, humic acid was applied to the soil at doses of 0.0 (H_0), 5.0 (H_5), and 10.0 (H_{10}) g/tree.

In this experiment, a factorial experiment in a randomized complete block design (RCBD) was employed with three replications. The experimental units consisted of individual trees, and each treatment was replicated three times. A total of fifty-four trees from the Ibrahimi apple cultivar were selected as the sample for this study.

4. Treatments application experimental setup

Spraying operations were conducted three times, with two sprays carried out in the spring and one in September. Additionally, the soil was treated with the application of humic acid and liquid organic fertilizer. The experimental trees were subjected to typical agricultural practices commonly followed in commercial apple orchards. These practices included irrigation, fertilization, pruning, and pest control, all of which were implemented according to standard agro-technical procedures.

Table1. Properties of orchard soil under experimental trees

Particle size distribution			Textural Class	EC*	pH**	Field capacity	Organic matter	Total $CaCO_3$	Available N	Available P	Available K
(%)				(dsm^{-1})			(%)			(mg Kg^{-1})	
Clay	Silt	Sand	Clay	0.78	7.82	38.6	1.46	1.3	136	14.2	277
50.02	29.88	20.10									

5. Measurements

- **Leaf Area (cm^2):** Randomly selected five leaves from the middle portion of the shoot were collected, and their respective leaf areas (in cm^2) were measured. The Digimizer program, operating on the Windows 7 system, was utilized for this measurement.
- **Leaf Chlorophyll Contents (mg g^{-1} fresh weight):** Fresh leaf samples representing the middle part of the shoots were collected during the first week of June. These samples were then subjected to colorimetric chlorophyll analysis, following the method outlined by **Mackinney (1941).** The chlorophyll content was expressed in milligrams per gram of fresh weight**.**
- **Leaf Dry Weight (%):** Several leaves were gathered for sampling purposes and weighed. Subsequently, the leaves were dried until a stable weight was achieved. The percentage of dry matter was calculated by dividing the post-dry weight by the pre-dry weight and multiplying by 100.
- **Shoot Length (cm):** Four branches were selected from each experimental unit, and their lengths were measured using a metric tape at the beginning and end of the experiment. The difference between these measurements represents the shoot length change over the course of the experiment.

6.Statistical analysis

The collected data were organized into a table and analyzed statistically using a factorial experimental design with three replicates. The results obtained were subjected to analysis of variance (ANOVA) following the approach outlined by Elsahookie and Wuhaib (1990). To determine significant differences between the means of various treatments, a Least Significant Difference (LSD) test at a significance probability level of 0.05 was employed.

RESULTS AND DISCUSSION

Results

1.Leaf area (cm^2)

The effects of various therapies on leaf area are summarized in Table 2. According to the data, the application of 20 gm L^{-1} of moringa leaf extract (M_{20}) resulted in a significant increase in leaf area (20.98 cm^2), compared to the lower value of 18.89 cm^2 which was observed with the control treatment (M_0). Table 2 also indicates that adding 10 g of humic acid to the soil (H_{10}) led to a maximum leaf area value (20.72 cm^2), while the control treatment (H_0) exhibited a lower leaf area value.

Furthermore, Table 2 demonstrates that the soil application of liquid organic fertilizers (Vit-Org) at a rate of 10 ml resulted in Tree-1 (V_{10}) having the highest leaf area of 20.47 cm^2, while the control treatment (V_0) had a lower leaf area of 19.52 cm^2.

The interaction between the spray of moringa leaf extract and the soil application of humic acid significantly influenced the leaf area, particularly in the ($M_{20}H_{10}$) treatment, which gave the highest value of 21.98 cm^2, while the (M_0H_0) treatment had a lower leaf area of 18.33 cm^2. Regarding the interaction between the spray of moringa leaf extract and the soil application of liquid organic fertilizers (Vit-Org), the data in Table 2 show that the (M20V10) treatment resulted in the highest leaf area of 21.58 cm^2, while the (M_0V_0) treatment had a lower leaf area of 18.50 cm^2. The interaction between the soil application of humic acid and the liquid organic fertilizer significantly affected the leaf area, particularly in the ($H_{10}V_{10}$) treatment, which produced the highest value of 21.45 cm^2, compared to the control treatment (H_0V_0) with the lowest value of 19.11 cm^2.

Table 2. Response of leaf area (cm^2) of "Ibrahimi" apple trees to Moringa Extract, Humic Acid, and Liquid Organic Fertilizers (Vit-Org)

Vit-Org (V)	Humic Acid (H)	Moringa Leaves Extract (M)			V × H
		M_0	M_{10}	M_{20}	
	H_0	18.16	19.34	19.83	19.11
V_0	H_5	18.44	19.72	20.22	19.46
	H_{10}	18.89	19.98	21.10	19.99
	H_0	18.50	19.90	20.24	19.55
V_{10}	H_5	19.14	20.44	21.64	20.41
	H_{10}	20.22	21.26	22.86	21.45
L.S.D 0.05			1.57		0.91
		V × M			V
V_0		18.50	19.68	20.38	19.52
V_{10}		19.29	20.53	21.58	20.47
L.S.D 0.05			0.91		0.52
		H × M			H
H_0		18.33	19.62	20.04	19.33
H_5		18.79	20.08	20.93	19.93
H_{10}		19.56	20.62	21.98	20.72
L.S.D 0.05			1.11		0.64
M		18.89	20.11	20.98	
L.S.D 0.05			0.64		

Notably, the triple interaction between the study factors had a significant effect on the leaf area, particularly in the ($M_{20}H_{10}V_{10}$) treatment, which gave the highest value of 22.86 cm^2, while the control treatment ($M_0H_0V_0$) had the lowest value of 18.16 cm^2.

2. Leaf chlorophyll contents (mg g^{-1} fresh weight)

Table 3 shows the effect of the studied treatments on leaf chlorophyll contents (mg g^{-1} fresh weight). The data illustrate that increasing the rate of moringa leaf extract led to an increase in the leaf chlorophyll contents, with the control treatment showing the lowest values. Similarly, the application of liquid organic fertilizer resulted in increased values for leaf chlorophyll contents. Additionally, as the rate of humic acid increased, the values of the leaf chlorophyll contents also increased, while the control treatment exhibited the lowest values. Moreover, the interactions between the study factors, both twice and triple had a significant impact on all the studied aspects of vegetative growth.

Table 3. Response of leaf chlorophyll contents (mg g^{-1}) of "Ibrahimi" apple trees to Moringa Extract, Humic Acid, and Liquid Organic Fertilizers (Vit-Org)

Vit-Org (V)	Humic Acid (H)	Moringa Leaves Extract (M)			V × H
		M_0	M_{10}	M_{20}	
	H_0	23.68	24.26	26.87	24.94
V_0	H_5	24.04	24.68	29.38	26.03
	H_{10}	24.88	25.74	30.56	27.06
	H_0	24.12	25.28	30.22	26.54
V_{10}	H_5	24.92	26.45	31.27	27.54
	H_{10}	26.16	27.98	33.26	29.13
L.S.D 0.05			2.04		1.18
		V × M			V
V_0		24.20	24.89	28.93	26.00
V_{10}		25.06	26.57	31.58	27.73
L.S.D 0.05			1.18		0.68
		H × M			H
H_0		23.90	24.77	28.54	25.73
H_5		24.48	25.56	30.32	26.78
H_{10}		25.52	26.86	31.91	28.09
L.S.D 0.05			1.44		0.83
M		24.63	25.73	30.25	
L.S.D 0.05			0.83		

3. Leaf dry weight (%)

Table 4 provides information on the impact of treatments on leaf dry weight Data demonstrated that 20 gL^{-1} of moringa leaf extract (M_{20}) considerably increased leaf dry weight. weight was 40.63%, while the lower values for leaf dry weight in the control treatment were 36.60% (M_0). Table (4.1.c) also demonstrates that humic acid applied to soil at 10 $gTree^{-1}$ (H_{10}) gave the highest leaf dry weight of 39.99 %. Moreover, the control treatment had a lower value for leaf dry weight, (H_0). Table 4 demonstrates that the application of liquid organic fertilizers to soil (Vit-Org) at 10 $mlTree^{-1}$ (V_{10}) the greatest leaf dry weight of 39.31%, while the control treatment's leaf dry weight was lower, (V_0) of 37.52 %.

Table 4. Response of leaf dry weight (%) of "Ibrahimi" apple trees to Moringa Extract, Humic Acid, and Liquid Organic Fertilizers (Vit-Org)

Vit-Org (V)	Humic Acid (H)	Moringa Leaves Extract (M)			V × H
		M_0	M_{10}	M_{20}	
	H_0	34.56	35.66	37.36	35.86
V_0	H_5	35.78	37.12	40.06	37.65
	H_{10}	37.15	38.74	41.26	39.05
	H_0	35.00	36.27	39.88	37.05
V_{10}	H_5	37.85	40.12	41.90	39.96
	H_{10}	39.22	40.26	43.28	40.92
L.S.D 0.05			2.04		2.85
		V × M			V
V_0		35.83	37.17	39.56	37.52
V_{10}		37.36	38.88	41.69	39.31
L.S.D 0.05			1.65		0.95
		H × M			H
H_0		34.78	35.97	38.62	36.46
H_5		36.82	38.62	40.98	38.81
H_{10}		38.19	39.50	42.27	39.99
L.S.D 0.05			2.02		1.16
M		36.60	38.03	40.63	
L.S.D 0.05			1.16		

In particular, the triple interactions between the research variables had a considerable impact on leaf dry weight ($M_{20}H_{10}V_{10}$) treatment and gave the highest leaf dry weight of 43.28 % as compared with control treatment ($M_0H_0V_0$) which gave the lowest values for this trait of 34.56 %.

The interactions between spraying a moringa leaf extract and applying humic acid to the soil had a substantial impact on the leaf's dry weight, particularly the interaction treatment. ($M_{20}H_{10}$) gave the highest leaf dry weight of 42.27 %, while lower leaf dry weight values were 34.73% in (M_0H_0) treatment. As for spraying moringa leaf extract and their interaction with soil application of liquid organic fertilizers (Vit-Org), data in Table 4 cleared that ($M_{20}V_{10}$) treatment gave the highest leaf dry weight of 41.69 %, while lower value of this trait was 35.83 % in (M_0V_0) treatment. Interaction between soil application of humic acid and liquid organic fertilizer significantly effect in leaf dry weight especially at ($H_{10}V_{10}$) treatment" and gave the highest leaf dry weight of 40.92 % as compared with control treatment (H_0V_0) which gave the lowest values for this trait of 35.86 %.

4.Shoots length (cm)

Table 5 indicates that there was a significant increase in shoot length with spraying with moringa leaf extract, where the treatment (M_{20}) gave the highest averages for this trait amounting to 26.68 cm, which was significantly superior to the rest two treatments. The results also confirm that increase in concentrations of addition of humic acid led to an increase in shoot length, as third treatment 10 g.Tree-1 (H_{10}) was significantly superior to treatment (H_5) and (H_0), which gave 24.81 cm. Table 5 also shows that the soil application of liquid organic fertilizers (Vit-Org) at 10 ml.Tree-1 (V_{10}) gave the highest shoot length of 34.34 cm, while lower value in shoot length was in control treatment (V_0) of 21.76 cm.

Table 5. Response of shoot length (cm) of "Ibrahimi" apple trees to Moringa Extract, Humic Acid, and Liquid Organic Fertilizers (Vit-Org)

Vit-Org (V)	Humic Acid (H)	Moringa Leaves Extract (M)			V × H
		M_0	M_{10}	M_{20}	
V_0	H_0	18.65	19.48	23.46	20.53
	H_5	19.00	21.00	25.02	21.67
	H_{10}	19.24	22.37	27.66	23.09
V_{10}	H_0	19.20	22.30	25.16	22.22
	H_5	20.68	24.16	28.00	24.28
	H_{10}	21.94	26.88	30.76	26.53
L.S.D 0.05			1.57		2.79
		V × M			V
V_0		18.96	20.95	25.38	21.76
V_{10}		20.61	24.45	27.97	24.34
L.S.D 0.05			1.61		0.93
		H × M			H
H_0		18.93	20.89	24.31	21.38
H_5		19.84	22.58	26.51	22.98
H_{10}		20.59	24.63	29.21	24.81
L.S.D 0.05			1.97		1.14
M		19.79	22.70	26.68	
L.S.D 0.05			1.41		

The interactions between moringa leaves extract spray and soil application of humic acid significantly affected in shoot length especially the interaction treatment ($M_{20}H_{10}$) gave the highest increased in shoot length of 29.21 cm, while lower values of increased of shoot length was 18.93 cm in (M_0H_0) treatment. As for spraying moringa leaf extract and their interaction with soil application of liquid organic fertilizers (Vit-Org), data in Table 5 cleared that ($M_{20}V_{10}$) treatment gave the highest increased in shoot length of 27.97 cm, while lower value of this trait was 18.96 cm in (M_0V_0) treatment. Interaction between soil application of humic acid and liquid organic fertilizer significantly effect in increased in shoot length especially at ($H_{10}V_{10}$) treatment and gave the highest value of 26.53 cm as compared with control treatment (H_0V_0) which gave the lowest values for this trait of 20.53 cm.

Triple interactions between study factors had a significant effect in shoot length specially ($M_{20}H_{10}V_{10}$) treatment and gave the highest shoot length of 30.76 cm as compared with control treatment ($M_0H_0V_0$) which gave the lowest values for this trait of 18.65 cm.

Discussion

The superiority of moringa extract rates compared to control may be attributed to its nutrient-rich composition, including nitrogen, phosphorus, potassium, and micronutrients, which can supplement the nutritional needs of apple trees and facilitate improved nutrient uptake for enhanced growth. Additionally, moringa extract stimulates root growth in apple trees, leading to better nutrient absorption (Abd El-Hady and Shehata, 2019) and overall plant vitality. The extract's abundance of bioactive compounds, such as antioxidants and phytochemicals, contributes to strengthening the tree's natural defense mechanisms against pests and diseases, safeguarding the apple trees from various pathogens that may pose a threat. These results are in harmony with those of Rani *et al.* (2018); Meireles *et al.* (2020).

The superiority of humic acid rates compared to control may be due to it offers numerous benefits to apple trees. It enhances nutrient availability and uptake by facilitating the chelation of essential nutrients, leading to improved overall nutrient status and growth (Hamail *et al.* 2014 a, b, c). Furthermore, Humic acid stimulates root growth, increasing the surface area for nutrient absorption through the proliferation of root hairs. This results in stronger root systems, enabling better water and nutrient extraction from the soil. Humic acid also improves the tolerance of apple trees to abiotic stresses like drought, high temperatures, and salinity by enhancing soil water-holding capacity and mitigating negative environmental effects. Additionally, it improves soil structure and nutrient availability, further supporting the trees' health and productivity. These results are in agreement with those of Hidayatullah *et al.* (2018); and Zydlik *et al.* (2021).

The superiority of liquid organic fertilizers compared to control may be due to their liquid form offering several advantages and being convenient to prepare. They are free from weed seeds, fungi, and pathogens, ensuring a safer application. These fertilizers can be easily applied to vegetative crops, incorporated into the soil, or mixed with irrigation water. Similar results were found by Al-Aareji and Al-Barwari, (2017); and El Shawish, (2018).

CONCLUSION

Based on the results presented, it can be concluded that the application of moringa leaf extract, humic acid, and liquid organic fertilizer had significant effects on leaf area, leaf chlorophyll content, leaf dry weight, and shoot length in "Ibrahimi" apple trees. The interactions between these treatments further influenced the observed parameters. These findings suggest the potential of these treatments to enhance the growth and physiological characteristics of apple trees.

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استجابة أشجار التفاح لمستخلص المورينجا وحمض الهيوميك والأسمدة العضوية السائلة (فيت-أورج)

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الملخص

لاستكشاف التأثيرات المحتملة للجمع بين المحفزات الحيوية والأسمدة العضوية على أداء نمو أشجار التفاح الإبراهيمي (التي يبلغ عمرها خمس سنوات المطعمة على أصل Quince)، تم إجراء دراسة بحثية كان هدفها هو تقييم تأثير الرش الورقي لمستخلص أوراق المورينجا، جنبًا إلى جنب مع الاضافة الأرضية للأسمدة العضوية السائلة، وكذلك الإضافة الارضية لحمض الهيوميك بجرعات مختلفة. مستخلص أوراق المورينجا كان بجرعات ٠,٠ و١٠,٠ و٢٠,٠ جم/لتر، بينما تم اضافة الأسمدة العضوية السائلة بجرعات ٠,٠ و١٠,٠ مل/شجرة. بالإضافة إلى ذلك، تم اضافة حمض الهيوميك إلى التربة بجرعات ٠,٠ و٥,٠ و١٠,٠ جم/شجرة. كان الهدف الأساسي لهذا البحث هو تقييم التأثير المجتمع لهذه المعاملات على أداء نمو أشجار النوع التجاري لتفاح الإبراهيمي. تم تقييم أداء نمو أشجار التفاح من خلال دراسة صفات مختلفة، مثل المساحة الورقية (سم^2)، ومحتوى الكلوروفيل في الأوراق (ملجم/جم، الوزن الطازج)، والوزن الجاف للأوراق (%)، وطول الساق (سم).أشارت النتائج إلى أن زيادة المعدل المضاف من مستخلص أوراق المورينجا أدي إلى زيادة في هذه الصفات، حيث أظهرت معاملة الكنترول أقل القيم. بالمثل، أدى تطبيق الأسمدة العضوية السائلة إلى زيادة القيم لجميع الصفات المدروسة. بالإضافة إلى ذلك، كلما زاد معدل حمض الهيوميك، زادت قيم الصفات أيضًا. وعلاوة على ذلك، كانت التفاعلات بين عوامل الدراسة، سواء على نطاق مزدوج أو ثلاثي، لها تأثير ملحوظ على جميع جوانب نمو الأجزاء الخضرية التي تمت دراستها.