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Effect of organic fulvic acid application on the growth and yield performance of four melon (Cucumis melo L.) cultivars toward sustainable agricultural production

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Abstract

The field experiment was conducted during the 2025 spring season at the Experimental Farm of the Department of Plant Production, Northern Technical University, to evaluate the effects of organic fulvic acid on the growth and yield of four melon (*Cucumis melo L.*) cultivars and its potential to support more sustainable production with lower reliance on chemical fertilizers. The study followed a split-plot arrangement within a randomized complete block design, with three replicates. The main plots consisted of four cultivars: 'Polydor', 'Athena', 'Galia', and the local cultivar 'Malouki'. The subplots received two fulvic acid concentrations, 0 and 6 mL L^{-1}, applied twice: at the four-true-leaf stage and again 15 days later. Data were analyzed using SAS, and treatment means were compared by Duncan's multiple range test at the 5% probability level. The analysis of variance showed that 'Galia' significantly outperformed the other cultivars in fruit diameter, fruit number per plant, average fruit weight, yield per plant, and total yield. Fulvic acid application also improved these quantitative traits, with 6 mL L^{-1} producing the best response compared with the control. The most favorable interaction was observed for 'Galia' combined with 6 mL L^{-1} fulvic acid, indicating strong potential for sustainable melon production systems.

Keywords: cultivar performance, foliar application, fulvic acid, watermelon, (*Cucumis melo L.*), yield ingredients

Introduction

Melon *Cucumis melo* L. Is vegetable crops tasks belonging to the Cucurbitaceae family Cucurbitacea which is of vegetable crops president planted in Iraq is characterized by high nutritional value (Lester, 1996) the total acreage of the various varieties of melon in the world of 1997 about 1,041 million hectares and more states, the cultivation of melons are China, Turkey, Iran and the United States of America, Mexico, and China is one of the most international product of watermelon as grown 35000 not produces 8 million tons per annum (Yang et al., 2023).

As for the level of Arab countries, Morocco ranks first in the production of watermelon crop, followed by Iraq and Egypt in the total cultivated area amounted to 22,000, 21,000, 20,000 hectares to the three countries, but at the global level, the three countries respectively ranked eleventh, twelfth and thirteenth in the world, respectively, (FAO 1999), while the 2007 statistics indicate a decrease in the yield per hectare of watermelon in Iraq to 9.188 tons / ha (Arab Organization for agricultural development 2007)

Watermelons need a long, warm and dry growing season to provide the fruit with an attractive fragrance and flavor (Lester, 1996). Watermelons are propagated by seeds which are either sown directly in the field or transported as seedlings with whole roots (Guan et al., 2014). The development and productivity of watermelon is influenced by several factors, including environmental conditions—especially the temperature features of the Variety, the nutritional status of the plant, all of which directly affect the growth and vegetative production (Yang et al., 2023).

Despite the success of the use of chemical fertilizers in the cultivation of watermelons, their excessive use has led to economic and environmental problems

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due to their high costs and adverse effects on soil health and the environment (Yang et al., 2023; Mostfa et al., 2025).

Investigating alternative, environmentally acceptable nitrogen sources is becoming more and more important in order to sustain production while minimizing environmental harm. These alternatives include organic acids, like fulvic and humic acids, which are rich in essential macronutrients and enhance soil fertility and nutrient absorption without endangering humans or the environment (Stephenson, 1968).

Fulvic acid (FA), a low molecular weight organic compound with aliphatic and aromatic structures, dissolves in water in alkaline, neutral, and acidic conditions (Maosong et al., 2005). It improves soil structure, plant productivity, and nutrient absorption by forming soluble complexes with micronutrients (Ahmed et al., 2026). Additionally, it has been demonstrated to increase overall plant health, boost photosynthetic activity, and promote root formation, all of which improve yield performance (Guner and Wehner, 2004).

This study was conducted to close the knowledge gap since there aren't many studies that examine the combined impacts of melon cultivars and organic acid foliar sprays in Iraq, especially in Mosul.

This study aims to: Determine which of the four melon cultivars is most adapted to the Nineveh Governorate's environmental circumstances.

Analyze the effects of organic fulvic acid on the growth and yield characteristics of melon.

To achieve sustainable production and reduce reliance on chemical fertilizers, ascertain the ideal cultivar-fulvic acid concentration relationship.

Materials and Methods

Experimental Site and Design

The experiment was carried out at Northern Technical University's Experimental Farm of the Department of Plant Production in Mosul, Iraq, during the spring growing season of 2025. A moldboard plow was used to prepare the experimental soil in two perpendicular ploughs, which were followed by leveling and harrowing.

Two beds, each 2 m long and 1 m wide, made up each experimental unit. On March 20, 2019, seeds were hand planted, with a 50 cm gap between each plant. All treatments received consistent application of standard cultural methods, including as weeding, watering, and disease and pest management. Triple superphosphate (45% P_2O_5) at 150 kg ha^{-1} and urea (46% N) at 100 kg ha^{-1} were used for fertilization. following the recommendations of (Lester, 1996).

Fulvic acid treatments were applied twice as foliar sprays: the first after the development of the fourth true leaf and the second 15 days later. A fungicide (Beltanol) was applied at a concentration of (1 mL. L^{-1}) as a preventive treatment once every two weeks after seedling emergence.

Experimental Factors

The study included two factors arranged in a split-plot design within a Randomized Complete Block Design (R.C.B.D.) with three replications:

Cultivar (Main plots): [Polydor, Athena, Galia, Malouki(local cultivar)]

Fulvic Acid Concentration (Subplots): [0 mL. L^{-1}(control), 6 mL. L^{-1}]

Treatments were combined factorially (4 × 2 × 3= 24 total treatments).

Measured Traits

1 - Fruit Diameter (cm): Measured using a measuring tape on four randomly selected fruits per plot; the mean value was recorded.

2 - Number of Fruits per Plant: Determined by counting all fruits harvested from each plant in the experimental unit and dividing by the number of plants.

3 - Average Fruit Weight (g): Calculated by dividing the total fruit yield per plant by the number of fruits per plant:

$$\text{Average fruit weight} = \frac{\text{total yield per plant}}{\text{number fruit per plant}}$$

4 - Yield per Plant (kg $plant^{-1}$): Obtained by multiplying the number of fruits by the average fruit weight.

Plant yield (kg)= Number of fruits × Average fruit weight (kg)

5 - Total Yield (t ha^{-1}): Calculated from the experimental unit yield using the following formula:

$$\text{Total yield (t ha}^{-1}\text{)} = \frac{\text{experimental unit yield x 2200}}{\text{unit area (m}^2\text{) x 1000}}$$

where 2200 m² represents the area of one dunum.

Statistical Analysis

The data was statistically analyzed using the statistical analysis program SAS (version 2017). The averages were compared using the Duncan multi-range test (DMRT) at a probability level of 5% as described by (AL-Rawi et al., 2000).

Results and Discussion

Effect of Cultivar and Fulvic Acid on Yield Components

1. Fruit Diameter (cm)

The results of **Table 1** indicate that, with the exception of the domestic variety "Malouki", the characteristic of the stem diameter of the variety "Gallia" was much larger than "Polydor" and "Athena", measuring (14.43cm). While the plants treated with (6 ML.L^{-1}) had the largest average diameter of watermelon fruits (14.10 cm) in terms of fulvic acid levels, significantly superior to the control treatment (0 ML. L^{-1}).

The interaction between cultivar and fulvic acid followed a similar pattern: the 'Galia' × 6 mL L^{-1} treatment produced the largest fruit diameter (15.88 cm), which was significantly higher than all other treatment combinations, except the 'Malouki' × 6 mL L^{-1} interaction.

These findings imply that fulvic acid's stimulating effect and cultivar-specific genetic variation are important factors in improving fruit development.

2. Number of Fruits per Plant

Both cultivar and fulvic acid concentration had a significant impact on the number of fruits per plant, as shown in **Table 2.** With 4.58 fruits per plant, the "Galia" cultivar yielded the most fruits, greatly surpassing "Polydor" and "Malouki"'. Similarly, In comparison to the control (3.60 fruits $plant^{-1}$), spraying with 6 mL L^{-1} fulvic acid produced the greatest number of fruits (4.83 fruits $plant^{-1}$).

According to the interaction effect, "Galia" treated with 6 mL L^{-1} produced the most fruits (5.57 fruits $plant^{-1}$), followed by "Athena" × 6 mL L^{-1} (5.42 fruits $plant^{-1}$). This could be explained by fulvic acid-stimulated improved photosynthetic activity and increased nutrient uptake.

3. Average Fruit Weight (g)

The "Galia" cultivar produced the heaviest fruits (769.78 g $fruit^{-1}$), considerably more than "Polydor" and "Athena," according to **Table 3.** When 6 mL L^{-1} of fulvic acid was applied, the average fruit weight rose to 628.81 g $fruit^{-1}$ from 512.72 g in the control.

The highest fruit weight (799.45 g $fruit^{-1}$) was obtained by the combined treatment of "Galia" × 6 mL L^{-1}, which was statistically comparable only with "Malouki" × 6 mL L^{-1}, demonstrating the synergistic interaction between cultivar genetics and the organic amendment.

4. Yield per Plant (kg $plant^{-1}$)

The "Galia" cultivar produced the highest yield per plant (3.56 kg $plant^{-1}$), greatly outperforming the other cultivars, as indicated in **Table 4** (Fulvic acid at 6 mL L^{-1}

Table 1. The impact of fulvic acid and variety on fruit diameter cm^{-1} and how they interact

Cultivars	Concentrations of fulvic acid used (ml $liter^{-1}$)		Average impact of the cultivar
	0	6	
Polydor	11.25 d	13.84 b	12.55 c
Galia	12.97 b	15.88 a	14.43 a
Athena	11.47 d	12.55 b	12.01 c
Malouki	12.57 b	14.11 ab	13.34 ab
Mean acid effect ml L^{1}	12.07 b	14.10 a	

Duncan's multiple range test at a probability level of 0.05 indicates that the means for each factor and interaction that share the same letter or letters do not significantly differ from one another.

Table 2. Impact of fulvic acid, cultivar, and their combination on fruit production $per\ plant^{-1}$

Cultivar	Concentrations of fulvic acid used (ml $liter^{-1}$)		Average impact of the cultivar
	0	6	
Polydor	4.07b	4.22b	4.15a
Galia	3.59c	5.57a	4.58a
Athena	3.15c	5.42 a	4.29a
Malouki	3.22 c	4.10b	3.66b
Mean acid effect ml $liter^{-1}$	3.60b	4.83a	

Duncan's multiple range test at a probability level of 0.05 indicates that the means for each factor and interaction that share the same letter or letters do not significantly differ from one another.

Table 3. Effect of cultivar, fulvic acid, and their interaction on fruit weight (g^{-1})

Cultivar	Concentrations of fulvic acid used (ml $liter^{-1}$)		Average impact of the cultivar
	0	6	
Polydor	410.00c	604.78b	507.39b
Galia	740.11ab	799.45a	769.78a
Athena	299.78e	400.48c	350.13c
Malouki	600.99b	710.52ab	655.76ab
Mean acid effect ml $liter^{-1}$	512.72b	628.81a	

Duncan's multiple range test at a probability level of 0.05 indicates that the means for each factor and interaction that share the same letter or letters do not significantly differ from one another.

Table 4. Effect of cultivar, fulvic acid, and their interaction coefficients on Yield per Plant (kg plant⁻¹)

Cultivar	Concentrations of fulvic acid used (ml liter^{-1})		Average impact of the cultivar
	0	6	
Polydor	1.67d	2.55b	2.11 b
Galia	2.66b	4.45a	3.56 a
Athena	0.944de	2.17c	1.56 c
Malouki	1.94d	2.91b	2.43 b
Mean acid effect ml liter-1	1.80b	3.02a	

Duncan's multiple range test at a probability level of 0.05 indicates that the means for each factor and interaction that share the same letter or letters do not significantly differ from one another.

produced a yield that was much higher (3.02 kg plant^{-1}) than the control (1.80 kg plant^{-1}).

"Galia" × 6 mL L^{-1} produced the highest yield (4.45 kg plant^{-1}), demonstrating the beneficial impact of fulvic acid on assimilate translocation and nutrient use efficiency.

5. Total Yield (t. ha^{-1})

Table 5 shows that the 'Galia' cultivar again outperformed the others, with the highest total yield (52.17 t ha^{-1}). Application of 6 mL L^{-1} fulvic acid enhanced total yield to 45.49 t ha^{-1}, compared with 25.61 t ha^{-1} in the untreated control. The interaction between the 'Galia' cultivar and 6 mL L^{-1} fulvic acid produced the maximum total yield (64.11 t ha^{-1}), statistically comparable only with the 'Malouki' × 6 mL L^{-1} treatment.

The superior performance of the 'Galia' cultivar in fruit diameter, fruit weight, and yield traits can be attributed to its genetic potential and adaptability to the local environment. In Cucurbita pepo L., Piya et al. (2007) found similar results, noting notable varietal variations in fruit size and production.

It is possible that the nutritional and physiological functions of fulvic acid, including better absorption of nutrients, stimulation of root growth, increased photosynthetic activity, are responsible for the marked improvement in yield traits resulting from its application (Kamel et al., 2014; Suh et al., 2014). In addition, fulvic acid helps micronutrients, increasing the availability and movement of these nutrients throughout the plant (Ahmed et al., 2026).

Additionally, fulvic acid promotes better enzyme activity, cell membrane permeability, and glucose translocation, all of which increase fruit production and yields (Suhaini et al., 2023; Başalma, 2014). Similar results have been observed for crops like faba beans, cucumbers, okra, and tomatoes (Lycopersicon esculentum L.). (AM et al., 2015; Al-Shammary et al., 2018; Abdel-Baky et al., 2019 ; Hameed and Salim, 2022).

Sustainable agricultural production systems and environmentally friendly practices are promoted by the positive interaction of the variety and fulvic acid, which indicates an effective effect in which the physiological response to specific genotypes is especially "Galea" maximized through the administration of organic nutrients.

Conclusion

The idea of agricultural and production systems aimed at environmentally friendly technology and goals through the positive interaction of the variety and fulvic acid, which suggests a synergistic effect in which the physiological response to specific genotypes—especially "Galea"—is maximized under the administration of organic nutrients. Under the climatic conditions of Nineveh Governorate in Iraq, the bilateral relationship between fulvic acid and the "Galea" Variety at 6 ml. L^{-1} resulted in the highest results in terms of fruit quality and yield. These findings demonstrate fulvic acid's function in improving soil fertility and efficient nutrient absorption, which eventually results in higher yields and superior fruits. Using organic fulvic acid rather than chemical fertilizers is a practical and sustainable way to lower environmental pollution while maintaining high production, according to all the indicators that have been considered, which promotes sustainable agriculture and ecologically friendly fertilizer management practices worldwide.

Table 5. Effect of cultivar, fulvic acid, and their interaction coefficients on total yield per unit area (t.ha^{-1})

Cultivar	Concentrations of fulvic acid used (ml liter^{-1})		Average impact of the cultivar
	0	6	
Polydor	20.45 c	41.21 b	30.83 b
Galia	40.22 b	64.11 a	52.17 a
Athena	11.42 d	25.87 c	18.65 c
Malouki	30.34 c	50.77 a	40.56 b
Mean acid effect ml liter^{-1}	25.61 b	45.49 a	

Duncan's multiple range test at a probability level of 0.05 indicates that the means for each factor and interaction that share the same letter or letters do not significantly differ from one another.

Recommendations

1 - Use of Fulvic Acid:

In the Nineveh Governorate, foliar application of organic fulvic acid at 6 mL L^{-1} is advised to improve melon yield and fruit quality.

2 - Cultivar Selection:

Because of its exceptional productivity and adaptability, the "Galia" cultivar is advised for cultivation.

3 - Future Research:

Additional research ought to look into:

The effect of higher concentrations of fulvic acid.

The performance of additional melon cultivars under different environmental circumstances.

the long-term effects of applying organic acid on nutrient dynamics and soil health.

These findings support the shift from chemical-based to organic, environmentally safe agricultural systems and aid in the development of sustainable production strategies for melon cultivation.

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