Response of Growth and Yield of Three Cucumber Hybrids with Nano Iron and Nano super fifty Foliar Application in a Greenhouse Environment

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Abstract

The experiment was conducted in a greenhouse in the field located in the Al-Azzawiyah area, Al-Musayyab District, 30 km north of the center of Babylon province , to study the growth and yield of three cucumber hybrids in protected cultivation, based on the effect of spraying with nano-iron and Super Fifty for the autumn agricultural season of 2023-2024. The experiment was designed as a 3×3 factorial experiment using a split plot system according to a randomized complete block design (RCBD) with three replicates. The first factor included three cucumber hybrids: hybrid 182-108, hybrid Falcon Star RZ, and hybrid 62-145 of the Beta Alpha variety. The second factor included three spray levels (control, spraying with nano-chelated iron at a concentration of 2 g/L and spraying with nano-Super Fifty extract at a concentration of 2 g/L). The means of the treatments were compared using the least significant difference (LSD) test at a probability level of 0.05. The results can be summarized as follows:

Hybrid 62 excelled in number Leaves, leaf area, fruit number, fruit length, per-plant yield, and greenhouse yield, while hybrid 182 excelled in plant height. The nano-super fiftieth treatment also excelled in plant height, leaf number, leaf area, fruit number and weight, per-plant yield, and greenhouse yield. The interaction results indicated that hybrid 62 and the nano-super fiftieth treatment excelled in plant height, leaf number, leaf area, fruit number, per-plant yield, and total greenhouse yield.

Keywords: cucumber, nano iron, nano super fifty, food production

Introduction

Cucumber (Cucumis sativus L.) is a summer vegetable crop belonging to the Cucurbitaceae family. It is a monoecious plant with separate male and female flowers on the same plant. It is cross-pollinated, and the fruit is roughly cylindrical, elongated, and pointed at the tips. It is widely cultivated in tropical and subtropical regions. India and Africa are believed to be the original homeland of the water cucumber (Behera et al., 2022). In Iraq, cucumber is grown in open fields in two seasons (spring and fall), and is also grown in protected environments under plastic tunnels, greenhouses, and glasshouses (Matloub et al., 1989). Cucumber is widely consumed fresh or pickled in salads and fast food (Dumitru and Sursa, 2019). The total production rate of cucumbers in Iraq is 185,484 tons, with a productivity of 8.8 tons per hectare and an area of 21,018.7 hectares (Central Statistical Organization, 2021). It is noted that the local production of cucumbers is low compared to

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global production. The improvement in the quantity of cucumber production in Iraq is still below the standard. The reason for the low production of this crop is the deterioration of local genetic structures as a result of inbreeding, genetic mixing, and poor crop management. This problem can be overcome and the yield of cucumbers can be increased better by cultivating genetic structures with high productivity, good quality, and resistance to pests and unsuitable environmental conditions, as well as paying good attention to agricultural maintenance operations. Gynoeious cucumber hybrids with female flowers and parthenocarpic fruit are used in protected cultivation. These hybrids are characterized by abundant fruiting in a short period of time compared to the Monoeious varieties used in open cultivation. The hybrid type is chosen according to the desire of the farmer and marketing (Lu et al., 2020). It has become necessary to use modern strategies for fertilizing vegetable crops to increase production, including nanotechnology. Nanotechnology is defined as materials, systems, and processes operating at a scale of 100 nanometers (nm) or less. One of the most important uses of nanotechnology is nanofertilizer (Ditta, 2012). Nanofertilizers have unique properties due to their small size and large surface area, which leads to increased absorption and, consequently, increased photosynthesis, thus increasing plant production (Singh et al., 2016). Iron (Fe) plays many functions in the major metabolic processes of living organisms and plants. It is involved in photosynthesis, respiration, enzymatic processes, the cell cycle, oxygen transport and storage, and hormone and DNA synthesis (Sega et al., 2020.(

Despite its abundance in the earth's crust, iron deficiency, caused by its low solubility in soils at moderate and high pH (alkaline and calcareous soils), is a common nutritional disorder affecting crops in many regions of the world. Iron deficiency impairs crop quality and productivity (Konate et al., 2018). Sanda et al. (2022) demonstrated in an experiment on three cucumber cultivars: Darina, Market-more, and Poinsett-75, that Poinsett-75 was excelled in fruit diameter. Darina was also excelled in fruit number, fruit weight per plant, and total yield, which reached 20.25 fruits.plant-1, 3910 g, and 4.28 ton.ha-1 in the first season. Market-more achieved the highest yield of 18.86 ton.ha-1. Kasali et al. (2024) conducted an experiment on three cucumber cultivars, Poinsett, Greengo, and Monalisa, using 0, 2.5, and 5 ton ha-1 of organo-mineral fertilizers. Greengo produced the highest number of leaves and fruit length of 19.44 leaves.plant-1 and 78.40 cm, respectively, followed by Monalisa and Poinsett, which produced the least. Greengo recorded the highest flowering percentage in the first days, reaching 50%, outperforming Monalisa and Poinsett. The cultivars treated with 5.0 t/ha-1 of organo-mineral fertilizer achieved 50% flowering in 29 days, while the control treatment achieved 50% flowering in 33 days. Merghany et al. (2019) in their experiment to know the effect of nano fertilizers on cucumber plant where different concentrations of liquid nano NPK 3, 4.5, 6 and 9 ml were used, the concentration of 6 ml.L-1 achieved a significant difference in the number of leaves of the plant before forty days and the leaf area, plant height and number of leaves on the plant after 60 days which amounted to 22.67 leaves. plant-1, 188.2 cm2. plant-1 and 177.8 cm. plant-1, 24.33 leaves. plant-1. Guillén-Enríquez et al. (2023) found the effect of nano-iron spraying on the growth and yield of cucumber plant Poinsett 76 indeterminate

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growth, where four concentrations of Fe2O3 NPs (Fe nanoparticles) were used, namely 0, 50, 75 and 100 mg.L-1. The concentration of 75 mg.L-1 was excelled in the total yield, fruit length, firmness and T.S.S, which reached 3.03 tons.h-1, 20.66 cm, 0.3 N and 4.68 Brix o, respectively, while the concentration of 100 mg.L-1 was significantly excelled in the leaf content of chlorophyll and total protein, which reached 40.98spad, 48.73 mg-1 and 0.039 mg-1, respectively, excelled to the control treatment and the rest of the treatments.

In light of the above, the aim of this study was to evaluate the growth and yield of three cucumber hybrids under the influence of iron and nano-algae extract (Super Fifty) in organic farming.

Materials and Methods

The experiment was conducted in a private field in the Al-Azzawiya area - Al-Musayyab District, 45 km north of the city center of Hillah, Babil Governorate, at longitude 44.5E and latitude 32.7N, during the autumn 2023 agricultural season. The experiment aimed to study the response of three cucumber hybrids to spraying with nano-iron and nano-algae extract (Super Fifty) grown in unheated greenhouses. Field soil samples were taken from different areas before the experiment, at a depth of 0–30 cm. They were then air-dried, ground, and passed through a 2 mm sieve. The samples were analyzed to determine some of the chemical and physical properties of the field soil. Table 1 shows some of the physical and chemical properties of the field soil.

Table 1: Some of the physical and chemical properties of the field soil before planting

values	units	traits
7.9	....	**pH**
3.1	m^3/ds	**Electrical conductivity (EC)**
3.4	gm. kg	**Organic matter**
12	mg. kg	**Available nitrogen**
4.9	mg. kg	**Available phosphorus**
15.0	mg. kg	**Available potassium**
1.13	mg. kg	**Bulk density**
155	gm. cm3	**Sand**
600	gm. kg	**Silt**
245	g.kg	**Clay**
silty clay loam	**texture**	

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The chemical and physical properties of the soil were analyzed in the Al-Muradiyyah Laboratory of the Babylon Agriculture Directorate.

The field soil designated for the experiment was prepared after removing overgrown weeds and plants, followed by a thorough and homogeneous plowing, smoothing, and leveling. The land was divided into three replicates, each comprising nine experimental units. Each experimental unit was represented by a terrace measuring 3 m x 0.80 m, with a distance of 0.75 m between experimental units to prevent mixing between treatments. A buffer space was left at the beginning and end of each section. The number of plants in the experimental unit was 12, with a distance of 50 cm between each plant on both sides of the terrace. A drip irrigation system was installed. After seed germination and the appearance of the second true leaf, the seedlings were transferred to their permanent location in the 508 m² greenhouse, alternating between the two sides of the terrace, on September 23, 2023, during the fall season. After transplanting, the fungicide (Pentanol) was added to the irrigation water at a concentration of 1 ml/L-1 to prevent seedling wilt disease. After the seedlings reached the sixth true leaf stage, the splicing threads were placed and tied to the main wire at a height of 2 m above the soil surface.

The study included two factors:

The first included three cucumber hybrids for protected cultivation:

-Hybrid 182-108, designated H1

-Hybrid 62-145, Beta Alpha, designated H2

-Hybrid Falcon Star RZ, designated H3

The second factor included four organic fertilizer treatments:

•control (without fertilization), designated S0

•Spraying with nano-iron at a concentration of 2 gm. 1 liter, symbol S2

•Spraying with 2 ml of Super Fifty nano algae extract. 1 liter, symbol S3

The spraying of nano iron and Super Fifty nano was distributed over four sprays, 10 days apart. The first spray was one month after germination, on November 1. The plants were sprayed until completely wet, with the addition of a spreading agent to reduce surface tension. Super Fifty algae extract is a seaweed extract manufactured using nanotechnology by a Turkish company. The experiment was designed as a 3×3 factorial experiment using a split plot system according to a randomized complete block design (RCBD) with three replicates, with 27 experimental units (9 experimental units within each replicate). Treatments were randomly distributed. Treatment means were compared using the least significant difference (LSD) test at a probability level of 0.05 (Al-Sahouki and Wahib, 1990). They were distributed as follows:

•Hybrids represent the main plot.

•Spray treatments represent the subplots.

Study indicators:

•Plant height (cm(

•Number of leaves (leaf.plant-1(

•Leaf area (cm2.plant-1(

•Number of fruits . plant (fruit.plant-1(

•Fruit weight (g(

•Fruit length (cm(

•Yield per plant (kg(

•Total yield of the greenhouse (tons/greenhouse) (508 m2(

Results and Discussion

Table 2 shows significant differences between the hybrids in the studied traits. Hybrid 182 (S1) excelled with the highest average plant height, reaching 143.91. Hybrid 62 (H2) also excelled with the highest average number of

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leaves, leaf area, and fruit number, with averages of 27,072 leaves, 1,391.22 cm² plant, and 31,333 fruits.plant, respectively. Hybrid 182 (S1) and Falcon (S3) hybrids, which achieved the lowest averages for the above traits. The results of the same table indicate that spraying with iron and Super Fifty nanoparticles significantly affected the averages of the studied traits. Super Fifty nanoparticles (S3) excelled and achieved the highest average plant height, leaf number, leaf area, and fruit number, reaching 149.16 cm², 31,667 leaves, and 1,477.11 cm². Plant and 35,333 fruits . plant-1, while the control treatment (S1) recorded the lowest average for the traits studied in Table 2. The results of the two-way interaction between hybrids and nano-spray treatments indicate significant differences in the traits studied in Table 2. The hybrid 182 treatment, sprayed with Super Fifty Nano (H1S3), excelled with the highest average plant height of 151.077 cm. The hybrid 62, sprayed with Super Fifty (H2S3), also achieved the highest average number of leaves, leaf area, and fruit number, reaching 32,667 leaves and 1,730.11 cm2 per plant and 40,887 fruits . plant-1. Meanwhile, the hybrid 182 and the control fertilization treatment (H1S1) recorded the lowest average yields for plant height, leaf number, leaf area, and fruit number

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Table 2: Effect of hybrids, spraying with nano-five and super-fifty, and their interaction on plant height, number of leaves, leaf area, and number of fruits.

Fertilization treatments	Plant height cm	Number of leaves per plant	Leaf area cm2 per plant	Number of fruits per plant
H1	143.91	26.036	1146.00	25.742
H2	140.13	27.076	1391.22	31.333
H3	139.07	25.224	1179.74	25.889
L.S.D 0.05	**0.413**	0.274	2.81	0.469
S1	131.74	18.703	915.00	19.631
S2	142.22	27.966	1324.85	28.000
S3	149.16	31.667	1477.11	35.333
L.S.D 0.05	**0.400**	0.148	2.44	0.375
H1S1	134.220	17.887	874.78	18.890
H1S2	146.447	29.223	1342.33	26.223
H1S3	151.077	30.997	1220.89	32.113
H2S1	130.777	20.223	1048.67	21.447
H2S2	139.663	28.337	1394.89	31.667

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H2S3	149.970	32.667	1730.11	40.887
H3S1	130.223	18.000	821.56	18.557
H3S2	140.557	26.337	1237.33	26.110
H3S3	146.457	31.337	1480.33	33.000
L.S.D 0.05	**0.634**	0.301	3.99	0.630

It is noted from Table 3 that there are significant differences between the hybrids in the studied traits, as the hybrid 62 (H2) excelled with the highest average of fruit weight, fruit length, yield per plant and total yield of the plastic house with an average of 81.84 g, 17.33 cm, 2.630 kg and 3.632 tons, respectively, outperforming the hybrid 182 (V1) and the Falcon hybrid (V3), which gave the lowest average for the above traits. The results of the same table indicate that the nano spray treatments had a significant impact on the traits studied in Table 3, as the nano iron (S2) spray treatment was excelled and achieved the highest average fruit length of 17.27 cm. The super fifty spray treatment was also excelled and achieved the highest average fruit weight, yield per plant and total yield of the plastic house with an average of 83.80 g, 2.971 kg and 4.160 tons. The greenhouse was treated in succession, while the control treatment (S0) recorded lower results for the traits studied in Table 3. The results of Bi-interaction between hybrids and nano-spray treatments indicate significant differences in the traits studied in Table 3. Hybrid 62 and nano-iron (H2S2) sprayed excelled with the highest average fruit weight and fruit length, reaching 89.44 g and 18.18 cm, respectively. Hybrid 62 and the nano-super-fifty (H2S3) spray also excelled with the highest average plant and greenhouse yields, reaching 3.587 kg and 5.022 tons. Greenhouse-1, while hybrid 182 and the control treatment (H1S0) recorded the lowest average fruit weight and length, plant yield, and greenhouse yield.

Table 3: Effect of hybrids, nano-iron and super-fifty sprays, and their interaction on fruit weight, fruit length, plant yield, and greenhouse yield.

Fertilization treatments	**Fruit weight in g**	**Fruit length in cm**	**Plant yield in kg**	**Greenhouse yield in tons**
H1	73.26	15.98	1.929	2.701
H2	81.84	17.33	2.630	3.682
H3	76.52	16.70	2.011	2.815
L.S.D 0.05	2.97	1.64	0.0798	0.111
S1	66.74	15.62	1.313	1.838
S2	81.07	17.27	2.286	3.200

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S3	83.80	17.12	2.971	4.160
L.S.D 0.05	2.89	1.18	0.0792	0.110
H1S1	64.00	15.20	1.209	1.693
H1S2	72.11	15.83	1.891	2.648
H1S3	83.67	16.91	2.687	3.762
H2S1	68.33	16.32	1.469	2.057
H2S2	89.44	18.18	2.833	3.966
H2S3	87.75	17.50	3.587	5.022
H3S1	67.89	15.34	1.260	1.764
H3S2	81.66	17.81	2.132	2.985
H3S3	80.00	16.93	2.640	3.696
L.S.D 0.05	4.58	2.06	0.124	0.174

From the above, the results of Tables 2 and 3 indicate that the variation in cucumber hybrids for the studied traits is due to genetic variation among hybrids, the hybrids' response to soil conditions and factors in which the experiment was planted (Table 1), and their response to climatic conditions during the growing season. This is consistent with the findings of Athari et al. (2021), Sanda et al. (2022), Manea (2017), and Ali et al. (2022.(

The excelledity of the Super Fifty nano-treatment and nano-iron spraying for the studied traits in Tables 2 and 3 is due to the role of nano-fertilizer and its nano-elements. These elements contribute to the activation of enzymes, the synthesis of organic compounds, proteins, chlorophyll pigments, and carotenoids, and the regulation of vital activities within the plant related to cell growth and division. This is because the adequate presence of nutrients increases the efficiency of photosynthesis and the synthesis of amino and nucleic acids and energy compounds, which leads to increased fruit set and, consequently, increased production. In addition to its role in protecting the chlorophyll molecule from degradation, iron plays an indirect role in chlorophyll formation and protects proteins from losing their bioavailability (Stanton et al., 2022). The increased growth and yield of nanofertilizers are due to their properties, such as small particle size, effective surface area, rapid penetration of cell walls to vascular bundles, and ease of absorption by the plant, thus increasing its concentration within the plant (Ruttaky-Nedecky et al., 2017). Iron also plays a role in biological processes, acting as a cofactor in activating reactions for chlorophyll formation and cooperating with zinc, boron, copper, and molybdenum in protecting chlorophyll from degradation (Cakmak et al., 2023). Increasing the concentration of iron and adding it in nanoscale forms increases its availability to the plant, thereby increasing the efficiency of mineral absorption and transport within the plant (Singh et al., 2021). These results are consistent with those of Gupta et al. (2022), Guillén-Enríquez et al. (2023), and Mahdi et al. (2022). We conclude from this

study that hybrid 62 and the Super Fifty nano spray treatment achieved the highest average plant yield and total greenhouse yield.

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