Foliar Spraying with Nano-iron, Gibberellin, and Benzyl Adenine Infullonse on Quantity of Elements, Vegetative Growth and yield of *Anethum Graveolens* L.

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Abstract

The experiment was conducted in the field of the Department of Horticulture and Landscape Engineering, College of Agriculture at the University of Babylon, during the agricultural season 2022-2023 to study the effect of combinations of growth regulators and nano-iron on the growth and yield of dill plants. The experiment was carried out according to the split plate system and with three replicates, with fifteen treatments in each replicate. The treatments were distributed The first factor (gibberellin and benzyl adenine) is on the main panels, as it includes (H1: comparison, H2: gibberellin 25 and benzyl adenine 25 $mg.L^{-1}$, H3: gibberellin 50 and benzyl adenine 25 $mg.L^{-1}$, H4: gibberellin 50 and benzyl adenine 50 $mg.L^{-1}$, H5: Gibberellin 100 and benzyl adenine 50 $mg.L^{-1}$, and the treatments of the second factor (nano-iron) were distributed on the secondary panels, as it included three concentrations (0, 50, 100) $mg.L^{-1}$. The experiment included 45 experimental units, and they were The results are as follows: There are significant differences between the combinations of growth regulators in most vegetative traits and yield, where the treatment (H5) was significantly excelled in plant height, number of branches, and dry weight of the root compared to the control treatment, while the treatment (H3) was significantly excelled in the number of seeds in the inflorescence. The main traits compared to the control treatment, while the rates of total yield and percentage of potassium were higher in the treatment (H2) compared to the control treatment. The results also showed a significant excelled of the treatment with nano-iron in most of the studied traits compared to the control treatment, as the spraying treatment at a concentration of 100 $mg.l^{-1}$ excelled in the average dry weight of the root, the percentage of total chlorophyll, the total vegetative yield, the number of flower inflorescences, the number of seeds, and the percentage of nutrients (nitrogen, Potassium. As for the percentage of phosphorus, it was significantly higher in the spraying treatment at a concentration of 50 $mg.L^{-1}$ compared to the control treatment. The results of the interaction treatments between the combinations of growth regulators and nano-iron showed significant excelled in most of the studied traits compared to the control treatment, as the treatment (H_4Fe_2) excelled significantly and achieved the highest rate for the trait number of seeds (1494 seeds) and the percentage of phosphorus (0.498%). The treatment (H2Fe3) excelled.) significantly in the total vegetable yield (30400 $kg.ha^{-1}$). The spray treatment (H4Fe3) was significantly excelled in the number of flower inflorescences (43.00 inflorescences . $plant^{-1}$) and the percentage of nitrogen (4.087%). As for the (H5Fe3) treatment, it was significantly excelled in the average root dry weight (13.90 g .$plant^{-1}$). As for the percentage of potassium, it was significantly higher in the treatment ($_{H2Fe2}$), giving (1.947%). The treatment (H3Fe3) gave the highest percentage of total chlorophyll (138.8 mg.100 g^{-1}). It was also shown that the treatment (H3Fe2) was excelled in terms of the number of branches (7.87).

Keywords. *Anethum graveolens* L., Gibberellin, Benzyl adenine,Dill.

introduction:

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Dill (*Anethum graveolens* L.) is one of the plants of the Apiaceae family, which includes more than 250 species. Its original homeland is Asia Minor, Iran, and North Africa (Egypt), and it is found in the eastern and western Mediterranean [7]. Given the nutritional importance of leafy plants when Peoples, its cultivation has spread in many parts of the world, including Iraq, and its uses have diversified and the demand for it has increased, as the world is now witnessing a return to nature and natural food. Dill is one of the important leafy herbs, due to its high nutritional and medicinal value, as its leaves contain between 7.7 - 10.5% dry matter. It contains 3.8-5.8% carbohydrates, 1.7-3.5% protein, and 1-1.5% fiber, in addition to being rich in vitamins [7]. Its fresh and dry green leaves are used in food as a flavor and odor enhancer in many foods and industries. It is an essential spice, and it is also used in the manufacture of perfumes and cosmetics. Boiling its fruits is used as a gas repellent in case of colic, especially in children, as a tranquilizer for the nerves, to improve the work of the heart and lungs, and to regulate blood pressure, and it is also useful in the digestive process. Dill oil, with its distinctive fragrant aroma, is also of global economic importance [2].

Plant growth regulators play a large and important role in growth, functional tissue specialization, and redistribution of dry matter within the plant for the purpose of vital activities. Gibberellin is a plant growth regulator that has a major role in increasing growth through its effect on the processes of cell division and expansion. It increases the meristematic area and has a clear effect on the expansion of the cell wall. It also affects the construction of nucleic acids (DNA, RNA, and protein), and all of these effects have a major role in physiological processes within the plant. [3]. As for the physiological effects of cytokinins, they stimulate cell division as well as stimulate cell expansion due to the increase in the thickness of the stem, hypocotyl, and roots due to increased stimulation of cell expansion laterally. It also plays a role in delaying leaf senescence and works to stimulate the transfer of nutrients and break the dormancy phase in seeds and sprouts, as well as About breaking Apical dominance. It has an effect on the emergence and formation of chloroplasts, stimulates the emergence of flowers in long-day plants, and stimulates the formation of some enzymes such as alpha-amylase [21]Micronutrient fertilizers, especially iron, also play an important role in the life of plants, as they raise their immune status and increase the process of photosynthesis, respiration, and other biochemical and physiological activities. These materials are converted to nano-sized to change their chemical and biological properties, as well as their catalytic properties, facilitate their absorption by the plant, increase its chemical and biological interactions, provide plants and soil with elements for a longer period than traditional ones, and alleviate soil pollution problems resulting from the use of excess fertilizers [14]. The importance of iron lies in the fact that it is included in the following compounds: cytochromes, ferredoxin, and phytoferitin, which are important in photosynthesis [9]. As well as the production of amino acids [20] It has an important role in absorbing nitrogen, increasing leaf area, and has a direct effect on the protein production process [22]

Materials and methods

Implementation of the experiment

This experiment was conducted in the field of the Department of Horticulture and Landscape

Engineering at the College of Agriculture at the University of Babylon during the 2022-2023 agricultural season to study the effect of five different concentrations of growth regulator combinations (gibberellin and benzyl adenine) and three different concentrations of nano-iron on growth traits and vegetative yield in dill plants. . The soil was prepared and plowed using a Mold-board plows, and leveled manually with adjustment and smoothing machines. It was divided into two furrow, each one 25 meters long and 2.5 meters wide. Then a drip irrigation system was installed, after which the seeds were planted directly in the field on 10/17/2022 in the form of lines with Two lines in each experimental unit, 20 pits in each line, ten holes, between one pit and another, 20 cm, and between one line and another in the same experimental unit, 30 cm, and the distance between one experimental unit and another is 60 cm. After germination, on 11/14/2022, the thinning process was performed for the growing plants, leaving three plants. Only in each pit, so that the number of plants was 60 in one experimental unit, and service operations were conducted for the crop, such as weeding and hoeing whenever required. After a month had passed from the date of germination, urea fertilizer was added to the treatments, according to the fertilizer recommendation (90 $kg.ha^{-1}$) followed for the dill plant. It was added in two batches, the first batch was on 11/22/2022 and was 4 g per experimental unit, and the second batch was in the same amount on 12/22/2022.

Experimental design

The treatments were distributed in a factorial experiment in split plates, with three replicates, and each replicate had fifteen treatments that included a test of two factors. The first factor was as follows: foliar spraying with growth regulators, and it was distributed on the main plates. It was symbolized by the symbol (H) and had five levels: H1 (control), H2(Gibberellin 25 + benzyl adenine 25 $mg.l^{-1}$), H3 (gibberellin 50 + benzyl adenine 25 $mg.l^{-1}$), H4 (gibberellin 50 + benzyl adenine 50 $mg.l^{-1}$), H5 (gibberellin 100 + benzyl adenine 50 $mg.l^{-1}$). The second factor was as follows: foliar spraying with nano-iron fertilizer, which was distributed on the secondary panels and is symbolized by the symbol (F): -F1 control, -F2 spraying 50 mg L^{-1}, -F3 spraying 100 mg $L^{-1.}$ The experiment included 45 experimental units.

Soil analysis: Soil analysis tests were conducted before planting in the soil laboratory in the Al-Qadisiyah Agriculture Directorate Water and Soil Division

Table (1): Some of the physical and chemical traits of field soil before planting.

Field soil	
12.5	clay %
37.5	Sand %
50	silt %
7.2	P.H
13.1	potassium ppm
0.021	Nitrogen %
0.42	Organic matter
0.351	Phosphorus %
2.43	(EC (ds.cm
Loam silty	Soil texture

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Studied traits:

Ten plants were left for the purpose of making measurements and taking readings from them, and the other ten were for the purpose of mowing. Five plants were randomly selected from each experimental unit to take measurements from. The following traits were taken:

Plant height (cm)

The height of each of the plants taken was measured from the surface of the soil to the highest peak of the plant using a tape measure.

Number of branches (branch.plant^{-1})

it calculated the total number of branches on each of the plants taken.

Dry weight of root (g. plant^{-1})

The weight was measured after the roots were air-dried and completely dried in the electric oven at a temperature of 68°C until the weight was constant, and they were weighed using a sensitive balance.

Total leaf chorophyll content (mg.100 g^{-1} Fresh weight):

Leaves were taken from five plants from each experimental unit randomly, after cleaning them and washing them well with water and leaving them to dry. Then (1 g) was taken from them and placed in a ceramic mortar for the purpose of grinding them. After that, acetone 20 ml, 80% concentration, was added. After that, the tissue was crushed well until the tissue bleached, and then it was isolated of the dyes using filter paper. The Spectrophotometer was used in the graduate studies laboratory at the College of Agriculture, Al-Qasim Green University, to measure the optical absorption of the dyes at two wavelengths (645 and 663) nanometers. Then the amount of total chlorophyll (mg of dye 100 g $^{-1}$) was calculated according to the following equation:

Total Chlorophyll(mg.100 g-1)=20.2D(645)+8.02D(663)

Vegetative yield per unit area (kg.ha^{-1})

The plants were mowed on 12/26/2022. Thirty plants from each experimental unit were cut from the soil surface level and weighed directly in the field after mowing using a field balance.

Number of flower inflorescences (inflorescence.plant^{-1}):

it calculated the number of flower inflorescences for each randomly selected plant and took the total average.

Number of seeds in the main inflorescence (seed.inflorescence-1):

The number of seeds in the main inflorescence of each randomly selected plant from each experimental unit was counted.

Percentage of nitrogen in leaves:

The percentage of total nitrogen was calculated using the Kjeldahl Micro device using the method approved by [18]

Percentage of phosphorus:

The percentage of phosphorus in dill plants was measured using the molybdate-ammonium phenadate reduction method [6]

Percentage of potassium:

The percentage of potassium in the plant was calculated according to the method used by [6] using a flame spectrometer whose readings were self-calibrated based on the standard curve for potassium prepared by the manufacturer of the device.

Results and discussion

Plant Height(cm)

The results of Table (2) indicate that there are significant differences in the rate of plant height between the combinations of growth regulators, as the spraying treatment with gibberellin 100 mg.L^{-1} and benzyl adenine 50 mg.L^{-1} gave the highest rate as it gave 81.5 cm compared to the control treatment that gave

The lowest rate is 33.5 cm. From the same table, no significant difference was observed between the spraying treatments with nano-iron in the plant height rate. The results of the binary interactions between the combinations of growth regulators and nano-iron indicate that there is excelled for the spraying treatment with gibberellin 100 mg.L^{-1} with benzyl adenine 50. mg.L^{-1} and nano-iron at a concentration of 0 mg.L^{-1} significantly affected the rest of the intervention treatments, as it gave the highest average plant height of 84.6 cm compared to the control treatment, which gave the lowest average plant height of 32.3 cm.

Number of lateral branches (branches .plant^{-1})

From the data in Table (2), it was shown that there were significant differences between the spraying treatments with combinations of growth regulators, as the spraying treatment with gibberellin 100 mg. $L^{-1}$and benzyl adenine 50 mg.l-1 gave the highest average number of lateral branches, reaching 6.72 branches .plant^{-1}, in comparison. With the control treatment, which gave the lowest average number of lateral branches, which amounted to 3.98 branches .plant^{-1}. From the same table, it was shown that there were no significant differences between the spraying treatments with nano-iron in the average number of branches. As for the binary interaction between the combinations of growth regulators and nano-iron, there were significant differences between the treatments, as the spraying treatment with gibberellin gave 50 mg. $L^{-1}$and benzyl adenine 25. mg. L^{-1} and nano-iron at a concentration of 50 mg.L^{-1} had the highest average number of lateral branches reaching 7.87 branches .plant^{-1} compared to the spraying treatment with gibberellin 0 mg. L^{-1}, benzyl adenine 0 mg. $L^{-1}$and nano-iron at a concentration of 100 mg. L^{-1}, which gave the lowest average number of lateral branches, reaching 3.40 branches .plant^{-1}.

Dry weight of root (g. plant^{-1})

The results of Table (2) show that there are significant differences between the spraying treatments with combinations of growth regulators, where the spraying treatment with gibberellin 100 mg. $L^{-1}$and benzyl adenine 50 mg. $L^{-1}$was significantly excelled to the rest of the treatments, as it gave (8.01 g.plant^{-1}) While the H3 and H4 treatments did not differ significantly between them, they were excelled to the control treatment, which gave 2.91 g.plant^{-1}. As for the spraying treatments with nano-iron, it showed that there are significant differences, as the spraying treatment with a concentration of 100 mg.L^{-1} gave a significant excelled on the rest of the treatments, as it gave 6.86 g.plant^{-1}, while the spraying treatment with a concentration of 50 mg.L^{-1} gave the lowest rate of 4.34 gm.plant^{-1}. As for the interactions between the combinations of growth regulators and nano-iron, there are significant differences between the treatments, as the results showed a significant excelled for the spray treatment with gibberellin 100 mg. L^{-1}, benzyl adenine 50 mg. L^{-1}, and nano-iron at a concentration of 100 mg. L^{-1}, which gave 13.90 g.plant^{-1} compared to the control treatment, which gave the lowest rate of 1.76 g.plant^{-1}.

Total chlorophyll content of leaves (mg.100 g^{-1} fresh weight:(

The results of Table (2) indicate that there are no significant differences between the spray treatments with combinations of growth regulators in the total chlorophyll content of the leaves. From the same table, we notice that there are significant differences between the spray treatments with nano-iron, where the spray treatment with a concentration of 100

mg.L^{-1} was excelled, which gave 121.4 mg.100 g^{-1} compared to the control treatment that gave 112.1 mg.100 g^{-1}. As for the interaction between the two factors, we notice significant differences, as the spraying treatment with gibberellin 50 mg. L^{-1}, benzyl adenine 25 mg. L^{-1}, and nano-iron outperformed At a concentration of 100 mg.L^{-1}, it gave 138.8 mg.100 g^{-1} compared to the spraying treatment with gibberellin 50 mg.L^{-1}, benzyl adenine 25 mg.L^{-1}, and nano-iron at a concentration of 0 mg.L^{-1}, which gave the lowest rate of 104.4 mg. .100 g^{-1}.

Total vegetative yield (kg.ha^{-1})

The results of Table (2) indicate that there are significant differences between the spraying treatments with combinations of growth regulators in the total vegetative yield, as the spraying treatment with gibberellin 25 mg.l-1 and benzyl adenine 25 mg. $L^{-1}$was excelled, as it gave 23287 kg.ha^{-1} compared to the treatment. The control, which gave the lowest rate, amounted to 27,460 kg.ha^{-1}. As for the spraying treatments with nano-iron, significant differences were recorded, as the spraying treatment at a concentration of 100 mg. L^{-1}gave the highest rate, amounting to 22,339 kg.ha^{-1}, compared to the control treatment, which gave the lowest rate. It reached 17715 kg.ha^{-1}. From the same table, significant differences were recorded in the interaction coefficients between the combinations of growth regulators and nano-iron, as the spraying treatment with gibberellin 25 mg.L^{-1}, benzyl adenine 25 mg. L^{-1}, and nano-iron at a concentration of 100 mg.L^{-1} gave the highest yield rate of 30,400 kg.ha. $^{-1}$ compared to the control treatment, which gave the lowest yield rate of 9833 kg.ha-^{1}.

Number of flower inflorescences (inflorescence.plant^{-1}):

We note from Table (2) that there are significant differences between the spraying treatments with combinations of growth regulators, as the spraying treatment with gibberellin 50 mg. $L^{-1}$and benzyl adenine 50 mg. L^{-1}gave the highest average number of flower inflorescences, amounting to 38.11 inflorescences.plant^{-1} compared to the control treatment, which gave The lowest rate is 15.11 inflorescences.plant^{-1}. From the same table it is clear that there is a significant difference between the spraying treatments with nano-iron, and the spraying treatment with a concentration of 100 mg. $L^{-1}$was excelled, as it gave 29.13 inflorescences.plant-1 compared to the control treatment, which gave 20.73 inflorescences.plant^{-1}. As for the interaction between the combinations of growth regulators and nano-iron, we note that there is a significant difference between the treatments, as the spraying treatment with gibberellin 50 mg. L^{-1}, benzyl adenine 50 mg. $L^{-1}$and nano-iron at a concentration of 100 mg. $L^{-1}$was excelled, which gave 43.00 inflorescences.plant^{-1}.compared to the control treatment, which gave the lowest rate of 11.00 inflorescences.plant^{-1}.

Number of seeds in the main inflorescence (seed.inflorescence^{-1}):

From the data in Table (2), we notice that there are significant differences between the spray treatments with growth regulator combinations in the number of seeds in the main inflorescence, as all spray treatments with growth regulator combinations excelled compared to the control treatment, and did not differ significantly between them, as the highest rate of seed number when spraying treatment with gibberellin was 50. mg. $L^{-1}$and benzyl adenine 25 mg. L^{-1}, which gave (1272 seeds.inflorescence-1) compared to the control treatment, which gave (537

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seeds.inflorescence^{-1}). From the same table, we note that there are significant differences between the treatments that were sprayed with nano-iron, as the spraying treatment with a concentration of 100 mg. L^{-1}was excelled, which gave (1110 seeds inflorescence $^{-1}$) compared to the control treatment, which gave the least number of seeds (918 seeds inflorescence $^{-1}$). It is noted from the same table that there is a significant difference between the interaction coefficients between the factors, as the spraying treatment with gibberellin 50 mg.L-1, benzyl adenine 50 mg.L^{-1}, and nano-iron at a concentration of 50 mg.L^{-1} gave the highest average number of seeds in the main inflorescence, amounting to 1494. Seed.Inflorescence-1 compared to the spraying treatment with gibberellin 0 mg.L^{-1}, benzyl adenine 0 mg.L^{-1}, and nano-iron at a concentration of 50 mg.L^{-1}, which gave the lowest rate of 508 seeds.Inflorescence^{-1}.

Percentage of nitrogen in leaves:

The results of Table (2) indicate that there are no significant differences between the spraying treatments with combinations of growth regulators in the percentage of nitrogen. As for the spraying treatments with nano-iron, we notice significant differences between the treatments, as the spraying treatments with a concentration of 100 mg. L^{-1}and the spraying with a concentration of 50 mg.L^{-1} excelled. , which respectively gave 3.849% and 3.664% compared to the control treatment, which gave the lowest rate of 3.379%, and which did not differ significantly between them. From the same table, we notice that there are significant differences between the interaction coefficients between the factors, as the spraying treatment with gibberellin 50 mg.L^{-1}, benzyl adenine 50 mg.L-1, and nano-iron at a concentration of 100 mg.L^{-1} gave the highest percentage of nitrogen, reaching 4.087%, in When spraying treatment with gibberellin 50 mg.L^{-1}, benzyl adenine 25 mg.L^{-1}, and nano-iron at a concentration of 0 mg.L^{-1} gave the lowest rate of 3.173%.

Percentage of phosphorus in leaves:

The results of Table (2) showed that there were no significant differences between the spraying treatments with combinations of growth regulators in the percentage of phosphorus. From the same table we notice that there are significant differences between the spraying treatments with nano-iron, where the spraying treatment with a concentration of 50 mg.L^{-1} was excelled, as it gave 0.344% in comparison. With the control treatment that gave 0.224%. As for the binary interaction, we notice that there are significant differences between the treatments, as the spraying treatment with gibberellin 50 mg. L^{-1}, benzyl adenine 50 mg. L^{-1}, and nano-iron at a concentration of 50 mg. L^{-1}gave the highest rate of 0.498%, while the spraying treatment with gibberellin gave 50 mg.L^{-1}, benzyl adenine 50 mg.L^{-1}, and nano-iron at a concentration of 0 mg.L^{-1}, the lowest rate was 0.130%.

Percentage of potassium in leaves:

We note from Table (2) that there are significant differences between the spraying treatments with combinations of growth regulators in the percentage of potassium, as the spraying treatment with gibberellin 25 mg. L^{-1} and benzyl adenine 25 mg. L^{-1}gave the highest percentage of 2.260% compared to the spraying treatment with gibberellin 100. mg.L-1 and benzyl adenine 50 mg. L^{-1}, which gave the lowest percentage of 1.672%. As for the spraying treatments with nano-iron, significant differences showed, as the spraying treatment with a concentration of 100 mg. L^{-1}was excelled, which gave the highest percentage of

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2.018% in comparison. With the spraying treatment at a concentration of 50 mg. L^{-1}, which gave the lowest percentage of 1.823%. From the same table, we note that there are significant differences between the interaction coefficients between the combinations of growth regulators and nano-iron, as the spraying treatment with gibberellin 25 mg. With the spraying treatment with gibberellin 100 mg. L^{-1}, benzyl adenine 50 mg. L^{-1}, and nano-iron at a concentration of 0 mg. L^{-1}, which gave the lowest percentage of 1.573%.

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Table (2) The effect of growth regulators and nano-iron on the studied vegetative traits.										
Potassium %	**Phosphorus %**	**Nitrogen %**	**Number of inflorescences (inflorescence.plant^{-1})**	**The number of seeds in an inflorescence (seed.Inflorescence^{-1})**	**Total vegetative yield, kg.ha^{-1}**	**Total chlorophyll mg.kg^{-1}**	**Dry weight of root (g)**	**Number of branches(branch.plant^{-1}**	**Plant height cm**	**Effect of growth regulators**
2.100	0.297	3.478	15.11	537	12460	118.0	2.91	3.98	33.5	H1
2.260	0.285	3.671	24.56	1091	23287	118.0	3.86	5.80	54.8	H2
1.816	0.266	3.577	24.00	1272	21490	119.1	5.77	6.42	78.3	H3
1.774	0.313	3.689	38.11	1263	17111	11.4	6.56	5.63	70.2	H4
1.672	0.284	3.736	21.67	1055	22779	123.9	8.01	6.72	81.5	H5
0.123	N.S	N.S	7.930	280.1	6027.6	N.S	1.481	2.482	13.74	L.S.D
Effect of nano-iron										
1.933	0.224	3.379	20.73	918	17715	112.1	5.05	6.08	65.9	Fe1
1.823	0.344	3.664	24.20	1102	18222	120.7	4.34	5.56	60.6	Fe2
2.018	0.298	3.849	29.13	1110	22339	121.4	6.86	5.4	64.4	Fe3
0.072	0.074	0.2906	2.081	96.5	1726.9	8.94	0.824	N.S	N.S	L.S.D
Effect of interaction between growth regulators and nano- iron										
1.820	0.433	3.416	11.00	537	9833	117.1	1.76	4.07	32.3	H1Fe1
1.920	0.170	3.547	18.33	508	13887	116.5	2.72	4.47	33.8	H1Fe2
2.560	0.288	3.472	16.00	567	13660	120.5	4.23	3.40	34.3	H1Fe3
2.580	0.175	3.565	17.33	935	19367	114.0	4.73	6.60	58.8	H2Fe1
1.947	0.367	3.565	23.33	1100	20093	130.0	4.35	4.50	52.5	H2Fe2
2.253	0.312	3.883	33.00	1238	30400	109.9	2.49	6.30	53.0	H2Fe3
1.910	0.138	3.173	18.33	1338	25053	104.4	4.72	5.80	81.1	H3Fe1
1.760	0.397	3.715	21.33	1331	17127	114.1	6.07	7.87	74.8	H3Fe2
1.777	0.262	3.884	32.33	1146	22290	138.8	6.51	5.60	79.0	H3Fe3
1.780	0.130	3.341	35.33	956	17273	105.1	7.91	6.73	72.7	H4Fe1
1.793	0.498	3.640	36.00	1494	15313	123.1	4.59	5.07	60.9	H4Fe2
1.750	0.310	3.087	43.00	1338	18747	105.9	7.17	5.10	77.0	H4F3
1.573	0.246	3.397	21.67	826	17047	119.8	6.15	7.20	84.6	H5Fe1
1.693	0.289	3.853	22.00	1076	24690	119.7	3.98	5.90	81.1	H5Fe2
1.750	0.317	3.957	43.00	1262	26600	132.0	13.90	7.07	78.6	H5Fe3
0.171	0.165	0.894	8.426	313.5	6492.4	23.20	1.988	2.964	18.44	L.S.D

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Discussion:

The results of Table (2) showed a significant increase in the studied indicators (plant height, number of branches, root dry weight, total yield, number of flower inflorescences, number of seeds in the main inflorescence) with the addition of growth regulators (gibberellin and benzyl adenine). The increase in plant height can be attributed The connection between gibberellin and benzyl adenine in regulating the process of building endogenous auxin, which has a very important role in cell elongation, in addition to the competitive balance between auxin and gibberellin, which regulates apical dominance [13] The significant increase in the number of branches can be due to the role of gibberellin in encouraging The growth of lateral shoots by stimulating cell division and elongation, which means providing more nutrients for the growth and development of those branches [19] and the role of benzyl adenine in reducing the effectiveness of auxin in showing apical dominance [12] This is consistent with what It was reached by [16] when they found a significant increase in the number of branches of the black seed plant as a result of treating it with gibberellin. The increase in total yield is due to the fact that spraying the plants with gibberellin and benzyl adenine led to improved vegetative growth and caused an increase in the height of the plant and the number of lateral branches, which was reflected in an increase Vegetative yield. This was reflected in an increase in the dry weight of the root, as well as an increase in the percentage of potassium in the leaves, which led to an increase in the rates of photosynthesis, the construction of proteins, and the transfer of carbohydrates to the roots, which caused an increase in the dry weight of the root, and this is consistent with the findings of [10] There was an increase in The total chlorophyll content of leaves when interacting with nano-iron can be due to the important role of benzyl adenine in the formation of chloroplast during leaf growth and development (Mohammed, 1985), in addition to its effective role in preventing the breakdown of chlorophyll and the degradation of proteins [1]. The number of flower inflorescences and the number of seeds in the main inflorescence is due to the fact that spraying plants with growth regulators led to an increase in the number of branches in the plant, as well as the percentage of chlorophyll, in addition to the role of growth regulators in transferring nutrients to the consumed parts, represented by new leaves, flowers, and seeds, and then increasing their number [17] and the role of essential gibberellin acid in increasing the number of flowers formed. These results agreed with the findings of [11] when adding gibberellin acid to black seed plants, as well as with the findings of [4]. The results of spraying with nano-iron show a significant increase in the dry weight of the root, the percentage of total chlorophyll, the vegetative yield, the number of flower inflorescences, and the number of seeds in the main inflorescence. The reason for the significant increase in the studied vegetative traits treated with nano-iron is due to the role of iron in the process of photosynthesis and the construction of the necessary DNA and RNA nucleic acids. For cell division, in addition to that, it has an essential role in the formation of the chlorophyll molecule, which is involved in the process of photosynthesis, and in building the materials necessary for plant growth [6] and this is consistent with what was indicated by [8] Adding iron led to an increase in

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vegetative growth. And what happens to strawberry plant. The results of the interaction between gibberellin, benzyl adenine, and nano-iron indicate a significant increase in most of the vegetative growth traits studied. This is due to the role of the common factors in increasing the physiological processes within the plant, which causes an increase in the process of photosynthesis, cell division, enzyme activity, and chlorophyll formation, which is then reflected in plant growth. In general, the vegetative total increased, which caused an increase in all the vegetative and root traits studied. The results indicate that spraying with gibberellin and benzyl adenine had a significant effect in increasing the percentage of potassium, and this can be due to improving vegetative growth, which reflects positively on increased potassium absorption. Also, potassium absorption increased as a result of the increased rate of root growth, which spreads to a larger area and absorbs a larger amount of potassium. This is consistent [15] who stated that the absorption of potassium and its transfer to the leaves is affected by plant growth, as it is directly proportional to the growth of the plant, as it increases with an increase and its absorption decreases with a decrease in the plant growth rate. And an increase in the percentage of nitrogen and the percentage of phosphorus when interacting with nano-iron. This can be explained by the role of gibberellin in increasing the level of endogenous auxin, which plays an important role in the movement of nutrients [13] in addition to the effect of benzyl adenine on the reception and transfer of dissolved nitrogenous compounds from Certain leaves to other leaves, that is, it affects the formation of attractive places that have an advantage in attracting and accumulating mineral nutrients such as nitrogen and transferring them from leaves and old tissues to new leaves and effective tissues such as growing tips (Saleh, 1991). This is consistent with what [5] found when spraying with gibberellin.

The results show that spraying with nano-iron has achieved significant differences in increasing the percentage of nitrogen, the percentage of phosphorus, and the percentage of potassium. The reason for this increase is due to the role of nano-iron in increasing the activity of enzymes that contribute to building cells as a result of increasing the efficiency of photosynthesis, as iron is involved in enzyme synthesis. Ferrodoxin, which is a transporter of electrons, which in turn accelerates the process of photosynthesis and thus increases growth indicators that include the vegetative and qualitative traits of the plant (Sharifi et al., 2016). The results of the interaction between growth regulators and nano-iron indicate a significant effect on nitrogen, phosphorus, and potassium, and this effect is due to the role of Growth regulators and nano-iron and their interaction together increase vegetative and root growth, which reflects positively on increased absorption of nutrients, which increases the plant's content of them.

Conclusions:

1. The use of combinations of growth regulators led to significant differences in most of the traits studied and had a significant effect in improving the traits of vegetative growth and yield.
2. Spraying treatment with nano-iron had a significant effect on most of the vegetative traits studied.
3. Spraying treatment with gibberellin 25 $mg.L^{-1}$, benzyl adenine 25 $mg.L^{-1}$ and nano-iron at a concentration of 100 $mg.L^{-1}$ is excelled in total vegetative yield.

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