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The effect of spraying arginine acids and nano iron fertilizer on the growth and chemical indicators of *Antirrhinum majus* L

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ABSTRACT

The experiment aimed to assess the impact of arginine and nano-iron floral spray fertilizer on the growth and chemical markers of *Antirrhinum majus* L. An experiment was carried out in the nursery of the Agricultural Division at the University of Kufa during the 2021-2022 growing season, using 25% green saran shading. The experiment included two factors: the first being the amino acid arginine, present in the solution at four concentrations (0, 20, 40, and 60) mg L⁻¹. The second factor includes Nano-iron, present in the solution at four different concentrations: 0, 30, 60, and 90 mg L⁻¹. The experiment was conducted using a completely randomized block design (RCBD) with three replications. The results showed that the application of an arginine spray at a dosage of 60 mg L⁻¹ supplemented with 90 mg of Nano-iron at a concentration L-1 caused a significant increase in the indicators of the study such as the plant height (55.61 cm), number of leaves (288.3 leaves plant-1), number of total branches (8.70 branches Plant-1), number of inflorescences (6.53 inflorescence Plant-1), diameter of inflorescence (18.03 cm), number of florets in inflorescence (23.76 Floret Inflorescence-1), length of flower peduncle (22.25 cm), length of inflorescence (17.17 cm), age of flower on plant (27.93 days), Leaf content of total chlorophyll (30.54 mg 100 g⁻¹), total carbohydrates (12.93 mg g⁻¹), nitrogen (3.05%), phosphorus (2.01%), iron (50.04 g L⁻¹), and flower content of anthocyanin (23.06 mg 100 g⁻¹). Compared to the control treatment, which exhibited the lowest levels. Therefore, it can be concluded that using arginine and iron nanoparticles enhances the growth and flowering characteristics of snapdragon.

Keywords: Arginine Acids, Nano Iron, Fertilizer, Growth, Chemical indicators, Snapdragon

Introduction

Antirrhinum majus L. (snapdragon) belongs to the family Scrophulariaceae and is considered a herbaceous annual winter plant, but it will survive if it is planted in a place protected from the sun's heat in the summer (Hayden, 2024) [1]. The demand for its flowers increases during the period when the flowers of other plants are less or in the period between the flowering of plants, and plants are suitable for cultivation in pots, in basins, and panels (Qiao *et al.*, 2023; Hayden, 2024) [2, 1]. The recent years have witnessed the introduction of new varieties of Halaq al-Saba' plant to Iraq, such as "Rocket Mix." and "Snapshot Mix." And "Rocket Golden", "Rocket Red", "Snapshot Yellow" and "Snapshot Red" through the first Baghdad International Flower Show, which was held in April 2009 at Al-Zawra Gardens. In order to obtain the flowering inflorescences of snapdragon of high quality in terms of flowering density, size of inflorescences and longevity of the flower on the plant, the plant is treated with the amino acid arginine, which is an aliphatic amino acid and has the symbol R or Agr, an organic compound with molecular formula C₆H₁₄O₂, which has a role Important in many biological processes in plants in terms of plant growth and development and flowering stimulation (Cho *et al.*, 2017 [3]). (It also has a role in most of the processes inside the plant, and from it comes its role in resistance, where its importance and roles emerge in each stage of the plant. The plants were also sprayed with nano iron, as iron is one of the essential nutrients for plant growth and it is a slow to medium element within the plant tissues (Kermeur *et al.*, 2023) [4]. It has a major role in metabolic processes such as DNA and RNA synthesis, photosynthesis, respiration and chlorophyll content. It has a role in plant biochemical pathways (Jhanji *et al.*, 2023) [5]. Iron is also the electron donor to the energy compound NADH in the first photosystem, and many morphological changes occur as a result of iron deficiency (Barker *et al.*, 2015 [6]). Iron nanoparticles can be considered a rich and effective source of bivalent iron due to its high stability and gradual release of iron in a wide range of pH between 3 to 11 (Alwan *et al.*, 2024) [7], where iron particles are 10 to 1000 times more effective than conventional iron fertilizers and the most common and the reason is due to It has more surface area available for interaction (Kumar *et al.*, 2025; Alkarawi, 2025) [9, 8], which leads to an increase in vegetative, flowering and chemical growth. Thus, ob

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taining high quality plants in terms of flowers and flower age on the plant to increase the aesthetic value in gardens and parks.

Materials and methods

The experiment was carried out in the agricultural nursery at the University of Kufa, in a house covered with green saran, with a shading percentage of 25%. To show how snapdragons respond to foliar spraying of fertilizer containing arginine and nano-iron in the autumn planting season of 2021-2022.

When the snapdragon seeds (Sonnet Orange, imported from the American company SAKATA) on 4/10/2021 were sown in plastic agricultural trays measuring (55 x 28) cm, filled with peat moss. After the snapdragon seeds had germinated, once the plantlets attained a height of 4-5 cm, they were placed in plastic pots with dimensions of 25 cm diameter and 24 cm height. Each pot, weighing 5 kg, contained one plant grown in an agricultural medium made of a 3:1 soil-to-peat moss mixture. Soil analysis appears in Table No. (1), and peat moss in Table No. (2), both conducted in the Graduate Studies Laboratory of

the Department of Soil and Water Sciences at the College of Agriculture, University of Kufa.

Table 1. chemical analysis of the soil before planting

Features	Value	Unit
pH	7.5	-
EC	3.9	dS m ⁻¹
N	30.5	mg L ⁻¹
P	12.6	mg L ⁻¹
K	144.5	mg L ⁻¹
CaCO ₃	12.5	%
Soil Organic matter	2.1	%
Clay	16.5	%
Silt	8.0	%
Sand	75.5	%
Soil texture	Sandy Loam	

Table 2. Peat moss analysis

S	Mg	K ₂ O	P ₂ O ₅	N	pH	EC
120	100	180	160	140	7.82	2.63
mg L ⁻¹	mg L ⁻¹	mg L ⁻¹	mg L ⁻¹	mg L ⁻¹	-	dS m ⁻¹

The experiment included the influence of two factors:

The first factor: Arginine was sprayed at four different concentrations (0, 20, 40, and 60) mg L⁻¹.

The second factor involves spraying nano iron at four concentrations (0, 30, 60, and 90) mg L⁻¹.

The first spray was applied three times for the first factor. For the second factor, the first spray was applied 38 days after planting the plants in pots, when the plants reached the age of 5-4 pairs of true leaves; the second spray was applied 21 days after the first spray, and the third spray was applied 21 days after the second spray.

The first spray of arginine was on 12.08.2021, the second spray was on December 29, 2022, the third spray was on 19.01.2022, the first spray for nano iron was on 12.12.2021, the second spray was 02.01.2022, and the third spray was on 23.01.2022. Spraying continued until the leaves were fully wet and droplets of the solution dripped off in the early morning, using a 2-liter hand-held sprinkler to avoid sunlight and reduce evaporation.

Markers Indicating Our Study Areas

Vegetative Growth Indicators

Plant height (cm): The plant's height was recorded using a tape measure from the soil surface in the pot to the tallest point of the vegetative structure.

Total leaf count (per plant⁻¹): The sum of leaves for each experimental unit, used to compute the average values for each treatment.

Indicators Of Flower Growth

Number of inflorescences (inflorescences plant⁻¹)

The number of inflorescences per plant was calculated for each experimental unit, and the average number of inflorescences per treatment was recorded on 29.03.2022.

Inflorescence length (cm): The length of the inflorescence was measured with a measuring tape for each experimental unit, starting from the area of contact of the flower stand with the main stem to the lower base of the inflorescence when the flower bud appears

Number of florets (florets⁻¹)

For each treatment, the number of florets in each plant's inflorescence was tallied, and the average floret count per experimental unit was established.

Chemical indicators

Determination of the total chlorophyll content of leaves (mg 100 g⁻¹) was estimated according to the method of Alsina et al. (2016) [10].

The percentage of N (%) was estimated according to the method of Al-Sahhaf (1989).

The flower anthocyanin dye content (mg 100 g⁻¹) was estimated using the method described by Sakar et al., (2008) [11].

Statistical analyses

The experiment used a completely randomized design (CRD) with a factorial arrangement to assess the effects. Treatment methods were compared using the LSD test at the 0.05 probability level, with statistical analyses conducted using SAS software (Landau and Everitt, 2003) [12].

Results and discussion

The results in Table (3) show that spraying *Antirrhinum majus* L. with arginine at 60 mg L⁻¹ significantly enhanced vegetative growth indicators. The plant height and total leaf count reached 53.07 cm and 228.2 leaves per plant, respectively, compared to the control treatment. It reached 38.29 cm and 127.2 leaves in Plant⁻¹. The reason is the important role of amino acids in the process of carbon metabolism, as they are a main source of nitrogen necessary for building important proteins and enzymes involved in building plant cells and then increasing the division and elongation of plant cells, which leads to an increase in plant height, number of branches, and number of leaves on the plant (Bhatla et al., 2023) [13].

It is noted from Table (3) that spraying *Antirrhinum majus* L. with nano iron at a concentration of 90 mg L⁻¹ led to a significant increase in the indicators of vegetative growth, plant height, and total number of leaves, which reached 50.39 cm and 195.7 leaves. It reached 44.72 cm and 128.8 leaves in Plant⁻¹. The reason for the increase in the vegetative total of a plant is due to the important role of the nano-iron element in plant growth, which affects increasing and improving vegetative growth indicators as it performs many important functions in the plant, being the driving force for many vital activities carried out by the plant (Rout et al., 2015) [14]. Its importance also stems from its crucial role in the direct formation of cytochromes, acting as an electron carrier in respiration and photosynthesis. Moreover, it is involved in the composition of a Flavoproteins mineral, which has an active function. It plays a role in biological oxidation processes and participates in the synthesis of enzymes like catalase and peroxidase (Minjun et al., 2022) [15]. The results in Table (3) show that spraying *Antirrhinum majus* L. with arginine at 60 mg L⁻¹ significantly enhanced flowering growth indicators.

There was an increase in the number of flowering inflorescences, the length of the flowering inflorescence, and the number of florets per inflorescence, reaching 6.40 inflorescences per plant and 14.18 cm,

compared to the control treatment, which had 5.21 inflorescences per plant and 9.68 cm. The reason could stem from arginine's involvement in the synthesis and preparation of hormones connected to flowers, which increases the overall number of flowers on the plant (Yao *et al.*, 2025) [16]. The results in Table (3) indicate that spraying the snapdragon with nano-iron at a concentration of 90 mg L⁻¹ resulted in a notable rise in flowering growth indicators, including an increased number of inflorescences, longer inflorescences, and more florets per flowering inflorescence. This reached 5.93 inflorescences plant⁻¹ and 12.72 cm, compared to the control treatment, which amounted to 5.63 inflorescences plant⁻¹. As a result, the number of flowers per plant increased (Pourbeyrami and Sardari, 2026) [17]. It also contributes to the lipid composition of nuclear membranes, chloroplasts, and mitochondria, and aids in forming cell wall proteins. Thus, it was determined that iron is essential for plants for cell division and respiration, and it plays a role in producing ferredoxin, a protein that facilitates electron transfer in photophosphorylation (Iyanagi, 2022) [18].

The results in Table (3) show that foliar spraying of snapdragon with arginine at 60 mg L⁻¹ caused a notable rise in the chemical growth indicators, and a rise in chlorophyll and nitrogen content, along with anthocyanin dye levels in flowers, reaching 28.87 mg L⁻¹, 3.17%, and 21.40 mg L⁻¹, respectively, compared to the control treatment values of 22.80 mg L⁻¹, 1.62%, and 9.82 mg L⁻¹.

This is because of arginine's physiological function, which modifies the osmotic potential within the plant tissue. An increase in it lowers the osmotic effort, causing a reduction in the cell's water potential, which enhances the cell's capacity to absorb water and dissolved nutrients from the growth medium, thereby promoting the plant's vegetative growth.

Consequently, the chlorophyll content in the leaves increases (Al-Janabi *et al.*, 2022) [19]. Table 3 results indicate that foliar spraying of snapdragon with nano iron at 90 mg L⁻¹ significantly enhanced the chemical growth indicators. There was an increase in chlorophyll content, nitrogen, and anthocyanin dye in flowers, reaching 26.60 mg L⁻¹, 2.84%, and 16.72 mg L⁻¹, respectively, compared to the control treatment values of 24.64 mg L⁻¹, 1.66%, and 13.05 mg L⁻¹. This is because the treatments sprayed with chelated iron were superior, resulting in an increase in the total chlorophyll content of the leaves. The reason for this is the iron element, which gave an increase in the percentage of nitrogen in the leaves, since nitrogen is incorporated in the porphyrin framework, composed of four five-membered pyrrole rings with nitrogen atoms. According to Liu *et al.* (2025) [20], magnesium is part of the chlorophyll pigment's composition.

From the table (3) results indicate that spraying snapdragons with arginine at 60 mg L⁻¹ and nano iron at 90 mg L⁻¹ caused a significant rise in chemical, vegetative, and flowering growth indicators, as the plant's height, leaf count, inflorescence number, and flowering length increased. The floral inflorescence measured 55.61 cm, with 288.3 leaves, and included the number of florets, leaf content of chlorophyll and nitrogen, and flower content of anthocyanin pigment. The floral inflorescence measured 55.61 cm, with 288.3 leaves, and included the number of florets, leaf content of chlorophyll and nitrogen, and flower content of anthocyanin pigment. mg 100 g⁻¹ and 3.50% and 23.06 mg 100 g⁻¹ compared to the control treatment, It measured 34.34 cm and had 93.7 leaves. Plant⁻¹: 4.93 Inflorescence Plant⁻¹: 8.94 cm and 17.41 Inflorescence⁻¹ and 20.91 mg. 100 g⁻¹ and 5.13 mg/100 g⁻¹.

Table 3. Impact of foliar application of snapdragon with varying arginine and nano iron concentrations on vegetative, flowering, and chemical growth parameters.

P%	N %	Chlorophyll content (mg.100 g ⁻¹)	No. florets inflorescence ⁻¹	Inflorescence length (cm)	No. inflorescences plant ⁻¹	No. leaves plant ⁻¹	plant height (cm)	Treatments
0.84	1.62	22.20	18.19	9.68	5.21	127.2	38.29	Control Arg (0)
0.92	2.13	24.44	19.81	11.34	5.45	157.8	47.82	20 mg L ⁻¹
0.99	2.49	26.62	21.32	11.77	6.00	175.8	51.97	40 mg L ⁻¹
1.24	3.17	28.87	22.87	14.18	6.40	228.2	53.07	60 mg L ⁻¹
0.188	0.194	0.913	0.236	0.226	0.201	16.81	1.152	LSD 0.05
0.32	1.66	24.64	19.87	10.72	5.63	128.8	44.72	Control Fe (0)
0.72	2.36	25.16	20.27	11.66	5.72	183.6	47.52	30 mg L ⁻¹
1.23	2.56	25.73	20.85	11.87	5.79	181.0	48.52	60 mg L ⁻¹
1.71	2.84	26.60	21.21	12.72	5.93	195.7	50.39	90 mg L ⁻¹
0.188	0.194	0.913	0.236	0.226	0.201	16.81	1.152	LSD 0.05
0.18	1.23	20.91	17.41	8.94	4.96	93.7	34.34	Control Fe (0)
0.23	1.25	22.03	17.86	9.56	4.96	130.0	36.33	Control Arg 0 mg L ⁻¹
0.33	1.66	22.69	18.50	9.97	5.26	135.3	40.65	30 mg L ⁻¹
0.54	2.35	23.16	19.00	10.26	5.40	150.0	41.82	60 mg L ⁻¹
0.56	1.36	23.64	19.16	9.56	5.40	150.0	42.36	90 mg L ⁻¹
0.68	2.37	23.75	19.40	10.34	5.40	153.3	48.66	Control Fe (0)
0.76	2.28	24.75	20.16	11.75	5.50	153.3	49.83	20 mg L ⁻¹
0.86	2.42	25.61	20.53	11.62	5.50	176.7	50.44	30 mg L ⁻¹
								60 mg L ⁻¹
								90 mg L ⁻¹

(continued on next page)

P%	N %	Chlorophyll content (mg.100 g ⁻¹)	No. florets inflorescence ⁻¹	Inflorescence length (cm)	No. inflorescences plant ⁻¹	No. leaves plant ⁻¹	plant height (cm)	Treatments	
1.04	1.46	25.88	20.53	11.67	5.86	156.7	50.68	Control Fe (0)	40 mg L ⁻¹
1.11	2.47	26.61	21.33	11.88	5.86	198.0	51.03	30	mg L ⁻¹
1.21	2.53	26.91	21.46	11.58	6.00	170.0	52.48	60	mg L ⁻¹
1.55	3.53	27.08	21.56	11.78	6.30	169.7	53.69	90	mg L ⁻¹
1.56	2.59	28.12	21.98	11.84	6.30	105.7	51.51	Control Fe (0)	60 mg L ⁻¹
1.64	3.35	28.26	22.50	11.71	6.40	255.3	54.07	30	mg L ⁻¹
1.64	3.69	28.56	23.26	13.75	6.40	265.3	51.10	60	mg L ⁻¹
2.01	3.05	30.54	23.76	14.10	6.53	288.3	55.61	90	mg L ⁻¹
0.376	0.389	1.827	0.472	17.17	0.403	33.62	2.303	LSD 0.05	

Conclusions

The foliar application of arginine and nano-iron significantly influenced the growth characteristics of snapdragon plants. The application of arginine acid at 60 mg L⁻¹ was the most effective concentration, showing a significant impact on most snapdragon plant traits, exhibiting superior performance in the majority of the study's metrics. Applying arginine (60 + 90 mg L⁻¹) together with nano-iron as a foliar spray positively affected the plants, leading to the highest levels of vegetative, flowering, growth indicators.

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