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Effect of spraying with arginine and chelated zinc on growth and flowering indicators of geranium (*Pelargonium hortorum*)

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Abstract

The study was conducted to explore the impact of spraying arginine at four concentrations (0, 10, 20, and 30 mg L⁻¹), and chelated zinc at four concentrations (0, 20, 40, and 60 mg L⁻¹) alone or in combination on the growth parameters (plant height, number of leaves, total leaf chlorophyll content, leaf soluble carbohydrate content) and flowering traits (number of inflorescences, and length of inflorescence stalk) of geranium plants, Pinto Premium Deep Red cv. Plants were sprayed three times monthly interval, with the first spraying beginning 32 days after the seed sowing date. The experiment was carried out using a Randomized Complete Block Design (RCBD), and the data were analyzed using one way ANOVA, and comparisons were made according to the Least Significant Difference (LSD) test at a probability level of (0.05). Results showed that Spraying with arginine at a concentration of 30 mg.L⁻¹ combined with chelated zinc at a concentration of 60 mg.L⁻¹ resulted in a significant increase in plant height, number of leaves, total leaf chlorophyll content, leaf soluble carbohydrate content, number of inflorescences, and length of inflorescence stalk compared to the control treatment and the individual treatments for both arginine and chelated zinc.

Keywords: *Pelargonium hortorum*, Geranium, Arginine, Chelated Zn

Introduction

Geranium plant (*Pelargonium hortorum*) belongs to the *Geranaceae* family, which includes more than 6 genera and hybrids. It is a medium-height perennial herbaceous plant that grows to approximately (50 cm), with thick, succulent branches and semi-round leaves with inwardly grooved edges, covered with hairs that give it a smooth texture and is distinguished by the presence of a circular ring on the blade that differs in color from the rest of the leaf color (Al-Batal, 2010). Its flowers are beautiful to look at, and may be solitary or in clustered umbels on a long, slow stalk that is not suitable for cutting, their colors are bright, including red, white, crimson, purple, and pink. The plant's original habitat is South Africa (Elena and Lucian, 2010) [22].

Ealayawi and Al-Dulaimy, 2023a, b) [9, 10], *Carissa carandas* (Hamed & Ahmed, 2024) [28]. Zinc is one of the essential micronutrients for plants growth because of its important role in protein synthesis, also, it is necessary for plant growth and development and for completing its life cycle, as it regulates sugar consumption and increases the energy units needed to produce chlorophyll and helps in the synthesis of auxins (Michalczyk and Ackland, 2006). Mengel and Kirkby (2001) [5] indicated that zinc increases the biological synthesis of vitamins, affects carbohydrate and phosphate exchange in plants, and is necessary for the synthesis of the amino acid tryptophan, which is the precursor to IAA, which helps in plant growth and is also necessary for the biosynthesis of chlorophyll, DNA, RNA, and protein synthesis. Several studies were used zinc for improving vegetative and flowering growth of *Antirrhinum majus* (Hadi & Saeed, 2019) [26], *Rosmarinus officinalis* (Mehrabani *et al.*, 2018) [34], geranium (Vojodi *et al.*, 2016) [42], *Artemisia annua* (Khudsar *et al.*, 2004) [32], *Chrysanthemum* (Derakhshani *et al.*, 2011) [20] and *Iris* (Yu *et al.*, 2024) [43]. Due to the importance of arginine for *plant* growth and flowering, and the importance of zinc in *plant* growth and development, as well as the

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importance of geranium *plant* economically, this study aims to test the effect of foliar spraying with arginine and zinc and their interaction in improving the vegetative and flowering growth of geranium *plant*.

Amino acids have a significant impact on *plant* growth and development. They are organic compounds and serve as the basic unit of proteins synthesis (Goyal, 2011) [25]. One of amino acid group is arginine, an aliphatic amino acid, Its molecular formula is $C_6H_{14}N_4O_2$, and its molecular weight is 174.2 g mol⁻¹. Its chemical name is 2-amino-5- guanidinopentanoic acid. Arginine is a protein storage agent as a precursor of polyamine and nitric oxide. Arginine has many physiological roles, including improving *plant* growth (Shafeek *et al.*, 2012). It has a role in polyamide synthesis, promoting cell division, root formation, chlorophyll formation, and promoting flower growth in plants as it is an essential amino acid in urea production (Nasibi *et al.*, 2013) [37]. Positive Arginin effects on the growth and quantitative and qualitative yield of various plants has been reported like marigold (Arbani *et al.*, 2020, Haghpavar *et al.*, 2023) [27, 15], strawberry (Alvegetative and flowering growth of geranium *plant*.

Materials and Methods

The study was conducted at the research station of the College of Agriculture, University of Kufa, during 2025-2026 growing season to demonstrate the role of arginine and chelated zinc in the growth and flowering of geraniums. Seeds of the Pinto Premium Deep Red variety, produced by the Swiss company Syngenta, were sown on October 1, 2025, in plastic growing trays containing peat moss. After germination and the seedling reaching a height of 4-5 cm (*i.e.*, the appearance of true leaves), they were transplanted into 25 cm plastic pots in diameter and 24 cm high in a growing medium consisting of river soil and peat moss in a 1:3 ratio, weighing 5 kg, at a rate of one *plant* per pot. The soil was analyzed according Black (1965) (Table 1), and the peat moss was also analyzed) Table 2).

Table 1: Some chemical and physical properties of soil

pH	ECds m-1	OM%	CaCO3%	Nmg Kg-1	Pmg Kg-1
7.4	3.1	1.3	10.9	12.4	12.9
Kmg Kg-1		Sandgm Kg-1	Siltgm Kg-1	Claygm Kg-1	Soil texture
14.3		390	500	110	Silty loam

Table 2: Some chemical properties of peat moss.

pH	EC ds m-1	P2O5mg L-1	Nmg L-1	K2Omg L-1	Mgmg L-1	Smg L-1
7.87	2.66	160	140	180	100	120

Three sprays of arginine at four levels (0, 10, 20, 30) mg.L⁻¹ and chelated zinc at four concentrations (0, 20, 40, and 60 mg/L) were applied alone or in combination, the first spray after the seedlings were transplanted into pots and new leaves appeared on the plants when they had 4-5 pairs of true leaves; the second spray 21 days after the first; and the third spray 21 days after the second. Liquid bleach was added at a rate of two drops per liter of spray solution as a spreading agent. A layer of agricultural nylon (polyethylene) was laid on the floor of the greenhouse under the pots to prevent weed growth in the soil and to avoid salt leaching into the pots. Place thin plastic dishes under each pot to keep the potting soil moist. The recommended fertilizer was Di ammonium phosphate (DAP) at a rate of 0.5 g/pot⁻¹, three times every 30 days for all treatments, and irrigation and

weeding were carried out as needed.

Number of Inflorescences (inflorescence plant⁻¹)

The number of inflorescences per plant was counted, and the average number of inflorescences was calculated.

Inflorescence Stem Length (cm)

The length of the inflorescence was measured using a measuring tape for each experimental unit, starting from the point where the inflorescence stem attaches to the main stem and extending to the base of the inflorescence at the point where the flower bud appears. The average length was then calculated for each treatment.

Chemical Parameters

Total Leaf Chlorophyll

Leaf chlorophyll content (mg 100g⁻¹ FW) was estimated according to the Goodwin (1976) [24] method.

Total Leaf Soluble Carbohydrate (mg g⁻¹)

Leaf carbohydrate content was estimated according to Dubois *et al.* (1956) [21] method.

The experiment was carried out using a Randomized Complete Block Design (RCBD), and the data were analyzed using one way ANOVA, and comparisons were made according to the Least Significant Difference (LSD) test at a probability level of (0.05).

Results

The same table also indicates that spraying with arginine at a concentration of 30 mg/L with chelated zinc at a concentration of 60 mg/L resulted in a significant increase in plant height, number of leaves, total leaf chlorophyll content, total soluble carbohydrates, number of inflorescences, and inflorescence length, reaching 23.95 cm, 98.00 leaves/plant, 23.78 mg/100g⁻¹, 34.35 mg/g⁻¹, 7.74 inflorescences/plant, and 20.06 cm, respectively, compared to the control treatment of 14.23 cm, 20.65 leaves/plant, 15.19 mg/100g⁻¹, 20.85 mg/g⁻¹, 1.00 inflorescences/plant, and 7.05 cm, respectively.

The table data showed that spraying with chelated zinc at a concentration of 60 mg L⁻¹ led to a significant increase in plant height, number of leaves, total leaf chlorophyll content, total soluble carbohydrates, number of inflorescences, and inflorescence stalk length, reaching 16.70 cm, 28.33 leaves/plant, 20.30 mg/100g⁻¹, 34.97 mg/g⁻¹, 2.65 inflorescences/plant, and 13.04 cm, respectively, compared to the control treatment which reached 14.23 cm, 20.65 leaves/plant, 15.19 mg/100g⁻¹, 20.85 mg/g⁻¹, 1.00 inflorescences/plant, and 7.05 cm, respectively.

Vegetative Growth Indicators

Plant Height (cm)

Plant height was measured using a measuring tape from soil to the highest point at the flower bud stage for each experimental unit, and the average was calculated for each treatment.

Total Number of Leaves (leaf plant⁻¹)

Total number of leaves for each experimental unit was calculated, and the average values were calculated for each treatment.

Floral Growth Indicators

The results in Table (3) show that spraying with arginine at a concentration of 30 mg/L led to a significant increase in plant

height, number of leaves, total leaf chlorophyll content, total soluble carbohydrates, number of inflorescences, and length of the inflorescence stalk, reaching 27.01 cm, 36.32 leaves/plant, 17.27 mg/100g⁻¹, 22.64 mg/g⁻¹, 4.02 inflorescences/plant, and

13.84 cm, respectively, compared to the control treatment, which reached 14.23 cm, 20.65 leaves/plant, 15.19 mg/100g⁻¹, 20.85 mg/g⁻¹, 1.00 inflorescences/plant, and 7.05 cm, respectively.

Table 3: Effects of Arginine and Chelated Zinc on vegetative growth and flowering indicators of geranium (*Pelargonium hortorum*) plant.

Arginine (mg L ⁻¹)	Chelated Zinc (mg L ⁻¹)	Plant Height (cm)	Number of Leaves (leaf plant ⁻¹)	Number of Inflorescences	Inflorescence Stalk Length (cm)	Total leaf chlorophyll(mg 100g ⁻¹ FW)	Total carbohydrate (mg g ⁻¹)
0	0	14.23	20.65	1.00	7.05	15.19	20.85
20	15.43	25.33	1.65	10.65	17.01	33.46	
40	21.45	30.66	2.01	14.22	19.19	34.05	
60	16.70	28.33	2.65	13.04	20.30	34.97	
10	0	18.43	37.34	2.66	11.32	21.26	31.55
20	25.56	42.01	3.01	16.23	18.94	34.78	
40	21.78	53.00	3.34	13.24	16.63	33.22	
60	23.16	56.02	3.00	15.25	18.92	35.94	
20	0	24.40	45.65	3.01	12.87	19.17	28.50
20	26.07	62.65	3.65	17.08	20.34	30.75	
40	26.60	65.01	4.00	17.57	21.56	35.75	
60	28.57	61.02	4.00	15.03	16.52	34.90	
30	0	27.01	36.32	4.02	13.84	17.27	22.64
20	29.02	74.02	4.67	18.08	19.32	36.34	
40	30.89	83.66	5.33	19.05	20.26	36.51	
60	23.95	98.00	7.34	20.06	23.78	34.35	
L.S.D.(P≤0.05)		0.719	2.020	0.623	0.698	1.710	0.052

Discussion

The results in Table (3) show that spraying treatments with arginine and zinc alone or in combination have achieved a significant increase in the vegetative growth indicators of the geranium plant, as the plant height and number of leaves and floral indicators have increased. This is due to the important role of each factors (arginine and Zinc) in their effects. For arginine may due to the important role in carbon metabolism process, as they are a primary source of nitrogen necessary for building proteins and important enzymes involved in building plant cells, and thus increasing the division and elongation of plant cells, which in turn leads to an increase in plant height, the number of branches, and the number of leaves on the plant (Taiz and Zeiger, 2006) [40]. The reason may be due to the role of amino acids, which are a nitrogen source for building proteins and enzymes and supplying energy that promotes vegetative and root growth (Nahed and Balbaa, 2007) [36], and that spraying them on the plant achieves an increase in the number of cell divisions and their expansion, and thus achieves a great effect on the indicators of vegetative growth (Baqir *et al.*, 2019) [16]. Spraying with amino acids on plants has multiple effects, especially arginine, which plays an important role as it is involved in the formation of polyamines (Abdul Hafez, 2006) [2]. Polyamines are characterized by their participation in the process of modifying enzyme activity (Enzyme Activity Modulation), cell division and elongation, and are involved in plant growth (Belal *et al.*, 2016) [17]. In addition, it plays a role in the plant in a group of different vital processes such as gene expression and protein synthesis. All of this positively affects the indicators of vegetative growth, as it leads to the height of the plant, the number of main branches, and the number of leaves per plant, and thus an increase in leaf area and consequently an increase in the dry weight of the vegetative system (Afifipour and Khosh-Khui, 2015) [6]. The reason may be due to the effectiveness of the Urease enzyme and the role of amino acids absorbed by the plant leaves, which reduces nitrogen loss through volatilization (EL-Ghamry *et al.*, 2009) [23]. This is consistent with the study of

Al-Taher and others (2014) [14] that spraying arginine on geranium plants led to a significant increase in plant height and number of leaves. It is also consistent with Abd-Elkader (2020) [3] that spraying arginine on *Gerbera* plants led to a significant increase in plant height and number of leaves. This is reflected positively in the increase in the number of flower clusters and the length of the flower stalk (Abdel-Aziz and Balbaa, 2007) [1]. It is observed from the results of Table (3) that the effect of spraying zinc on geranium plants led to a significant increase in vegetative growth indicators, as the height of the plant, the number of leaves, and the number of branches increased. This may be due to the important role of zinc and its positive role in the vital processes it carries out through carbohydrate production and the action of enzymes that regulate plant growth through the hormone indole acetic acid, which is the main one responsible for auxin biosynthesis, which in turn leads to an increase in plant elongation and helps to regulate the effect of auxin in most vital processes and the development of plant tissues and stimulates leaf growth, as well as increasing the efficiency of the photosynthesis process by increasing the content of pigments and the formation of energy compounds and activating a number of enzymes involved in this process, which increases the products of the photosynthesis process and thus increases vegetative growth in the plant. Zinc also has an important role in the accumulation of dry matter in different plant parts (Shireen *et al.*, 2018) [39].

Conclusions

We conclude that spraying geranium plants with arginine and chelated zinc significantly improved all growth characteristics studied and spraying arginine at a concentration of 30 mg L⁻¹ on geranium plants had the most positive effect among the concentrations, giving them an advantage in most of the studied indicators. Also plants exhibited the highest rates in vegetative, floral, and chemical growth indicators when sprayed with the amino acid arginine at a concentration of 30 mg L⁻¹ along with chelated zinc at a concentration of 60 mg L⁻¹.

Also, zinc is considered one of the micronutrients that plants need in small amounts, but its deficiency is one of the most important determinants of plant growth. When its deficiency is severe, the plant may not be able to complete its life cycle. It also has an important role in regulating sugar consumption, as well as increasing the energy required for chlorophyll production, which in turn positively affects vegetative growth indicators (Ain *et al.*, 2016) ^[7]. Zinc works to activate the enzymes responsible for protein and chlorophyll synthesis and increases the activity of the carboanhydrase enzyme, which is involved in CO₂ fixation and stomata opening. It also helps in the absorption and concentration of potassium in guard cells, which leads to efficient carbon synthesis, which leads to increased activity in nutrient synthesis in the plant (Keiko *et al.*, 2004). Zinc affects the synthesis of chlorophyll pigment, which directly impacts the production of essential nutrients for the plant (Taiz and Zeiger, 2010) ^[41]. This aligns with the findings of Amin *et al.* (2011) on snapdragons, who demonstrated that zinc significantly influences the plant's vegetative, chemical, and floral characteristics. The increase in plant height, number of leaves, total chlorophyll and total soluble carbohydrate content of leaves, number of inflorescences, and length of inflorescence stalk is due to the role of chelated zinc in building the amino acid tryptophan, which is one of the primary building blocks for the plant hormone (IAA) necessary for cell elongation and promoting apical dominance (MacDonald, 2000) ^[33]. Zinc is an essential element for a large number of enzymes such as Enolase and Carbonicanhydrase, which are involved in the synthesis of carbohydrates, fats, and proteins, as well as in the metabolism of micronutrients, which play an important role in starch production in plants (Cakmak, 2008) ^[19]. Zinc has a role in these important vital processes within the plant, represented by the height of the plant and the number of branches, which led to an increase in the number of leaves, which was reflected positively on the increase in the dry weight of the vegetative system (Hartmann *et al.*, 2002) ^[29]. This is consistent with what Hassan *et al.* (2013), Abdul Wahid (2014) ^[4], and Al-Karawi and Abdul Kadhim (2019) ^[11] concluded, that spraying zinc on the *Dahlia hybrida* L. Albion cultivar had a positive effect on the indicators of vegetative, floral, and chemical growth of the plant. We conclude that spraying geranium plants with arginine and chelated zinc significantly improved all growth characteristics studied and spraying arginine at a concentration of 30 mg L⁻¹ on geranium plants had the most positive effect among the concentrations, giving them an advantage in most of the studied indicators.

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