Effect of organic acids and vitamins on some growth traits of Matthiola incana

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Abstract

During the autumn season of 2023-2024, a pot experiment was carried out in one of the plastic houses of Baqubah Nursery affiliated to the Directorate of Agriculture in Diyala Governorate to study the effect of humic acids (humic and fulvic) in four concentrations: 0, 1 g L-1 humic, 0.5 g L-1 fulvic, and 1 g L-1 humic plus 0.5 g L-1 fulvic, and vitamins (thiamine and riboflavin) in five concentrations, which are 0, thiamine 100 mg L-1, thiamine 200 mg L-1, riboflavin 50 mg L-1, and riboflavin 100 mg L-1 on some of the vegetative traits of Matthiola incana. The research was carried out as a factorial experiment according to the randomized complete block design (RCBD) and with three replicates. The fulvic acid 0.5 g L-1 gave a significant increase in the leaf area and dry weight of leaves, reaching 1396 cm2 and 14.76 g, respectively; the humic acid 1 g L-1 + fulvic acid 0.5 g L-1 gave a significant increase in the fresh weight of leaves, reaching 89.07 g. The thiamine spray treatment at a concentration of 200 mg L-1 significantly increased the plant height and number of leaves, reaching 98.56 cm and 45.80 respectively, while the riboflavin spraying at a concentration of 100 mg L-1 significantly increased the leaf area and fresh weight of leaves, reaching 1474 cm2 and 88.66 g, respectively.

Keywords. Matthiola incana, humic acid, thiamine and riboflavin

Introduction

Matthiola incana is an annual winter plant. The genus Matthiola includes about 50 species that originated mainly in the Mediterranean Basin and Asia, and some of them originated in South Africa. The most important species used as flowers is the incana species, which means grey or white, referring to the color of the leaves of this species. Matthiola flowers are found in a simple, single terminal cluster inflorescence. Matthiola flowers are preferred for their beautiful shape, color, and scent [8]. The use of organic fertilizers has become one of the modern agricultural trends that use natural organic resources to grow crops and improve their production away from industrial chemicals that may cause harm to the environment and human health [23]. Humic substances are essential components of water and soil ecosystems, and are essential for soil formation and the carbon and nutrient cycle in nature. The interactions between microbes, clay and minerals depend on humic substances. To reduce the problem of oxidation and increase soil fertility, many researchers have begun to use humic acids such as humic and fulvic acids to improve soil properties and plant growth. Crop production in alkaline soils is often limited due to the lack of nutrients [13]. In general, the use of organic materials (humic and fulvic acids) is necessary to achieve good yields in this type of soil. These organic materials consist of various nitrogenous compounds including decomposed amino and aromatic compounds [7.[

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Vitamins belong to the group of bio-regulator compounds, as low concentrations of them greatly affect plant growth. They regulate factors that affect a number of physiological processes, such as the process of enzyme building, in addition to their role as a cofactor for enzymes, as well as protecting the plant from the harmful effects of high temperatures, and they also lead to a positive increase in bio-building processes [11]. Thiamine (vitamin B1) is an important vitamin for growth and is a water-soluble vitamin. This vitamin is considered a growth hormone because it moves from one part of the plant to another, where it is manufactured in the leaves and then moved to the root [10]. Thiamine is an essential component for the biosynthesis of enzymes and plays an important role in carbohydrate metabolism [15]. Thiamine encourages root growth through its role in the division of the root meristem, and adding thiamine to the plant plays a role in increasing growth due to its effect on increasing cytokines and gibberellins [24]. Riboflavin (vitamin B2) is a member of the B group of vitamins and is a major contributor to many metabolic enzymes, electron transport, and growth and metabolism enhancement in many plant species. Riboflavin is known as the primary precursor to coenzymes such as riboflavin monophosphate and flavin adenine dinucleotide, which are indispensable cofactors in oxidation and reduction processes in all living organisms. These cofactors are required by plants for a variety of critical processes such as the citric acid cycle, fatty acid oxidation, photosynthesis, and DNA repair [12]. Post-harvest losses in Matthiola incana include flower abscission and stem bending. Matthiola flowers are sensitive to ethylene, which causes flower drop, incomplete flower development, and short post-harvest life. The severe decline in flower quality in Matthiola may result from bending, abnormal stem development, and twisted stems. These factors reduce flower quality. Therefore, the study aimed to evaluate the effect of humic and fulvic acids and vitamins of thiamine and riboflavin on some of the vegetative traits of Matthiola incana.

Materials and Methods

The experiment was carried out in one of the plastic houses affiliated with the Baqubah Nursery Research Station, Diyala Agriculture Directorate in Autumn season of 2023-2024. The experiment was conducted from 1/10/2023 to 30/4/2024. The seeds of the Matthiola incana plant imported from the American Pan American Company were planted in plastic dishes containing peat moss on 17/10/2023. One seed was planted in each hole and left in the plastic houses. The ground of the plastic houses was prepared and cleaned, the soil was leveled and covered with a plastic cover to prevent the growth of the weeds. The planting medium was prepared, consisting of a mixture of sand and peat moss at a ratio of 3 sand and 1 peat moss. Samples were taken from the planting medium and some of its chemical and physical properties were analyzed in the Central Laboratory for Soil, Water and Plant Analysis, University of Baghdad/ College of Agricultural Engineering Sciences, Table (1). The process of sterilizing the growing medium in the pots was carried out using the systemic fungicide Hymexazol (liquid) at a rate of 1 ml L-1 according to the manufacturer's recommendations as a preventive and therapeutic addition to plants from fungal infection. After the appearance of 3-4 true leaves, the seedlings were transported on 20/11/2023 into plastic pots with a diameter of 24 cm and a height of 19 cm, with one plant in each pot. A fertilization program

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was developed for all plants using balanced NPK fertilizer (20:20:20), as it was added to the soil at a rate of 1 g L-1 once every two weeks throughout the research period according to the manufacturer's recommendation. The cover of the plastic house was removed on 20/3/2024, and the necessary service operations continued, including weeding and combating insect and disease infections.

Table 1. The physical and chemical properties of soil

Measurements	Value	Unit of measurement
Texture of soil	Sand	-
Sand	692	g. kg^{-1}
Silt	120	g. kg^{-1}
Clay	188	g. kg^{-1}
Ph	7.01	-
Ec	0.8	$ds.m^{-1}$
N	13.0	mg. kg^{-1}
P	5.25	mg. kg^{-1}
K	113.22	mg. kg^{-1}
Carbonate minerals	312	g. kg^{-1}
Organic matter	6.2	g. kg^{-1}
Ca^{+2}	3.22	meq L^{-1}
Mg^{+2}	2.15	meq L^{-1}
Na^{+}	2.01	meq L^{-1}
Cl	4.35	meq L^{-1}
K	0.48	meq L^{-1}
HCO_3	1.5	meq L^{-1}
CO_3	Nill	meq L^{-1}

Two factors were studied in the experiment. The first factor was the addition of humic acids (humic and fulvic) in four concentrations: 0, 1 g L-1 humic, 0.5 g L-1 fulvic, and 1 g L-1 humic plus 0.5 g L-1 fulvic. The second factor represents the spraying of vitamins (thiamine and riboflavin) in five concentrations, which are 0, thiamine at a concentration of 100 mg L-1, thiamine at a concentration of 200 mg L-1, riboflavin 50 mg L-1, and riboflavin at a concentration of 100 mg L-1. Humic acid was imported from the American company Agrotech and fulvic acid from the Chinese company Humate (Tianjin) through a local chemical office. Humic acids were added to the potting soil three times after a week of the transportation process and with a two-week interval between each addition. Vitamins (B1, B2) were imported from the English company BDH Chemicals Ltd. England through a local chemical office. The plants were sprayed with vitamins three times after the appearance of 3-4 pairs of true leaves and with a two-week interval between each spray. The surface of the potting soil was covered to prevent the vitamin spray from touching the soil surface. A barrier was placed between the experimental units to prevent the spray from flying to other treatments.

Experimental design

A factorial experiment (4×5) was conducted with three replicates according to the Randomized Complete Block Design (RCBD) [4]. The experiment included 60 experimental units, each experimental unit had 6 pots, and each pot had one plant, thus, the number of plants was 360. The number of treatments and their combinations used in the experiment was 20 treatments for each replicate. The data were analyzed according to the SAS statistical program (2003), and the arithmetic means were compared using Duncan's multiple range test at a probability level of 0.05.

Studied Characteristics

Plant height (cm(

Plant height was measured using a measuring tape, and the height was taken from the area of contact of the plant stem with the soil surface of the pot to the end of the top of the inflorescence of the plant.

Number of leaves (leaf-1 plant(

The number of leaves for all plants in the experimental unit was measured and the average was calculated.

Leaf area (cm2(

Leaf area was measured according to the method of [1], and calculated according to the following equation

) +1.66length x width) 0.531

Then the leaf area was calculated by multiplying the average number of leaves x the area of one leaf for four plants, and four leaves from

Fresh weight of leaves (g)

The fresh weight of leaves was calculated using a sensitive balance by taking 4 leaves randomly from each plant in the experimental unit and measuring the fresh weight of the leaves of each plant according to what was mentioned by [5 .[

Fresh weight of leaves (g) = Total fresh weight of leaves 24/24 × number of leaves

Dry weight of leaf (g(

The fresh weight of the leaf was calculated and then air dried at room temperature in a shaded place until the weight was fixed, then the dry weight of the leaf was calculated using the same method used to calculate the fresh weight of the leaf.

Results

Plant height (cm(

The results in Table (2) showed no significant differences in the plant height trait when humic acids were added individually and at all concentrations used. The thiamine spray treatment at a concentration of 200 mg L-1 was significantly excelled in plant height, reaching 98.56 cm, but it did not differ significantly from the other thiamine and riboflavin spray treatments compared to the control treatment, which gave the lowest plant height, reaching 95.44 cm. The interaction between the humic acid 1 g L-1 + fulvic acid 0.5 g L-1 with the thiamine spray treatment 200 mg L-1 showed a significant superiority in plant height, reaching 100.83 cm compared to the control treatment, which reached 91.92 cm.

Number of leaves (leaf-1 plant(

The results of Table (3) showed no significant differences in the number of leaves when adding humic acids individually and for all concentrations used. The thiamine spray treatment 200 mg L-1 was significantly excelled in the number of leaves, reaching 45.80, but it did not differ significantly from the other thiamine and riboflavin spray treatments compared to the control treatment 43.52. The interaction between the fulvic acid 0.5 g L-1 and the thiamine spray 200 mg L-1 resulted in a significant superiority in the number of leaves, reaching 47.50 compared to the control treatment, which recorded the lowest number of leaves, reaching 42.35.

Leaf area (cm2(

The results of Table (4) showed a significant increase in the leaf area when adding humic acids individually, as the fulvic acid 0.5 g L-1 gave a significant increase, reached 1396 cm2 compared to the rest of the treatments. The riboflavin 100 mg L-1 led to a significant increase in the leaf area, as it reached 1474 cm2 compared to the other treatments, while the control treatment recorded the lowest leaf area at 1057 cm2. The interaction between the fulvic acid 0.5 g L-1 and the thiamine 200 mg L-1 resulted in a significant superiority in the leaf area, reaching 1810 cm2, compared to the comparison treatment's 849 cm2.

Fresh weight of leaves (g)

The results of Table (5) showed a significant increase in the fresh weight of leaves, as the humic acid 1 g L-1 + fulvic acid 0.5 g L-1 gave a significant increase, which reached 89.07 g compared to the rest of the treatments. The spraying of riboflavin 100 mg L-1 led to a significant increase in the fresh weight of leaves, which reached 88.66 g, but it did not differ significantly from the treatment of spraying thiamine 100 mg L-1 and thiamine 200 mg L-1, as they recorded the lowest fresh weight of 82.65 and 82.32 g, respectively, compared to the control treatment, 73.71 g. The interaction between the treatment of adding humic acid 1 g L-1 + fulvic acid 0.5 g L-1 with the treatment of spraying thiamine 200 mg L-1 resulted in a significant superiority in the fresh weight of leaves, which reached 97.31 g compared to the control treatment, which recorded the lowest fresh weight of leaves, which reached 62.33 g.

Dry weight of leaf (g(

The results presented in Table (6) demonstrated significant differences in the dry weight of leaves. The fulvic acid 0.5 g L-1 and the humic acid 1 g L-1 + fulvic acid 0.5 g L-1 significantly increased the dry weight of leaves, reaching 14.76 and 14.49 g, respectively, compared to the treatments of humic acid 1 g L-1 and comparison, which recorded the lowest dry weight of leaves, reaching 12.62 and 12.47 g, respectively. The results showed no significant differences in the vitamin concentrations. The interaction between the fulvic acid 0.5 g L-1 and the riboflavin 100 mg L-1 showed a significantly excelled in the dry weight of leaves, which reached 16.48 g compared to the control treatment of 11.04 g.

Table 2. Effect of adding humic and fulvic acids and spraying thiamine and riboflavin vitamins on plant height (cm(

Plant height (cm)						
Humic acids (g L^{-1})	Vitamin concentrations (mg L^{-1})					Mean
	Without spray (0)	Thiamine (100)	Thiamine (200)	Riboflavin (50)	Riboflavin (100)	
Without addition	91.92 c	95.58 abc	98.83 ab	97.58 ab	97.58 ab	96.30 A
Humic 1	97.17 ab	98.84 ab	97.33 ab	94.75 bc	99.00 ab	97.42 A
Fulvic 0.5	96.00 abc	94.17 bc	97.25 ab	97.25 ab	97.25 ab	96.38 A
Humic 1+ Fulvic 0.5	96.67 abc	98.17 ab	100.83 a	96.67 abc	98.08 ab	98.08 A
Mean	95.44 B	96.69 AB	98.56 A	96.56 AB	97.98 A	

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Table 3. Effect of adding humic and fulvic acids and spraying thiamine and riboflavin vitamins on number of leaves

Number of leaves						
Humic acids (g L^{-1})	Vitamin concentrations (mg L^{-1})					Mean
	Without spray (0)	Thiamine (100)	Thiamine (200)	Riboflavin (50)	Riboflavin (100)	
Without addition	42.35 c	47.27 ab	44.37 abc	42.47 bc	43.50 abc	43.99 A
Humic 1	44.07 abc	45.33 abc	44.33 abc	44.28 abc	44.00 abc	44.40 A
Fulvic 0.5	43.50 abc	44.00 abc	47.50 a	42.67 abc	44.50 abc	44.43 A
Humic 1+ Fulvic 0.5	44.17 abc	45.67 abc	47.00 abc	45.17 abc	45.67 abc	45.53 A
Mean	43.52 B	45.57 AB	45.80 A	43.66 AB	44.42 AB	

Table 4. Effect of adding humic and fulvic acids and spraying thiamine and riboflavin vitamins on leaf area

Leaf area (cm^2)						
Humic acids (g L^{-1})	Vitamin concentrations (mg L^{-1})					Mean
	Without spray (0)	Thiamine (100)	Thiamine (200)	Riboflavin (50)	Riboflavin (100)	
Without addition	849 i	1561 bc	1087 fgh	954 hi	1458 cd	1182 B
Humic 1	1168 efg	1020 ghi	953 hi	996 ghi	1694 ab	1166 B
Fulvic 0.5	1259 ef	1300 de	1810 a	1445 cd	1165 efg	1396 A
Humic 1+ Fulvic 0.5	953 hi	1066 gh	1163 efg	910 hi	1581 bc	1135 B
Mean	1057 C	1237 B	1253 B	1076 C	1474 A	

Table 5. Effect of adding humic and fulvic acids and spraying thiamine and riboflavin vitamins on fresh weight of leaves

Fresh weight of leaves (g)						
Humic acids (g L^{-1})	Vitamin concentrations (mg L^{-1})					Mean
	Without spray (0)	Thiamine (100)	Thiamine (200)	Riboflavin (50)	Riboflavin (100)	
Without addition	62.33 d	79.54 bc	76.81 cd	76.46 cd	89.05 abc	76.84 B
Humic 1	74.95 cd	81.32 bc	78.21 bc	80.98 bc	81.80 bc	79.45 B
Fulvic 0.5	79.96 bc	83.58 abc	76.96 cd	77.10 cd	90.25 abc	81.57 B
Humic 1+ Fulvic 0.5	77.59 c	86.16 abc	97.31 a	90.75 abc	93.55 ab	89.07 A
Mean	73.71 C	82.65 AB	82.32 AB	81.32 B	88.66 A	

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6. Effect of adding humic and fulvic acids and spraying thiamine and riboflavin vitamins on dry weight of leaves

Dry weight of leaves (g)						
Humic acids (g L^{-1})	Vitamin concentrations (mg L^{-1})					Mean
	Without spray (0)	Thiamine (100)	Thiamine (200)	Riboflavin (50)	Riboflavin (100)	
Without addition	11.04 g	13.89 a-g	11.43 efg	13.15 a-g	12.85 b-g	12.47 B
Humic 1	14.89 a-e	11.18 fg	12.19 d-g	12.74 b-g	12.11 d-g	12.62 B
Fulvic 0.5	13.88 a-g	15.15 a-d	13.36 a-g	14.94 a-d	16.48 a	14.76 A
Humic 1+ Fulvic 0.5	14.54 a-f	12.59 c-g	16.21 ab	13.38 a-g	15.73 abc	14.49 A
Mean	13.59 A	13.20 A	13.30 A	13.55 A	14.29 A	

Discussion

The results showed that adding humic and fulvic acids improved all of the plant's vegetative growth traits. This is because humic and fulvic acids work to make roots and root hairs grow faster and increase the nutrients in the soil [9]. This enhances the potential for the plant to benefit, facilitates the easy absorption of these nutrients by the root cells, and leads to their accumulation within the plant tissues. This process is positively reflected in the increase in cell division, the growth of vascular bundles and transport vessels, and the expansion of wood and bark tissues, ultimately increasing the diameter of the stem [17]. The addition of high humic acids, represented by fulvic acid, resulted in an increase in leaf area. This increase may be attributed to the growth of roots and root hairs, which contribute to the utilization of soil nitrogen. This, in turn, has a positive effect on cell division, improving the characteristics of vegetative growth and effectively increasing the number of leaves, their width, and their area [9,22]. Spraying the Matthiola plant with vitamins had a positive effect on the vegetative growth characteristics, as foliar spraying with thiamine led to a significant superiority in most vegetative growth characteristics represented by plant height, number of leaves, leaf area, and fresh weight of leaves. This may be attributed to the fact that thiamine is considered one of the antioxidants that prevents oxidation that occurs in plants, as it increases the process of photosynthesis and enhances stress tolerance in plants by increasing the transmission of calcium signals and activating genes responsible for stress. It also plays an important role in balancing good plant growth and stress resistance [16]. This is consistent with [19], who showed that there is a significant effect when spraying thiamine on the iris plant on the vegetative growth characteristics represented by leaf area. The reason for the increase in plant height when treated with thiamine may be due to the entry of thiamine into the composition of the enzyme coenzyme Thiamine Pyrophosphate (TPP), as it works to remove the carboxyl group from organic acids such as pyruvic acid to give the enzyme coenzyme acetate during the process of glycolysis. In this process, the energy compound ATP and many amino acids are formed within a series of vital processes that lead to the formation of the compound indole acetaldehyde, which is the compound

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that generates the auxin indole acetic acid (IAA), which works to elongate the cells and thus increase the height of the plant [14]. These results are consistent with what was mentioned by [2], and confirmed by [18], when spraying thiamine on zinnia plants, it led to significant differences in vegetative and floral growth treatments. The reason may be due to the appropriate environmental conditions, such as temperature, humidity, and good lighting. Thiamine regulates the metabolic reticulum during the light period, which leads to early flowering, opening of the first basal inflorescence, and improving most floral traits [21]. Foliar spraying with riboflavin led to a significant increase in vegetative growth characteristics because it entered into the composition of the enzymes known as FMN and FAD, which are important organic compounds responsible for oxidation and reduction processes, including the reduction of nitrates in plant cells as one of the steps in the synthesis of amino acids and a series of vital processes that lead to the construction of the acetaldehyde compound, which is the intermediate compound that generates the auxin indole acetic acid that works to elongate cells and increase the height of the plant. The reason for the increase in the number of leaves is due to its role in carbohydrate metabolism and its entry into the group of enzymes known as flavin-enzymes, which is linked to iron, zinc, or molybdenum, which plays a role in the synthesis and growth of amino acids, which are the basic units of DNA and RAN, and chlorophyll, which plays a role in growth and increasing the number of leaves [3]. The positive relationship between leaf area and photosynthesis increases chlorophyll and increases the percentage of dry matter, and it affects the increase in cell volume and thus increases the diameter of the stem. These results agree with [6] in its study on henna plants. The increase in leaf area is due to the enzymes responsible for the photosynthesis process and the increase in the root system, which is a center for plant hormones, including cytokinins, which increase the strength of vegetative growth, including leaf area [20.[

Conclusion

The results of this study show that foliar spraying of thiamine and riboflavin along with humic and fulvic acids had a positive effect on most of the vegetative growth characteristics of the Matthiola plant.

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