# Impact of thiamine and riboflavin vitamins with humic and fulvic acids on some flowering traits of Matthiola incana

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**Abstract**

A pot experiment was done in one of the plastic houses at Baqubah Nursery, Directorate of Diyala Agriculture, in the season of 2023-2024 to find out how the vitamins, thiamine and riboflavin, as well as humic and fulvic acids, affected some flowering traits of Matthiola incana. The thiamine spraying at a concentration of 200 mg L-1 significantly increased the inflorescence length, reaching 46.08 cm. The riboflavin spray treatment at a concentration of 100 mg L-1 significantly increased the number of inflorescences in the plant, the inflorescence diameter, and the fresh and dry weight of the inflorescence, reaching 1.96 inflorescence plant-1, 6.91 cm, 52.34 g, and 13.70 g, respectively. The addition of 1 g L-1 of humic acid and 0.5 g L-1 of fulvic acid together significantly increased the number of inflorescences in the plant, their diameter, their length, and total carbohydrates in the inflorescence, reaching 1.91 inflorescence plant-1, 6.70 cm, and 46.00 cm, and 40.53%, respectively. The interaction between the humic acid 1 g L-1 + fulvic acid 0.5 g L-1 and the riboflavin 100 mg L-1 showed a significant superiority in the number of inflorescences and fresh and dry weight of inflorescence, which reached 3.00 inflorescence plant-1, 56.42 g, and 14.51 g, respectively. The interaction between the fulvic acid 0.5 g L-1 and the riboflavin 100 mg L-1 showed a significant superiority in the inflorescence diameter, which reached 7.30 cm. The interaction between the humic acid 1 g L-1 + fulvic acid 0.5 g L-1 and the thiamine 200 mg L-1 showed a significant superiority in the inflorescence length, which reached 48.58 cm. The interaction between the treatment of adding fulvic acid 0.5 g L-1 and the thiamine 200 mg L-1 showed a significant superiority in the percentage of total carbohydrates in the inflorescence, as it reached 45.33%.

**Keywords. Matthiola incana, vitamins, humic acid**

## Introduction

The Shabwi plant 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 [4]. 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 [8]. 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,

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where it is manufactured in the leaves and then moved to the root [7]. Thiamine is an essential component for the biosynthesis of enzymes and plays an important role in carbohydrate metabolism [11]. 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 [16]. 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, and 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 [9]. 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 [15]. 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 [10]. 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 [3]. 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 impact of thiamine and riboflavin vitamins with humic and fulvic acids on some flowering traits of Matthiola incana.

Materials and Methods

The study took place in the plastic house at the Baqubah Nursery, Directorate of Diyala Agriculture, from 1/10/2023 to 30/4/2024. The seeds of the Matthiola incana plant were obtained from the American Pan American Company through import, and the seeds were planted in plastic dishes containing peat moss on 17/10/2023. One seed was planted in each hole and left in the plastic house. The ground of the plastic house 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.(

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**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 $L^{-1}$ |

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 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. Two factors were studied in the experiment. The first factor was the addition of humic acids (humic and fulvic) in four concentrations: non addition (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 non-spray (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) [2]. 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.

The studied characteristics

Number of inflorescences in the plant

The number of inflorescences in each plant in the experimental unit was calculated, and the average for each treatment was calculated.

Inflorescence diameter (cm(

The inflorescence diameter for each plant in the treatment was measured using the vernier by taking the distance between the two furthest points of the petals and calculating its average.

Inflorescence length (cm)

The inflorescence length was measured using a measuring tape from its base to the end of the inflorescence top for each plant in the treatment and calculating its average.

Fresh weight of inflorescence (g)

The fresh weight of inflorescence was measured using a sensitive balance by randomly picking two inflorescences from each experimental unit, and the fresh weight of each was measured and calculated their average.

Dry weight of inflorescence (g)

After calculating the fresh weight of the inflorescence, the two inflorescences were taken and air-dried at room temperature in a shaded place for approximately two weeks until the weight was fixed, then their dry weight was measured using the same method used to calculate the fresh weight of the inflorescence.

Total carbohydrates in inflorescence(%)

The sample of inflorescence was dried and ground, then 1 gram of dry sample powder was taken and 10 ml of distilled water was added to it, and it was put in a centrifuge for 15 minutes at a speed of 300 rpm. The solution was put in a volumetric flask and completed to 50 ml, then 1 ml of the solution was taken and 1 ml of phenol and 5 ml of concentrated $H_2SO_4$ acid were added, then the absorbance of the solutions was read using a spectrophotometer at a wavelength of 490 nm and according to the percentage of carbohydrates:

Carbohydrate content=(concentration × dilution)/( 10 x 1 ml x sample weight) x100

Results

Number of inflorescences in the plant

The results presented in Table (2) demonstrated significant differences in the number of inflorescences in the plant. The

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humic acid 1 g L-1 + fulvic acid 0.5 g L-1 significantly increased the number of inflorescences in the plant, reaching 1.91 inflorescence plant-1, compared to the comparison treatment, which recorded the lowest number of inflorescences, reaching 1.34. inflorescence plant-1. The thiamine 200 mg L-1 and riboflavin 100 mg L-1 were significantly superior in the number of inflorescences, reaching 2.12 and 1.96 inflorescence plant-1, respectively, compared to the other treatments. The interaction between the humic acid 1 g L-1 + fulvic acid 0.5 g L-1 and the riboflavin 100 mg L-1 showed a significant superiority in the number of inflorescences, which reached 3.00 inflorescence plant-1, compared to the comparison treatment of 1.16 inflorescence plant-1.

Inflorescence diameter (cm(

The results in Table (3) showed that the humic acid 1 g L-1 + fulvic acid 0.5 g L-1 significantly increased the inflorescence diameter, reaching 6.70 cm, followed by fulvic acid 0.5 g L-1 and humic acid 1 g L-1 (6.84 and 6.51 cm), respectively, compared to the comparison treatment, which recorded the lowest inflorescence diameter, reaching 6.28 cm. The riboflavin 100 mg L-1 was significantly superior in the inflorescence diameter, reaching 6.91 cm compared to the other treatments. The interaction between the fulvic acid 0.5 g L-1 and the riboflavin 100 mg L-1 showed a significant superiority in the inflorescence diameter, which reached 7.30 cm compared to the comparison treatment of 5.29 cm.

Inflorescence length (cm)

The results in Table (4) showed that the humic acid 1 g L-1 + fulvic acid 0.5 g L-1 significantly increased the inflorescence length, reaching 46.00 cm, compared to the other treatments. The thiamine 200 mg L-1 was significantly superior in the inflorescence length, reaching 46.08 cm compared to the other treatments. The interaction between the humic acid 1 g L-1 + fulvic acid 0.5 g L-1 and the thiamine 200 mg L-1 showed a significant superiority in the inflorescence length, which reached 48.58 cm compared to the comparison treatment of 39.92 cm .

Fresh weight of inflorescence (g)

The results in Table (5) showed no significant differences between the humic acids in the fresh weight of inflorescence, while the riboflavin 100 mg L-1 was significantly superior in the fresh weight of inflorescence, reaching 52.34 g compared to the other treatments. The interaction between the humic acid 1 g L-1 + fulvic acid 0.5 g L-1 and the riboflavin 100 mg L-1 showed a significant superiority in the fresh weight of inflorescence, which reached 56.42 g compared to the comparison treatment of 29.68 g.

Dry weight of inflorescence (g)

The findings in Table (6) revealed no significant differences between the humic acids in the dry weight of inflorescence. The riboflavin 100 mg L-1 significantly outperformed the other treatments in terms of the dry weight of inflorescence, reaching 13.70 g. The interaction between the humic acid 1 g L-1 + fulvic acid 0.5 g L-1 and the riboflavin 100 mg L-1 revealed a significant superiority in the dry weight of inflorescence, which reached 14.51 g compared to the comparison treatment of 9.59 g.

Total carbohydrates in the inflorescence(%)

The results in Table (7) showed the humic acid 1 g L-1 + fulvic acid 0.5 g L-1 significantly increased the total carbohydrates

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in inflorescence, reaching 40.53% compared to the other treatments, while there were no significant differences between the vitamins. The interaction between the treatment of adding fulvic acid at a concentration of 0.5 g L-1 and the treatment of spraying thiamine at a concentration of 200 mg L-1 showed a significant superiority in the percentage of total carbohydrates in the inflorescence, as it reached 45.33% compared to the comparison treatment, which reached 32.33%.

**Table 2. Effect of adding humic and fulvic acids and spraying thiamine and riboflavin vitamins on number of inflorescences in the plant**

| Number of inflorescences | | | | | | |
|---|---|---|---|---|---|---|
| Humic acids (g $L^{-1}$) | Vitamin concentrations (mg $L^{-1}$) | | | | | Mean |
| | Without spray (0) | Thiamine (100) | Thiamine (200) | Riboflavin (50) | Riboflavin (100) | |
| Without addition | 1.16 g | 1.66 ef | 1.33 gf | 1.22 g | 1.33 gf | 1.34 C |
| Humic 1 | 1.16 g | 1.33 gf | 1.83 de | 1.33 gf | 2.16 cd | 1.56 B |
| Fulvic 0.5 | 1.55 efg | 1.38 gf | 2.50 bc | 1.39 gf | 1.33 gf | 1.63 B |
| Humic 1+ Fulvic 0.5 | 1.33 gf | 1.22 g | 2.83 ab | 1.16 g | 3.00 a | 1.91 A |
| Mean | 1.30 B | 1.40 B | 2.12 A | 1.27 B | 1.96 A | |

**Table 3. Effect of adding humic and fulvic acids and spraying thiamine and riboflavin vitamins on inflorescence diameter**

| Inflorescence diameter (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 | 5.29 e | 6.72 a-d | 5.97 de | 6.49 a-d | 6.94 abc | 6.28 B |
| Humic 1 | 6.86 abc | 6.21 cd | 6.89 abc | 6.33 bcd | 6.25 cd | 6.51 AB |
| Fulvic 0.5 | 6.63 a-d | 6.31 bcd | 6.98 abc | 6.95 abc | 7.30 a | 6.84 A |
| Humic 1+ Fulvic 0.5 | 6.83 abc | 6.84 abc | 6.46 a-d | 6.21 cd | 7.14 ab | 6.70 A |
| Mean | 6.40 B | 6.52 B | 6.57 AB | 6.50 B | 6.91 A | |

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**Table 4. Effect of adding humic and fulvic acids and spraying thiamine and riboflavin vitamins on inflorescence length (cm)**

| Inflorescence length (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 | 39.92 f | 44.58 a-f | 44.75 a-f | 44.08 a-f | 41.42 def | 42.95 B |
| Humic 1 | 41.83 def | 46.00 a-d | 44.08 a-f | 45.67 a-e | 43.08 b-f | 44.13 B |
| Fulvic 0.5 | 40.75 ef | 43.08 b-f | 46.92 abc | 42.25 c-f | 45.67 a-e | 43.73 B |
| Humic 1+ Fulvic 0.5 | 44.17 a-f | 45.67 a-e | 48.58 a | 48.00 ab | 43.58 b-f | 46.00 A |
| Mean | 41.67 C | 44.83 AB | 46.08 A | 45.00 AB | 43.44 BC | |

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

| Fresh weight of inflorescence (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 | 29.68 c | 52.96 ab | 34.83 bc | 50.05 ab | 52.99 ab | 44.10 A |
| Humic 1 | 47.56 abc | 46.53 abc | 46.69 abc | 42.50 abc | 46.92 abc | 46.04 A |
| Fulvic 0.5 | 43.83 abc | 37.66 abc | 55.48 a | 51.68 ab | 53.02 ab | 48.33 A |
| Humic 1+ Fulvic 0.5 | 47.99 abc | 53.33 ab | 46.86 abc | 45.98 abc | 56.42 a | 50.12 A |
| Mean | 42.27 B | 47.62 AB | 45.97 AB | 47.55 AB | 52.34 A | |

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

| Dry weight of inflorescence (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 | 9.59 c | 12.58 abc | 12.43 abc | 12.20 abc | 12.46 abc | 11.85 A |
| Humic 1 | 12.88 ab | 11.43 abc | 12.24 abc | 12.51 abc | 13.59 ab | 12.53 A |
| Fulvic 0.5 | 11.22 bc | 11.75 abc | 13.19 ab | 11.15 bc | 14.25 ab | 12.31 A |
| Humic 1+ Fulvic 0.5 | 11.33 bc | 12.97 ab | 11.81 abc | 12.01 abc | 14.51 a | 12.53 A |
| Mean | 11.26 B | 12.18 B | 12.42 AB | 11.97 B | 13.70 A | |

**Table 7. Effect of adding humic and fulvic acids and spraying thiamine and riboflavin vitamins on total carbohydrates in the inflorescence**

| Total carbohydrates in the inflorescence (%) | | | | | | |
|---|---|---|---|---|---|---|
| Humic acids (g $L^{-1}$) | Vitamin concentrations (mg $L^{-1}$) | | | | | Mean |
| | Without spray (0) | Thiamine (100) | Thiamine (200) | Riboflavin (50) | Riboflavin (100) | |
| Without addition | 32.33 e | 35.00 de | 40.33 a-d | 37.33 cde | 40.33 a-d | 37.07 B |
| Humic 1 | 40.00 a-d | 43.00 abc | 39.33 a-d | 37.00 cde | 35.00 de | 38.87 AB |
| Fulvic 0.5 | 37.00 cde | 39.00 a-d | 45.33 a | 40.33 a-d | 40.00 a-d | 40.33 A |
| Humic 1+ Fulvic 0.5 | 44.33 ab | 41.00 a-d | 38.00 b-e | 38.33 b-e | 41.00 a-d | 40.53 A |
| Mean | 38.42 A | 39.50 A | 40.75 A | 38.25 A | 39.08 A | |

**Discussion**

The results showed that adding humic and fulvic acids improved all of the plant's floral 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 [5]. 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 [12]. Humic acids have a positive effect on floral growth characteristics by promoting good vegetative

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group development and increasing photosynthesis effectiveness. This, in turn, enhances the quality of the floral group by securing essential major and minor elements for the flowering process, as well as providing the plant with other organic compounds from the photosynthesis process. This is consistent with the results of [6,13]. Spraying the Matthiola plant with vitamins had a positive effect on the vegetative and floral growth characteristics, leading to the superiority of most floral growth characteristics. Spraying thiamine on zinnia plants 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 [14]. 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 [1 .[

Conclusion

The findings of this research demonstrated that adding humic and fulvic acid with thiamine and riboflavin to the Matthiola plant improved most of its flower growth traits.

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