Effect of gibberellin and methyl jasmonate on the vase age and qualitative characteristics of rose leaves and flowers *Rosa hybrida* cv. Red Intuition – DELstriro

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Abstract

The experiment was conducted at the Agricultural Research Station of the College of Agriculture, University of Kufa, during the spring season 2024 to study the effect of spraying gibberellic acid (0, 75, 150, and 225 mg L^{-1}) and methyl jasmonate (0, 50, 100, and 200 mg L^{-1}) in the qualitative characteristics of flowers and the flowering age of rose plants. A factorial experiment was carried out using a Randomized Complete Block Design (RCBD) with three replications. The results showed that the vase age and flower stem diameter increased when plants were sprayed with gibberellic acid at concentrations of 75 and 150 mg L^{-1} with 200 mg L^{-1} of methyl jasmonate, while an improvement was observed in flower diameter and carotenoid content of leaves when treated with gibberellic acid at a concentration of 75 mg L^{-1} with 100 mg L^{-1} of methyl jasmonate. As for the number of petals, an increase in their number was observed when spraying with gibberellic acid at a concentration of 150 mg L^{-1} with 100 mg L^{-1} of methyl jasmonate, while the higher concentrations of 225 mg L^{-1} of gibberellic acid in combination with 200 mg L^{-1} methyl jasmonate led to an inhibition in the hydrogen peroxide content of leaves. It could be concluded from this study the role that plant growth regulators play in supporting plant growth, which has a positive impact on the state of plant growth and improving the qualitative characteristics of flowers, but this requires further studies on this subject in order to increase interest and encourage the spread of cultivation and circulation of cut flowers as an economic resource for the region.

Keywords: cut flowers, MeJA, GA3, rose, carotenoid.

Introduction

Rose (*Rosa hybrida*) is a perennial plant belonging to the Rosaceae family. The Rosa genus includes several species, up to 200 species, and about 30 000–35 000 commercial cultivars, most of which are hybrids. The original homeland of the rose plant is not known, as the rose plant was transported from Syria to Europe during the Crusaders' campaigns in the thirteenth century AD because it is a hybrid plant and not a wild one

[1]. DNA examination proved that this species resulted from the hybridization of three types of roses: the musk rose, the French rose, and the Fedchenko rose from Central Asia, meaning that it has no original homeland, and the exact place where it was hybridized is not known [2]. The rose plant is considered one of the oldest ornamental plants and the most popular of all flowers. It is called the Queen of Flowers for its beauty, scent, and attractive appearance [3]. The perfume, pharmaceutical, and cosmetics industries rely mainly on growing the rose plant, and the flower petals are also used in the manufacture of rose jam and some sweets [4, 5]. The leaves are simple, compound, five-leafleted, with a serrated edge. The leaves are distributed around the stem axis, alternately or opposite each other. The flowers are hermaphrodite, have a light scent, and are characterized by different colors, such as white, yellow, pink, red, orange, and even black. They contain (15-40) stamens arranged in alternating circumferences. The leaves surrounding the floral calyx are green [6]. Cut flowers are metabolically active plant organs that require many requirements related to growth from the beginning of planting to full flowering at the levels of morphological growth, the surrounding environment, and the physiological state of the plant [7, 8]. The life of the flowers in the vase is considered one of the most important factors in the cut flower industry and is defined as the time required for a flower to wilt in water [9]. Many chemical compounds and some natural materials extracted from plants have been used to preserve cut flowers after picking and extend their vase life [10], including plant growth regulators [11]. Plant growth regulators have revolutionized flower cultivation by studying their various effects on plant growth, which control growth and flowering to obtain high-quality flowers, including gibberellic acid, which has multiple effects on the metabolism of plants, and also has a role in delaying the yellowing of leaves and keeping them green and maintaining the level of plant pigments such as chlorophyll and carotenoids [12]. Prolonging the life of flowers and activating the root response in absorbing nutrients [13]. Through studies and research, it was found that gibberellins play a major role in the physiology of horticultural crops after harvest, including cut flowers [14].

Methyl jasmonate, symbolized by MeJA and its molecular formula $C_{13}H_{20}O_3$, is an organic compound used to Stimulates the plant's defense system during the growth and production stage [15], as well as during post-harvest operations of horticultural crops [16]. It also can improve seed and root growth and flowering [17, 18]. Plants produce jasmonic acid and methyl jasmonate in response to many biotic and abiotic stresses, especially biotic stresses resulting from the attack of herbivores by animals and the plant being injured. This substance accumulates in the affected parts of the plant. Methyl jasmonates can stimulate plants to produce many different types of defensive chemicals, such as phytoalexins (antimicrobials), nicotine, or proteinase inhibitors. Proteinase inhibitors interfere with insect digestion and discourage the insect from devouring the plant again [19]. In recent experiments, it was found that methyl jasmonate showed effectiveness in preventing bacterial growth in plants when sprayed on the leaves [20].

Based on the above, this study aims to know the effects of spraying different concentrations of gibberellin and methyl jasmonate and the interaction between them on

rose plants, as well as studying their future effects on the flowers cut from them, including knowing the effect of the study factors on the age in the vase.

Materials and Methods

The experiment was carried out at the research station of the College of Agriculture, University of Kufa, during the agricultural season 2023-2024, and the maximum and minimum temperatures and relative humidity were recorded during the experiment period from (1/2/2024 - 1/5/2024). The plants were imported from Iran (Dutch variety) and were replanted in pots with a capacity of 5 kg containing a medium consisting of 3 soil: 1 peat moss on 5/1/2024. After 3 weeks, the plants were pruned to a height of 25 cm, and they were fertilized with the high-nitrogen NPK chemical fertilizer 15:3:5 with irrigation water for the purpose of accelerating vegetative growth [21]. After 30 days of the nitrogen fertilizer batch, the plants were fertilized with high-phosphorous NPK fertilizer 5:30:15 with irrigation water in order to encourage the plant to flower [22, 23]. All operation services and irrigation were carried out periodically according to the plant's need. The plants were treated with gibberellin (GA3) at concentrations of (0, 75, 150 and 225) mg L^{-1}, while MeJA was sprayed at concentrations of (0, 50, 100 and 200) mg L^{-1}. The treatments began on 1/3/2024 and the sprayings were repeated three times, with an interval of 12 days between one spraying and another, making sure to fertilize the plants with a high-phosphorous fertilizer at each spraying to maintain the strength of seedling growth and encourage flower formation. A factorial experiment was carried out using a Randomized Complete Block Design (RCBD) with three replications, so the number of plants used in the study was (4 x 4 x 3 x 3) = 144 plants. Analysis of variance (ANOVA) was conducted and means were compared according to Duncan's multinomial test at the 5% probability level [24]. In order to demonstrate the effect of experimental factors on vase lifespan, the flowers were placed after harvesting in a flower preservation solution of hydroxyquinoline citrate 8-HQC at a concentration of 200 ppm for the purpose of preventing the growth of fungi and bacteria. A flower preservation solution was prepared, which consists of 8-HQC at a concentration of 0.2 g L^{-1}, sucrose at a concentration of 30 g L^{-1}, and Ascorbic acid at a concentration of 0.2 g L^{-1}. Distilled water was added to this solution and then heated until boiling in order to speed up the dissolution process and homogenize the components. At the same time, air bubbles dissolved in the preservation solution were eliminated, after which the solution was cooled to room temperature and the acidity was adjusted to pH=3 [25, 26]. In order to elucidate the effect of study factors on the qualitative characteristics of flowers and vase lifespan, the following characteristics were measured: vase age (calculating the number of days from picking until the flower wilts), flower diameter (measuring the two furthest opposite points at the stage of full bloom), flower stand diameter (measured after the process of Flower picking), number of petals (calculated after the end of the flower life after picking), carotenoid content of leaves (estimated according to the method of [27], hydrogen peroxide content in leaves (according to the method mentioned by [28].

Results and Discussion

vase age (day)

The results in Table (1) show that there are significant differences in vase lifespan with varying concentrations of gibberellin acid, where the spray treatment at concentrations of 75 and 150 mg L^{-1} led to the highest survival period of flowers in the vase, amounting to (9.42 and 9.08 days, respectively), and there were no significant differences between them, while they differed significantly from the other treatments. All used concentrations of methyl jasmonate had a significant effect on flowering vase age, and no significant differences appeared among them, but they differed significantly from the control treatment. The results of the interaction between the study factors indicate that using the interaction concentration of 75 and 150 mg L^{-1} of gibberellin with 200 mg L^{-1} of methyl jasmonate resulted in the longest survival period for the flowers in the vase, amounting to (9.67 days), which did not differ significantly from the treatment of 0 mg L^{-1} of gibberellin with 100 mg L^{-1} of methyl jasmonate.

Table (1): Effect of gibberellic acid and methyl jasmonate and their interaction on the vase life (day) of the rose flowers.

		MeJA mg L^{-1}				Average
GA_3 mg L^{-1}	Treatment	0	50	100	200	
	0	5.33 e	9.01 a-c	9.67 a	8.67 a-c	8.17 b
	75	9.67 a	9.01 a-c	9.33 ab	9.67 a	9.42 a
	150	9.33 ab	9.01 a-c	8.33 b-d	9.67 a	9.08 a
	225	8.01 cd	9.01 a-c	7.33 d	8.67 a-c	8.25 b
	Average	8.08 b	9.01 a	8.67 a	9.17 a	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Flower diameter (mm)

The results shown in Table (2) indicate that there is a significant difference in the diameter of the flower after harvesting with the use of different concentrations of gibberellin, where the 75 and 225 mg L^{-1} treatment gave the highest effect compared to the rest of the treatments, amounting to (85.46 and 82.65 mm, respectively), while the results from the same table indicate that plants treated with a concentration of 100 mg L^{-1} of methyl jasmonate gave the highest rates compared to the rest of the treatments, amounting to (84.71 mm). The results indicate that the interaction treatment between gibberellin at a concentration of 75 mg L^{-1} and methyl jasmonate at a concentration of 100 mg L^{-1} produced the highest average flower diameter after harvesting (92.72 mm), which differed significantly from the treatments (Table 2).

Table (2): Effect of gibberellic acid and methyl jasmonate and their interaction on the flower diameter (mm) of the rose flowers.

		MeJA mg L^{-1}				Average
GA_3 mg L^{-1}	Treatment	0	50	100	200	
	0	80.98 c-f	77.09 e-g	82.85 c-e	74.84 g	78.94 b
	75	84.75 bc	83.33 b-d	92.72 a	81.05 c-f	85.46 a
	150	83.31 cd	74.14 g	79.83 c-g	76.08 fg	78.33 b
	225	79.67 c-g	89.13 ab	83.45 b-d	78.36 d-g	82.65 a
	Average	82.178 ab	80.92 b	84.71 a	77.58 c	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Diameter of flower stand (mm)

The results shown in Table (3) indicate that there is a significant difference in the diameter of the flower stand as a result of spraying gibberellin, as the 150 mg L^{-1} treatment gave the highest rate of (6.82 mm) compared to the rest of the treatments, which did not differ significantly among themselves, while treating rose plants with a concentration of 100 mg L^{-1} of methyl jasmonate resulted in the highest rates of (6.76 mm), which did not differ significantly from the rest of the treatments, while it differed significantly from the comparison treatment, which gave the lowest rates of (6.01 mm). The interaction treatment between gibberellin 150 mg L^{-1} and methyl jasmonate 200 mg L^{-1} resulted in a significant increase in the diameter of the flower holder, producing the highest rates of (7.73 mm) compared to the rest of the treatments (Table 3).

Table (3): Effect of gibberellic acid and methyl jasmonate and their interaction on the flower stem diameter (mm) of the rose flowers.

		MeJA mg L^{-1}				Average
GA_3 mg L^{1}	Treatment	0	50	100	200	
	0	5.73 h	6.41 d-f	6.76 b-e	6.63 b-f	6.37 b
	75	6.47 c-f	6.83 b-e	6.86 b-d	5.87 gh	6.51 b
	150	6.23 fg	6.39 ef	6.93 bc	7.73 a	6.82 a
	225	5.61 h	6.99 b	6.51 c-f	6.37 ef	6.37 b
	Average	6.01 b	6.65 a	6.76 a	6.64 a	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Number of petals (petal $flower^{-1}$)

The results of the statistical analysis shown in Table (4) indicate that there is a significant difference in the number of petals as a result of spraying gibberellin. The results showed that treating the plants with a concentration of 150 mg L^{-1} gave the highest rate of (46.83 petals $flower^{-1}$) compared to the rest of the treatments, while the spraying treatment with methyl jasmonate at a concentration of 50 mg L^{-1} gave the highest rates

of (46.17 petals flower^{-1}) compared to the rest of the treatments. The results also showed that the binary interaction had a significant effect on the above trait, as it showed that treating the plants with 150 mg L^{-1} gibberellin and 50 mg L^{-1} methyl jasmonate produced the highest rate of (58.01 petals flower^{-1}), which did not differ significantly from the intervention treatment of 150 mg L^{-1} gibberellin with 100 mg L^{-1} methyl jasmonate (Table 4).

Table (4): Effect of gibberellic acid and methyl jasmonate and their interaction on the number of petals of the rose flowers (petal flower^{-1}).

		MeJA mg L^{-1}				Average
GA_3 mg L^{-1}	Treatment	0	50	100	200	
	0	32.67 ef	36.67 d	43.00 bc	35.01 d-f	36.83 c
	75	36.01 de	44.01 bc	35.33 d-f	34.67 d-f	37.50 c
	150	32.33 f	58.01 a	54.67 a	42.33 **c**	46.83 a
	225	34.01 d-f	46.01 b	44.33 bc	35.01 d-f	39.83 b
	Average	33.75 d	46.17 a	44.33 b	36.75 c	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

Carotenoid content of leaves (mg g-1 fresh weight)

The results shown in Table (5) showed significant differences in the carotenoid pigment, as its results varied with the difference in gibberellin concentration, as the 75 mg L^{-1} treatment recorded the highest rate of (2.781 mg g^{-1} fresh weight) compared to the rest of the treatments. As for the effect of treatment with methyl jasmonate, the results from the same table indicate that the treatment with a concentration of 100 mg L^{-1} gave the highest rates (2.725 mg g^{-1} fresh weight), which did not differ significantly from the treatment with 50 mg L^{-1}, while the comparison treatment gave the lowest rates reached (2.137 mg g^{-1} fresh weight). The results of the interaction between the study factors also indicate that treatment with gibberellin at a concentration of 75 mg L^{-1} with methyl jasmonate at a concentration of 100 mg L^{-1} produced the highest rate of carotene pigment amounting to (3.249 mg g^{-1} fresh weight), which differed significantly from the rest of the treatments and from the comparison treatment that gave the lowest readings was (1.794 mg g^{-1} fresh weight) (Table 5).

Table (5): Effect of gibberellic acid and methyl jasmonate and their interaction on the carotene content (mg g^{-1} fresh weight) of the rose leaves.

		MeJA mg. L^{-1}				Average
GA_3 mg. L^{-1}	Treatment	0	50	100	200	
	0	1.794 h	2.208 e-g	3.134 ab	2.612 cd	2.437 b
	75	2.573 cd	2.831 bc	3.249 a	2.468 de	2.781 a
	150	2.117 e-h	2.856 bc	2.341 d-f	1.915 gh	2.307 bc
	225	2.068 f-h	2.456 de	2.175 e-g	1.863 gh	2.141 c
	Average	2.137 b	2.588 a	2.725 a	2.214 b	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.)

Hydrogen peroxide content of leaves (µM g^{-1} fresh weight)

The data presented in Table (6) indicate that there were significant effects of spraying with gibberellin and methyl jasmonate on the hydrogen peroxide content of the leaves, as treatment with 225 mg L^{-1} of gibberellin led to a reduction in the hydrogen peroxide content amounting to (0.122 µM g^{-1} fresh weight) compared with the rest of the treatments, as for the methyl jasmonate treatments, the results indicate that the plants treated with a concentration of 100 mg L^{-1} obtained the lowest hydrogen peroxide content of (0.136 µM g^{-1} fresh weight) compared to the rest treatments. The results of the interaction between the studied factors also indicate that using a treatment of 225 mg L^{-1} of gibberellin with both 100 and 200 mg L^{-1} of methyl jasmonate resulted in a reduction in the hydrogen peroxide content amounting to (0.083 and 0.077 µM g^{-1} fresh weight) which did not differ significantly from the treatment of 75 mg L^{-1} of gibberellin with 0 mg L^{-1} of methyl jasmonate, compared to the rest of treatments (Table 6).

Table (6): Effect of gibberellic acid and methyl jasmonate and their interaction on the hydrogen peroxide content (µM g^{-1} fresh weight) of the rose leaves.

		MeJA mg. L^{-1}				Average
GA_3 mg. L^{-1}	**Treatment**	**0**	**50**	**100**	**200**	
	0	0.078 f	0.294 a	0.083 f	0.151 de	0.151 b
	75	0.099 f	0.282 a	0.209 bc	0.221 b	0.203 a
	150	0.226 b	0.2188 b	0.168 de	0.173 de	0.196 a
	225	0.179 cd	0.142 e	0.083 f	0.077 f	0.122 c
	Average	0.145 bc	0.233 a	0.136 c	0.155 b	

Means within a column, row and their interactions followed with the same letters are not significantly different from each other according to Duncan multiple ranges test at significant level of 5%.

The results obtained through the current experiment show that increasing the concentration of gibberellins up to a concentration of 150 mg L^{-1}, and methyl jasmonate, up to a concentration of 100 mg L^{-1} for each separately, has improved the survival of flowers in the vase due to the main role of plant growth regulators in regulating the physiological and morphological development of the plant, in addition to the role of these regulators in improving the quality and quantity of flowers before and after harvest and reducing the harmful effects of ethylene production, which causes aging and wilting of flowers [19]. In the interaction treatment, the effect of treatment with gibberellins at a concentration of 150 mg L^{-1} and methyl jasmonate at a concentration of 200 mg L^{-1} was the most positive and influential in enhancing the flower life characteristic, which reached double compared to the control treatment. This is due to their role in inhibiting the production of hydrogen peroxide, which has an effective role in increasing the production of abscisic acid, which leads to an increase in the production of ethylene, which affects flower aging and wilting [11, 19, 29], so it is noted from

(Table 1) that increasing the concentration of gibberellins must be accompanied by an increase in the concentration of methyl jasmonate in order to be effective in regulating the physiological processes of flowers in the post-harvest period. The results of this study were consistent with what was found in the study conducted by [30]

The data obtained from (Table 2) also indicate that using gibberellin acid alone stimulates linear growth at the expense of flower diameter due to the imbalance between rapid growth and nutrient absorption, as the plant takes more time between absorbing nutrients from the soil and transferring them to the leaves and then manufacturing and utilizing them in growth, while the effect of gibberellin is more severe than the effective absorption process, which creates a state of quantitative imbalance within the plant, especially at high concentrations, a severe elongation of the plant is observed at the expense of the thickness of the stem, as shown in (Table 3). When rose plants were treated with gibberellic acid at a concentration of 150 mg L^{-1} with methyl jasmonate at a concentration of 200 mg L^{-1}, there was an increase in the diameter of the flower indicated in (Table 2). On the contrary, it was noted that increasing the concentration of methyl jasmonate led to an increase in the diameter of the flower. This is because this treatment achieves a balance between nutrient absorption and plant growth, in addition to increasing the carbohydrate content in plant tissue stores, which is the result of increased chlorophyll activity in the leaves. This growth regulatory effect can be observed in treatments of the interaction between the two growth regulators, which indicates the presence of this harmony between them, which is reflected in the plant responded to their combined effect on growth and increasing the diameter of flowers, and this is consistent with the findings of [19, 31**]**. Also, this joint effect between them extended to the increase in the number of petal leaves, which was mentioned when rose plants were treated with a concentration of 150 mg L^{-1} of gibberellic acid with methyl jasmonate at concentrations of 50 and 100 mg L^{-1} as shown in (Table 4). The results of this study were consistent with what was found in the study conducted by [32]

The data obtained from (Table 5) indicate that treatment with methyl jasmonate is more effective than gibberellins in delaying the decomposition of carotenoids and preserving them, as carotenoids are of great importance in the physiological processes within the plant, represented by metabolism and construction. They are no less important than chlorophyll, as carotenoids participate in directing energy to the roots in absorbing the necessary nutrients necessary for plant life and then transferring them to the leaves in order to manufacture them according to the plant's needs, carotenoids give rise to the first signal for the start of photosynthesis processes. It is noted from the same table that treating rose plants with a concentration of 75 mg L^{-1} of gibberellic acid with methyl jasmonate at a concentration of 100 mg L^{-1} enhanced the content of carotenoids in the leaves, the role of which is reflected in maintaining the bright color of the flower and delaying the appearance of dull color on the flowers, and this is consistent with the findings of [19].

It is noted from (Table 6) the role of methyl jasmonate and its effect, whether individually or in combination with gibberellic acid, in reducing the leaves' content of hydrogen peroxide. This is due to the role of the study factors in inhibiting the effectiveness of the enzyme responsible for its production, which increases its activity and effectiveness after the harvesting process or when the plant is exposed to stress, as an increase in the activity of the hydrogen peroxide enzyme is accompanied by an increase in the production of the growth inhibitor abscisic acid and an increase in the production of ethylene, which precedes the stage of flower senescence [33].

It can be concluded from this study the significant role that plant growth regulators can play in increasing flowering lifespan and improving flower quality characteristics. The results also showed that there is a great harmony between these two types of plant growth regulators, and this is what became clear that the flowering lifespan was doubled with the use of overlapping treatments compared to the comparison treatment and the single treatments, due to their common role in reducing the effectiveness of the hydrogen peroxide enzyme. The results also proved that the use of methyl jasmonate in the overlapping treatments, it compensated for the negative effect of gibberellin in increasing the length at the expense of the flower diameter. It can be recommended from this study that future studies can be conducted on other combinations of plant growth regulators and to test their ability to improve and increase the production of cut flowers and make them an economic resource for the region.

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