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Impact of thidiazuron, malic and citric acids on growth and flowering of *rosa hybrida* L. cv. "Arthur Bell"

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***Abstract*---**The experiment was carried out in one of the fields affiliated to the Baqubah Nursery Research Station /Diyala Agriculture Directorate. The experiment was conducted for the period from 1/10/2020 to 10/6/2021, to study the effect of foliar spraying with thidiazuron (TDZ) at concentrations 1,2 and 4 mg L^{-1} in addition to spraying with distilled water as a comparison treatment, and foliar spraying with organic acids, malic acid (MA) at concentrations 150 and 300 mg L^{-1}, and citric acid (CA) at concentrations 150 and 300 mg L^{-1}, in addition to spraying with distilled water as a comparison treatment, on growth and flowering of *Rosa hybrida* L., cv. "Arthur Bell" with yellow flowers, The experiment was carried out according to a randomized complete block design (RCBD) as a factorial experiment (4×5) with three replications. Spraying plants with thidiazuron led to improve all the characteristics of vegetative and flowering growth, Treatment with a concentration of 4 mg L^{-1} of thidiazuron was superior in giving the best results for the characteristics of number of leaves, dry weight of leaves, percentage of carbohydrates in leaves, content of total carotenoids in leaves, number of flowers, flower diameter, flower duration, dry weight of flowers, and petals content of total carotenoids, the values of these traits were 59.44 leaf $plant^{-1}$, 10.02 g, 21.65%, 28.93 mg, 100 g^{-1} and 6.26 $flowerplant^{-1}$, 9.82 cm, 14.12 days, 11.83 g and 74.01 mg 100 g^{-1} respectively, while spray treatment with 2 mg L^{-1} of thidiazuron was superior in the characteristics of plant height, leaf area, and flowering stem length, the values of these traits were 46.72 cm, 1519.33 cm^2 and 32.02 cm, respectively. Foliar spraying with organic acids, malic and citric acids, led to improve the characteristics of vegetative and flowering growth, spraying treatment with 300 mg L^{-1} of citric acid gave the best results

for the characteristics of plant height, number of leaves, dry weight of leaves, percentage of carbohydrates in leaves, content of total carotenoids in leaves, number of flowers, flower diameter, flower stem length, flower duration, flower dry weight, and petals content of total carotenoids, the values of these traits were 48.90 cm, 58.81 leaf plant^{-1}, 9.88 g and 21.28 % and 29.93 mg 100 g^{-1} dry weight, 6.49 flower plant^{-1}, 9.59 cm, 32.45 cm, 13.58 days, 12.19 g, 72.68 mg 100 g^{-1}, respectively, while treatment with 150 mg L^{-1} of citric acid was superior in the leaf area (1519.59 cm^2).The interaction between the concentrations of thidiazuron and the organic acids, malic and citric, showed a significant improvement in all vegetative and flowering growth characteristics of rose plant, treatment TDZ4×CA300 was significantly superior and gave the best results in terms of number of leaves, percentage of carbohydrates in leaves, content of total carotenoids in leaves, number of flowers, flower diameter, flower duration, dry weight of flowers, and petals content of total carotenoids, the values of these traits were 68.13 leaf plant^{-1}, 23.16%, 32.17 mg 100 g^{-1}, 7.16 flower plant^{-1}, 10.68 cm,15.61 days, 13.72g and 78.16mg 100 gm^{-1}, respectively.

***Keywords*---**Thidiazuron, Malic acid, Citric Acid, vegetative growth, floral growth.

Introduction

Rose (*Rosa hybrida* L.) is one of the most famous and important ornamental plants, which belongs to the Rosaceae family, The genus of Rosa contain 200 species and more than 30,000 varieties, and these numbers are increasing. More than 80 varieties are produced in the Netherlands by the Agricultural Research Center (Esselink and *etal.*, 2003; Senapati and Rout, 2008; Ahmed *etal.*, 2010). Rose flowers are important cut flowers, and therefore many studies have focused on their quality in pre- and post-harvest periods. Their flowering life is often very short, and they are characterized by wilting and early neck bending (Lu *etal.*, 2010).

Rose are one of the most widespread flowering shrubs in private and public gardens in Iraq, as there is no garden without one or more types of rose, as they are characterized by the multi-colored flowers and their suitability as cut flowers, as well as flowers fragrant of some species. The ability of roses to withstand high temperatures during the summer contributed to the success of their cultivation in the various regions of Iraq. (Amin *etal.*, 2010), Most types of roses are native to Asia, and a few are native to Europe, North America and northwest Africa (Amin *etal.*, 2011).

Thidiazuron TDZ is a kind of synthetic cytokinine belonging to Phenylurea derivatives, which is more effective compared to adenine group cytokinine (Mok *etal.*, 1982; Shudo, 1994) due to its high stability in plant tissues where it is not degraded by oxidase/dehydrogenase (CKX) cytokinine enzymes. It has a long duration of effect that contributes to its high efficacy (Nisler *etal.*, 2016).The

physiological activity of cytokinins is represented by stimulating cell division and expansion in different plant organs, breaking the apical dominance and growth of lateral buds, activating the transport and representation of nutrients and metabolites, delaying leaf aging, enhancing photosynthesis activity, maintenance of chlorophyll content, increased stress tolerance, hormonal regulation of plant organs and other effects (Salman and saleh, 2016 ; Nisler, 2018).

Malic acid is one of the important organic acids in Krebs cycle, it is osmotically active and enters into the living reactions of the cell, it is formed in guard cells of leaves exposed to light as malic acid and malate. Malic acid as a proton (H) moves from the guard cells to the subsidiary cells, often the balanced anions in the form of malic acid (malate) within cells that guard the entry of potassium.The other importance of malic acid is that it may be a major source of proton needed for H- and K+ ion exchange during stomata opening (Devlin and Witham, 1991).Citric acid is one of the acids in the Krebs cycle (TAC) that is the most efficient and effective in releasing energy and is found in mitochondria with oxygen (Devlin and Witham, 1991), citric acid contributes to the formation of all compounds and components that contribute to the synthesis of plant tissues and the formation of their parts, such as proteins, carbohydrates, lipids, as well as cytoplasm, cytochrome, phytochrome, and photosynthetic pigments (Verma and Verma, 2008), Plant growth regulators such as thidiazuron and organic acids such as malic and citric acids may have desired effects in both vegetative and flowering growth and prolong the life of cut flowers for a wide range of plants, and accordingly the use of growth regulators and organic acids may increase these effects through interactions between them therefore, this study aims to know the effect of treatment with thidiazuron, malic and citric acids and the interaction between them on the vegetative and flowering growth characteristics of *Rosa hybrida* L.cv. "Arthur Bell".

Materials and Methods

The experiment was carried out in one of the fields of the Baqubah Nursery Research Station the Center /Diyala Agriculture Directorate, in the fall season for the year 2021-2020. The experiment was conducted for the period from 1/10/2020 to 10/6/2021.Rose plant "Arthur Bell" was used at the age of two years planted in pots (25 cm diameter), containing soil and peatmoos in a ratio of 3:1.Soil culture was analyzed in the laboratory of the Department of Soil and Water Resources, University of Baghdad /College of Agricultural Engineering Sciences, Table (1).

Table (1)
Some chemical and physical properties of agricultural soil

Adjective	the value	Unit
EC (1:1)	1.46	ds m^{-1}
P^H (1:1)	6.5	-
Organic matter	1.789	**%**
$CaCO_3$	169.13	gm kg^{-1}
Ready items		
nitrogen	28.95	mg kg^{-1}

phosphorous	10.22	mg kg^{-1}
potassium	218.4	mg kg^{-1}
Soil Separators		
Mud	109.0	g kg^{-1}
silt	131.0	g kg^{-1}
Sand	760.0	g kg^{-1}
Tissue class	Sandy Loam	

The plants were pruned by keeping two branches on the main stem of the plant, 7-10 cm high, to form the structure of the plant that will bear the yield, two branches were chosen on the plant to leave the heart open for lighting and ventilation. Plants were fertilized with NPK fertilizer (20:20:20) at a rate of 1 g L^{-1} every month for the duration of the study, the necessary service operations were carried out such as hoeing, weeding and controlling insect and disease infections whenever needed.

The experiment included two factors, as the first factor represented in foliar spraying with Thidiazuron (TDZ) with different concentrations of 1, 2 and 4 mg L^{-1} and symbolized by TDZ1, TDZ2 and TDZ4 respectively, in addition to spraying with distilled water as a comparison treatment and symbolized by TDZ0 and thus the factor includes four concentrations, The plants were sprayed with thidiazuron twice, the first spraying was carried out on 3/3/2021 and the second spray 15 days after the first spray, As for the second factor, it was represented in foliar spraying with organic acids (OA), malic acid (MA) and citric acid (CA) with different concentrations of 150 and 300 mg L^{-1} of malic acid and symbolized by them as MA150 and MA300 respectively, In addition to spraying with distilled water as a comparative treatment and symbolized by OA0, and thus the second factor contains five concentrations, the plants were sprayed with organic acids twice, the first spray was conducted two days after the first spray with thidiazuron and the second spray was conducted two days after the second spray with thidiazuron, Liquid soap was added at concentration of 0.1%, as a surfactant compound, Plants were sprayed until completely wet using a 2-liter hand-held sprayer.

The research was carried out as a factorial experiment (4×5) according to the Randomized Complete Block Design (RCBD) and with three replications (Al-Rawi and Khalaf Allah, 2000), to study the effect of two factors, the first is foliar spraying with thidiazuron and symbolized by (TDZ) and the second is organic acids and symbolized by It has (OA) malic acid and citric acid, the experiment included 60 experimental units, 6 potsin each experimental unit, one plant in each pot, and thus the number of experimental plants was 360 plants. The data were analyzed according to the statistical program SAS (2003).Means were compared using Duncan's Multiple Range Test (DMRT) ($P \leq 0.05$).

Experimental measures included the vegetative growth qualities like plant height, number of leaves, leaf area, dry weight of leaves, percentage of carbohydrates in leaves, content of total carotenoids in leaves, and floral growth qualities like number of flowers, flower diameter, flower stem length, flower duration, flower dry weight and petals content of total carotenoids. The percentage of carbohydrates in

the leaves was calculated according to the method of Krishnaveni *etal*. (1984), total carotenoids content in the leaves and petals was estimated according to the method of Ranganna (1999).

Results

Vegetative growth traits:
Plant height (cm)

The results of Table (2) showed that all thidiazuron concentrations led to a significant increase in plant height compared to the control treatment, Treatment of spraying with 2 mg L^{-1} was superior in giving the highest plant height (46.72 cm), which did not differ significantly from the treatment of spraying with concentrations 4 and 1 mg L^{-1},the height of the plant was 45.75 and 44.46 cm, while the lowest height of plant was when the comparison treatment was 42.70 cm. The treatment of spraying with malic and citric acids led to a significant increase in the height of the plant compared to the control treatment, and the treatment of spraying with a concentration of 300 mg L^{-1} of citric acid was superior in giving it the highest plant height of 48.90 cm, compared to the rest of the treatments, and the comparison treatment recorded the lowest plant height of 41.79 cm, The result of the interaction between the two studied factors showed a significant effect on plant height, and the treatment TDZ2×CA300 was superior in recording the highest plant height that reached 51.34 cm, while the lowest plant height was when the treatment TDZ0×OA0 was 39.77 cm.

Number of leaves (leaf plant^{-1})

It was noticed from the results of Table (2) that all thidiazuron concentrations led to a significant increase in the number of leaves compared to the control treatment, and the spraying treatment with a concentration of 4 mg L^{-1} was superior in giving it the most number of leaves, which was 59.44 leaves plant^{-1},Whereas the comparison treatment recorded the lowest number of leaves, which was 47.57 leaf plant^{-1}, Spraying plants with malic and citric acids led to a significant increase in the number of leaves compared to the control treatment, and the treatment of spraying with a concentration of 300 mg L^{-1} of citric acid in giving it the most number of leaves was 58.81 leaf plant^{-1}, but it did not differ significantly from the treatment of spraying with concentration 300 mg L^{-1} of malic acid, the number of leaves was 56.68 leaf plant^{-1}, while the control treatment recorded the lowest number of leaves was 47.64 leaf plant^{-1}, The results of the interaction between the two studied factors showed a significant effect on the number of leaves, and the treatment TDZ4×CA300 was superior in giving it the most number of leaves, which amounted to 68.13 leaf plant^{-1}, while the treatment TDZ0×OA0 recorded the lowest number of leaves, which amounted to 43.53 leaf plant^{-1}.

Leaf area (cm^2)

The results of Table (2) showed that spraying with thidiazuron led to a significant increase in the leaf area of the plant, and the treatment of spraying with a concentration of 2 mg L^{-1} was superior in recording the largest leaf area of the

plant amounted to 1519.33 cm^2, which did not differ significantly from the treatment of spraying with a concentration of 4 mg L^{-1} The leaf area was 1500.20 cm^2, Whereas, the comparison treatment recorded the smallest paper area, which was 1102.33 cm^2, The results showed that the foliar spraying with citric acid led to a significant increase in the leaf area of the plant, and the two spraying treatments with concentrations 150 and 300 mg L^{-1} were superior in giving them the largest leaf area of the plant amounted to 1519.59 and 1470.92 cm^2 respectively, compared to the comparison treatment that recorded the smallest leaf area amounted to 1183.75 cm^2, The interaction between the treatments of thidiazuron and malic and citric acids had a significant effect on the leaf area, and the treatment TDZ2×CA150 was superior in recording the largest leaf area amounted to 1915.67 cm^2, which did not differ significantly from the interaction treatment TDZ4×CA150 where the leaf area was 1839.00 cm^2, while the treatment recorded TDZ0×OA0 the smallest leaf area was 865.00 cm^2.

Dry weight of leaves (g)

The results of Table (2) showed a significant increase in the dry weight of leaves when spraying with thidiazuron at all concentrations, and the treatment of spraying with concentration 4 mg L^{-1} was superior in giving it the highest dry weight of leaves amounted to 10.02g , while the comparison treatment recorded the lowest dry weight of leaves which reached 7.50g . It is noted from the results that all treatments of plants spraying with malic and citric acids led to a significant increase in the dry weight of leaves, and the treatments of spraying with concentrations of 300 and 150 mg L^{-1} of citric acid and 300 mg L^{-1} of malic acid were superior to them in giving them the highest dry weight of leaves that reached 9.88 and 9.78 and 9.41 g, respectively, which did not differ significantly between them,Whereas, the comparison treatment recorded the lowest dry weight of leaves, which was 7.18 g.

The result of the interaction between the two studied factors showed a significant effect on the dry weight of leaves, and the treatment TDZ4×CA150 was superior in giving it the highest dry weight of leaves amounted to 12.14 g, while the treatment TDZ0×OA0 recorded the lowest dry weight of leaves amounted to 5.22 g.

Percentage of carbohydrates in the leaves (%)

The results of Table (2) showed that all concentrations of thidiazuron led to a significant increase in the percentage of carbohydrates in the leaves, and the spray treatment with concentration 4 mg L^{-1} was superior in giving it the highest percentage of carbohydrates in the leaves, which amounted to 21.65%,While the lowest percentage of carbohydrates in the leaves when the comparison treatment amounted to 18.03 %, All plants spraying treatments with malic and citric acids led to a significant increase in the percentage of carbohydrates in the leaves, and the spraying treatment with a concentration of 300 mg L^{-1} of citric acid excelled in giving it the highest percentage of carbohydrates in the leaves amounted to 21.28%, while the lowest percentage of carbohydrates was In the papers when the comparison treatment amounted to 18.18%.

The result of the interaction between the studied factors showed a significant effect on the percentage of carbohydrates in the leaves, and the treatment TDZ4×CA300 was superior in recording the highest percentage of carbohydrates in the leaves amounted to 23.16%, while the lowest percentage of carbohydrates in the leaves was when the treatment TDZ0×OA0, which amounted to 16.31%.

Table (2)
Effect foliar spraying with thidiazuron, malic and citric acids, and interaction between them on vegetative growth of *Rosa sp*.

A- Effect of Thidiazuron							
Characters / Treatments		Plant height (cm)	Number of leaves	Leaves area (cm^2)	Dry weight of leaves	Total carbohydrate (%)	Total carotenoids (mg 100 g^{-1})
TDZ0		42.70b	47.57c	1102.33c	7.50d	18.03d	24.17d
TDZ1		44.46ab	51.56b	1289.80b	8.55c	19.28c	26.36c
TDZ2		46.72a	56.53a	1519.33a	9.48b	20.05b	27.79b
TDZ4		45.75a	59.44a	1500.20a	10.02a	21.65a	28.93a
B- Effect of Malic and Citric Acids							
OA0		41.79c	47.64c	1183.75c	7.18c	18.18d	22.40d
MA150		42.41c	52.89b	1189.67c	8.19b	19.10c	25.44c
MA300		46.14b	56.68ab	1400.67b	9.41a	19.93bc	27.96b
CA150		45.29b	52.85b	1519.59a	9.78a	20.28b	28.34b
CA300		48.90a	58.81a	1470.92a	9.88a	21.28a	29.93a
C- Effect of A× B							
TDZ0	OA0	39.77d	43.53h	865.00h	5.22k	16.31f	20.07g
	MA150	41.99cd	48.34fgh	1105.00g	7.25ij	17.01ef	23.17ef
	MA300	43.56bcd	49.23efgh	1198.67fg	7.67hij	18.11def	24.27de
	CA150	42.53cd	46.31gh	1192.67fg	8.31fghi	18.29de	25.22d
	CA300	45.65abcd	50.42efgh	1150.33fg	9.05defg	20.45bc	28.14bc
TDZ1	OA0	41.73cd	47.08fgh	1214.00efg	8.58efgh	17.55ef	22.11f
	MA150	41.88cd	52.12defgh	1149.33fg	7.68hij	18.28de	24.23de
	MA300	45.54bcd	53.35cdefg	1423.33d	8.35fghi	19.50cd	28.18bc
	CA150	43.91bcd	50.20efgh	1131.00g	9.12defg	20.58bc	29.12b
	CA300	49.25ab	55.07cdef	1531.33c	9.01defg	20.47bc	28.15bc
TDZ2	OA0	42.40cd	50.33efgh	1262.33ef	8.16ghi	18.40de	24.14de
	MA150	43.25cd	57.06bcde	1192.33fg	8.50efgh	19.51cd	27.15c
	MA300	49.16ab	59.13bcd	1570.33bc	10.03cd	20.63bc	28.23bc
	CA150	47.43abc	54.50cdefg	1915.67a	9.55cde	20.67bc	28.19bc
	CA300	51.34a	61.63abc	1656.00b	11.15ab	21.03bc	31.26a
TDZ4	OA0	43.26cd	49.61efgh	1393.67d	6.77j	20.44bc	23.28ef
	MA150	42.52cd	54.02cdefg	1312.00de	9.32cdef	21.59ab	27.21c
	MA300	46.31abc	65.02ab	1410.33d	11.58a	21.47ab	31.17a
	CA150	47.30abc	60.40abcd	1839.00a	12.14a	21.59ab	30.81a
	CA300	49.37ab	68.13a	1546.00c	10.31bc	23.16a	32.17a

Means in each column followed by similar letters are not significantly different (P>0.05) according to Duncan's Multiple Range Test (DMRT).

Content of total carotenoids in leaves (mg 100 g^{-1} dry weight)

The results of table (2) showed that all concentrations of thidiazuron led to a significant increase in the content of total carotenoids in leaves, The treatment of spraying with a concentration of 4 mg L^{-1} was superior in giving it the highest content of total carotenoids in the leaves, which amounted to 28.93 mg 100 g^{-1} dry weight, while the lowest content of total carotenoids in the leaves was when it was compared to 24.17 mg 100 g^{-1} dry weight. All treatments of plants spraying with malic and citric acids led to a significant increase in the content of total carotenoids in the leaves compared to the control treatment, The spray treatment with concentration 300 mg L^{-1} of citric acid was superior in giving it the highest content of total carotenoids in the leaves amounted to 29.93 mg 100 g^{-1} dry weight, while the comparison treatment recorded the lowest content of total carotenoids in the leaves was 22.40 mg 100 g^{-1} dry weight.
The result of the interaction between the two studied factors showed a significant effect on the content of total carotenoids in the leaves, and the treatment TDZ4×CA300 was superior in recording the highest content of total carotenoids in the leaves was 32.17 mg 100 g^{-1} dry weight, while the lowest content of total carotenoids in the leaves was when the treatment TDZ0× OA0 as it reached 20.07 mg 100 g^{-1} dry weight.

-Flowering traits
Number of flowers

The results of Table (3) indicate that the number of flowers increased significantly when spraying with a concentration of 4 mg L^{-1} of thidiazuron, as the number of flowers was 6.26 flower $plant^{-1}$, but it did not differ significantly from the two treatments of spraying with concentrations 2 and 1 mg L^{-1}, as it reached The number of flowers was 5.94 and 5.71 flower $Plant^{-1}$, respectively, compared to the comparison treatment, which recorded the lowest number of flowers of 4.69 flower $Plant^{-1}$.It is noted from the results that spraying plants with malic and citric acids led to a significant increase in the number of flowers, and the treatment of spraying with a concentration of 300 mg L^{-1} of citric acid was superior in giving it the largest number of flowers that reached 6.49 flower $plant^{-1}$ which did not differ significantly from the two treatments of spraying with concentrations 150 and 300 mg L^{-1} of citric and malic acids respectively, as the number of flowers was 6.03 and 5.88 flower $plant^{-1}$, respectively, compared to the comparison treatment, which gave the lowest number of flowers, which was 4.74 flower $plant^{-1}$. The interaction treatments between the two studied factors showed a significant effect on the number of flowers, and the TDZ4×CA300 treatment was superior in giving it the largest number of flowers, which amounted to 7.16 flower $plant^{-1}$, while the treatment TDZ0×OA0recorded the lowest number of flowers, which was 3.16 flower $plant^{-1}$.

Flower diameter (cm)

The results of Table (3) showed that all thidiazuron concentrations led to a significant increase in flower diameter compared to the control treatment, and the spraying treatment with concentration 4 mg L^{-1} was superior in giving it the largest flower diameter of 9.82 cm, while the comparison treatment recorded the

smallest diameter of the flower when it reached 7.77 cm. All spraying treatments with malic and citric acids led to a significant increase in flower diameter compared to the control treatment, and the spraying treatment with concentration 300 mg L^{-1} of citric acid was superior in giving it the largest flower diameter of 9.59 cm, which did not differ significantly from the spray treatment with concentration 150 mg L^{-1} of citric acid, with a flower diameter of 9.49 cm,Compared to the comparison treatment, which recorded the smallest diameter of the flower was 7.79 cm. The result of the interaction between the two studied factors showed a significant effect on flower diameter, and the treatment TDZ4×CA300 was superior in recording the largest flower diameter of 10.68 cm, while the smallest flower diameter was when the treatment TDZ0×OA0 was 5.40 cm.

Flower stem length (cm)

The results of Table (3) showed that all concentrations of thidiazuron led to a significant increase in flower stem length compared to the control treatment, and the spraying treatment with concentration 2 mg L^{-1} was superior in giving it the highest flower stem length of 32.02 cm, which did not differ significantly from the treatment of spraying with concentration 4 mg L^{-1} as the length of the flower stem was 30.70 cm, while the minimum length of the flower stem was when the comparison treatment was 26.19 cm. The treatment of spraying with malic and citric acids led to a significant increase in the length of the flower stem compared to the comparison treatment, The treatment of spraying with a concentration of 300 mg L^{-1} of citric acid was superior in giving it the highest length of the flower stem, which reached 32.45 cm, which did not differ significantly from the treatment of spraying with malic acid at a concentration of 300 mg L^{-1}, where the length of the flower stem reached 30.78 cm, while it was less The length of the flower stem when compared to treatment was 26.03 cm. The result of the interaction between the two studied factors showed a significant effect in the length of the flower stem, and the treatment TDZ2×CA300 was superior in recording the highest flower stem length of 34.21 cm, While the minimum length of the flower stem when treatment TDZ0×OA0 was 22.35 cm.

Flower duration (day)

The results of Table (3) show that spraying plants with thidiazuron had a significant effect on flower duration, and the treatment of spraying with concentration 4 mg L^{-1} was superior in giving it the longest duration flower amounted to 14.12 days, while the shortest duration flower was when the control treatment was 11.12 days. The results indicated that all treatments of plants spraying with malic and citric acids led to a significant increase in flower life, and the treatment of spraying with a concentration of 300 mg L^{-1} of citric acid excelled in giving it the longest flowering period of 13.58 days, compared to the comparison treatment that recorded the shortest lifespan of the flower on the plant It was 11.41 days.

The interaction treatments between foliar spraying with thidiazuron and malic and citric acid showed a significant effect on flower life on the plant, and TDZ4×CA300 treatment excelled in giving it the longest flower life on the plant,

which was 15.61 days, while the treatment TDZ0×OA0 recorded the shortest flower life of 9.35 days.

Dry weight of flowers (g)

The results of Table (3) indicated that spraying plants with thidiazuron had a significant effect on the dry weight of flowers, and the treatment of spraying with a concentration of 4 mg L^{-1} was superior in giving it the highest dry weight of flowers that reached 11.83 g, which did not differ significantly from the treatment of spraying with a concentration of 2 mg L^{-1} Which gave the dry weight of flowers was 11.68 g, while the lowest dry weight of flowers was when the comparison treatment was 9.57 g, It was found that spraying plants with malic and citric acids had a significant effect on the dry weight of flowers, and the treatment of spraying with a concentration of 300 mg L^{-1} of citric acid was superior in giving it the largest dry weight of flowers reached 12.19 g, which did not differ significantly from the treatments of spraying with concentrations 150 mg L^{-1} of Citric acid, the dry weight of the flowers was recorded as 12.03 g, while the lowest dry weight of the flowers when the comparison treatment was 8.74 g. The interaction treatments between foliar spraying with thidiazuron and malic and citric acid had a significant effect on the dry weight of flowers, and the TDZ4×CA300 treatment was superior in giving it the highest dry weight of flowers amounted to 13.72 g, while the treatment TDZ0×OA0 recorded the lowest flower dry weight of 4.42 g.

Table (3)
Effect foliar spraying with thidiazuron, malic and citric acids, and interaction between them on floral growth of *Rosa sp*.

A- Effect of Thidiazuron							
Characters Treatments		Number of flowers	Flower diameter (cm)	Length of flower stalk (cm)	Flower duration (day)	dry weight of flower (g)	Total carotenoids in petals (mg 100 g^{-1})
TDZ0		4.69 b	7.77 c	26.19 c	11.1**2** d	9.57 c	66.67 c
TDZ1		5.7**1** a	8.83 b	29.82 b	12.27 c	10.98 b	69.77 b
TDZ2		5.94 a	9.07 b	32.02 a	13.1**1** b	11.6**8** a	71.79 b
TDZ4		6.26 a	9.82 a	30.70 ab	14.1**2** a	11.83 a	74.01 a
B- Effect of Malic and Citric Acids							
OA0		4.74 b	7.79 c	26.03 c	11.41 d	8.74 d	67.02 c
MA150		5.12 b	8.70 b	29.63 b	12.40 c	10.64 c	69.86 b
MA300		5.88 a	8.81 b	30.78 ab	13.09 b	11.49 b	71.70 ab
CA150		6.03 a	9.49 a	29.53 b	12.80bc	12.03 a	71.55 ab
CA300		6.49 a	9.59 a	32.45 a	13.58 a	12.19 a	72.68 a
C- Effect of A× B							
TDZ0	OA0	3.16f	5.40f	22.35e	9.35j	4.42g	65.22g
	MA150	4.22ef	8.18e	26.25cde	11.19jk	10.38e	66.59fg
	MA300	5.29cde	8.33de	27.42bcd	11.58hi	10.46e	68.36efg
	CA150	5.33cde	8.72cde	25.23de	11.92ghi	12.14bc	66.15fg
	CA300	5.45cde	8.24de	29.71abcd	11.54hi	10.47e	67.02fg

TDZ1	OA0	4.84de	8.53de	25.13de	11.17i	10.76de	67.33fg
	MA150	5.28cde	8.36de	30.76abc	12.33efghi	9.30f	70.04defg
	MA300	6.03abcd	8.53de	30.18abc	12.71efg	11.75cd	68.20efg
	CA150	6.10abcd	9.32bcde	30.42abc	11.88ghi	11.52cd	72.89abcde
	CA300	6.28abcd	9.43bcd	32.59a	13.25cdef	11.59cd	70.41cdefg
TDZ2	OA0	5.34cde	8.38de	29.34abcd	12.23gh	10.71de	68.40efg
	MA150	5.32cde	9.08bcde	31.18ab	12.35fgh	11.59cd	69.70defg
	MA300	5.69abcde	8.61cde	33.24a	13.39cde	11.78cd	74.17abcd
	CA150	6.30abcd	9.29bcde	32.11ab	13.64cde	11.34cde	71.56bcdef
	CA300	7.05ab	10.00ab	34.21a	13.92bc	12.96ab	75.14abcd
TDZ4	OA0	5.61bcde	8.85bcde	27.31bcd	12.88defg	9.07f	67.14fg
	MA150	5.66abcde	9.17bcde	30.32abc	13.72bcd	11.29cde	73.11abcde
	MA300	6.49abc	9.78abc	32.27a	14.66b	11.96c	76.08ab
	CA150	6.39abc	10.64a	30.34abc	13.75bcd	13.11a	75.58abc
	CA300	7.16a	10.68a	33.28a	15.61a	13.72a	78.16a

Means in each column followed by similar letters are not significantly different (P>0.05) according to Duncan's Multiple Range Test (DMRT).

Content of total carotenoids in the petals (mg 100 g^{-1} dry weight)

The results of Table (3) showed that spraying plants with thidiazuron significantly affected the content of total carotenoids in the petals, and the treatment of spraying with concentration 4 mg L^{-1} was superior in giving it the highest content of total carotenoids in the petals, which amounted to 74.01 mg 100 g^{-1} dry weight, while it gave The control treatment had the lowest content of total carotenoids in the petals, which was 66.67 mg 100 g^{-1} dry weight. It was found that spraying plants with malic and citric acids had a significant effect on the content of total carotenoids in the petals, and the treatment of spraying with a concentration of 300 mg L^{-1} of citric acid was superior in giving it the highest content of total carotenoids in the petals amounted to 72.68 mg 100 g^{-1} dry weight, which did not differ Significantly about the two spraying treatments with concentrations of 300 and 150 mg L^{-1} of maleic and citric acid, which were 71.70 and 71.55 mg 100 g^{-1} dry weight, respectively, While the lowest content of total carotenoids in the petals when the control treatment was 67.02 mg 100 g^{-1} dry weight. Interaction between the two studied factors showed a significant effect on the content of total carotenoids in the petals, and the treatment TDZ4×CA300 was superior in recording the highest content of total carotenoids in the leaves amounted to 78.16 mg 100 g^{-1} dry weight, while the lowest content of total carotenoids in the petals was when the treatment TDZ0× OA0 as it reached 65.22 mg 100 g^{-1} dry weight.

Discussion

The results showed that foliar spraying of rose plants with thidiazuron had a positive effect on the characteristics of vegetative and flowering growth, and the treatment of spraying with a concentration of 4 mg L^{-1} of thidiazuron recorded the best results for the characteristics of the number of leaves, the dry weight of the leaves, the percentage of carbohydrates in the leaves, and the content of the leaves of total carotenoids, number of flowers, flower diameter, flower age on the plant, dry weight of flowers, and petals content of total carotenoids, while

spraying treatment with a concentration of 2 mg L^{-1} of thidiazuron gave the best results for the characteristics of plant height, leaf area, and flower stem length, The increase in plant height, number of leaves, leaf area and dry weight of leaves may be due to the role of cytokinine in breaking the apical dominance and increasing cell division in the apical meristems and cambium and adding new cells to the plant, which led to an increase in these traits (Mazher *etal.*, 2011; Pai and Desai, 2018).The increase in plant height may be due to the fact that the effect of cytokinine is not only limited to stimulating cell division and expansion, but also extends to the elongation of cells (Saleh, 1991).

The increase in the number of leaves and leaf area resulting from treatment with thidiazuron may be due to the role of cytokinine in encouraging the growth of the principles of Leaves through cell division, differentiation, and development (Davies, 1994),it also may be due to the role of thidiazuron in stimulating the transfer of nutrients and products of photosynthesis inside the plant, which leads to improved growth (Guo *etal.*, 2011).

Stimulating growth can be attributed to the fact that Phenylurea type cytokinine increase the activity of the enzyme peroxidase, which removes the toxicity of super oxide and controls the level of hydrogen peroxide and the speed of cell division, thus stimulating growth. In addition, the increase in the activity of this enzyme is related to the accumulation of dry weight and the increase in the number of axillary buds blooming (Kapchina –Toteva *etal.*, 2005).

The increase in photosynthetic pigments such as total carotenoids in the leaves may be due to the increased content of auxin and cytokinine, which were stimulated when the plant was sprayed with thidiazuron (Shudo, 1994). The cytokines help in the movement of nutrients within the plant, which leads to improved growth (Saeed and Amin, 2012).

The reason for the increase in the dry weight and carbohydrate content in the leaves may be due to the vigor and activity of the vegetative growth of the plant resulting from spraying with thidiazuron, which is represented by the increase in the height of the plant, the number of leaves and the leaf area, and a reflection of this in an increase in the efficiency of the photosynthesis process and an increase in CO_2 inside the leaf, which is the basic unit in building carbohydrates (Jordan and Ogren, 1984), part of the carbohydrates are exploited in the growth of the leaf, while the other part is transferred to the rest of the plant parts such as the branches and stems to help in its growth and construction, and the surplus is stored in those plant parts (Hamman *etal.*, 1996).

The increase in the number of flowers and the dry weight of the flower as a result of foliar spraying with thidiazuron may be a result of breaking the apical dominance and stimulating the lateral buds to grow and form new branches, and thus increase the number of flowers, this may be due to the increase of synthesized substances in the leaves, especially carbohydrates, and their transfer to the flowers, which leads to an increase in the dry weight of the flower (Stern *etal.*, 2003). The increase in flower stem length and flower diameter may be due to the role of cytokinine in breaking the apical dominance, increasing cell division in the apical meristems and cambium, and adding new cells to the plant, which led

to an increase in these traits (Mazher *etal.*, 2011).The increase in flower duration and the petals' content of total carotenoids treated with thidiazuron may be due to the nutritional stock of photosynthesis or the persistence of photosynthesis, which caused an improvement in the percentage of necessary carbohydrates in the leaves (Reid *etal.*, 2002). The improvement of flower growth characteristics when treated with cytokinine may be due to increase in the synthesis of sugars through the activation of α-amylase enzyme (Abbas and Saleh, 2020). The improvement of vegetative and flowering growth characteristics as a result of spraying with thidiazuron is in agreement with what was found by Nishijima *etal.* (2006) on *Petunia hybrida*, and Ojaghi *etal.* (2013) on *Alstroemeria,* and Zhang *etal.* (2019) on *Dendrobium*, and Taj ALdeen and Abd El-Aal (2021) on *Aglaonema commutatum*.

The results showed that foliar spraying with the organic acids malic and citric had a positive effect on the vegetative and flowering growth characteristics of rose. The improvement of vegetative and flowering characteristics may be due to its participation in growth, respiration, photosynthesis, hormone and protein synthesis (Mirzapour *etal.*, 2013), It stimulates cell growth, a source of carbon and energy, and protects plants from ammonium toxicity (with the formation of amide) (Talebi *etal.*, 2014).

Increase in plant height when treated with organic acids may be due to their participation in increasing the growth of plants because they are carbon materials or compounds that build plant tissues (Talebi *etal.*, 2014), or it may be due to the role of organic acids in improving the absorption of ions in general (especially nitrogen and phosphorous) (Arcand and Schneider, 2006; Bais *etal.*, 2006).

The increase in number of leaves and dry weight of leaves may be due to the positive effect of foliar spraying with organic acids, as it regulate the process of photosynthesis and growth, and its role as a catalyst in increasing, activating and effective enzymes and reducing the damage arising from the oxidation process through its cooperation with other antioxidants (Noctor and Foyer, 1998; Khiamy, 2003), or it may have a role in protecting plant cells from aging as it controls the various disorders that occur in the plant (Ibrahim *etal.*, 2007).

The increase in leaf area may be due to the significant effect of organic acids on the vegetative growth characteristics because they are antioxidants, as their action is similar to the natural auxin that encourage growth within the plant (Ahmed *etal.*, 1997), or it may lead to an increase in root growth and thus increase the ability of plants on absorbing large quantities of nutrients from the soil, including the elements that have a direct effect on building chlorophyll and thus increasing the nutrients synthesized in leaves, which leads to an increase in total carbohydrates content that enter the growth of plants, including the leaves, as their leaf area increases (Ahmed *etal.*, 1998; Omar, 1999).

The effect of foliar spraying with organic acids is effective in increasing the growth and formation of vegetative parts, enhancing photosynthesis, and increasing the content of pigments, including total carotenoid pigment in leaves, and it affects plant growth as it can improve the morphological, physiological and enzymatic activity, and these results are consistent with Eidyan *etal.* (2014).

The results showed that foliar spraying with organic acids led to an increase in flower diameter and prolonging flower duration, and this may be due to its role in stimulating metabolism and metabolic processes (Starck, 2007), or it may be due to its important role in the physiological activity of plants and is part of Krebs cycle, and is important for the metabolic reactions of carbohydrates, fats and proteins and is an intermediate product (Zandieh *etal.*, 2015; Emami *etal.*, 2015), quality and thus marketability can be affected by factors in the pre-harvest, harvest and post-harvest stages (Danaee and Abdossi, 2016).

The increase in number of flowers, dry weight of flower and petals content of total carotenoids may be due to the role of these acids in many metabolic and physiological processes, as they preserve the chloroplast from oxidation as it is an antioxidant factor, and because organic acids are antioxidants, they protect cells plant aging and increase the amount of nutrients in the different plant organs, As a result, it works to improve the nutritional status of the plant, which, in turn, was positively reflected in improving the quantitative characteristics of flowers, including an increase in the number of flowers and an increase in the dry weight of the flower as a result of increased cell division and expansion due to the availability of sufficient food for them, which led to the lack of competition between flowers for nutrients, which was reflected positively in increasing the total number of flowers as a result of improving the nutritional status of the plant by increasing the efficiency of the photosynthesis process, which led to an increase in the synthesized of carbohydrates in the leaves and their transfer to the different parts of the plant for consumption, especially in the flowers, and thus improved floral growth characteristics (Shaddad *etal.*, 1990; Eidyan *etal.*, 2014; Zandieh *etal.*, 2015).

Improvement of vegetative and flowering growth characteristics as a result of spraying with organic acids is in agreement with what was found by Jafari and Hadavi (2012) on *Anethum graveolens*, Darandeh and Hadavi (2012) on *Lilium spp.*, Farshid *etal.* (2013) on *Rosa sp.* Talebi *etal.* (2014) on *Gazania rigens* L., El-Shanhorey *etal.* (2016) on *Polianthes tuberosa* L., Abdossi and Danaee (2019) on *Dianthus caryophyllus* L., and Babarabie *etal.* (2018) on *Gerbera jamesonii*.

Conclusions

From the results of the present study, it can be concluded that foliar spray with thidiazuron and the organic acids, malic and citric, positively affected the vegetative and floral growth qualities of Rose. Treatment of TDZ4×CA300 gave the best results in terms of number of leaves, percentage of carbohydrates in leaves, content of total carotenoids in leaves, number of flowers, flower diameter, flower duration, dry weight of flowers, and petals content of total carotenoids

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