Effect of Levels and Application Methods of Iron and Zinc on Growth and Flowering of *Rosa hybrida* Cv. "Dallas"

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ABSTRACT

The present study was carried out during two successive seasons of 2012/2013 and 2013/2014 at a commercial nursery at Alexandria city to investigate the effect of foliar spraying or/and soil application (with irrigation water) four times of four concentrations of chelated iron (0, 30, 60 and 120 ppm) and three concentrations of chelated zinc (0, 75 and 150) singly or in combinations (24 treatments) on the growth, flowering and chemical composition of *Rosa hybrida* cv. "Dallas". Results of the two seasons indicated that using the two nutrient elements (iron and / or zinc) singly or in combinations as a foliar spraying led to positive significant effects on all the studied parameters, compared with adding them as a soil application. Spraying iron at 30 - 60 ppm alone or combined with zinc at 75 ppm gave significant increases in the most studied parameters of rose plant, compared with the other treatments. While using the two nutrient elements at their highest concentrations (120 ppm iron or 150 ppm zinc) alone or in combinations led to decrease the most studied parameters of *Rosa hybrida* cv. "Dallas", compared with their lower concentrations.

Key words: *Rosa hybrida* cv. "Dallas", chleted iron and zinc fertilizers.

INTRODUCTION

Rose, a symbol of affection, elegance, inspiration, spirituality and source of aesthetic gratification for human begins, is one of the leading cut flowers in global floriculture trade. It has always been the most favorite flower in the world. There is hardly any event where roses are not displayed in varied fashion. Cut rose flowers play an important role in event decoration and add charm to different occasion.

Roses are being grown with other plant management practices, proper ratio of macro and micronutrients is indeed a secret of success and help to increase yield by enhancing the adequate quantities of nutrients must be supplied to plants.

Iron is an essential micronutrient for almost all living organisms because it plays critical role in metabolic processes such as DNA synthesis, photosynthesis, chlorophyll synthesis, respiration, nitrogen fixation, uptake mechanisms (Kim and Rees, 1992). It is also an active cofactor of many enzymes that are necessary for plant hormone synthesis, such as ethylene, lipoxygenase, 1-aminocyclopropane acid -1- carboxylic oxidase (Siedow, 1991), or abscisic acid. Further, it is necessary for reduction of nitrates and sulphate and it is involved in numerous electron transfer chain (Mamatha, 2007).

Iron deficiency severely affects plant development and growth, and excess iron in cell is toxic. Iron deficiencies may occur at high soil pH, free calcium carbonate, low organic matter, cool, damp springs, low soil oxygen level, high temperature, and high soil phosphorus, copper, manganese and zinc levels.

Zinc is also essential element for the normal healthy growth and reproduction of plants. This element is required in small amounts to allow the normal function of several key physiological pathways as well as to ensure the structural and functional integrity of membranes. Thus zinc has important roles in growth regulation, enzyme activation, gene expression and regulation, phytohormones activity, protein synthesis, photosynthesis, carbohydrate metabolism, fertility, seed production, water uptake and defense against disease (Marschner, 1995). Zinc is the only metal that is requirednall sis–enzyme classes (oxidoreductases transferases, hydrolases, lyases, is omreases and ligases) (Sadeghzadeh, 2013). The requirement of zinc for the function of a wide of enzymes indicates that the metabolism of proteins, carbohydrates and auxins as well as productive processes are hampered under zinc deficiency (Romheld and Marschner, 1991).

Zinc deficiencies may occur at high soil pH (more than 7.0), presence of calcium-and/or magnesium-carbonate high organic content, cool soil temperature, wet soil, bright sunlight and high levels of phosphorus, copper, iron, and manganese.

The use of iron or zinc chelates is an effective way of providing the element to plants under high soil-fixing conditions. The chelating agent is made up of complex molecules capable of reacting with the elements and combining it into the complex molecular structure. The element therefore is not fixed by the soil and remains in a soluble and bio-available form to the plants.

Foliar sprays of iron and/or zinc materials are widely used for both deficiency correction and for nutrition maintenance. Iron or zinc sprays are most effective when applied to young plants and when repeated at 10-day with two weeks' intervals.

In Egypt, most of the soils have high pH ultimately binding naturally present micronutrients with soil particles and make them unfavorable to plants required for various metabolic processes. Due to this, flower development and quality of roses is badly affected.

Thought the objective of this research was to determine the effect of different levels of iron and zinc adding alone or in combinations dissolved in irrigation water or as a foliar spray on the growth, flowering and chemical composition of *Rosa hybrida* cv. "Dallas" under the conditions prevailing in Alexandria region.

MATERIALS AND METHODS

The present study was carried out under plastic house during two successive seasons of 2012/2013 and 2013/2014 at a commercial nursery for flowers and ornamental plants in suburb of Alexandria city, to investigate the effect of different concentrations and application methods of the chelated iron and zinc fertilizers on some vegetative growth, flowering characteristics and chemical analysis of the grafted plants – old almost one year of *Rosa hybrida cv. "Dallas"* planted in 30 cm plastic pots filled with a mixture of peatmoss and perlite at a ratio of 4:1 by volme, respectively.

Rosa hybrida L. cv. "Dallas" was used for its popularity in Egypt Flower Trade. The plants were obtained from a commercial nursery for flowers and ornamental plants in Cairo city, which was imported from Netherlands. The mean length of the used plant was about 25 cm and each one had two main branches.

Two types of fertilizers were used in this experiment, *i.e.* chelated iron "Fe-EDDHA" a soluble water compound contains 6% Fe and chelated zinc "Zinc-EDTA" contains 15% soluble water Zn. The used concentrations of iron were zero (control), 30, 60 and 120 ppm, while the concentrations of zinc were zero (control), 75 and 150 ppm. The two fertilizers were used on the plants singly and with all possible combinations between them (24 treatments). Two application methods were chosen for adding the different concentrations of the two used nutritional elements. These methods were spraying on the plant foliage (foliar-spraying) and / or to the soil dissolving in irrigation water (soil-application). The plants under the foliar application were sprayed at 8 O' clock A.M. until the run-off point with applying the fertilizer solution to both upper and lower surface of the leaves with using "New Film" at a rate of 1 ml / l as a surfactant for enhancing the efficiency of the used materials. The control treatment was sprayed with tap water which had 'New Film" at a rate of 1 ml / l.

Whereas, the soil-application treatments were done at the same time of foliar spraying with adding 500 ml of the solution of the different concentrations of the used nutritional elements to each pot - medium / time, while the control treatment was irrigated with 500 ml water.

The different fertilizer treatments were repeated 4 times at 7 days' interval starting 21 days after the final transplanting date *i.e.* on 21 and 28 Feb. and 7 and 14 march 2013 and 2014, respectively.

Each plant under the experiment was fertilized with 1.5 g/ l from a compound Kristalon fertilizer (19N: $19P_2O_5$: $19K_2O$: 2MgO) dissolved in irrigation water three times / week until the end of the experiment. To avoid salt accumulation around the root zone every two weeks the substrate was leached by using tap water to get out the excessive salts.

After the last treatment the plants were left for 6 months for the evaluation (until 14 September, 2013 and 2014, respectively). Averages of temperature degrees and relative humidity during the experiment period were 25 ± 2^oC and 70-80%, respectively. All the normal culture practices of growing rose plants were applied as usual manner.

Data collected were plant height (measured at flowering stage of the plants), number of blind shoots /plant (non-flowering branches which were existed on each plant at the end of the experiment), flowering time (time taken from last treatment date to showing color of the first flower bud "day"), flowers diameter (cm at full-opening stage), flower duration on the plant (from showing color stage of each flower to its fading stage "day"), number of cut flowers per plant (during the period from 14 March till 14 September),

The chemical analysis and the amount of the available nutrients of the used medium are shown in the following Table.

pH(1:5)	EC(1:10)µs/m	Cations (meq/l)				Anions (meq/l)			
		Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^-	HCO_3^-	Cl^-	SO_4^-
3.65	148	3.60	1.40	0.55	0.01	0.00	1.60	0.60	3.36

Available macronutrients (mg/kg)			Available micronutrients (mg/kg)			
N	P	K	Cu	Fe	Mn	Zn
124.78	4.40	93.00	0.00	15.60	1.81	2.78

flower stalk length (from the point of branching with leaving 2 leaves up to the bottom of the flower "cm"), flower fresh weight (samples from each treatment were collected at full opening stage "g"), and leaf chlorophyll content (chlorophyll index) (SPAD unites), leaf total carbohydrates content (%), leaf total iron concentration (ppm), and leaf total zinc concentration (ppm) at the end of the xperiment.

The experimental layout was designed to provide a split-split design, where the application method was the main plot, iron concentration was the sub plot, while zinc concentration was the sub-sub plot. Every treatment had three replicates. Each replicate contained 24 different treatments. Four plants were used as a plot for each treatment in each replicate (Snedecor and Cochran, 1980).

RESULTS AND DISSCUTION

Generally, the analysis of variance of most the collected data of the two seasons showed that the F-values of the application method, iron concentration, zinc concentration, the combination between application method and iron concentration and the combination between iron and zinc concentrations were significant, while the other treatments were not significant, with some exceptions.

Plant height (cm):

Data of the two seasons presented in Table (1) indicated that adding iron with any level and with any application method led to a significant increase the plant height, compared to control treatment. Also, using 60 ppm iron as a foliar spray gave the highest value of plant height, compared to the other concentrations and application method.

These results were probably due to that the used growing medium had non-enough available amount of iron to need the growth of the used cultivar, and adding iron at a specific concentration as foliar spray was more effective on rose growth than that of its soil application, due to soil conditions probably led to decrease the uptake of the added elements to the soil, as a result the plant height of rose plant could be increased. Similar trend of results was reported by Soleymani and Sharajabian (2012) on forage sorghum and Ashoori *et al.* (2013) on grapevine.

Data presented in Table (2) indicated that using iron at any concentration combined with zinc at any concentration led to a significant increase the rose plant height, compared to the control treatment in the two experimental seasons. Also data of the two seasons showed that the highest value of the plant height was obtained from using iron at 60 ppm combined with zinc at 75 ppm, compared to the other combinations.

Table 1: Means of some studied parameters of *Rosa hybrida* cv. "Dallas" as influenced by the interaction between iron concentration and its application method in the two seasons of 2012/2013 and 2013/201.

Characters	Season	Foliar spraying				Soil drench				L.S.D. at 0.05
		Fe concentration (ppm)				Fe concentration (ppm)				
		0	30	60	120	0	30	60	120	
Plant height (cm)	Frist	78.13	85.52	89.02	82.45	73.14	82.24	81.25	82.50	1.70
	Second	82.79	89.12	92.51	86.79	79.22	84.67	85.06	85.19	2.21
Number of blind shoots/plant	Frist	4.76	6.13	6.51	5.71	4.23	5.01	5.19	5.60	0.25
	Second	5.29	6.59	6.70	6.06	4.85	5.38	5.69	5.80	0.20
Flowering time (day)	Frist	14.33	6.89	8.44	10.77	16.33	13.00	11.88	10.66	1.32
	Second	11.78	6.22	7.22	9.21	13.89	11.55	10.66	9.89	0.93
Flower diameter (cm)	Frist	8.09	10.14	9.42	8.84	3.54	8.12	8.54	8.80	0.67
	Second	8.61	10.65	10.06	9.51	7.37	8.88	9.28	9.55	0.65
Flower duration (day)	Frist	11.89	19.55	18.11	14.66	10.33	11.55	13.00	13.11	1.39
	Second	15.11	21.66	20.00	17.89	11.77	14.44	14.44	16.11	1.23
Stalk length (cm)	Frist	54.56	67.80	65.12	62.57	48.83	57.61	59.17	61.17	3.06
	Second	59.62	72.97	69.69	68.95	54.49	61.21	63.68	55.64	2.07
Flower fresh weight (g)	Frist	5.50	9.01	8.77	8.15	4.74	6.62	7.58	8..32	0.52
	Second	6.36	10.17	9.76	8.73	5.40	7.94	8.41	9.21	0.34
Chlorophyll index (SPAD units)	Frist	57.70	66.37	70.02	64.32	55.98	58.06	61.89	63.64	2.24
	Second	60.07	69.88	68.57	65.78	59.60	65.86	66.83	64.31	1.57
Total carbohydrates(%)	Frist	9.54	11.60	12.63	10.62	8.27	9025	9.43	10.52	0.65
	Second	11.20	13.30	14.02	11.39	9.97	10.81	11.01	11.49	0.99
Total zinc content (ppm)	Frist	21.86	32.40	31.21	30.71	19.35	27.51	30.91	29.48	0.83
	Second	25.87	34.43	32.96	32.76	20.38	29.57	32.21	30.61	0.66

Table 2: Means of plant height (cm), number of blind shoot/plant, flower diameter (cm) and total zinc content (ppm) of *Rosa hybrida* cv. "Dallas" as influenced by the combination between iron and zinc concentrations in the two seasons of 2012/2013 and2013/2014.

Fe conc. (ppm)	Zn conc. (ppm)	Plant height (cm)		Number of blind shoot/plant		Flower diameter (cm)		Total zinc content (ppm)	
		First season	Second season	First season	Second season	First season	Second season	First season	Second season
0	0	68.66	76.78	3.51	4.02	6.11	7.16	14.06	15.43
	75	79.06	84.01	5.44	5.76	8.82	9.16	24.91	27.41
	150	79.19	82.53	4.53	5.44	8.25	8.75	22.86	25.05
30	0	82.66	84.24	5.03	5.54	8.60	9.33	19.58	20.57
	75	84.76	89.87	6.19	6.36	9.65	10.32	36.58	38.98
	150	84.45	86.56	5.49	6.07	9.13	9.64	33.70	36.46
60	0	80.91	85.65	5.29	5.59	8.61	9.50	21.70	22.93
	75	89.85	91.42	6.54	6.78	9.50	9.99	35.73	37.46
	150	85.14	89.29	5.73	6.22	8.83	9.52	35.74	37.37
120	0	78.61	83.29	5.08	5.35	8.49	9.42	21.15	22.02
	75	87.37	89.44	6.43	6.69	9.37	9.96	35.60	37.20
	150	81.73	85.23	5.45	5.76	8.60	9.12	33.55	35.84
L.S.D. at 0.05		3.43	1.60	0.32	0.25	0.76	0.57	1.42	1.04

These results may be due to the importance of the two used nutrient elements in plants. Iron is a necessary element for enzyme system, synthesis of chlorophyll and enzyme activity, also, it regulates respiration, photosynthesis, reducing of nitrates and sulphate, that these reactions are essential to plant development and reproduction (Kim and Rees, 1992). While zinc is necessary for formation of auxins, which are growth promoting substances and they are responsible for cell division and elongation in plants (Alloway, 2008) consequently, using iron at a specific concentration combined with zinc at a proper concentration led to an increase in growth rate of rose plant, thus the plant height could be increased. Similar trend of results was reported by Helal and Khalil (1997) on *Catharanthus roseus* and Soliman (1997) on *Nigella sativa*.

Number of blind shoots / plant:

Data of the two seasons presented in Table (1) indicated that adding iron at any level for the both application methods led to a significant increase the number of blind shoots per plant, compared to control treatment. Also, using 60 ppm iron as a foliar spray gave the highest value of the number of blind shoots per rose plant, compared to the other treatments.

These results may be due to the role of iron in plant when it was used at a suitable concentration with the proper method. Iron activates several enzymes (catalase, peroxidase, alcohol, dehydrogenase, carbonic dehydrogenize, tryptophan synthesis etc.) and involved itself in chlorophyll synthesis and various physiological activates by which plant growth and development are encouraged, thus the side branches per plant (blind shoots), could be increased (Saini *et al.* 2015). Besides, spraying iron on rose plant led to a rapid absorption of it by the leaves and increase its effective on activation the vegetative growth, which led to an increase in the number of the blind shoot. Similar trend of results was reported by Bashir *et al.* (2013) on Gerbera.

With regard to the combinations between iron and zinc concentrations data presented in Table (2) showed that adding both iron and zinc at any concentration led to a significant increase in the number of blind shoots / plant, compared to the control treatment. Also, using iron at 30 ppm combined with zinc at 75 ppm gave the highest number of lateral branches / plant, compared to the other treatments.

These results were probably due to the synergistic effect of using the two elements together each at a suitable concentration and application method on activation the vegetative growth of rose plant, consequently the number of blind shoots per plant could be increased. Similar trend of results was reported by Mohammed *et al.* (1998) on *Pisum sativum*, L., El-Sawahly (2000) on *Borogo officinalis*.

Flowering time (day):

Generally, data of the two seasons in Table (3) showed that using Zn alone at any concentration led to a significant decrease in the time taken to showing color stage, compared to control treatment. Also, using zinc at 75 ppm gave the shortest time for showing color, compared to the other concentrations.

These results may be due to the role of Zn at a suitable concentration in plants. Zn is a necessary component of several enzyme systems, which regulate various metabolic activates within plants, thus using zinc at a suitable concentration accelerated the initiation of the flower buds to development and showing their color, consequently the time of flowering could be decreased. Similar trend of results was reported by Choudhary *et al.* (2016) on African marigold.

Furthermore, data of the two seasons presented in Table (1) showed that using iron as a foliar spray at any concentration led to a significant decrease in the time taken to showing color of flower buds of rose plant, compared to adding it to the soil. Besides, using iron at 30 ppm (as a foliar spraying) gave the shortest flowering time, compared to the other iron conccentrations and to adding it to the soil.

These results may be due to that spraying iron to the plant foliage accelerated its absorption within the plant and activated the flowering enzymes, which force the rose plant to fast developed and produced early flowers. Similar trend of results was reported by Bashir *et al.* (2013) on *Gerbera jamesonii*.

Flower diameter (cm):

Generally, data presented in Table (1) indicated that adding iron at any level for both application methods led to a significant increase in the flower diameter, compared to the control treatment. Also, using 30 ppm iron as a foliar spray gave the highest value of the flower diameter, compared to the other treatments.

These results might be due to that iron stimulates metabolic activity, with the stimulating effect on cell wall loosing, results on cell elongation along with cell enlargement, it results in enlarging flower diameter as reported by Poornima *et al*. (2018) on rose. Similar trend of results was reported by Almas and Madhuri (2014) on rose.

Furthermore, data presented in Table (2) indicated that application of iron combined with zinc at any concentration of each one led to a significant increase in the flower diameter of rose plant, compared to the control treatment. Also, using iron at 30 ppm combined with 75 ppm zinc gave the highest value of the diameter of the flower, compared to the other treatments.

These results were probably due to the synergistic effect of the two used nutrient elements at a suitable concentration for each on rose growth, as a result of their functions through stimulating metabolic activity, with the stimulating effect on cell wall losing, results on cell elongation and cell enlargement, thus the flower diameter could be increased.

Similar trend of results was reported by Fahad *et al.* (2014) on *Gladiolus* and Poornima *et al*. (2018) on rose.

Flower duration on the plant (day):

Generally, data presented in Table (3) showed that there was a significant increase in the flower duration on the plant with using the levels of zinc compared to the control treatment. Also, using zinc alone at 75 ppm gave the highest value of the flower duration on rose plant, compared to the other concentrations in the two seasons.

These results may be due to that the used growing medium had non-enough available amount of zinc for the used cultivar, consequently any addation of zinc led to encourage the vegetative growth of the plants, then the flower duration on the plant would be increased. Similar trend of results was reported by El-Naggar (2009) on *Dianthus caryophyllus*.

Besides, data of the two seasons presented in Table (2) indicated that adding iron at any level for both application methods led to significant increase the flower duration on the plant, compared to the control treatment, except of using iron at 30 ppm as soil drench in the first season. Also, using 30 ppm iron as a foliar spray gave the highest value of the flower duration on the plant, compared to the other treatments.

Table 3: Means of some studied parameters of *Rosa hybrida* cv. "Dallas" as influenced by the concentration of zinc in the two seasons of 2012/2013 and 2013/2014.

Characters	Season	Zn concentration (ppm)			L.S.D.at 0.05
		0.0	75	150	
Flowering time (day)	Frist	13.12	10.12	11.37	0.26
	Second	11.37	8.66	10.12	0.42
Flower duration (day)	Frist	12.37	15.91	13.79	1.07
	Second	14.66	18.58	16.41	1.10
Stalk length (cm)	Frist	54.37	64.52	59.92	1.05
	Second	60.20	69.38	64.01	1.25
Flower fresh weight (g)	Frist	6.52	8.25	7.23	0.31
	Second	7.39	9.40	7.95	0.41
Chlorophyll index (SPAD units)	Frist	58.49	66.25	63.25	0.86
	Second	62.85	70.14	65.64	0.92
Total carbohydrates (%)	Frist	9.14	11.36	10.20	0.28
	Second	10.41	12.83	11.70	0.60

Table 4: Means of total zinc content (ppm) of leaves of *Rosa hybrida* cv. "Dallas" as influenced by the interaction between zinc concentration and its application method in the two seasons of 2012/2013 and 2013/2014.

Application method	Zinc conc. (ppm)	Season	
		First season	Second season
Foliar spraying	0	20.38	21.58
	75	34.90	37.29
	150	31.86	34.89
Soil drench	0	17.86	18.89
	75	31.51	33.23
	150	31.06	32.47
L.S.D. at 0.05		1.00	0.74

These results were probably due to that using iron at a proper concentration and with the suitable method may have improves protein synthesis and more chlorophyll production resulted in production of food materials which it turns on better development of flower, consequently the flowering period could be increased. Similar trend of results was reported by Kakade *et al.* (2009) on *Callistephus chinensis* L. Nees.

Number of cut flowers / plant:

Data of two seasons in Table (5) revealed that using iron at 30 ppm combined with zinc at 75 ppm as a foliar spray gave the highest value of the cut flowers number per plant, compared to the other combinations.

These results might be due to the synergetic effect between the two elements, when each element was used at a specific concentration and with the proper application method. Iron relived the plant chlorosis and produced healthy green leaves which resulted in higher assimilate synthesis which may in turn have increased the flower production. While zinc activates several enzyme and involves itself in chlorophyll synthesis and various physiological activities by which plant growth and development are encouraged, due to which the flower yield might have been increased (Patel *et al.* 2017). Similar trend of results was reported by Poornima *et al.* (2018) on Floribanda rose.

Flower stalk length (cm):

Data of the two seasons presented in Table (3) showed that using zinc singly at any concentration led to a significant increase in the flower stalk length of rose plant, compared to the control treatment. Also, using zinc at 75 ppm alone gave the highest stalk of rose plant, compared to its other concentrations.

These results may be due to that the used growing medium had non-enough available amount of zinc for the used cultivar, consequently using the suitable concentration of it led to increases in cell division and growth rates of the plant, then their stalk length would be increased. Similar trend of results was reported by Fahad *et al.* (2014) on *Gladiolus grandiflorus* L.

Table 5: Means of number of cut flowers per plant of *Rosa hybrida* cv. "Dallas" as influenced by the application method, concentration of iron and zinc and their interactions in the two seasons of 2012/2013 and 2013/2014.

App. method	Fe conc. (ppm)	First season (2012 / 2013)				Second season (2013 / 2014)			
		Zn conc. (ppm)			Mean	Zn conc. (ppm)			Mean
		0	75	150		0	75	150	
Foliar spray	0	23.00	32.33	28.00	27.77	29.00	37.33	34.33	33.55
	30	30.00	48.33	35.33	37.88	33.66	56.33	38.33	42.77
	60	32.33	37.00	33.66	34.33	34.66	44.00	36.66	38.44
	120	24.00	34.66	29.00	29.22	28.33	37.66	36.00	33.99
Mean		27.33	38.08	31.49	32.30	31.41	43.83	36.33	37.19
Soil drench	0	17.00	23.33	23.66	21.33	23.66	27.00	26.00	25.55
	30	20.66	28.66	25.66	24.99	25.66	31.33	29.66	28.88
	60	28.33	35.00	30.66	31.33	31.00	40.00	34.00	35.00
	120	24.33	36.33	27.33	29.33	30.33	43.33	35.66	36.44
Mean		22.58	30.83	26.82	26.74	27.66	35.41	31.33	31.46
L.S.D. at 0.05		4.09				6.85			

Besides, data of the two seasons in Table (1) indicated that using iron at any concentration for both application methods led to a significant increase in the stalk length of flower of rose plant, compared to the control treatment. Also, using iron at 30 ppm as a foliar spray gave the highest value of flower stalk length, compared to the other concentrations and application method.

These results were probably due to the role of using iron at a suitable concentration and with the proper application method which led to activate the vegetative growth rate and cell division and elongation of rose plant, consequently the flower stalk could be increased. Similar trend of results was reported by Patel *et al.* (2017) on *Polianthes tuberosa* L.

Flower fresh weight (g):

Generally, data presented in Table (3) indicated that application of zinc alone at any concentration significantly increased flower fresh weight, compared to the control treatment. Also, data of the two seasons showed that application of zinc at 75 ppm gave the heaviest flower fresh weight, compared to its other concentrations.

These results may be due to that the used growing medium had non-enough available amount of zinc for the used cultivar, consequently any addation of it led to encourage the plant growth, then the flower fresh weight will increase. Similar trend of results was reported by Kakade *et al.* (2009) on *Callistephus chinensis* L. Nees and Fahad *et al.* (2014) on *Gladiouls grandiflorus* L.

Besides, data presented in Table (1) indicated that adding iron at any level for both application methods led to a significant increase in flower fresh weight, compared to control treatment in the two experimental seasons. Also, using 30 ppm iron as a foliar spray gave the highest fresh weight of rose flower in the two seasons, compared to the other concentrations and application method.

These results may be due to that the used growing medium had non-enough available amount of iron to need the growth of the used cultivar, and adding iron at a specific concentration and with suitable application method (foliar spray) led to activate the photosynthesis process, thus the amount of the stored produced food through the photosynthesis process could be increased which produced large flowers with many petals. Thus, the fresh weight of the produced flowers could be increased. Similar trend of results was reported by Kakade *et al.* (2009) on china aster (*Callistephus chinensis* L. Nees) and Fahad *et al.* (2014) on *Gladiolus*.

Leaf chlorophyll index (SPAD units):

Data presented in Table (3) showed that there was a significant increase in the chlorophyll index of rose leaves with increasing the level of zinc, compared to the control treatment.

Generally, using 75 ppm zinc alone gave the highest value of chlorophyll index in the leaves of the studied rose cultivar, compared to its other concentrations in the two seasons.

These results may be due to that using zinc at the suitable concentration activated the chlorophyll formation and simulative effect causing antioxidantal scavenging effect to protect chloroplasts, consequently the chlorophyll content in rose leaves could be increased. Similar trend of results was reported by Ai-Qing *et al.* (2011) on wheat and Khalifa *et al.* (2011) on iris.

Furthermore, data presented in Table (1) showed that adding iron at any level for both application methods led to a significant increase in the chlorophyll index of rose leaves, compared to the control treatment. Also, means of the two seasons showed that using 60 ppm iron as a foliar spray gave the highest values of the chlorophyll index in the leaves, compared to the other treatments.

These results might be attributed to the role of iron in plants. Iron is involved in the synthesis of chlorophyll and its essential for the maintenance of chloroplast structure and function, thus using its suitable concentration with the suitable application method will increase the formation (synthesis) of chlorophyll in the leaves. Similar trend of results was reported by Choudhary *et al*. (2016) *on Tagets erecta* L.

Leaf total carbohydrates percentage:

Data presented in Table (3) showed that there was a significant increase in the total carbohydrates percentage of rose leaves with increasing the level of zinc, compared to the control treatment.

Also, using 75 ppm zinc alone gave the highest values of the total carbohydrates percentage of the leaves of the studied rose cultivar, compared to its other concentrations in the two seasons.

These results may be due to that the used growing medium had non-enough available amount of it for the used cultivar, consequently using a suitable concentration of it increased the accumulation of the synthesized materials such as carbohydrates in the rose leaves. Similar trend of results was reported by Hassanain *et al.* (2006) on *Matricria chamomilla* L. plants and Pandy (2013) in black gram.

Besides, data presented in Table (1) cleared that adding iron at any concentration for both application methods led to a significant increase in the total carbohydrates percentage of rose leaves, compared to the control treatment. Also, using 60 ppm iron in both seasons as a foliar spray gave the highest values of the total carbohydrates percentage in the leaves of rose plant, compared to the other treatments.

These results may be due to that using iron at a proper concentration with the suitable application method acts as an important catalyst in the enzymatic reaction of metabolism. This ultimately would have helped in larger biosynthesis of photoassymilates, thereby enhanced the accumulation of carbohydrate in the leaves. Besides, foliar spraying of iron on rose plant led to a rapid absorption and translocation of it and increase the efficient of photosynthesis process, through increasing leaf area and leaf pigments, consequently the assimilated food could be increased, thus the leaf carbohydrate content would be too increased.

Similar trend of results was reported by Hassanain *et al.* (2006) on chamomile (*Matricaria chamomilla* L.) and Saini *et al*. (2015) on *Chrysanthemum.*

Leaf total iron content (ppm):

Generally, data of the two experimental seasons presented in Table (6) indicated that using iron combined with zinc at any concentration for both application methods led to a significant increase in the total iron content of the leaves of rose plant, compared to the control treatment.

Besides, adding iron at 60 ppm combined with zinc at 75 ppm as foliar spray gave the highest iron content of the leaves, compared to the other concentrations and application method.

These results were probably due to that adding the two nutrient elements together as a foliar spray at the suitable concentration for each led to activate and increase the absorption of iron within plant then the total iron content of the rose leaves could be increased. Similar trend of results was reported by Sahu *et al*. (2017) on *Gerbrea sp.*

Besides, data of the two seasons presented in Table (6) showed that increasing the level of iron over 60 ppm and / or zinc over 75 ppm led to a significant decrease in the total iron content of rose leaves, compared to using iron at 60 ppm combined with zinc at 75 ppm.

These results might be attributed to the antagonistic effect between iron and zinc especially at the high concentration within the plant, according the amount of the other element would be decreased. Similar trend of results was reported by Tarraf *et al.* (1994) on *Rosmarinus afficinalis* L. and Ashoori *et al.* (2013) on grabevine (*Vitis viniferea* L.).

Leaf total zinc content (ppm):

Data of the two seasons presented in Table (1) indicated that using iron at 30 ppm as a foliar or 60 ppm as a soil application gave the highest significant increase in the total zinc content of rose leaves, compared to the other levels, while increasing the iron concentration over the previous concentration led to a significant decrease in the total zinc content of the rose leaves.

These results may be due to that using iron at a high concentration regardless of the application method led to reduce the absorbed amount of zinc, as a results of the antagonistic effect between them, consequently, the total zinc content in rose leaves could be decreased. Similar trend of results was reported by Erdal *et al.* (2004) on strawberry.

Besides, data of the two experimental seasons in Table (4) showed that using zinc at the low level (75 ppm) with any application method gave the maximum significant increase of the total zinc content of rose leaves, compared to the other concentrations. While using zinc at the higher level (150 ppm) with any application method, led to a significant decrease in the leaf total zinc content (in most cases), compared to using it at 75 ppm.

These results might be attributed to that increasing the concentration of the applied zinc over the optimum level led to zinc nutritional inbalance effect on rose plant, consequently reducing its absorption and translocation within the plant and its leaves contained less amount of zinc.

Table 6: Means of leaf total iron content (ppm) of *Rosa hybrida* cv. "Dallas" as influenced by the application method, concentration of iron and zinc and their interactions in the two seasons of 2012/2013 and 2013/2014.

App. method	Fe conc. (ppm)	First season (2012 / 2013)				Second season (2013 / 2014)			
		Zn conc. (ppm)			Mean	Zn conc. (ppm)			Mean
		0	75	150		0	75	150	
Foliar	0	50.44	62.36	60.76	57.85	52.82	65.32	62.40	60.18
	30	65.95	85.84	82.17	77.98	73.31	88.48	83.97	81.92
	60	71.81	94.11	75.78	80.56	73.26	96.64	85.29	85.06
	120	68.41	78.91	72.26	73.19	72.48	81.69	76.23	76.80
Mean		64.15	80.30	72.74	72.39	67.96	83.03	76.97	75.99
Soil drench	0	48.46	59.55	56.57	54.86	51.10	61.16	59.28	57.18
	30	62.97	74.28	68.70	68.65	67.37	78.89	73.86	73.35
	60	65.35	78.56	72.45	72.12	70.44	81.41	73.69	75.18
	120	73.43	82.69	81.29	79.13	76.06	87.10	83.82	82.32
Mean		62.55	73.77	69.75	68.69	66.24	77.12	72.66	72.00
L.S.D. at 0.05		3.23				4.19			

Furthermore, data of the two seasons in Table (2) indicated that using iron at 30 ppm combined with zinc at 75 ppm gave the highest value of the total zinc content of rose leaves, compared to the other concentrations. While using iron alone or at its higher concentration combined with zinc at its higher level led to a significant decrease in the zinc content of rose leaves, compared to the previous treatment.

These results were probably due to the antagonistic effect between iron and zinc when they were applied at the unsuitable concentrations, consequently the absorbed and the translocation amount of zinc within rose plant could be decreased. Similar trend of results was reported by Tarraf *et al.* (1994) on *Rosmarinus officinalis* L. and Ashoori *et al.* (2013) on *Vitis viniferea* L.

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الملخص العربى

تأثير مستويات وطرق إضافة الحديد والزنك على نمو وإزهار الورد الهجين صنف "دالاس"

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أجري هذا البحث في مشتل تجارى فى مدينة الإسكندرية خلال موسمي ٢٠١٢/٢٠١٣، ٢٠١٣/٢٠١٤ بهدف دراسة تأثير تركيزات مختلفة وطرق الإضافة أربع مرات لكل من الحديد(صفر، ٣٠، ٦٠، ١٢٠ جزء في المليون) والزنك (صفر ،٧٥ ،١٥٠ جزء فى المليون) المخلبيين حيث أضيف كل عنصر إما منفردا أو مع عمل جميع التوافيق بينهما لتعطي ٢٤ معاملة وذلك علي بعض صفات النمو الخضري والزهري وبعض التحليلات الكيماوية لنبات الورد الهجين صنف "Dallas". نظراً لأهميته في تجارة زهور القطف.

وقد أظهرت نتائج الموسمين أن إستخدام العنصرين منفردين أو فى توافيق بينهما رشا على نبات الورد أدى إلى تأثير معنوى موجب على كل الصفات المدروسة على النبات بالمقارنة بإضافتهما للتربة ، وأن إستخدام الحديد بتركيز ٣٠ أو ٦٠ جزء فى المليون منفردا أو فى توافيق مع عنصر الزنك بتركيز ٧٥ جزء فى المليون أعطى أعلا زيادة معنوية تقريبا فى معظم الصفات المدروسة على نبات الورد بالمقارنة بالمعاملات الأخرى.

بينما إستخدام العنصرين بمستوياتهما العليا (١٢٠ جزء فى المليون حديد أو ١٥٠ جزء فى المليون زنك) منفردين أو فى توافيق بينهما أدى إلى نقص فى معظم الصفات المدروسة على نبات الورد صنف "Dallas" بالمقارنة بتركيزاتهما المنخفضة.