Plant Archives Vol. 19 No. 1, 2019 pp. 1783-1790 **e-ISSN:2581-6063 (online), ISSN:0972-5210**

EFFECT OF SPRAYING CHELATED AND NANO OF BOTH IRON AND ZINC ON THE GROWTH AND YIELD OF BROCCOLI (*BRASSICA OLERACEA* VAR. *ITALICA*)

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Abstract

A field experiment was conducted during the winter season 2017 at a private farm located south to Baghdad to investigate the effect of spraying chelated and nano fertilizers on the growth and yield of broccoli. The experiment included spraying chelated iron and nano iron at three concentrations 0, 100, and 200 mgFe.l^{-1} as well as spraying chelated and nano-zinc at three concentrations 0, 50, and 100 mgZn.l^{-1}. Results showed the superiority of the 200 mgFel^{-1} to other chelated iron concentrations in plant height, leaf area, dry weight, total chlorophyll content, and flower disc diameter with the values 67.6 cm, 65.5 dcm^2.plant^{-1}, 179.6g.plant^{-1}, 65.1mg.100g^{-1} fresh weight, and 19.6 cm respectively. The same concentration of nano-iron fertilizer was also superior in these traits producing 73.6 cm, 69.5 dcm.plant^{-1}. 188.3 mg. 100mg^{-1} fresh weight, and 68.2 cm respectively. Results also showed that the concentration 100mgZn.l^{-1} was superior to other chelated zinc in the traits of plant height, leaf area, dry weight, total chlorophyll content, flower diameter, flower weight, and total flower yield as the values of these traits were 65cm, 65.2 dcm^2.plant^{-1}, 177g.plant^{-1}, 66.8 mg.100mg^{-1} fresh weight, 19.1 cm, 733 g.plant^{-1}, and23.21t.ha^{-1} respectively. The same concentration of nan-zinc was also superior in these traits producing the values 67.9dcm.plant^{-1}, 185.3 gm.plant^{-1}, 66.5mg.100^{-1} fresh weight, 20.43 cm, 806g.plant^{-1} and 24.18t.ha^{-1}. Concerning the interaction between iron and zinc, the treatment of 200 mgFe.l-1 plus 100mgZn.l-1 of both chelated and nano iron and zinc were superior to other interactions and produced the highest values of plant height 71 and 76cm, leaf area 70.7 and 73.5dcm.plant^{-1}, dry matter 186 and 194 g.plant^{-1}, total chlorophyll content 70.9 and 73.3 mg.100mg^{-1} fresh weight respectively, whereas, regarding the total flower disc yield, the treatment of 100 mgFel-1 plus 100mgZn.l^{-1} of chelated fertilizer produced 24.63t.ha^{-1} and the treatment of 200mgFe.l^{-1} plus 50mgZn.l^{-1} produced 25.89t.ha^{-1}.

Key words : Micro nutrient, chelated, nano, broccoli.

Introduction

Nanotechnology plays an important role in increasing production and improving the quality of food produced by farmers. Many believe that this new technology will ensure the growing world's food needs as well as provide a range of economic and environmental benefits. Nanotechnology has proven its position in agricultural sciences and related industries as a multidisciplinary technology and pioneer in solving problems (Mousavi and Rezaei, 2011). Nanotechnology is considered a tool that helps in solving challenges facing farmers in managing crops by obtaining high producing crops and minimizing the use of synthetic chemicals (Kumar, 2013; Prasad *et al.*, 2014). Nanomaterials are defined as materials their minutes are between 1 to 100 nanometers, and because of their tiny sizeNanomaterials are defined as materials their minute sizes are between 1 to 100 nanometers, they behave in a way differs from the traditional materials of big size molecules as well as differ from them in the physical and chemical properties (Mazaherinia *et al.*, 2010; Ghorbani *et al.*, 2011). Bozorgi (2012) clarified that spraying nano-iron on the vegetative parts of eggplant, *Solanum melongena* L., at three concentrations (0, 1, and 2 g.l^{-1}) increased significantly all studied traits where

Table 1 : Some of chemical and physical properties of field's soil before planting.

pH	ECdS.m^{-1}	Available Mgkg^{-1}soil			O.M%	Soil texture	Soluble cations and anions M mole L^{-1}						
		N	P	K			Ca^{2+}	Mg^{2+}	Na^{+}	SO_4^{2-}	Cl^-	HCO_3^-	CO_3^{2-}
7.8	4.3	42	17	225	1.43	SICL	9.31	6.23	5.33	3.2	13.2	1.2	Nil

the treatment of 2g.l^{-1} recorded the highest averages of plant height, number of branches and number of fruits compared to the control treatment. Pariona *et al*, (2016) also explained that spraying granular iron nano on maize leaves at the five concentrations (0, 1, 2, 4, and 6 g.l^{-1}) led to significant linear increase in the plant height, leaf length, chlorophyll content, root dry weight, shoot weight, and weight of 1000 grains compared to control, in line with the concentration increment. Boghori (2016) referred to that foliar spray of nano-iron on sesame, *Sesamum indicum* L., plants at three concentrations (10, 20 and 30 mg.l^{-1}) increased significantly some qualitative and quantitative traits such as plant height, seed protein percentage, and weight of 1000 seeds compared to control.

Broccoli *Brassica oleracea* var. *Italica* belongs to the Cruciferae family rich in many vitamins such as A, B, carcinoids, folic acid, Nicene, and riboflavin, in addition to some nutrient elements such as calcium, iron, sodium, phosphor, and potassium (Michaud *et al.*, 2002); furthermore, Broccoli is a rich source of Sulforaphane which has shown anti-carcinogenic properties because it contains high levels of Glucosinolates, which have been proved to reduce cancer, so it has been noticed that eating more than one meal weekly reduces the risk of cancer by 45% (Kirsh *et al.*, 2007; Zhao *et al.*, 20078).

Materials and Methods

A field experiment was conducted at a private field, south of Baghdad to study during the winter season 2017 to study the influence of spraying iron, nano- iron, zinc, nano-zinc on the broccoli growth and yield. The study was a factorial experiment within the randomized complete block design (RCBD) included three replicates. The experiment involved spraying iron and nao-iron at three concentrations, 0, 100, and 200 mg Fe.l^{-1} of each, and spraying zinc and nano-zinc at three concentrations, 0, 50 and 100 mg.l^{-1} Zn of each. The soil was prepared, plowed, softened, and divided into experimental units. Soil samples were taken from the 0-30 cm beneath the soil surface from different locations of the field, mixed well to be uniform, dried by air, ground by polyethylene hummer, and passed through a 2 mm diameter sieve. Compound samples were taken to assess some soil physical and chemical characteristics (table 1). Broccoli plants were grown in furrows distancing by 75 cm from each other, and the distance between a plant and another was 40 cm. The plants were fertilized with 145 kgN.ha^{-1}, 80 kgP.ha^{-1} and 120 kgK.ha^{-1} (Hassn, 2004). The experimental treatments were applied through spraying the iron and zinc elements during three stages of plant life, 30, 45 and 45 days after planting. Weeding was done manually when needed.

Results

Plant height (cm)

Results in table 2 shows the significant effect of the chelated Iron. The concentration of 200mgFe.l^{-1} produced the highest plants averaged 65.6cm increasing by 14.57% compared to the lowest plant height 59 cm resulted from 0Fe.l^{-1}. The claw zinc at 100Zn.l^{-1} was also significantly superior in plant height producing 65cm with an increase of 9.06% compared to the lowest value resulted from 0Zn.l^{-1} producing 59.6 cm. The interaction between the concentrations of chelated iron and claw zinc was also affected significantly in the plant height. The treatments of 200 mgFe.l^{-1} with 100mgZn. L^{-1} produced the highest value of plant height 71cm with an increment percentage of 29.09% compared to the control that gave the least value 55cm. The table illustrates the significant superiority of 200 mg.l^{-1} of nano-iron in producing the highest value of plant height among all treatments 73.6cm increasing over the treatment of 0mg Fel^{-1} by 17.57% and over the treatment of 200Fe mg.l^{-1} of chelated iron by 8.87%. The nano- zinc at 50mg Zn.l^{-1} was significantly superior over other zinc treatments in this trait producing the highest value 65.3 cm increasing over the treatment of 0mgZn.l^{-1} by 8.72 and over the treatment of 100 mgZn.l^{-1} of claw zinc by 9.23%. Regarding the interaction between chelated iron and claw zinc, the treatment of 200mg Fe.l^{-1} plus 50mg Zn.l^{-1} was superior producing the highest plant height 76 cm increasing by 30.5% over the treatment of no spray giving the lowest value of this trait 58 cm; furthermore, the interaction between the nano fertilizes was superior to the claw fertilizers. The treatment of 200mgFe.l^{-1} plus 50mgZn.$l^{-1}$of nano fertilization was superior to the best interaction between claw fertilization by 7.04%.

Table 2 : The effect of spraying chelated and nano of both iron and zinc on plant height (cm).

Zn (Nano)						Zn (Chelated)					
	Average	**100**	**50**	**0**	**Treatments**		**Average**	**100**	**50**	**0**	**Treatments**
Fe Nano	62.6	64	66	58	0	**Fe Chelated**	59	63	59	55	0
	70.6	73	71	68	100		65.3	69	66	61	100
	73.6	76	76	70	200		67.6	71	69	63	200
	2	3			LSD		3	4			LSD
		70.6	71	65.3	Average			65	64.6	59.6	Average
		2			LSD			3			LSD

Table 3 : The effect of spraying chelated and nano of both iron and zinc onLeaf area (dcm^2.plan^{-1}).

Zn (Nano)						Zn (Chelated)					
	Average	**100**	**50**	**0**	**Treatments**		**Average**	**100**	**50**	**0**	**Treatments**
Fe Nano	56.2	60.1	56.3	52.4	0	**Fe Chelated**	55.1	58.2	54.1	53.2	0
	66.4	70.3	68.8	60.2	100		62.4	66.7	64.1	56.4	100
	69.5	73.5	69.9	65.3'	200		65.5	70.7	66.6	59.3	200
	4	6			LSD		3	5			LSD
		67.9	65	59.3	Average			65.2	61.6	56.3	Average
		4			LSD			3			LSD

Leaf area (dcm^2.plan^{-1})

Results in table 3 illustrate the significant superiority of 200 mg Fe.l^{-1} of chelated iron producing 67.6 dcm^2.plant^{-1} compared to the other concentrations of chelated iron with an increase of 22.86% over the concentration 0mg Fe.l^{-1} producing the lowest leaf area 55.1 dcm^2.plant^{-1}. The concentration 100mgZn.l^{-1}, producing 65.2 dcm^2.plant^{-1} was significantly superior to other chelated zinc concentrations, while the lowest value among chelated zinc treatments was 56.3 dcm^2.plant^{-1} recorded by the treatment of zero zinc, thus the treatment of 100mg Zn.l^{-1} surpassed over by 15.80%. Concerning the interaction between chelated iron and chelated zinc, Concerning the interaction between chelated iron and chelated zinc, the treatment of 200mgFe.l^{-1} with 100mg Zn.l^{-1} was significantly superior producing the highest leaf area 70.7 dcm^2.plant^{-1} with an increment percentage of 32.89% over the control treatment giving the lowest value 53.2 dcm^2.plant^{-1}. The same table revealed the significant superiority of 200 mg.l^{-1} of nano-iron producing the highest leaf area 69.5dcm^2.plan^{-1} compared to the

Other nano-iron concentrations, with an increment of 23.66% over the treatment of 0Fe.l^{-1} giving 56.2dcm^2.plant^{-1} and an increment of 6.1% over the treatment of 200mg.l^{-1} of chelated iron. On the other hand, the nano zinc at 100mgZn.l^{-1} was significantly superior producing the highest leaf area value compared to the other nano zinc treatments 67.9 dcm^2.plant^{-1}, *i.e.* increased by 14.5% over the treatment of 0mgZn.l^{-1} producing 59.3dcm^2.plant^{-1} and by 4.14% over the treatment of 100mg Zn.l^{-1} of chelated zinc. Regarding the interaction between nano-iron and nano-zinc, it also affected significantly. The treatment of 200 mg.l^{-1} plus 100 mg.l^{-1} produced the highest leaf area averaged 73.5 dcm^2.plant^{-1} with an increment percentage 40.26% over the control treatment (without spraying neither iron nor zinc) producing the lowest value of leaf area 52.4d cm^2.plant^{-1}. This treatment was also superior to the treatment interaction between 200mgFe.l^{-1}plus 100mg Zn.l^{-1} of chelated iron and chelated zinc in this trait by 3.96%.

Shoot dry weight (g.plant^{-1})

The results in table 4 indicated that the chelated iron at 200mgFe.l^{-1} was significantly superior in shoot dry weight producing the highest weight 179.6 g.plant^{-1}, increased by 16.39% over the lowest value of the trait 154.3 g.plant^{-1} gotten from the treatment of 0mgFe.l^{-1}. Among the chelated zinc treatments, 100mgZn.l^{-1} was significantly superior producing 177g .plant^{-1} and increasing by 11.11% over the lowest value 159.3g.plant^{-1} produced by 0mgZn.l^{-1}. Regarding the interaction between the chelated iron and chelated zinc, the treatment of 200mg Fe.l^{-1} plus 100mgZn.l^{-1} was superior giving 186g.plant^{-1} with an increment of 20.77% over the

Table 4 : The effect of spraying chelated and nano of both iron and zinc onShoot dry weight (g.plant^{-1}).

Zn (Nano)						Zn (Chelated)					
	Average	**100**	**50**	**0**	**Treatments**		**Average**	**100**	**50**	**0**	**Treatments**
Fe Nano	163	174	165	150	0	Fe Chelated	154.3	164	154	145	0
	179	188	178	171	100		171	181	172	160	100
	188.3	194	191	180	200		179.6	186	180	173	200
	3	6			LSD		4	7			LSD
		185.3	178	167	Average			177	168.6	159.3	Average
		3			LSD			4			LSD

Table 5 : The effect of spraying chelated and nano of both iron and zinc onTotal chlorophyll content (mg/100mg fresh weight).

Zn (Nano)						Zn (Chelated)					
	Average	**100**	**50**	**0**	**Treatments**		**Average**	**100**	**50**	**0**	**Treatments**
Fe Nano	50	55.9	50.2	44.4	0	Fe Chelated	51.0	60.7	48.3	44.2	0
	64.5	70.8	67.3	55.6	100		60.8	68.9	63.3	50.4	100
	68.2	73.3	70.4	60.9	200		65.1	70.9	67.7	56.8	200
	3	5			LSD		2.5	4.5			LSD
		66.5	62.6	53.6	Average			66.8	59.7	50.4	Average
		3			LSD			2.5			LSD

treatment control (without spraying) producing 145g.plant^{-1}. The table also indicated the significant superiority of nano-iron at 200mgFe.l^{-1} giving the highest value among other nao-iron concentrations 188.3g.plant^{-1} and surpassed the lowest value 163g.plant^{-1}, gotten from 0mgFe.l^{-1}, by 4.84%. The concentration of 100mgZn.l^{-1} was significantly superior to the other nano-zinc treatments and produced the highest weight among them 185.3g.plant^{-1}, thus increased by 10.95% over the concentration 0mg Zn.l^{-1} producing the lowest shoot dry weight 167g.plant^{-1} and by 4.68% over the concentration 100mgZn.l^{-1} of chelated zinc. Concerning the interaction between the nano-iron and nano-zinc, the treatment of 200mgFe.l^{-1} plus 100mgZn.l^{-1} was superior in this trait producing the highest value 194g.plant^{-1} increasing over the treatment of no spray, that produced the lowest value 150g.plant^{-1} by 29.33%; furthermore, this treatment was superior to the best treatment of the interaction between chelated iron and chelated zinc in this trait by 4.30%.

Total chlorophyll content (mg/100mg fresh weight)

Results in table 5 referred to the superiority of the concentration 200mg Fe.l^{-1} of the chelated iron significantly in the chlorophyll content. This treatment produced the highest value of chlorophyll among the treatment of chelated iron 65.1mg/100mg fresh weight, increased over the lowest value 51.01mg/100mg fresh weight recorded by the concentration 0mgFe.l^{-1} by 27.64%. The chelated zinc at the concentration of 100mg.l^{-1} was superior in this trait giving the highest value among other chelated zinc treatments 66.8mg/100mg fresh weight. The chelated zinc at the concentration of 100mg.l^{-1} was superior in this trait giving the highest value among other chelated zinc treatments 66.8mg/100mg fresh weight and surpassed by 32.53% over the lowest value 50.4 mg/100mg fresh weight, produced by the concentration 0mgZn.l^{-1} by 32.53%. The interaction between the chelated iron and chelated zinc revealed that the treatment of 200mgFel^{-1} plus 100mgZn.l^{-1} was significantly superior and produced 70.9 mg/100mg fresh weight, increasing over the lowest value 44.2 mg/100mg fresh weight, produced by the treatment of no spray, by 60.40%. The same table revealed the significant superiority of nano- iron at the concentration 200mgFe.l^{-1} to the other nano-iron concentrations. It produced the highest chlorophyll content 68.2 mg/100mg fresh weight and surpassed the lowest value 50 mg/100mg fresh weight produced by the concentration 0 mg Fel^{-1} of nano-iron by 36.4% and the value produced the concentration 200 mgFe.l^{-1} of chelated iron by 4.76%. Similarly, the concentration of nano-zinc 100mgZn.l^{-1} was significantly superior giving 66.5 mg/100mg fresh weight surpassing the lowest value produced by 0.mgZn.l^{-1} 53.6 mg/100mg fresh weight by 24.06%. The interaction between nano-

Table 6 : The effect of spraying chelated and nano of both iron and zinc onFlower disc diameter (cm).

Zn (Nano)						Zn (Chelated)					
	Average	**100**	**50**	**0**	**Treatments**		**Average**	**100**	**50**	**0**	**Treatments**
Fe Nano	17.7	18.8	17.9	16.4	0	**Fe Chelated**	16.9	17.5	16.9	16.5	0
	19.5	20.7	20.1	17.7	100		18.1	19.6	18.1	16.7	100
	21.26	21.8	22.3	19.7	200		19.6	20.3	20.7	17.8	200
	1.1	1.4			LSD		1.2	1.5			LSD
		20.43	20.1	17.9	Average			19.1	18.5	17	Average
		1.1			LSD			1.2			LSD

Table 7 : The effect of spraying chelated and nano of both iron and zinc on flower disc weight (g.plant^{-1}).

Zn (Nano)						Zn (Chelated)					
	Average	**100**	**50**	**0**	**Treatments**		**Average**	**100**	**50**	**0**	**Treatments**
Fe Nano	684.6	725	715	614	0	**Fe Chelated**	644	690	680	622	0
	778	856	790	688	100		768.6	821	805	680	100
	805.3	837	863	716	200		760	810	780	690	200
	23	35			LSD		20	30			LSD
		806	789.3	672.6	Average			773	755	664	Average
		23			LSD			20			LSD

iron and nano-zinc revealed that the treatment of 200mgFe.l^{-1} plus 100 mgZn.l^{-1} was significantly superior in this trait producing the highest value 73.3 mg/100mg fresh weight with an increment percentage of 65.09% compared to the lowest value gotten from the treatment of no spray 44.4 mg/100mg fresh weight and an increment percentage of 3.38% compared to the treatment of interaction 200mgFe.l^{-1} plus 100mg Zn.l^{-1} of the chelated iron and chelated zinc.

Flower disc diameter (cm)

Results in table 6 demonstrated the superiority of the chelated iron at the concentration 200mg Fe.l^{-1} producing the highest disc diameter among the other chelated iron concentrations 19.6 cm. This value was higher than the lowest one 16.9 cm produced by the concentration 0mg Fe.l^{-1} by 15.97%. The chelated zinc at the concentration 100mgZn.l^{-1} was also significantly superior to the other zinc concentrations. It gave 19.1 cm and so it exceeded the lowest diameter 17 cm, produced from the no zinc treatment, by 12.35%. The interaction between chelated iron and chelated zinc revealed the treatment of 200mgFe.l^{-1} plus 50mgZn.l^{-1} producing the flower disc of 20.7 cm was superior to the other treatments of interaction between chelated iron and chelated zinc and exceeded the lowest value 15.5 cm resulted from the no spray treatment. The nano-iron at the concentration 200mgFe.l^{-1} was significantly superior in the disc diameter giving 21.26 cm exceeding the lowest disc diameter 17.7cm resulted from 0mgFe.l^{-1} by 20.11% and the chelated iron at the concentration of 200mgFe.l^{-1} by 8.46%. The nano-zinc at the concentration 100mgZn.l^{-1} was also significantly superior in this trait producing 20.43 cm compared to the other nano-zinc concentrations. It was higher than the lowest value among them 17.9 cm by 14.13% and higher than the chelated zinc at the same concentration by 6.96%. The interaction between the nano-iron and nano-zinc revealed that the treatment of 200 mgFe plus 50mgZn led to a significant superiority in this trait giving the highest disc diameter 22.3 cm increasing over the lowest diameter 16.4cm, produced by the treatment of 0mg Fe.l^{-1} and 0mgZn.l^{-1}, by 35.97% and over the treatment of interaction between chelated iron and chelated zinc at the same concentrations (200mgFe.l^{-1} + 50mg Zn.l^{-1}) by 7.72%.

Flower disc weight (g.plant^{-1})

Results in table 7 referred to the significant superiority of the chelated iron treatment of 100mg Fe.l^{-1} giving the highest disc weight 768.6g.plant^{-1} compared to the other chelated iron treatments, while the lowest weight was 664g.plant^{-1} produced by the treatment of 0mgFe.l^{-1}, i.e. the superior treatment exceeded the lowest one by 15.75%. The concentration 100mg Zn.l^{-1} of chelated zinc

Table 8 : The effect of spraying chelated and nano of both iron and zinc onTotal flower disc yield ($t.ha^{-1}$).

	Zn (Nano)						Zn (Chelated)				
	Average	**100**	**50**	**0**	**Treatments**		**Average**	**100**	**50**	**0**	**Treatments**
Fe Nano	20.54	21.75	21.45	18.42	0	Fe Chelated	19.92	20.70	20.40	18.66	0
	23.34	25.68	23.70	20.64	100		23.06	24.63	24.15	20.40	100
	24.16	25.11	25.89	21.48	200		22.80	24.30	23.40	20.70	200
	0.32	0.55			LSD		0.31	0.42			LSD
		24.18	23.68	20.18	Average			23.21	22.65	19.92	Average
		0.32			LSD			0.31			LSD

was also significantly superior to other chelated zinc concentrations. It produced flower disc weighted $773g.plant^{-1}$ and exceeded the lowest value $664g.plant^{-1}$ by 16.41%. The interaction between the chelated iron and chelated zinc revealed the significant superiority of the interaction between $100mgFe.l^{-1}$ and $100mgZn.l^{-1}$ giving a flower disc weighted $821g.plant^{-1}$ and increased over the treatment free of iron and zinc that produced the lowest value $622g.plant^{-1}$. The table also illustrated the significant differences among nano-iron treatments, where the concentration of $200mgFe.l^{-1}$ was significantly superior in this trait producing $805.3g.plant^{-1}$, exceeding the lowest value among them $684.6g.plant^{-1}$, produced by the concentration $0mgFel^{-1}$, by 17.63%. The treatments of nano- zinc were also different among their concentrations. The concentration $100Zn.l^{-1}$ was significantly superior in the flower disc weight producing 806g.plant-1 and surpassing the lowest value $672g.plant^{-1}$, gotten from 0mg $Zn.l^{-1}$ by 19.94%, and increased over the concentration 100mg $Zn.l^{-1}$ of chelated zinc by 4.26%. The interaction between nano-iron and nano-zinc showed that the treatment of 200mg Fel^{-1} plus $50mgZn.l^{-1}$ was significantly superior in this trait giving the highest flower disc weight $863g.plant^{-1}$ with an increment percentage of 40.55% over the treatment of no spray that produced the lowest value $614g.plant^{-1}$. The value produced by the treatment was increased over the value produced by the same concentrations of chelated iron and chelated zinc by 5.11%.

Total flower disc yield ($t.ha^{-1}$)

Result in table 8 demonstrated the significant superiority of $100mgFe.l^{-1}$ of chelated iron to other chelated iron concentrations in the total yield $23.06t.ha^{-1}$ exceeding the lowest value among them $19.92t.ha^{-1}$, gotten from $0mgFe.l^{-1}$, by 15.76%. The chelated zinc at the concentration $100Zn.l^{-1}$ was significantly superior among other chelated zinc in this trait producing $23.21t.ha^{-1}$, whereas the concentration $0mgZn.l^{-1}$ gave the lowest value among them $19.92t.ha^{-1}$. So the highest value exceeded the lowest one by 16.41%. The interaction between the chelated iron and chelated zinc showed the significant superiority in total yield $24.63t.ha^{-1}$ resulted from $100mgFe.l^{-1}$ plus $100mgZn.l^{-1}$ that increased over the no spray treatment, producing $18.66t.ha^{-1}$, by 31.99%. The table also referred to the significant superiority of $200mgFe.l^{-1}$ among the other nano-iron in this trait producing $24.16t.ha^{-1}$, increasing over the lowest one among them $20.54t.ha^{-1}$ gotten from $0mgFe.l^{-1}$ by 17.63% and over the value gotten from the $100mgFe.l^{-1}$ of chelated iron by 4.77%.

The nano-zinc at the concentration $100mgZn.l^{-1}$ was significantly superior to other nano-zinc concentrations in this trait and produced $24.18t.ha^{-1}$ exceeding the lowest value among them $20.18t.ha^{-1}$ come from $0mgZn.l^{-1}$ by 19.94% and exceeding the value gotten from $100mgZn.l^{-1}$ of chelated zinc by 4.26%. The treatment of the interaction between $200mgFe.l^{-1}$ of nano-iron and $50mgZn.l^{-1}$ of nano-zinc was significantly superior to the other concentrations of nano-iron and nano-zinc in the flower disc yield. It produced $25.89t.ha^{-1}$ increasing over the no spray treatment, producing the lowest value $18.42t.ha^{-1}$ by 40.55% and over the treatment of $200mgFe.l^{-1}$ of chelated iron plus $50mgZn.l^{-1}$ of chelated zinc by 5.11%.

Discussion

The increase in the values of the studied traits affected by spraying iron and zinc may due to the role of these elements in influencing the plant growth and enhancing the vegetative part for utilizing them thus reflected positively on these traits. Iron plays in participating in constructing the main plant cell constituents of plant cell such as cytochromes, phytofurthin and ferredoxins which act as an electron transport in the process of photosynthesis, which stimulates the growth and thus, contributing to the plant height and leaf area increment (Incesu *et al.*, 2015); furthermore, iron plays a role in the biological processes contributing to chlorophyll synthesis, since its amount is 29-35% of the total iron amount in green leaves (Gezgin and Erdal, 2001); moreover, the iron has a role in the chlorophyll formation through participating in coproporphyrinogen oxidase, the enzyme necessary for the sixth step of profane metabolism and for á–aminolevulinic acid, the primary substance of chlorophyll synthesis (Barker and Stratton, 2015) clarifying the necessity of iron for photosynthesis and then increasing the carbohydrate content especially when zinc is existed, as both of them help to reduce the stomata resistance and increase the stoma conductivity providing the plant with so sufficient water and carbon oxide to continue the photosynthesis and uptake of the nutrients from the soil, thus leading to an increase in the growth and the shoot system weight (Kamiab and Zamanibahramabadi, 2016). In addition, iron plays an important role in participating in several enzymes such as Cytochromoxides, Nitrogenase, Catalase, Peptidease, Proteinase and Dehydrogenase as well as contributing to the leghemoglobin synthesis, the protein that acts as oxygen carrier at the process of nitrogen fixation. iron also represents the important part in the nitrogenase that affects the nitrogen fixation in nitrogen-fixing plants and leads to increasing the production of flower primordia in addition to providing an active transformer system assisting in the transfer of nutrients from sources (leaves) to sinks, thus it increases the nutrients reaching the flowers and then increasing the flower size. The plant height increment attributes to the zinc role in the amino acid, Tryptophan, the major material participating in the synthesis of Indol Acetic Acid (IAA), that hormone is necessary for cell and stem elongation (Hosseini *et al.*, 2007). Zinc also has a role in increasing the dry matter accumulation in different plant parts. It helps to plant hormone formation; moreover, it has a role in the metabolism of the nucleic acids, RNA and DNA, and in constructing the carotenes and genetic codes (Al-Arabi, 2008). The increment in the leaf area is also attributed to zinc. It participates to the plasma membrane and other different plant cells; as well as it increases the plant ability to absorb other elements from the soil and play an essential role in protecting plant cells against oxidation. Zinc is also necessary for photosynthesis as its deficiency results in decreasing photosynthesis by 50% as a result of reducing the activity of anhydrase that consequently leads to a shortage in CO_2 uptake (Zimmer, 2006). The increment in the total yield is due to the zinc role in increasing the fertilization percentage during the flowering stage. It helps to transfer photosynthetic products to the pollen grains giving them high vitality (Al-shabibi, 2002), in addition to its role in activating more than 300 enzymes (McCall *et al.*, 2000; Esfandiari *et al.*, 2016). These results consistent with those found by Mahdi (2014). Al-dulaimi and Al-Jumaili (2017 that adding iron and zinc increase the growth and yield traits.

The superiority of nano-fertilizers over the chelated fertilizers in all studied traits is because of their nanoparticles have a huge surface area increasing the enzymes and biochemical reactions. As they go directly to their intended destination and are characterized by ease of solubility and proliferation, which leads to increased reactions and enzymatic activities and increase cellular divisions, as well as the nanoparticles reduce or inhibit the formation of Reactive oxygen species (ROS) decreasing the oxidative damage, delaying senescence, and encouraging the vegetative growth of plant (Sorooshzadeh *et al.*, 2012; Morteza *et al.*, 2013). It is also attributed to the role of nanoparticles in adjusting the gene expression leading to biological paths affecting plant growth and development, as the unique properties of nanoparticles adjust the physicochemical properties of plants affecting the plant growth differently (Aslani *et al.*, 2014).

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