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EFFECT OF SOME FERTILIZATION TREATMENTS ON GROWTH, PRODUCTIVITY AND CHEMICAL CONSTITUENTS OF ROSELLE (*HIBISCUS SABDARIFFA* L.). PLANTS

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ABSTRACT: A field experiment was conducted during 2015 and 2016 seasons at the Experimental Farm, Horticulture Dept., Fac. Agric., Benha Univ. to evaluate the effect of some fertilization treatments [10, 20 and 30 m^3 compost/fed + bio fertilizer (nitrobein + phosphorein + potassiumag)] when compared with the recommended dose of chemical fertilizer in the presence of micro-nutrients Fe + Mn + Zn foliar spraying (0.0, 50, 100 and 150 ppm) as well as their interaction between them on some growth parameters, yield and chemical constituents of roselle (*Hibiscus sabdariffa* L.) plants during 2015 and 2016 seasons.

In this respect, all applied fertilizer treatments statistically and positively affected each of plant height, number of leaves, branches and fruits/plant, fresh and dry weight of leaves, branches and sepals/plant, sepals anthocyanin and vitamin-C content, leaf N, P, K, total carbohydrates, Fe, Zn and Mn content and total indoles but they decreased the values of total phenols contents, especially T_2 treatment (the recommended dose of chemical fertilizer) or 30 m^3 compost/fed + bio fertilizer (nitrobein + phosphorein + potassiumag), with the exception of sepals acidity with none significant differences in the two seasons. Also, all concentrations of micro-nutrients Fe + Mn + Zn significantly improved all the aforementioned parameters, especially using the high rates. Additionally, the highest values of plant height, number of leaves and branches/plant, fresh and dry weight of leaves and branches/plant, number of fruits/plant, seed yield/plant (g), leaf N, P, K, total carbohydrates, Fe, Zn and Mn content, total indoles as well as the lowest values of total phenols contents were recorded by the combined treatment between T_2 recommended dose chemical fertilizer and 150ppm Fe + Mn + Zn acid in both seasons. Moreover, the combined treatment between T_5 (30 m^3) compost/fed + bio fertilizer and 150 ppm Fe + Mn + Zn gave the highest values of fresh and dry weight of sepals/plant sepals acidity, sepals anthocyanin and vitamin-C content of roselle plants as compared with control in both seasons. Furthermore, the combined treatments of T_4 (20 m^3) compost/fed + bio fertilizer and 150 ppm Fe + Mn + Zn induced high significant increments in this concern in the two seasons.

Consequently, it is preferable to treat roselle plants with the combined treatment between T_2 (recommended dose of chemical fertilizer) or T_5 (30 m^3) compost/fed + bio fertilizer (nitrobein + phosphorein + potassiumag) and Fe + Mn + Zn at 150 ppm for enhancing growth and productivity of this plants.

Key words: Roselle, chemical & organic fertilization, micro-nutrients, growth, yield, anthocyanin, chemical composition.

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INTRODUCTION

Hibiscus sabdariffa L. (Roselle) is one of the most important plants of the Malvaceae Family. The plant is indigenous to tropic Africa (Kirby, 1963). Roselle is a folk remedy for abscesses, bilious conditions, cancer, cough, debility, dyspepsia, fever. Leaves are emollient and sedative. Fruits are scorbutic. The succulent calyx boiled in water is said to be a folk remedy for cancer (Duke, 1979), flowers contain gossyperin, anthocyanin and glycol side hibiscin, which may have diuretic and choleretic effects, decreasing the viscosity of the blood, reducing blood pressure and stimulating intestinal peristalsis (Perry, 1980 and Sanyo, 1981 and Hassan, 2009). It has antimicrobial activities due to its phenolic compounds. It contains protein, fibers, calcium, iron, carotenes and vitamin C (Fasoyiro *et al.,* 2005).

Recently, unconventional efforts are used to minimize the amounts of chemical fertilizers which applied to medicinal and aromatic plants in order to reduce production cost and environmental pollution without reduction of yield. Therefore, the trend now is using the bio and organic fertilizers. Bio fertilizers can influence plant growth directly through the production of phytohormones such as gibberellins, cytokinins and IAA that act as growth regulators and indirectly through nitrogen fixation and production of bio-control agents against soil-borne phytopathogens and consequently increase formation of metabolites which encourage the plant vegetative growth and enhance the meristematic activity of tissues to produce more growth (Glick, 2003 and Ahmed and Kibret, 2014). Organic fertilizers are obtained from animal sources such as animal manure or plant sources like green manure. Continuous usage of inorganic fertilizer affects soil structure. Hence, organic manures can serve as alternative to mineral fertilizers for improving soil structure (Shahram and Ordookhani, 2011) and microbial biomass (Suresh *et al.,* 2004). The addition of organic fertilizers to agricultural soils has beneficial effects on crop development and yields by improving soil physical and biological properties (Zheljazkov and Warman, 2004). Organic and bio fertilizers in comparison to the chemical fertilizers have lower nutrient content and are slow release but they are as effective as chemical fertilizers over longer periods of use (Naguib, 2011 and Mohamed *et al.,* 2012).

Moreover, activates micro-nutrients, especially Fe, Zn and Mn which act either as metal components of various enzymes or as functional, structural, or regulatory cofactors. Thus, they are associated with saccharide metabolism, photo-synthesis and protein synthesis Marschner, (1997).

Many investigators reported the stimulating effect of applied micronutrients as foliar spray on growth and flowering of different medicinal and aromatic plants. In this respect El-Khyat (2013) on *Rosmarinus officinalis,* Amran (2013) on *Pelargonium graveolens,* Youssef (2014) on *Echinacea purpurea* and Ghatas and Mohamed (2018) illustrated that, spray *Cymbopgon citruts* plants 150 ppm Fe + Mn + Zn four times a year to enhance the growth, essential oil yield and constituents and some chemical constituents of this plant.

Therefore, the purpose of this study was to evaluate the benefits of supplementing organic in the form of compost manure and bio fertilizers in the presence of micro-nutrients Fe + Mn + Zn on growth and yield of roselle plants and to minimize consuming chemical fertilizers.

MATERIALS AND METHODS

This work was carried out at the Experimental Farm, Fac. Agric., Moshtohor Benha Univ. during 2015 and 2016 seasons to study the effect of some fertilization treatments (10, 20 and 30 m^3 compost/fed + bio fertilizer (nitrobein + phosphorein + potassiumag)) when compared with recommended dose of chemical fertilizer in presence of micro-nutrients Fe + Mn +Zn foliar spraying (0.0, 50, 100 and 150 ppm) as

well as their interaction between them on some growth parameters, yield and chemical constituents of roselle (*Hibiscus sabdariffa* L.) plants during 2015 and 2016 seasons. Roselle seeds were obtained from Floriculture Farm, Horticulture Department, Faculty of Agriculture, Benha Univ. Seeds were sown in clay loam soils on mid-April of each seasons in plots (1 × 1 m) containing two rows (50 cm width) every row had two hills (50 cm apart), and one month later, the plants were thinned, leaving only one seedling/hill.

Physical and chemical analyses of the experimental soil were determined according to Jackson (1973) and Black *et al.* (1982), respectively. The obtained results of soil analyses are presented in Table (1).

This experiment was set up in a split plot design with three replicates. The main plot was employed by five fertilization treatments i.e. T_1 (control), T_2 recommended chemical fertilization dose; 100 kg/fed ammonium nitrate (33.5% N) + 300 kg/fed calcium super phosphate (15.5% P_2O_5) + 150 kg/fed potassium sulphate (48% K_2O) according to the Egyptian Ministry of Agriculture and Land Reclamation (2002), organic fertilizer (compost (containing plant sources and cattle manure; T_3 (10 m^3) compost/fed + bio fertilizer (nitrobein + phosphorein + potassiumag), T_4 (20 m^3) compost/fed + bio fertilizer, T_5 (30 m^3) compost/fed + bio fertilizer the chemical properties of the tested compost are presented in Table (2) Whereas, the sub plot was devoted to four of micro-nutrients Fe + Mn + Zn sprays i.e., control (tap water), 50, 100 and 150 ppm. The amount of N and K fertilizers were divided into three equal portions as side dressing and added at three dates on 15 June, 15 July and 15 August, respectively of both seasons. However, the amount of P-fertilizer and compost were added to the soil before seed sowing during soil preparation. Micro-nutrients Fe + Mn + Zn treatments were applied as foliar spray at 60, 90 and 120 days after planting, respectively.

The bio-fertilizer used were nitrobein *(Azotobacter chroococcum*) for nitrogein fixation), phosphorus solublizing bacteria; e.i., (*Bacillus megatherium*) phosphorein and potassiumag (active *Bacillus sp*). Which supplied by the Department of Microbiology, Agric. Res. Center, Giza was used in this study as biological activators. The strains were characterized by a good ability to infect its specific host plant and by its high efficiency in N-fixation, phosphate and potassium solublizing.

Table 1. Mechanical properties and chemical analysis of the experimental soil in the two seasons.

Parameters	Values		Parameters	Values	
	Mechanical properties			Chemical analysis	
	(2015)	(2016)		(2015)	(2016)
Coarse sand	3.22 %	3.75 %	**Organic matter**	1.55%	1.68 %
Fine sand	15.40 %	13.95 %	**$CaCO_3$**	0.95 %	1.05 %
Silt	26.20 %	25.80 %	**Available nitrogen**	0.55 %	0.62 %
Clay	55.18%	56.50%	**Available phosphorus**	0.26 %	0.22 %
Textural class	Clay loam	Clay loam	**Available potassium**	0.34 %	0.37 %
			pH	7.62	7.67
			EC (dS/m)	0.73	0.81

Table 2. Chemical properties of the used compost.

Parameters	Ec $dS.m^{-1}$ (1:5)	pH (1:5) %	Total C %	Total N %	Total P %	Total K %	Total Fe (ppm)	Total Zn (ppm)	Total Mn (ppm)	C:N ratio
Values	2.33	6.72	21.88	1.42	0.36	1.24	1378	245	212	15:1

The seeds of roselle were washed with water, thereafter the seeds were soaked in cell suspension of the mixture of nitrobein, phosphorein and potassiumag (1 ml contains 108 viable cell) for 30 min. Gum arabic (16 %) was added as an adhesive agent prior to soaking the seeds. The inoculated seeds were air dried at room temperature for one hour before planting. Another two applications were applied (1 kg/fed) as an aqueous solution, the first one was applied just before irrigation after 60 days from planting date, whereas the second one was done after 90 days from planting date to increase the power ability of bacteria.

Recorded data:

1. Plant growth:

Plant height (cm), number, fresh and dry weight of leaves (g) number, fresh and dry weight of branches (g) were taken at the beginning of flowering stage; September 2015 and 2016.

2. Fruits yield:

Number of fruits /plant, sepals fresh and dry weights/plant, seed yield/plant, were recorded at harvesting time (November 2015 and 2016).

3. Chemical constituents:

At harvesting time anthocyanin content was determined in air-dried roselle sepals according to the method described by Du and Francis (1973). Vitamin-C was determined in sepals as discribed in A.O.A.C. (1980). Sepals acidity (pH value) was determined according to Diab (1968). The percentage of N, P, K and total carbohydrates % were determined in the dry leaves during flowering stage, by Horneck and Miller (1998), Hucker and Catroux (1980), Horneck and Hanson (1998) and Herbert *et al.* (1971), respectively. Where total indoles and total phenols were determined in roselle fresh leaves according to A.O.A.C (1990). In addition, micronutrients Fe, Zn, and Mn (%) were determined in the digested samples by atomic absorption as described by Chapman and Paratt (1961).

Statistical analysis:

All data obtained in both seasons of study were subjected to analysis of variance as factorial experiments in split plot design. L.S.D. method was used to differentiate means according to Snedecor and Cochran (1989).

RESULTS AND DISCUSSION

Vegetative growth parameters:

1. Plant height (cm) and No. of leaves/plant:

Data presented in Table (3) indicate that, all studied fertilization treatments succeeded in increasing plant height and No. of leaves/plant of roselle (*Hibiscus sabdariffa* L.) plants in both seasons. However, the tallest plant and the highest No. of leaves/plant were achieved by T_2 (R.D. chemical NPK) followed by T_5 (30 m^3 compost/fed + bio) in the first and second seasons.

As for micro-nutrients treatments, data in the same Table indicate that there was appositive relationship between the values of these parameters and micro-nutrients concentration, hence as the concentration of micro-nutrients increased the values of plant height and No. of leaves/plant increased till reach to the highest increases at the highest concentration (150 ppm) in the two seasons.

Regarding the interaction effect between fertilization and micro-nutrients treatments data in Table (3) show that all resulted combinations increased the plant height and No. of leaves/plant of roselle plants with significant differences in most cases as compared with control plants in the two seasons of this study. However, the combination of T_2 (R.D. chemical NPK) showed to be the most effective ones for inducing the highest values of plant height and No. of leaves/plant especially those sprayed with micro-nutrients the highest concentration (150 ppm) as it scored (186.2

Table 3. Effect of some fertilization treatments on plant height and No. of leaves/plant of *Hibiscus sabdariffa* L plants during 2015 and 2016 seasons.

Micronutrients / Fertilization	Plant height/(cm)					No. of leaves/plant				
	0.0	50.0	100.0	150.0	Mean	0.0	50.0	100.0	150.0	Mean
				1st season						
T_1(Control)	142.3	146.2	151.3	156.2	149.0	112.3	118.4	121.9	128.3	120.2
T_2 (R.D. chemical NPK)	169.3	172.4	178.9	186.2	176.7	142.8	144.0	151.4	156.4	148.7
T_3 (10 m^3 compost/fed+bio)	146.5	149.3	156.2	159.7	152.9	121.9	126.3	128.3	132.0	127.1
T_4 (20 m^3 compost/fed+bio)	159.1	163.4	169.3	172.4	166.1	132.6	134.9	138.0	141.6	136.8
T_5 (30 m^3 compost/fed+bio)	164.9	169.8	178.2	182.4	173.8	138.7	141.2	146.1	149.8	144.0
Mean	156.4	160.2	166.8	171.4		129.7	133.0	137.1	141.6	
L.S.D at 0.05 for		Fertilization = 9.23 Micronutrients = 8.24 Interaction = 18.46					Fertilization = 6.85 Micronutrients = 6.12 Interaction = 13.71			
				2nd season						
T_1(Control)	151.6	154.1	159.8	164.7	157.6	123.4	128.1	131.2	134.2	129.2
T_2 (R.D. chemical NPK)	184.3	191.0	197.6	199.4	193.1	169.8	173.6	176.2	179.3	174.7
T_3 (10 m^3 compost/fed+bio)	163.4	169.2	173.8	179.3	171.4	149.3	152.6	154.6	156.3	153.2
T_4 (20 m^3 compost/fed+bio)	171.2	178.2	184.0	188.4	180.5	161.2	164.3	169.0	171.9	166.6
T_5 (30 m^3 compost/fed+bio)	176.4	181.5	189.3	194.6	185.5	164.6	169.8	171.2	173.6	170.1
Mean	169.4	174.8	180.9	185.3		153.7	157.7	160.6	163.1	
L.S.D at 0.05 for		Fertilization = 11.20 Micronutrients = 9.33 Interaction = 22.40					Fertilization = 6.53 Micronutrients = 5.83 Interaction = 13.10			

and 199.4 cm) and (156.4 and 179.3 cm) in the first and second seasons,respectively. Moreover, the combination of T_5 (30 m^3 compost/fed + bio) resulted in high increments in this concern particularly those received micro-nutrients at 150 ppm in both seasons. Irrespective control, the lowest values of this parameter were gained by T_3 (10 m^3 compost/fed + bio) combination, especially those received no micro-nutrients sprays in the two seasons. The remained treatments occupied an intermediate position between the abovementioned treatments in the two seasons.

2. Leaves fresh and dry weights/plant (g):

Data in Table (4) reveals that fresh and dry weights of leaves per plant were positively affected by all fertilization and micro-nutrients treatments in both seasons. However, the heaviest fresh and dry weights of leaves per plant of roselle plants were recorded by T_2 (R.D. chemical NPK) followed by T_5 (30 m^3 compost/fed + bio) in the first and second seasons.

Moreover, all treatments of micro-nutrients statistically increased the fresh and dry weights of leaves per plant, especially the highest concentration (150 ppm) in both seasons.

As for the interaction effect between fertilization and micro-nutrients treatments, it was observed that, the heaviest fresh and dry weights of leaves per plant in the first and second seasons were recorded by the combined treatment between T_2 (R.D. chemical NPK) with micro-nutrients at 150ppm, in both seasons. Furthermore, the combination of T_2 (R.D. chemical NPK) with micro-nutrients at 100ppm or T_5 (30 m^3 compost/fed + bio) with micro-nutrients at 150 ppm ranked the second and third values of these parameters in this concern in the first and second seasons, respectively. Regardless control, the lowest values of these parameters were gained by combination treatment between T_3 (10 m^3 compost/fed + bio) with 0.0 ppm micro-nutrients sprays in the two seasons.

3. No. of branches/plant, branches fresh and dry weights/plant (g):

Data in Table (5) illustrated that No. of branches per plant, fresh and dry weights of branches per plant were positively affected by all fertilization in both seasons. However, the highest values of these parameters of roselle plants were recorded by T_2 (R.D. chemical NPK) followed by T_5 (30 m^3 compost/fed + bio) in the first and second seasons. On the other side, the lowest values of these parameters were scored by control plants in both seasons.

Moreover, all treatments of micro-nutrients statistically increased No. of branches per plant, fresh and dry weights of branches per plant, especially the highest concentration (150 ppm) in both seasons.

As for the interaction effect between fertilization and micro-nutrients treatments data in Table (5) reveals that, the highest values of these parameters were recorded by the combined treatment between T_2 (R.D. chemical NPK) with micro-nutrients at 150 ppm, followed descendingly by the combined treatment between T_5 (30 m^3 compost/fed + bio) with micro-nutrients at 150ppm in both seasons.

The aforementioned results of tested fertilization treatment are in agreement with those obtained by Abou El-Ghait *et al.* (2012) on Indian fennel, El-Gendy *et al.* (2012) on roselle plants, Mohamed *et al.* (2012) on *Stevia rebaudiana*, Amran (2013) on *Pelargonium graveolens*, El-Khyat (2013) on *Rosmarinus officinalis*, El-Gendy *et al.* (2013) on guar plants, Sakr *et al.* (2014) on roselle plants, Youssef (2014) on roselle plants and Ghatas and Abdallah (2016) illustrated that, fertilize *Echinacea purpurea* plants with 75% chemical fertilizer (NPK) + 10 ton compost/fed + bio fertilizer (nitrobein + phosphorein) in combination with some micro-nutrients (Zn or B each at 100 ppm) as foliar spray to enhance the vegetative growth of plant. Whereas, the abovementioned results of micro-nutrients are nearly similar to those obtained by

Table 4. Effect of some fertilization treatments on leaves fresh and dry weight/plant (g)of *Hibiscus sabdariffa* L plants during 2015 and 2016 seasons.

Micronutrients / Fertilization	Leaves fresh weight/plant (g)					Leaves dry weight/ plant (g)				
	0.0	50.0	100.0	150.0	Mean	0.0	50.0	100.0	150.0	Mean
				1st season						
T_1(Control)	169.1	179.3	192.8	204.8	186.5	20.28	21.48	23.04	24.48	22.32
T_2 (R.D. chemical NPK)	221.6	231.2	248.6	258.9	240.1	26.52	27.72	29.76	30.96	28.74
T_3 (10 m^3 compost/fed+bio)	185.3	195.3	202.2	219.1	200.5	22.20	23.40	26.24	26.28	24.53
T_4 (20 m^3 compost/fed+bio)	203.3	207.7	220.8	234.0	216.5	24.36	24.84	26.40	28.08	25.92
T_5 (30 m^3 compost/fed+bio)	213.9	218.8	233.6	247.3	228.4	25.56	26.16	27.96	29.64	27.33
Mean	198.6	206.5	219.6	232.8		23.78	24.72	26.68	27.89	
L.S.D at 0.05 for		Fertilization = 19.4 Micronutrients = 17.3 Interaction = 38.8					Fertilization = 2.37 Micronutrients = 2.12 Interaction = 4.75			
				2nd season						
T_1 (Control)	215.3	226.2	241.0	247.9	232.6	22.16	24.12	26.51	27.17	24.99
T_2 (R.D. chemical NPK)	321.1	332.2	344.9	351.8	337.5	35.31	36.52	37.84	38.61	37.07
T_3 (10 m^3 compost/fed+bio)	214.2	281.2	292.6	299.5	271.9	23.54	30.91	32.12	32.89	29.87
T_4 (20 m^3 compost/fed+bio)	296.2	303.4	326.1	331.8	314.4	32.56	33.33	35.86	36.41	34.54
T_5 (30 m^3 compost/fed+bio)	308.3	320.4	333.7	339.1	325.4	33.96	35.20	36.63	37.29	35.77
Mean	228.2	292.7	307.7	314.0		29.51	32.02	33.79	34.47	
L.S.D at 0.05 for		Fertilization = 43.6 Micronutrients = 38.9 Interaction = 87.1					Fertilization = 2.69 Micronutrients = 2.40 Interaction = 5.38			

Table 5. Effect of some fertilization treatments on No. of branches/plant, branches fresh and dry weight /plant (g) of *Hibiscus sabdariffa* L plants during 2015 and 2016 seasons.

Micronutrients / Fertilization	No. of branches/plant					Branches fresh weight /plant (g)					Branches dry weight /plant (g)				
	0.0	50.0	100.0	150.0	Mean	0.0	50.0	100.0	150.0	Mean	0.0	50.0	100.0	150.0	Mean
1st season															
T_1(Control)	16.24	17.82	18.36	19.28	17.93	882	952	1026	1102	990.5	158.7	171.3	184.6	198.3	178.2
T_2 (R.D. chemical NPK)	24.62	25.91	27.001	28.32	26.47	1321	1456	1539	1624	1485	237.7	262.1	277.6	292.3	267.4
T_3 (10 m^3 compost/fed+bio)	18.37	19.20	21.24	22.64	20.36	991	1064	1197	1276	1132	178.4	191.3	215.6	229.5	203.7
T_4 (20 m^3 compost/fed+bio)	21.46	23.11	24.62	25.80	23.75	1156	1288	1368	1624	1359	208.1	231.4	246.2	292.3	244.5
T_5 (30 m^3 compost/fed+bio)	23.14	23.92	26.14	27.61	25.20	1268	1344	1482	1566	1415	228.3	241.8	266.8	281.6	254.6
Mean	20.77	21.99	23.47	24.73		1124	1221	1322	1438		202.2	219.8	238.2	258.8	
L.S.D at 0.05 for		Fertilization = 1.39 Micronutrients = 1.24 Interaction = 2.78					Fertilization = 92.6 Micronutrients = 82.7 Interaction =185.2					Fertilization =16.0 Micronutrients =14.3 Interaction = 32.0			
2nd season															
T_1(Control)	19.84	20.27	21.83	22.26	21.05	1064	1140	1261	1320	1196	202.3	216.4	239.2	251.0	227.2
T_2 (R.D. chemical NPK)	26.27	28.42	29.14	30.21	28.51	1456	1596	1711	1808	1641	276.3	303.2	325.4	342.7	311.9
T_3 (10 m^3 compost/fed+bio)	21.04	21.92	23.43	25.13	22.88	1176	1360	1357	1507	1350	223.7	258.1	257.6	286.3	256.4
T_4 (20 m^3 compost/fed+bio)	24.31	25.60	25.36	27.30	25.64	1344	1428	1475	1628	1469	255.9	271.0	281.2	309.2	279.3
T_5 (30 m^3 compost/fed+bio)	25.31	27.11	28.40	29.48	27.58	1408	1539	1652	1748	1587	267.4	292.4	313.4	332.4	301.4
Mean	23.35	24.66	25.63	26.88		1290	1413	1491	1601		245.2	268.2	283.4	304.3	
L.S.D at 0.05 for		Fertilization= 1.69 Micronutrients =1.51 Interaction=3.38					Fertilization=115.6 Micronutrients =96.3 Interaction=231.1					Fertilization=20.0 Micronutrients =17.9 Interaction=40.0			

Gomaa (2008) on *Hibiscus sabdariffa*, Youssef (2009) on rosemary plant, Amran (2013) on *Pelargonium graveolens*, El-Khyat (2013) on *Rosmarinus officinalis*, Youssef (2014) on *Echinacea purpurea*, and Ghatas and Mohamed (2018) demonstrated that, spray *Cymbopgon citruts* plants with 150 ppm Fe + Mn + Zn four times a year to enhance the vegetative growth of this plant.

Yield parameters:

1. No. of fruits/plant and seed yield/plant (g):

Data in Table (6) reveal that the highest No. of fruits/plant and seed yield/plant (g) were scored by T_2 (R.D. chemical NPK) treatment, followed by T_5 (30 m^3 compost/fed + bio) treatment in the first and second seasons.

Also, No. of fruits/plant and seed yield/plant (g) were greatly affected by spraying roselle plants with micro-nutrients treatments, particularly the highest concentration (150 ppm) as compared with unsprayed plants in the two seasons.

As for the interaction effect between fertilization and micro-nutrients treatments, data in Table (6) show that all resulted combinations increased these parameters in the two seasons. However, the highest No. of fruits/plant was recorded by the combined treatments between T_5 (30-ton compost/fed + bio) with micro-nutrients at 150 ppm as it scored (71.3 and 78.1) followed descendingly by T_2 (R.D. chemical NPK) with micro-nutrients at 150ppm as it scored (71.2 and 77.6) in the first and second seasons, respectively. whereas, the highest seed yield/plant was obtained by T_2 treatment combined with micro-nutrients at 150 ppm as it scored (54.66 and 56.70), followed by the combined treatment between T_5 and micro-nutrients at 150 ppm as it scored (54.20 and 56.12) in the first and second seasons, respectively. The differences between the abovementioned two combined treatments were not-significance in both seasons. The lowest values of this parameter were gained by combination treatment between T_1 (control) with 0.0 ppm micro-nutrients sprays in the two seasons.

2. Fresh and dry weights of sepals/plant:

It is clear from data in Table (7) that the heaviest fresh and dry weights of sepals/plant of roselle (*Hibiscus sabdariffa* L.) plants were recorded by T_5 (30 m^3 compost/fed + bio) followed descendingly by T_4 (20-ton compost/fed) in both seasons.

In addition, using the treatment T_2 (R.D. chemical NPK) ranked the third values of these parameters in the two seasons Remarkably, all concentrations of micro-nutrients resulted in significant increments in these parameters, especially those received the highest concentration (150 ppm) as compared with un-treated plants in the two seasons. Generally, all resulted interactions between fertilization and micro-nutrients treatments statistically affected the fresh and dry weights of sepals/plant in both seasons.

However, the heaviest fresh and dry weights of sepals/plant were gained by using the combined treatments between T_5 (30 m^3 compost/fed + bio) with micro-nutrients at 150 ppm followed descendingly by T_4 (20-ton compost/fed) with micro-nutrients at 150 ppm in both seasons. Moreover, the combination of T_2 (R.D. chemical NPK) resulted in high increments in this concern especially those received the highest concentration of micro-nutrients at 150 ppm in the two seasons.

These results are in close agreement with those reported by Sakr *et al.* (2014) on roselle plants and Youssef (2014) on roselle plant.

Chemical constituents:

1. Anthocyanin content:

Data in Table (8) show that the highest anthocyanin content of roselle (*Hibiscus sabdariffa* L.) plants (172.7 and 160.1 mg/100 g d.w.) was accumulated in sepals as a result of using T_5 (30 m^3 compost/fed + bio) treatment, followed descendingly by T_2 (R.D. chemical NPK) as it recorded (169.6 and 158.3 mg/100 g d.w.) in the first and

Table 6. Effect of some fertilization treatments on No. of fruits/plant and seed yield/plant (g) of *Hibiscus sabdariffa* L plants during 2015 and 2016 seasons.

Micronutrients / Fertilization	No. of fruits/plant					Seed yield/plant (g)				
	0.0	50.0	100.0	150.0	Mean	0.0	50.0	100.0	150.0	Mean
				1st season						
T_1(Control)	48.3	52.7	54.2	56.1	52.8	34.33	36.80	38.44	42.33	37.98
T_2 (R.D. chemical NPK)	61.2	63.9	67.3	71.2	65.9	42.51	46.44	51.44	54.66	48.76
T_3 (10 m^3 compost/fed+bio)	51.7	59.3	61.2	64.1	59.1	38.48	41.38	45.49	47.66	43.25
T_4 (20 m^3 compost/fed+bio)	56.2	62.4	63.8	68.2	62.7	40.88	43.11	47.88	50.22	45.52
T_5 (30 m^3 compost/fed+bio)	59.4	64.2	68.1	71.3	65.8	41.42	45.77	50.22	54.20	47.90
Mean	55.4	60.5	62.9	66.2		39.52	42.70	46.69	49.81	
L.S.D at 0.05 for		Fertilization = 4.28 Micronutrients = 3.82 Interaction = 8.56					Fertilization = 4.63 Micronutrients = 4.14 Interaction = 9.27			
				2nd season						
T_1 (Control)	56.2	58.2	59.8	61.0	58.8	37.66	39.68	42.33	43.98	40.91
T_2 (R.D. chemical NPK)	72.8	76.1	77.4	77.6	76.0	44.63	48.70	53.68	56.70	50.94
T_3 (10 m^3 compost/fed+bio)	59.3	62.4	61.9	64.0	61.9	39.78	42.68	47.66	49.78	44.98
T_4 (20 m^3 compost/fed+bio)	68.2	69.3	71.3	73.2	70.5	43.42	45.66	50.65	53.44	48.21
T_5 (30 m^3 compost/fed+bio)	73.2	75.2	76.8	78.1	75.8	45.77	47.70	54.60	56.12	51.00
Mean	65.9	68.2	69.4	70.8		42.25	44.88	49.78	52.00	
L.S.D at 0.05 for		Fertilization = 3.55 Micronutrients = 3.17 Interaction = 7.10					Fertilization = 3.59 Micronutrients = 3.21 Interaction = 7.19			

Table 7. Effect of some fertilization treatments on Sepals fresh and dry weight/plant (g) of *Hibiscus sabdariffa* L plants during 2015 and 2016 seasons.

Micronutrients / Fertilization	Sepals fresh weight/plant (g)					Sepals dry weight/plant (g)				
	0.0	**50.0**	**100.0**	**150.0**	**Mean**	**0.0**	**50.0**	**100.0**	**150.0**	**Mean**
				1st season						
T_1(Control)	115.2	124.8	129.6	134.4	126.0	20.73	22.32	23.22	24.12	22.60
T_2 (R.D. chemical NPK)	146.4	151.2	154.2	170.4	155.6	26.28	27.18	27.18	30.61	27.81
T_3 (10 m^3 compost/fed+bio)	127.5	147.5	152.5	160.1	146.9	22.86	26.46	26.47	28.82	26.15
T_4 (20 m^3 compost/fed+bio)	145.6	161.2	163.3	176.8	161.7	26.10	28.98	29.34	31.68	29.03
T_5 (30 m^3 compost/fed+bio)	159.3	172.8	182.8	191.7	176.7	28.62	30.96	32.76	34.38	31.68
Mean	138.8	151.5	156.5	166.7		24.92	27.18	27.79	29.92	
L.S.D at 0.05 for		Fertilization = 12.64 Micronutrients = 11.29 Interaction = 25.29					Fertilization = 2.40 Micronutrients = 2.14 Interaction = 4.80			
				2nd season						
T_1 (Control)	128.8	133.4	135.7	140.3	134.6	24.32	25.27	25.65	26.60	25.46
T_2 (R.D. chemical NPK)	165.6	174.8	177.1	177.1	173.7	31.35	33.06	33.63	33.63	32.92
T_3 (10 m^3 compost/fed+bio)	141.6	148.8	146.4	153.6	147.6	26.79	28.12	27.74	29.07	27.93
T_4 (20 m^3 compost/fed+bio)	170.0	165.6	177.5	182.8	174.0	32.30	31.35	33.63	34.58	32.97
T_5 (30 m^3 compost/fed+bio)	189.8	195.0	197.6	202.8	196.3	35.91	37.05	37.43	38.38	37.19
Mean	159.2	163.5	166.9	171.3		30.13	30.97	31.62	32.45	
L.S.D at 0.05 for		Fertilization = 13.63 Micronutrients = 12.17 Interaction = 27.26					Fertilization = 2.28 Micronutrients = 2.04 Interaction = 4.57			

Table 8. Effect of some fertilization treatments on sepals acidity (pH value), vitamin-C (mg/100 g DW) and anthocyanin (mg/100 g DW) of *Hibiscus sabdariffa* L plants during 2015 and 2016 seasons.

Micronutrients / Fertilization	Sepals acidity (pH value)					Vitamin-C (mg/100 g DW)					Anthocyanin (mg/100 g DW)				
	0.0	**50.0**	**100.0**	**150.0**	**Mean**	**0.0**	**50.0**	**100.0**	**150.0**	**Mean**	**0.0**	**50.0**	**100.0**	**150.0**	**Mean**
1st season															
T_1(Control)	2.01	2.06	2.05	2.11	2.06	41.12	41.82	42.16	42.72	41.96	154.1	154.8	158.3	161.0	157.1
T_2 (R.D. chemical NPK)	2.12	2.15	2.18	2.18	2.16	44.10	44.83	47.01	48.79	46.18	164.8	169.4	170.4	173.8	169.6
T_3 (10 m^3 compost/fed+bio)	2.13	2.14	2.17	2.20	2.15	41.93	43.21	45.21	46.71	44.27	159.3	161.2	164.3	164.2	162.3
T_4 (20 m^3 compost/fed+bio)	2.09	2.16	2.16	2.19	2.15	43.21	43.16	46.37	47.81	45.14	163.8	167.3	164.1	168.0	165.1
T_5 (30 m^3 compost/fed+bio)	2.14	2.17	2.19	2.21	2.18	44.82	45.62	48.21	49.70	47.09	169.2	172.4	174.2	175.1	172.7
Mean	2.10	2.12	2.15	2.18		43.04	43.73	45.79	47.15		162.2	165.0	166.3	168.4	
L.S.D at 0.05 for		Fertilization = N.S. Micronutrients = N.S. Interaction = N.S.					Fertilization = 2.54 Micronutrients = 2.27 Interaction = 5.08					Fertilization = 5.73 Micronutrients = 5.12 Interaction = 11.47			
2nd season															
T_1(Control)	2.08	2.11	2.14	2.13	2.12	38.41	38.92	39.21	39.94	38.37	148.3	149.6	151.0	152.4	150.3
T_2 (R.D. chemical NPK)	2.18	2.20	2.22	2.21	2.20	43.21	44.29	44.92	45.70	44.53	151.0	158.3	161.2	162.8	158.3
T_3 (10 m^3 compost/fed+bio)	2.17	2.19	2.19	2.21	2.19	42.69	43.12	44.01	45.21	43.76	150.2	151.3	153.6	156.8	153.0
T_4 (20 m^3 compost/fed+bio)	2.19	2.18	2.21	2.24	2.21	42.27	43.94	44.82	45.63	44.17	149.8	156.2	159.8	161.9	156.9
T_5 (30 m^3 compost/fed+bio)	2.18	2.21	2.23	2.25	2.22	44.36	44.81	45.86	46.22	45.31	152.1	159.6	163.2	165.4	160.1
Mean	2.16	2.18	2.20	2.21		42.19	43.02	43.76	44.54		150.3	155.0	157.8	160.0	
L.S.D at 0.05 for		Fertilization = N.S. Micronutrients = N.S. Interaction = N.S.					Fertilization = 1.55 Micronutrients = 1.38 Interaction = 3.09					Fertilization = 7.10 Micronutrients = 6.34 Interaction = 14.20			

second seasons, respectively with non-significant differences between them.

Additionally, all concentration of micro-nutrients succeeded in increasing anthocyanin content of roselle sepals, especially highest concentration (150 ppm) in both seasons.

Generally, T_5 (30 m^3 compost/fed + bio) treatment combined with micro-nutrients at 150 ppm gave the highest values in this concern (175.1 and 165.4 mg/100g d.w.) in the first and second seasons, respectively), followed by the combined treatment between T_5 (30 m^3 compost/fed + bio) treatment and micro-nutrients at 100 ppm (174.2 and 163.2 mg/100g d.w., in the first and second seasons, respectively). Also, the combined treatment between T_2 (R.D. chemical NPK) with micro-nutrients at 150 ppm ranked the third values in this concern as it resulted (173.8 and 162.8 mg/100 g d.w., in the first and second seasons, respectively). On the reverse, the lowest values of this parameter were recorded by combination treatment between T_1 (control) with 0.0 ppm micro-nutrients sprays as it recorded (154.1 and 148.3 mg /100g d.w.) in the first and second seasons, respectively.

2. Vitamin C:

Data in Table (8) indicate that the highest content of vitamin C (47.09 and 45.31 mg /100 g d.w.) was recorded by T_5 (30 m^3compost/fed + bio), followed by T_2 (R.D. chemical NPK) (46.18 and 44.53 mg/100 g d.w.) and T_4 (20 m^3compost/fed) treatments (45.14 and 44.17 mg /100 g d.w.) in the first and second seasons, respectively.

Moreover, all concentration of micro-nutrients resulted increments of this parameter especially the highest concentration (150 ppm) as compared with untreated plants in both seasons.

Generally, T_5 (30-ton compost/fed + bio) treatment combined with micro-nutrients at 150 ppm showed to be the most effective one for inducing the highest sepals vitamin-C content (49.70 and 46.22 mg /100 g d.w., in the first and second seasons, respectively). Also, the treatment of T_2 (R.D. chemical NPK) combined with micro-nutrients at 150 ppm or the combination treatment between T_5 (30 m^3 compost/fed + bio) with micro-nutrients at 100 ppm resulted highly increases of this parameter as compared with control in the two seasons.

3. Sepals acidity (pH value):

Data in Table (8) illustrated that all tested fertilization and micro-nutrients treatments as well as their interactions resulted in negligible effects in this parameter with non-significant difference in both seasons. In general, the highest pH value (2.21 and 2.25) was recorded by T_5 (30 m^3compost/fed + bio) treatment combined with micro-nutrients at 150 ppm in the first and second seasons, respectively. On the reverse, the lowest values of this parameter were recorded by combination treatment between T_1 (control) with 0.0 ppm micro-nutrients sprays as it recorded (2.01 and 2.08) in the first and second seasons, respectively. The remained treatments occupied an intermediate position between the abovementioned treatments in the two seasons.

4. Leaf N, P and K content:

Data presented in Tables (9 and 10) declare that the highest values of leaf N, P and K content of roselle plants were recorded by T_2 (R.D. chemical NPK), followed by T5(30 m^3compost/fed + bio)in the first and second seasons. On the reverse, the lowest values of this parameter were scored by T_1 (control) treatment in the two seasons. Also, all micro-nutrients concentration sprays increased leaf N, P and K, especially the highest concentration of micro-nutrients (150 ppm) in both seasons. As for the interaction effect between fertilization and micro-nutrients treatments, data in Tables (9 and 10) reveal that the greatest leaf N, P and K of roselle plants were obtained by the combined treatment between T_2 (R.D. chemical NPK) and micro-nutrients at 150 ppm, followed by T_5 treatment combined with micro-nutrients at 150 ppm of both seasons in most cases.

Table 9. Effect of some fertilization treatments on N % and P % of *Hibiscus sabdariffa* L plants during 2015 and 2016 seasons.

Micronutrients / Fertilization	N %					P %				
	0.0	**50.0**	**100.0**	**150.0**	**Mean**	**0.0**	**50.0**	**100.0**	**150.0**	**Mean**
					1st season					
T_1(Control)	2.29	2.32	2.31	2.34	2.32	0.137	0.139	0.141	0.143	0.140
T_2 (R.D. chemical NPK)	2.53	2.57	2.58	2.62	2.96	0.152	0.159	0.163	0.167	0.160
T_3 (10 m^3 compost/fed+bio)	2.31	2.36	2.37	2.39	2.36	0.148	0.147	0.149	0.154	0.150
T_4 (20 m^3 compost/fed+bio)	2.42	2.34	2.39	2.41	2.39	0.146	0.151	0.156	0.152	0.151
T_5 (30 m^3 compost/fed+bio)	2.47	2.49	2.51	2.53	2.50	0.149	0.154	0.159	0.159	0.155
Mean	2.40	2.42	2.43	2.46		0.146	0.150	0.154	0.155	
L.S.D at 0.05 for		Fertilization = 0.13 Micronutrients = N.S. Interaction = 0.26					Fertilization = 0.013 Micronutrients = 0.012 Interaction = 0.027			
					2nd season					
T_1 (Control)	2.34	2.37	2.39	2.41	2.38	0.142	0.148	0.147	0.151	0.147
T_2 (R.D. chemical NPK)	2.59	2.58	2.61	2.63	2.60	0.161	0.169	0.173	0.179	0.171
T_3 (10 m^3 compost/fed+bio)	2.42	2.46	2.48	2.49	2.46	0.149	0.153	0.156	0.164	0.156
T_4 (20 m^3 compost/fed+bio)	2.51	2.47	2.51	2.52	2.50	0.157	0.151	0.163	0.171	0.161
T_5 (30 m^3 compost/fed+bio)	2.54	2.56	2.57	2.59	2.57	0.162	0.167	0.169	0.174	0.168
Mean	2.48	2.49	2.51	2.53		0.154	0.158	0.162	0.168	
L.S.D at 0.05 for		Fertilization = 0.14 Micronutrients = N.S. Interaction = 0.28					Fertilization = 0.012 Micronutrients = 0.011 Interaction = 0.025			

Table 10. Effect of some fertilization treatments on K % and total carbohydrates % of *Hibiscus sabdariffa* L plants during 2015 and 2016 seasons.

Micronutrients / Fertilization	K %					Total carbohydrates %				
	0.0	50.0	100.0	150.0	Mean	0.0	50.0	100.0	150.0	Mean
				1st season						
T_1(Control)	1.39	1.41	1.46	1.50	1.39	12.64	12.84	13.02	13.17	12.92
T_2 (R.D. chemical NPK)	1.54	1.58	1.69	1.76	1.64	15.93	16.17	16.28	16.39	16.19
T_3 (10 m^3 compost/fed+bio)	1.46	1.47	1.59	1.62	1.54	13.72	13.94	13.93	14.21	13.95
T_4 (20 m^3 compost/fed+bio)	1.52	1.56	1.62	1.69	1.60	14.91	15.17	15.27	15.36	15.18
T_5 (30 m^3 compost/fed+bio)	1.51	1.59	1.67	1.74	1.63	15.82	16.21	16.29	16.42	16.19
Mean	1.48	1.52	1.49	1.66		14.60	14.87	15.00	15.11	
L.S.D at 0.05 for		Fertilization = 0.16 Micronutrients = 0.14 Interaction = 0.31					Fertilization = 0.36 Micronutrients = 0.32 Interaction=0.72			
				2nd season						
T_1 (Control)	1.45	1.49	1.47	1.54	1.49	13.72	13.94	14.21	14.82	14.17
T_2 (R.D. chemical NPK)	1.71	1.76	1.76	1.80	1.76	16.02	16.94	17.03	17.38	16.84
T_3 (10 m^3 compost/fed+bio)	1.53	1.56	1.64	1.69	1.53	14.34	14.62	14.91	15.02	14.72
T_4 (20 m^3 compost/fed+bio)	1.64	1.62	1.62	1.78	1.67	15.21	15.72	15.97	16.13	15.40
T_5 (30 m^3 compost/fed+bio)	1.69	1.73	1.74	1.79	1.73	16.11	16.92	17.12	17.43	16.90
Mean	1.60	1.63	1.65	1.72		15.08	15.63	15.85	16.16	
L.S.D at 0.05 for		Fertilization = 0.12 Micronutrients = 0.10 Interaction = 0.24					Fertilization = 0.46 Micronutrients = 0.41 Interaction = 0.92			

5. Leaf total carbohydrates contents:

Data in Table (10) clear that there were significant differences in leaf total carbohydrates content as response to the studied fertilization treatments when compared with control in both seasons. Meanwhile, the highest values of this parameter were scored by T_5 (30 m^3 compost/fed + bio), followed by T_2 (R.D. chemical NPK) in both seasons. The differences between the abovementioned two treatments were not-significance in both seasons.

With respect for the effect of micro-nutrients treatments, data in Table (10) show that all concentration of micro-nutrients (50, 100 and 150 ppm) resulted in significant increments in this parameter, with superiority for the highest concentration in both seasons.

As for the interaction effect between fertilization treatments and micro-nutrients treatments, data in Table (10) reveal that the highest values of total carbohydrates content (16.42 and 17.43 %) of roselle leaves were recorded by T_5 treatment combined micro-nutrients at 150 ppm, followed by the combined treatment between T_2 treatment combined micro-nutrients at 150 ppm(16.39 and 17.38 %), ,in the first and second seasons, respectively.

6. Leaf total indoles contents:

Data in Table (11) show that, all fertilization treatments resulted in an increment of total indoles in leaves of roselle plants when compared with control in both seasons. However, the highest values total indoles were registered by T_2 treatment followed by T_5 in the two seasons. The differences between the abovementioned two treatments were non-significance in both seasons. Besides, all concentration of micro-nutrients treatments scored an increment in this parameter, with superiority for the highest concentration in both seasons. Furthermore, the highest values of total indoles content (284 and 287 mg/100 g f.w.) of roselle leaves were recorded by T_2 treatment combined with micro-nutrients at 150 ppm, followed by the combined treatment between T_5 treatment combined with micro-nutrients at 150 ppm (279 and 284 mg/100 g f.w.) in the first and second seasons, respectively. On the contrast, the lowest values of this parameter were gained by T_1 (control.) combination, especially those received no micro-nutrients sprays in the two seasons.

7. Leaf total phenols contents:

Data in Table (11) illustrated that, all fertilization treatments decreased total phenols content in leaves of roselle plants when compared with control, especially T_2 (R.D. chemical NPK) as it scored (160 and 147 mg/100 g f.w.) followed ascendingly by T_5 (30 m^3compost/fed + bio) as it scored (162 and 149 mg/100 g f.w.) in both seasons. Moreover, all concentration of micro-nutrients treatments decreased this parameter, especially the highest concentration (150 ppm) sprayed plants in both seasons.

As for the interaction effect between fertilization treatments and micro-nutrients treatments, data in Table (11) reveal that, the lowest values of total phenols content (149 and 131 mg/100 g f.w.) of roselle leaves were recorded by T_2 treatment combined with micro-nutrients at 150 ppm, followed ascendingly by the combined treatment between T_5 treatment and micro-nutrients at 150 ppm (151 and 134 mg/100 g f.w.) in the first and second seasons, respectively. On the contrast, the highest values of this parameter were resulted by T_1 (control) combined with no micro-nutrients sprays (181 and 178 mg/100 g f.w.) in the first and second seasons, respectively. The remained treatments occupied an intermediate position between the abovementioned treatments in the two seasons.

8. Leaf Fe, Zn and Mn content:

Data in Table (12) reveal that the highest leaf Fe, Zn and Mn content of roselle plants were obtained by T_2 (R.D. chemical NPK), followed by T_5 (30 m^3compost/fed+ bio) in

Table 11. Effect of some fertilization treatments on total indoles (mg/100 g FW) and total phenols (mg/100 g FW) of *Hibiscus sabdariffa* L plants during 2015 and 2016 seasons.

Micronutrients / Fertilization	Total indoles (mg/100 g FW)					Total phenols (mg/100 g FW)				
	0.0	50.0	100.0	150.0	Mean	0.0	50.0	100.0	150.0	Mean
				1st season						
T_1(Control)	239	242	249	254	246	181	173	174	169	174
T_2 (R.D. chemical NPK)	253	269	273	284	270	169	164	159	149	160
T_3 (10 m^3 compost/fed+bio)	243	248	259	264	254	178	171	168	162	170
T_4 (20 m^3 compost/fed+bio)	241	256	258	273	257	171	168	169	153	165
T_5 (30 m^3 compost/fed+bio)	251	267	269	279	267	173	163	161	151	162
Mean	245	256	262	271		174	168	166	157	
L.S.D at 0.05 for		Fertilization = 13.89 Micronutrients = 12.4 Interaction = 27.80					Fertilization = 7.62 Micronutrients = 6.80 Interaction = 15.23			
				2nd season						
T_1 (Control)	245	251	258	261	254	178	170	167	161	169
T_2 (R.D. chemical NPK)	263	271	273	287	274	162	158	136	131	147
T_3 (10 m^3 compost/fed+bio)	251	259	269	273	263	172	167	159	148	162
T_4 (20 m^3 compost/fed+bio)	259	267	268	276	268	173	164	142	141	155
T_5 (30 m^3 compost/fed+bio)	258	269	274	284	271	164	161	138	134	149
Mean	255	263	268	276		170	164	148	143	
L.S.D at 0.05 for		Fertilization = 12.66 Micronutrients = 11.3 Interaction = 25.31					Fertilization = 5.84 Micronutrients = 5.21 Interaction = 11.67			

Table 12. Effect of some fertilization treatments on Fe %, Zn % and Mn % of *Hibiscus sabdariffa* L plants during 2015 and 2016 seasons.

Micronutrients / Fertilization	Fe %					Zn %					Mn %				
	0.0	**50.0**	**100.0**	**150.0**	**Mean**	**0.0**	**50.0**	**100.0**	**150.0**	**Mean**	**0.0**	**50.0**	**100.0**	**150.0**	**Mean**
							1st season								
T_1(Control)	0.044	0.052	0.0055	0.058	0.052	0.022	0.023	0.024	0.025	0.024	0.013	0.013	0.014	0.015	0.014
T_2 (R.D. chemical NPK)	0.058	0.067	0.070	0.073	0.067	0.025	0.029	0.031	0.033	0.030	0.015	0.016	0.017	0.019	0.017
T_3 (10 m^3 compost/fed+bio)	0.047	0.056	0.059	0.062	0.056	0.023	0.025	0.024	0.028	0.026	0.014	0014	0.015	0.016	0.015
T_4 (20 m^3 compost/fed+bio)	0.055	0.062	0.065	0.069	0.063	0.024	0.026	0.030	0.031	0.028	0.014	0.015	0.016	0.016	0.015
T_5 (30 m^3 compost/fed+bio)	0.060	0.066	0.071	0.072	0.066	0.026	0.029	0.030	0.032	0.029	0.016	0.017	0.018	0.018	0.017
Mean	0.053	0.058	0.064	0.067		0.024	0.026	0.028	0.030		0.014	0.015	0.016	0.017	
L.S.D at 0.05 for		Fertilization = 0.0040 Micronutrients = 0.0036 Interaction = 0.0081					Fertilization = 0.0013 Micronutrients = 0.0012 Interaction = 0.0026					Fertilization = 0.0012 Micronutrients = 0.0011 Interaction = 0.0024			
							2nd season								
T_1(Control)	0.042	0.050	0.053	0.056	0.050	0.020	0.022	0.023	0.026	0.023	0.012	0.013	0.015	0.015	0.014
T_2 (R.D. chemical NPK)	0.057	0.066	0.071	0.074	0.067	0.026	0.028	0.030	0.032	0.029	0.016	0.018	0.018	0.020	0.018
T_3 (10 m^3 compost/fed+bio)	0.049	0.055	0.060	0063	0057	0.021	0.024	0.027	0.029	0.025	0.013	0.014	0.016	0.017	0.015
T_4 (20 m^3 compost/fed+bio)	0.055	0.062	0.068	0.070	0.064	0.023	0.026	0.029	0.030	0.027	0.014	0.016	0.016	0.017	0.016
T_5 (30 m^3 compost/fed+bio)	0.056	0.064	0.070	0.074	0.066	0.025	0.028	0.029	0.031	0.028	0.015	0.017	0.018	0.018	0.017
Mean	0.052	0.059	0.064	0.067		0.023	0.026	0.028	0.030		0.014	0.016	0.017	0.018	
L.S.D at 0.05 for		Fertilization = 0.0050 Micronutrients = 0.0040 Interaction = 0.009					Fertilization = 0.0016 Micronutrients = 0.0014 Interaction = 0.0031					Fertilization = 0.0013 Micronutrients = 0.0012 Interaction = 0.0026			

both seasons. Also, all concentration of micro-nutrients increased leaf Fe, Zn and Mn content, particularly the highest concentration in both seasons. Concerning the interaction effect between fertilization and micro-nutrients treatments, data in Table (12) show that the greatest leaf Fe, Zn and Mn content of roselle plants were obtained by T_2 treatment combined with micro-nutrients at 150 ppm, followed by the combined treatment between T_5 and micro-nutrients at 150 ppm in both seasons. The differences between the abovementioned combined treatments were not significant in both seasons. On the reverse, the lowest values of this parameter were gained by T_1 (control) combination, especially those received no micro-nutrients sprays in the two seasons.

The aforementioned results of fertilization concerning chemical constituents are in parallel with those obtained by Abou El-Ghait *et al.* (2012) on indian fennel, El-Gendy *et al.* (2012) on roselle plants, , Mohamed *et al.* (2012) on *Stevia rebaudiana*, Amran (2013) on *Pelargonium graveolens*, El-Khyat (2013) on *Rosmarinus officinalis*, Sakr *et al.* (2014) on roselle plants, Youssef (2014) on roselle plants and Ghatas and Abdallah 2016. illustrated that, fertilize *Echinacea purpurea* plants with 75 % chemical fertilizer (NPK) + 10 ton compost/fed + bio fertilizer (nitrobein + phosphorein) in combination with some micro-nutrients (Zn or B each at 100 ppm) as foliar spray to enhance the chemical composition of plant. Whereas, the abovementioned results of micro-nutrients are nearly similar to those obtained by Gomaa (2008) on *Hibiscus sabdariffa*, Youssef (2009) on rosemary plant, Amran (2013) on *Pelargonium graveolens*, El-Khyat (2013) on *Rosmarinus officinalis*, Youssef (2014) on *Echinacea purpurea* and Ghatas and Mohamed (2018) demonstrated that, spray *Cymbopgon citruts* plants with 150ppm Fe + Mn +Zn four times a year to resulted highly increments of N, P, K , total carbohydrate Fe, Zn and Mn content of this plant.

The obtained results of this study may be due to the role of fertilization and micro-nutrients in growth and development of the plants; where the use of N-fixing bacteria (nitrobein) as a bio-fertilizer product containing nitrogen fixing bacteria, e.g. Azotobacter and Azospirillum was found to have not only the ability to fix nitrogen but also to release certain phytohormones of cytokinins, gibberellins and auxins which could enhance plant growth through absorption of nutrients and so on enhancing photosynthesis process Hegde *et al.* (1999). Microorganisms used as bio-fertilizers may affect the integrity of growing plants by one mechanism or more such as nitrogen fixation production of growth promoting substances or organic acids, enhancing nutrients uptake or protection against plant pathogens Hawaka (2000). Moreover, when organic manures (compost) added as fertilizer, it led to decrease soil pH which in turn increasing solubility of nutrients for plant uptake, in some cases organic materials may act as low release fertilizer. Recently, on the way of sustainable agriculture with minimum effects, the use of organic manures (compost or chicken manure, ... etc) as natural soil amendments is recommended to replace the soluble chemical fertilizers. They improve the structure of weak-structured sandy soils and increase their water holding capacity. Also, they improve soil fertility, and stimulate root development, induce active biological conditions and enhancing activities of micro-organisms especially those involved in mineralization Suresh *et al.* (2004). Furthermore, to interpret and evaluate the effect of chemical fertilization concerned in this study, on augmenting the different tested vegetative growth parameters, yield component parameters and chemical constituents of roselle plants. It is important to refer to the physiological roles of nitrogen, phosphorus and potassium in plant growth and development. Such three macronutrient elements are the common elements usually included in fertilizers. Plant supplement with these macronutrients in form of fertilizers is necessary because the

soil is usually in deficient of them due to plant removal leaching or they are not readily available for plants. Therefore, such addition of well-balanced NPK fertilization quantities insured production of high productivity and chemical constituents of roselle plants.

For adequate plant growth and production, micronutrients are needed in small quantities in balance of macronutrients. However, their deficiencies cause a great disturbance in the physiological and metabolic processes in the plant. Plants normally take up nutrients from soils through their roots although nutrients can be supplied to plants as fertilizers by foliar sprays (Baloch *et al.,* 2008). Moreover, activates micro-nutrients, especially Fe, Zn and Mn act either as metal components of various enzymes or as functional, structural, or regulatory cofactors. Thus, they are associated with saccharide metabolism, photo-synthesis and protein synthesis Marschner (1997). Therefore, sufficient amount of these nutrients in the plant is necessary for normal growth, in order to obtain satisfactory yield (Yassen *et al.,* 2010). So, micronutrients such as Fe, Zn and Mn have important roles in growth and chemical composition roselle plant.

Consequently, it is preferable to treat roselle plants with the combined treatment between T_2 recommended dose of chemical fertilizer or T_5 30 m^3 compost/fed + bio fertilizer (nitrobein + phosphorein + potassiumag) combined with Fe +Mn +Zn at 150 ppm for enhancing growth and productivity of this plants.

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تأثير بعض معاملات التسميد على نمو وانتاجية والمحتوى الكيماوى لنبات الكركدية

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أجريت تجربة حقلية خلال عامي ٢٠١٥ و ٢٠١٦ في مزرعه التجارب بقسم البساتين بكلية الزراعه، جامعه بنها لتقييم تأثير اضافه مستويات مختلفه من الكمبوست (١٠، ٢٠، ٣٠ متر مكعب/فدان + التسميد الحيوي (المكون من النتروبين + الفوسفورين + البوتاسيوماج) مقارنه باستخدام الجرعة الموصى بها من السماد الكيماوى في وجود مخلوط سماد العناصر الصغرى من الحديد والمنجنيز والزنك بتركيز (صفر، ٥٠، ١٠٠، ١٥٠ جزء في المليون) وايضا معاملات التفاعل بينهم على النمو والمحصول والمحتوى الكيماوى لنبات الكركديه خلال موسم ٢٠١٥ ، ٢٠١٦.

فى هذا الصدد اثرت كل معاملات التسميد المضافة تاثيرا ايجابيا واحصائيا على كل من طول النبات، عدد الأوراق والأفرع والثمار للنبات، والوزن الطازج والجاف للأوراق والافرع والسبلات للنبات، محتوى الأنثوسيانين وفيتامين سى للسبلات، ومحتوى الأوراق من النيتروجين والفوسفور والبوتاسيوم، ومحتوى الأوراق من الكربوهيدرات الكليه، ومحتوى الأوراق من الحديد والزنك والمنجنيز، ومحتوى الأوراق من الاندولات الكلية، ولكنها قللت محتوى الأوراق من الفينولات الكلية خاصة معاملة الجرعة الموصى بها من السماد الكيماوى أوسماد الكمبوست بمعدل ٣٠ متر مكعب/فدان + التسميد الحيوي (المكون من النتروبين + الفوسفورين + البوتاسيوماج) ماعدا صفة محتوى الحموضة كانت الفروق غير معنوية فى الموسمين. ايضا كل تركيزات مخلوط سماد العناصر الصغرى من الحديد والمنجنيز والزنك حسنت الصفات المذكوره سابقا خاصه عند استخدام التركيزات المرتفعة.

بالاضافة الى انه قد سجلت أعلى القيم لكل من طول النبات، عدد الأوراق والأفرع للنبات، والوزن الطازج والجاف للأوراق والافرع للنبات، عدد الثمار/نبات، محصول البذرة/نبات بالجم، محتوى الحموضة والأنثوسيانين وفيتامين سى للسبلات، ومحتوى الأوراق من النيتروجين والفوسفور والبوتاسيوم، ومحتوى الأوراق من الكربوهيدرات الكليه، ومحتوى الأوراق من الحديد والزنك والمنجنيز، ومحتوى الأوراق من الاندولات الكلية، ولكنها سجلت اقل القيم فى محتوى الأوراق من الفينولات الكلية باستخدام معاملة التفاعل بين الجرعة الموصى بها من السماد الكيماوى ومخلوط سماد العناصر الصغرى من الحديد والمنجنيز والزنك بتركيز ١٥٠ جزء فى المليون فى كلا الموسمين. علاوة على ذلك اعطت معاملة التفاعل بين سماد الكمبوست بمعدل ٣٠ متر مكعب/فدان + التسميد الحيوي (المكون من النتروبين + الفوسفورين + البوتاسيوماج) ومخلوط سماد العناصر الصغرى من الحديد والمنجنيز والزنك بتركيز١٥٠ جزء فى المليون اعلى القيم لكل من عدد الثمار للنبات ، والوزن الطازج والجاف للسبلات للنبات ، محتوى الحموضة والأنثوسيانين وفيتامين سى للسبلات لنبات الكركديه مقارنة بالكنترول فى الموسمين. كما ادى استخدام معاملة التفاعل بين سماد الكمبوست بمعدل ٢٠ متر مكعب/فدان + التسميد الحيوي (المكون من النتروبين + الفوسفورين + البوتاسيوماج) ومخلوط سماد العناصر الصغرى من الحديد والمنجنيز والزنك بتركيز١٥٠ جزء فى المليون زيادة معنوية كبيرة فى هذا الصدد فى كلا الموسمين.

وبناء علي ذلك يفضل معاملة نبات الكركديه بالجرعة الموصى بها من السماد الكيماوى او معاملة التداخل بين معاملة التفاعل بين سماد الكمبوست بمعدل ٣٠ متر مكعب /فدان ومخلوط سماد العناصر الصغرى من الحديد والمنجنيز والزنك بتركيز١٥٠ جزء فى المليون لتحسين وزياده النمو وانتاجية هذا النبات.