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Managing Roselle Plant (*Hibiscus sabdariffa L.*) Requirements of Fertilizers and Irrigation Grown under Upper Egypt Conditions.

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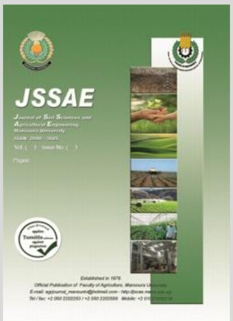

ABSTRACT

Egypt is one of the countries that produce the best Hibiscus(karkadeh)in world, especially in Upper Egypt. Determine the fertilization and irrigation requirements consider of the most important agricultural practices for roselle plant as a medicinal plant.A field experiment was carried out during the two successive summer growing seasons 2017 and 2018 at Kom Ombo Agriculture Research Station,Aswan Governorate, Egypt (24° 28' 38.604'' N and 32° 56' 50.671'' E),to evaluate the response of roselle plant to NPK fertilizers rates, compost as organic fertilizer and irrigation at different intervals. Treatments were carried out as Split Split Plot Design with three replicates; the main plots were three irrigation intervals(every 3, 6 and 9 days);the split plots were organic fertilizer, Org_0(without)and Org_1(4 m^3 fed^{-1} compost "Hundz soil compost"),and the sub split plots were 3 rates of NPK fertilizers(100; 75 and 50 % of recommended NPK).Results showed that growth of roselle plant significantly responded to fertilization at 100% NPK, compost and irrigation every 3 days,where fruits number and weight and sepals yield showed adverse response. They were superior with fertilization at 75 and 50 % NPK,compost and irrigation every 6 days. Sepal's content of nitrogen,anthocyanin and cyaniding significantly were affected by the interaction of NPK-fertilizers rates with compost and irrigation intervals, and also the plant uptake of NPK. Results concluded maximize yield of roselle plant grown in Aswan Governorate fertilized plants with 56.25 kg N, 22.5 kg P_2O_5 & 27 kg K_2O per fed(75% of RD NPK),along with compost application and irrigation every 6 days.

Keywords: *Hibiscus sabdariffa L.*, mineral NPK fertilizers, compost & irrigation intervals.

INTRODUCTION

Roselle (*Hibiscus sabdariffa* L.) is one of the Malvaceae family plants. It is one of medicinal plants; it contains large quantities of organic acids (oxalic, malic, citric and tartaric acids), vitamin C, and two types of anthocyanin, namely: hibiscin (delphinidin) and gossyperin (cyanidin). It has a favorable effect on the functions of the stomach possession; it kills various types of bacteria and micro-organisms, and as such, decreases blood pressure and causes relaxation of the rest parts of the body. Furthermore, the red color (anthocyanin) is also used in the food industry i.e., sweets, tea pies and sauces (Aziz *et al.*, 2007, Lin *et al.*, 2007, Mohamed *et al.*, 2007 and Hassan, 2009).

Roselle plant is known as "karkadeh" in Egypt and the most Arab countries. The world's best roselle (Hibiscus) comes from Sudan, Nigeria, Mexico, Egypt, Senegal, Tanzania and Mali. However China and Thailand are the largest producers in the world, and control supply (Wikipedia, 2020). Hibiscus is grown successfully in tropical and sub-tropical climates. The plant can grow readily in well-drained soils and can tolerate poor soils, high temperature and drought. It requires 4-8 months with minimum night-time temperature 20° C, 13h of sunlight. This may explain why Roselle cultivation is mainly accustomed to grow in Upper Egypt soils (El- Boraie et al., 2009).

Aswan is one of the Egyptian governorates which lie at the southernmost of Upper Egypt (23.59˚N 32.82˚E), it consider of suitable climate zone for cultivation and production karkadeh, which characterized by a high relative value of quality in world. It has a hot desert climate during summer (average high temperatures above 40 °C and average low temperatures remain above 25 °C), according to The Egyptian Meteorological Authority reports 2010-2020.

Managing fertilization and irrigation of roselle plants as a medicinal plants consider of the most important agriculture practices for us. Fertilizers rate can change rates of plant growth, maturity time and plant yield, phytochemical contents of plant and seed capabilities. Adequate fertilization programs supply the amounts of plant nutrients needed to sustain maximum net returns (Bekeko, 2014).

The highest values of roselle grown in clayey soil (in Sharkia governorate, Egypt): i.e., plant height, number of branches/plant, total dry weight/plant, yield components (fruits number, sepals and seed yield per plant and per fed.) and chemical constituents (N, P and K percentages as well as total soluble solids) were achieved with NPK fertilizers rate: 68 Kg N + 32 kg P_2O_5 + 24 kg K_2O and 4 L humic acid per fed (Fahmy and Hassan 2019).

At conditions of middle Egypt (El-Fayoum governorate), the maximum increase of roselle plant growth (plant height, number of branches and fresh weight per plant), yield (dry weight of sepals and seeds per plant and per fed) under different soils texture (clay, sandy loam and loamy sand soils) was obtained by the treatment of 500 kg ammonium sulfate (100 kg N), 150 kg calcium superphosphate (22.5 kg P_2O_5) and 50 kg potassium sulfate (24 kg K_2O) per fed + bio-fertilizers "Azotobacterine and phosphorein" (Ghabour *et al.*, 2019).

Organic fertilization is a very important method of providing the plants with their nutritional requirements without having undesirable impact on the environment.

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Also, organic fertilizers play a major role in order to achieve sustainable agriculture; it provides soil humus for stabilizing soil fertility, as a suitable source of macro- and micronutrient (Nabila and Aly 2002, Taheri *et al.,* 2011 and Khatab 2016).

Nabila and Aly (2002) found that dressing both chicken manure and animal manure enhanced plant height, number of branches and fruits, mass production of the plants, fresh and dry weights of sepals per plant and per feddan, and anthocyanin content, while the acidity was reduced. Gendy *et al*., (2012) found that the interaction effect of cattle manure (30 m^3 fed^{-1}) combined with mixture of biofertilizers (phosphorein and nitrobein) gave the best results of roselle plants; sepals yield, seed yield, the anthocyanin and vitamin C contents in sepals as well as the chemical constituents of leaves per plant (nitrogen, phosphorus, potassium, protein and total carbohydrates) under clay loam soil conditions.

Treated roselle plants with the combined treatment of half chemical fertilizer dose+ 15m^3 compost/fed combined with 200 ppm ascorbic acid is safely and better than full chemical fertilizer dose, where it significantly induced the highest values of plant height, number of leaves, branches and fruits per plant, fresh and dry weight of branches, leaves and sepals per plant, seed and sepals yield, seed fixed oil, sepals anthocyanin and vitamin-C content, leaf N, P, K, Fe, Zn and Mn uptake; also increased the available N nutrients in the soil as well as the macronutrients concentrations (Youssef *et al*., 2014 and Al- Sayed *et al*., 2019).

Managing irrigation is very important for roselle plants, where drought stress reduces yield of such medicinal and aromatic plants. Most of researchers were focused on water stress effect on biomass, yield and active constituents of different medicinal and aromatic plants. However in a lot of cases, they stated an increase in flowering and dry yield (Babatunde and Mofoke 2006, El-Boraie *et al*., 2009 and Seghatoleslami *et al*. 2013).

Drought stress or overwatering exhibited a decrease in flowers number, fresh weight and dry weight; however an increment in anthocyanin due to the increase of water supply and added that stresses condition is an elevator for carbohydrate accumulation that amassed into anthocyanin and other secondary metabolites (El-Boraie *et al*., 2009). On the other hand, Seghatoleslami *et al*. (2013) found that water supply level had no significant effects on roselle plant height, stem diameter, number of branches and stomatal closure, but only connected with chlorophyll contents in leaves.

Increasing water supply or reduction of water intervals were connected with a surge increase in the final yield of roselle calyx. Khalil and Yousef (2014) found the maximum growth, yield and fruit quality of Hibiscus that grown in sandy soil (Ismailia governorate, Egypt) was produced under the effect of interaction treatment; (2304 m^3 fed^{-1}) with fertilization at 100%NPK (300 kg ammonium sulphate+ 100 kg potassium sulphate+ 300 kg calcium superphosphate)+ Humic acid in both seasons, but the anthocyanin% revealed reversed trend, where the maximum significant means were obtained under interaction between irrigation water quantity 1152 m^3 fed^{-1} with fertilization at 100%NPK+Humic acid.

Therefore, the objective of this study was to evaluate the effect of interaction among mineral NPK fertilization rates and compost as organic manure with irrigation intervals on growth, yield and nutrient content of roselle plants grown in Upper Egypt soils (Aswan governorate).

MATERIALS AND METHODS

A field experiment was carried out during the two successive growing summer seasons of 2017 and 2018 at Kom Ombo Agriculture Research Station, ARC, Aswan governorate, Egypt (24° 28' 38.604" N and 32° 56' 50.671" E) to evaluate the response of roselle plant to NPK fertilizers rates, organic fertilizer (Hundz-soil compost) and irrigation intervals.

Treatments were carried out as Split Split Plot Design with three replicates. The main plots were three irrigation intervals (every 3, 6 and 9 days). The split plots were two treatments of compost "Hundz-soil compost"; Org_0 (without) and Org-HS (4 m^3 HS-compost per fed). The sub split plots were 3 rates of NPK fertilizers (as a percentage of recommendation of previous studies, Agricultural Research Center, Ministry of Agriculture and Land Reclamation, Egypt) as follows:

NPK1: 75 kg N, 30 kg P_2O_5 & 36 kg K_2O per fed (100% NPK).

NPK2: 56.25 kg N, 22.5 kg P_2O_5 & 27 kg K_2O per fed (75%NPK).

NPK3: 37.5 kg N, 15 kg P_2O_5 & 18 kg K_2O per fed (50%NPK).

The experimental plot area was 10.5m^2. Roselle seeds (cv. Sabahia 17) were sown in the first week of May and harvested in the first week of October in both seasons 2017 and 2018. Roselle seeds were obtained from of Medicinal and Aromatic Plants department, Horticulture Research Institute, Agricultural Research Center, Ministry of Agriculture and Land Reclamation, Egypt.

Samples of soil were randomly taken from the field experiments before sowing, and then analyzed according to Page (1982) as shown in Table (1).

Table 1. Some physical and chemical properties of the experiment site soil before sowing (Average of the two seasons).

Properties	**Particle size distribution**					**OM**	**$CaCO_3$**	**SP**	**pH***	**EC****
Soil samples	**Sand %**	**Silt %**	**Clay %**	**Texture class**		**%**	**%**	**%**	**(1:2.5)**	**(dSm^{-1})**
Values	79.2	13.5	7.3	Sandy loam		0.57	3.98	27.50	7.87	1.90
Properties	Soluble cations and anions (meq/100 g soil)							Available NPK (mg kg^{-1})		
Soil samples	Ca^{++}	Mg^{++}	Na^+	K^+	CO_3^{-}	HCO_3^-	Cl^-	SO_4^{-}	N	P	K
Values	6.0	2.4	10.1	0.50	N.D***	0.75	15.6	2.65	28	5.31	111

pH in 1:2.5 soil: water suspension; ** EC in soil paste extract; N.D (not detected)**

Fertilizers were applied as follows: phosphorus fertilizer was applied as calcium super phosphate fertilizer (15% P_2O_5) with soil preparation; potassium was applied as potassium sulphate fertilizer (48% K_2O) with sowing. Nitrogen fertilizer was applied as ammonium nitrate fertilizer (33.5 % N) at two equal doses after emergence by 15 days and after 30 days of the first dose. Also, all the recommended field practices of roselle plant were carried out for the two seasons according to recommendations of

Agricultural Research Center, Ministry of Agriculture and Land Reclamation, Egypt.

Compost was applied at the rate of 4 m^3 fed^{-1} with soil preparation (tillage practice). Some physical chemical properties of the applied compost (HS) were carried out according to Page, (1982) as shown in Table 2.

Table 2. Some properties of the applied compost.

Properties	pH*	EC** dSm^{-1}	Moisture (%)	Weight of m^3 ($kg\ m^{-3}$)	WSC (%)	O.M. %	C:N Ratio	% C	% N	% P	% K
Values	7.6	1.40	3.0	216	278	78.20	35.4 : 1	45.3	1.3	0.08	0.11

***pH in 1:10 water suspension; **EC in 1:10 water extract; WSC (water saturation capacity)**

At harvest, plants of each plot were harvested and yield parameters were recorded; Plant height (cm), branches No. per plant, fresh and dry weight of plant, fruits No. per plant, fruits fresh weight per plant and feddan, fresh and dry weight of sepals per plant and feddan, NPK content in dry leaves and spelates, anthocyanin and cyanidin concentration in dry spelates, and NPK uptake per feddan.

Samples of leaves, spelates and plant were taken randomly from each plot for chemical analysis. Nitrogen, phosphorus, and potassium concentrations were determined at the wet digested plant samples by sulphuric and perchloric acids according to Chapman and Pratt (1982). Anthocyanin and cyanidin % in spelates were determined according to A.O.A.C. (1990).

The statistical analysis was done according to the method of Gomez and Gomez (1984) and treatment means values were compared against least significant differences test (L.S.D.) at significant level 5%.

RESULTS AND DISCUSSION

Growth of plant:

Data in Table 3 show that application of mineral NPK fertilizers rates, compost (HS-compost) and irrigation at different intervals had significant effect on growth of plant i.e., plant height, number of branches per plant, fresh and dry weight of plant. Growth of plant significantly responded to rates of NPK fertilizers with superior rate of NPK1 (100%NPK), but without significant differences with rate of NPK2 (75%NPK) in some times. Application of HS-compost increased growth of plant with highly significant differences with treatment without HS-compost application. Also, the growth of plant i.e., plant height, branches No. per plant and fresh weight of plant significantly increased with decreasing the irrigation intervals with superior the values of irrigation every 3 days, but dry weight of plant was higher with irrigation every 6 days than other intervals (3 or 9 days).

Table 3. Influence of mineral NPK fertilizers rates, Hundz-soil-compost and irrigation intervals on growth of plant.

Treatments			Plant height (cm)	Branches No. $plant^{-1}$	Plant F.w (g $plant^{-1}$)	Plant dry weight (g $plant^{-1}$)
Interaction NPK*Org*I effect						
I1	Org_0	NPK1	215.2	41.0	386.7	115.0
		NPK2	208.6	39.5	313.3	110.0
		NPK3	199.8	37.8	253.3	88.3
	Mean		206.9	39.4	317.8	104.4
	Org-HS	NPK1	217.9	44.6	450.0	123.3
		NPK2	215.2	41.6	433.3	116.7
		NPK3	201.9	40.3	350.0	103.3
	Mean		211.7	42.1	411.1	114.4
Mean I1 (every 3 days)			209.4	40.8	364.5	109.4
I2	Org_0	NPK1	181.9	33.7	363.0	123.3
		NPK2	174.5	33.8	350.5	116.7
		NPK3	157.1	33.1	298.7	100.0
	Mean		171.2	33.5	336.4	113.3
	Org-HS	NPK1	204.3	41.4	414.2	128.0
		NPK2	193.4	39.9	390.0	127.0
		NPK3	183.6	38.1	348.5	110.0
	Mean		193.7	39.8	384.2	121.6
Mean I2 (every 6 days)			182.5	36.7	360.3	117.5
I3	Org_0	NPK1	161.8	34.5	253.3	98.4
		NPK2	157.1	31.9	260.0	92.0
		NPK3	150.5	27.4	220.0	73.0
	Mean		156.5	31.3	244.4	87.8
	Org-HS	NPK1	163.6	34.1	346.7	106.0
		NPK2	160.0	33.7	296.7	104.7
		NPK3	153.1	26.6	280.0	85.0
	Mean		158.9	31.5	307.8	98.6
Mean I3 (every 9 days)			157.7	31.4	276.1	93.2
Significance level as LSD at 5%						
I (irrigation intervals)			2.48	1.68	10.27	2.55
Org (HS-compost)			3.65	0.84	5.66	2.31
NPK-rates			3.16	0.93	5.05	2.74
Org*I			7.21	1.46	9.79	Ns
NPK*I			5.47	1.61	8.75	8.00
NPK*Org			4.47	ns	7.14	6.53
NPK*Org*I			8.25	2.27	12.38	11.32

Also, the interaction of treatments (NPK*Org*I) had significant effect on plant growth, with superior the treatments of interactions: I1*HS*NPK1 for plant height, branches number and fresh weight of plant. On the other hand, the interaction of I2*HS*NPK1 had the highest value of dry weight of plant, but was insignificant with that of interaction of I2*Org-HS*NPK2 (Table 3).

The response of plant growth due to increasing rate of NPK fertilizers could due to initial status of soil before sowing which was poor in available NPK. Nitrogen, phosphors and potassium are of the macronutrients of plant; nitrogen is the main component in nucleic acids and protein synthesis, phosphors is an essential component of the energy compounds ATP and ADP, where potassium is an activator of many enzymes (Marschner, 2012). These results agree with those obtained by Abbas and Ali (2011), Khalil and Yousef (2014), Khatab (2016) and Hewidy *et al*., (2018).

The pronounced effect of increased irrigation interval up to 6 days on plant's fresh and dry weights may be attributed to the availability of sufficient moisture around the root thus causing a greater growth of root and biomass, higher absorption of nutrients and higher vegetative biomass. On the other hand, the reduction of plant growth with increasing the interval between irrigations up to 9 days could be due to suffering plant of shortage in available water and consequently to water stress, which had the drop in cell expansion and culmination more from reduced turgor pressure (Shao *et al*., 2008).

In this respect, Khalil and Yousef, (2014) found an increment in the available soil moisture water (by increasing irrigation water quantity) combined with 100% NPK+humic acid enhanced plant height, and gave the best result of plant height. Also, Hewidy *et al*., (2018) under loamy soil conditions showed that the highest results of roselle plant height, stem diameter, number of leaves, branches and fruits and dry weight of plant were gained at irrigation interval every 4 days and compost application at 15 t fed^{-1}.

Fruits and sepals yields:

Data in Tables 4 and 5 show the effect of treatments on fruits and sepals yields as fruits No. per plant, fruits fresh weight per plant, sepals fresh and dry weight per plant, sepals yield (kg per fed) and dry weight of plant (kg per fed).

Fruits No. and fresh weight of fruits and sepals per plant significantly increased with decreasing NPK fertilizers rate up to NPK3 (50% NPK). Application of HS-compost as organic fertilizer enhanced fruits and sepals yield as compared with treatment of control (without HS-compost application). Also, Irrigation every 6 days maximized the values of fruits and sepals number and weight (Table 4) compared with other intervals (3 and 9 days). The interaction of treatments (mineral NPK fertilization with HS-compost and irrigation intervals) had significant effect on fruits number, sepals and fruits weight per plant with superior the effect of interaction treatments: I2*HS-compost*NPK2 and I2*HS-compost*NPK3, without significant differences between them (Table 4). Similar results were reported by Khatab (2016) and Hewidy *et al*., (2018).

Table 4. Influence of mineral NPK fertilizers rates, Hundz-soil compost and irrigation intervals on roselle fruits and sepals weight.

Treatments			Fruits No. $plant^{-1}$	Fruits fresh weight (g $plant^{-1}$)	Sepals fresh weight (g $plant^{-1}$)	Sepals dry weight (g $plant^{-1}$)
Interaction NPK*Org*I effect						
I1	Org_0	NPK1	24.7	227.1	106.3	15.4
		NPK2	26.3	268.3	116.3	14.7
		NPK3	25.9	326.3	119.7	14.4
	mean		25.6	273.9	114.1	14.9
	Org-HS	NPK1	44.7	303.1	125.7	21.1
		NPK2	36.7	356.3	151.0	18.4
		NPK3	40.8	332.9	139.0	21.6
	mean		40.7	330.8	138.6	20.4
Mean I1 (3 days)			33.2	302.3	126.3	17.6
I2	Org_0	NPK1	33.7	308.7	148.7	22.5
		NPK2	37.6	302.7	135.0	21.0
		NPK3	37.3	314.9	145.7	19.1
	mean		36.2	308.8	143.1	20.9
	Org-HS	NPK1	26.5	305.7	140.3	19.6
		NPK2	38.9	352.3	162.0	24.8
		NPK3	37.7	339.4	163.3	22.7
	mean		34.4	332.5	155.2	22.3
Mean I2 (6 days)			35.3	320.6	149.2	21.6
I3	Org_0	NPK1	25.2	174.0	86.3	14.4
		NPK2	30.5	193.0	107.3	12.9
		NPK3	28.8	194.3	107.7	12.0
	mean		28.2	187.1	100.4	13.1
	Org-HS	NPK1	37.7	262.3	142.0	17.8
		NPK2	38.2	292.3	136.7	16.4
		NPK3	41.7	323.3	166.3	15.8
	mean		39.2	292.6	148.3	16.7
Mean I3 (9 days)			33.7	239.9	124.4	14.9
Significance level as LSD at 5%						
I (irrigation intervals)			Ns	6.57	2.72	1.17
Org (HS-compost)			1.54	5.24	1.57	0.47
NPK-rates			1.66	6.18	3.36	ns
Org*I			2.67	9.08	2.72	0.82
NPK*I			2.87	10.69	5.82	1.34
NPK*Org			2.34	8.74	Ns	1.09
NPK*Org*I			4.06	15.13	8.22	1.89

Table 5. Influence of mineral NPK fertilizers rates, Hundz-soil-compost and irrigation intervals on fruits and sepals yield (Roselle yield per fed).

Treatments			Fruits fresh weight ($kg\ fed^{-1}$)	Sepals fresh weight ($kg\ fed^{-1}$)	Sepals dry weight ($kg\ fed^{-1}$)	Plant dry weight ($kg\ fed^{-1}$)
Interaction NPK*Org*I effect						
I1	Org_0	NPK1	4995	2339	338.9	2353
		NPK2	5902	2559	323.8	2260
		NPK3	7179	2633	317.4	1933
	mean		6026	2510	326.7	2182
	Org-HS	NPK1	6059	2755	475.5	2487
		NPK2	6667	3058	465.1	2420
		NPK3	7325	2798	405.5	2200
	mean		6684	2870	448.7	2369
Mean I1 (3 days)			6355	2690	387.7	2276
I2	Org_0	NPK1	6791	3271	494.0	2420
		NPK2	6659	2970	463.0	2713
		NPK3	6929	3205	421.2	2570
	mean		6793	3148	459.4	2568
	Org-HS	NPK1	6305	2589	430.3	2583
		NPK2	7751	3631	545.2	2860
		NPK3	7467	3593	499.0	2493
	mean		7174	3271	491.5	2646
Mean I1 (6 days)			6984	3210	475.4	2607
I3	Org_0	NPK1	3828	1899	316.2	2160
		NPK2	4246	2361	284.4	2127
		NPK3	4275	2369	263.3	1540
	mean		4116	2210	288.0	1942
	Org-HS	NPK1	5771	3007	392.6	2200
		NPK2	6431	3124	361.4	2193
		NPK3	6945	3659	348.2	1607
	mean		6383	3263	367.4	2000
Mean I1 (9 days)			5250	2737	327.7	1971
LSD at 5%						
I (irrigation intervals)			145.4	58.8	21.88	55.5
Org (HS-compost)			115.8	35.7	10.11	Ns
NPK-rates			136.2	73.9	Ns	Ns
Org*I			200.6	61.8	17.5	Ns
NPK*I			235.9	128.1	30.1	183.7
NPK*Org			192.7	104.6	24.5	150.0
NPK*Org*I			333.7	181.1	42.5	259.9

As shown in Table 5 the yield of fruits and sepals as fresh and dry weight per fed were significantly affected by rates of NPK fertilizers with superior the values of mineral fertilizers at the rate of NPK2 (56.25 kg N, 22.5 kg P_2O_5 & 27 kg K_2O per fed). Application of HS-compost significantly increased yields of fruits and sepals as fresh and dry weight (kg per fed) compared to without application. Also, fruits and sepals yield per fed significantly affected by irrigation intervals, where the highest values of fruits and sepals yields were recorded at irrigation of plants every 6 days (I2) as compared with other intervals. Interaction of fertilization at rate of 75%NPK, with HS-compost and irrigation every 6 days attained the highest values of fruits and sepals fresh weight (7751 and 3631 kg fed^{-1}, respectively), sepal's dry yield (545.2 kg fed^{-1}) and plant dry weight (2860 kg fed^{-1}). As well as the interactions of Org*NPK, I*NPK and Org*I significantly effect on fruits and sepals yields. These results are agreed with Youssef *et al.,* (2014) and Al- Sayed *et al.,* (2019).

It obvious from previous mentioned result that application of HS-compost with mineral NPK fertilizers at the rate of NPK2 (75 % of recommended) had integrated effect on fruits and sepals yield. These results may be attributed to that application of mineral NPK fertilizers alone give nutrients in the faster available forms when applied, but application of HS-compost as organic form supply the soil with nutrient as in slow fertilizer. The fertilizer units applied in organic form have higher use efficiency by plant than that applied in inorganic form (Carrubba, 2015). Furthermore, organic fertilizers improve physical, chemical and microbiological characteristics of the soil and increasing hold's capacity, which lead to increase in yield (Khalil and Yousef, 2014). Whereas, many studies reported that application organic fertilizer alone was not sufficient for economic production. Thus, the best practice of fertilization the integration between the both sources of fertilizers chemical and organic (Hassan 2009 and Khalil and Abdel-Kader, 2011).

In sandy soil at Siwa Oasis, Egypt, Khatab (2016) reported that supplying compost of pressed olive cake + chicken manure (1:1 at rate of 2 t. fed^{-1}) combined with 48 kg K_2O, 40 kg N and 30 kg P_2O_5 per fed resulted in the highest values of plant growth parameters and sepals yield.

Number of fruits per plant increased with increasing the irrigation interval, where fresh and dry weight of fruits and sepals per plant (Table 4) and per fed as a yield (as shown in Table 5) were higher under irrigation every 6 than other intervals. In this respect, most of researchers stated an increase in flowering and dry yield with water stress (Seghatoleslami *et al*., 2013). In another research, water schedule under light soil cultivations did not affect Roselle plant height and branches number but instead number of leaves and calyx yield significantly increased under longer intervals only (Babatunde and Mofoke, 2006). Also, Hewidy *et al*., (2018) under loamy soil found that number of Roselle fruits, dry weight of plant and calyx were the highest with irrigation interval every 4 days and compost application at 15 t fed^{-1}.

NPK concentration in leaves and plant uptake:

Data in Table 6 show that irrigation intervals had significant effect on NPK concentration and uptake in plant; NPK concentration in leaves increased with increasing the irrigation intervals, but the uptake was maximize with irrigation intervals every 6 days as compared with other intervals (3 or 9 days). Application of HS-compost had significant effect on the uptake of NPK in plant (kg fed^{-1}), but had not significant effect on their concentration of leaves. The uptake of NPK significantly was affected by rates of mineral fertilizers NPK; where the difference between treatments of NPK2 (75% of RD-NPK) and NPK1 (100% of RD-NPK) was insignificant.

Application of mineral NPK fertilizers rates with HS-compost and irrigation intervals as interaction of treatments significantly had significant effect on the plant uptake of NPK (Table 6). The highest value of plant uptake of NPK (kg fed^{-1}) was recorded at the interaction of I2*HS-compost*NPK2. Interaction of HS-compost with irrigation intervals significantly affected the plant uptake of NPK, with superior the interaction of HS-compost*I2. On the hand, the uptake of plant of NPK decreased with increasing the interval of irrigation (every 9 days), but application of HS-compost enhancing the uptake of plant and growth under this irrigation interval. So, it could be concluded that irrigation every 9 days caused shortage of available water to plant growth and nutrient uptake, as well as had water stress on growing plant.

Table 6. Influence of mineral NPK fertilizers rates, Hundz-soil-compost and irrigation intervals on NPK-concentration and uptake of roselle plant (kg fed^{-1}).

Treatments			NPK % IN leaves			NPK-uptake in plant (kg fed^{-1})		
			N	P	K	N	P	K
Interaction NPK*Org*I effect								
I1	Org0	NPK1	1.26	0.129	0.507	29.65	3.04	11.93
		NPK2	1.36	0.146	0.542	30.74	3.30	12.25
		NPK3	1.49	0.143	0.421	28.80	2.76	8.14
	Mean		1.37	0.139	0.490	29.73	3.03	10.77
	Org-HS	NPK1	1.59	0.173	0.513	39.54	4.30	12.76
		NPK2	1.38	0.153	0.545	33.40	3.70	13.19
		NPK3	1.27	0.144	0.525	27.94	3.17	11.55
	Mean		1.41	0.156	0.527	33.63	3.72	12.50
Mean I1 (3 days)			1.391	0.148	0.509	31.68	3.38	11.64
I2	Org0	NPK1	1.51	0.122	0.487	36.54	2.95	11.79
		NPK2	1.59	0.121	0.493	43.14	3.28	13.38
		NPK3	1.32	0.144	0.490	33.92	3.70	12.59
	Mean		1.47	0.129	0.490	37.87	3.31	12.58
	Org-HS	NPK1	1.44	0.148	0.510	37.20	3.82	13.17
		NPK2	1.70	0.159	0.453	48.62	4.55	12.96
		NPK3	1.55	0.135	0.487	38.64	3.37	12.14
	Mean		1.56	0.147	0.484	41.49	3.91	12.76
Mean I1 (6 days)			1.517	0.138	0.487	39.68	3.61	12.67
I3	Org0	NPK1	2.11	0.172	0.536	45.58	3.72	11.58
		NPK2	1.60	0.169	0.516	34.03	3.59	10.98
		NPK3	1.28	0.165	0.519	19.71	2.54	7.99
	Mean		1.66	0.169	0.524	33.11	3.28	10.18
	Org-HS	NPK1	1.50	0.154	0.502	33.00	3.39	11.04
		NPK2	1.80	0.135	0.548	39.47	2.96	12.02
		NPK3	1.33	0.128	0.464	21.37	2.06	7.46
	Mean		1.54	0.139	0.505	31.28	2.80	10.17
Mean I1 (9 days)			1.603	0.154	0.514	32.19	3.04	10.18
LSD at 5%Significance level								
I (irrigation intervals)			0.09	Ns	0.015	2.053	0.312	0.220
Org (HS-compost)			Ns	Ns	Ns	0.828	0.105	0.317
NPK-rates			0.07	Ns	0.018	1.734	0.215	0.472
Org*I			0.061	0.0046	0.0149	1.997	0.184	0.481
NPK*I			0.122	Ns	0.0321	3.644	0.449	0.947
NPK*Org			Ns	0.0113	Ns	2.975	0.367	Ns
NPK*Org*I			0.172	Ns	0.0454	5.154	0.636	Ns

Sepals content of NPK, anthocyanin and cyaniding:

Sepals content of K, anthocyanin and cyaniding not affect by different irrigation intervals, but sepal's content of nitrogen and phosphors were significantly affected. Also, application of HS-compost significantly affected sepal's content of NPK, but not significantly affected sepals content of anthocyanin and cyaniding. In the same trend, mineral NPK fertilizers at different rates had significant effect, on sepal's content of nitrogen, phosphors, potassium and anthocyanin, but had insignificant effect on sepals content of cyanidin. Interaction of NPK-rates*HS-compost* Irrigation intervals had significant effect on sepals content of nitrogen, phosphors, anthocyanin and cyanidin (as shown in Table 7).

These results come in agreement with those of Abbas and Ali (2011), Ghasemi *et al*. (2015) and Khatab (2016) who found that applying potassium fertilizer at different rates increased anthocyanin and sugar contents of roselle sepals. Also, application of compost enhanced growth and yield of different plant traits and active anthocyanin contents (Oyewole and Mera, 2010 and Khalil and Yousef, 2014). El-Sherif and Sarwat (2007) and Yasser *et al*. (2011) reported that application of organic manure to roselle increased vegetative growth parameters, number of branches and fruits, sepal yield and a slight increase in the protein and phosphorus content of sepals.

The reduction in plant content and uptake of NPK as a result of water stress could be attributed primarily to soil water deficiency, which reduces the flow rates of nutrients in soil, their absorption by roots and its translocation through the different organs and tissues of plant (Khalil, 2012). Whereas, the anthocyanin content was affected by irrigation intervals with increasing irrigation interval the anthocyanin content of roselle sepals was significantly increased (Khalil and Abdel-Kader, 2011, Khalil and Yousef, 2014 and Hewidy *et al.* 2018). This result may be attributed to water stress; the shortage of water supply usually led to many disturbances in physiological characters of the plant, i.e., the reduction in chlorophyll content, indicating the rise in production of plant secondary metabolites like total flavonoids, phenolic and anthocyanin contents (Jaafar *et al.* 2012).

Table 7. Influence of mineral NPK fertilizers rates, Hundz-soil-compost and irrigation intervals on spelates content of NPK, anthocyanin and cyanidin.

Treatments			NPK % in Spelates			Anthocyanin	Cyanidin
			N	P	K	%	%
Interaction NPK*Org*I effect							
I1	Org_0	NPK1	0.45	0.122	2.19	6.849	0.994
		NPK2	0.53	0.105	2.22	6.880	0.994
		NPK3	0.55	0.097	2.33	6.887	0.996
	mean		0.51	0.108	2.25	6.872	0.995
	Org-HS	NPK1	0.59	0.122	2.31	6.921	0.996
		NPK2	0.58	0.120	2.32	6.872	0.989
		NPK3	0.54	0.134	2.44	6.871	0.997
	mean		0.57	0.126	2.36	6.888	0.994
Mean I1 (3 days)			0.54	0.117	2.30	6.880	0.994
I2	Org_0	NPK1	0.61	0.100	2.16	6.968	1.006
		NPK2	0.59	0.126	2.29	6.910	1.006
		NPK3	0.66	0.170	2.22	6.878	0.899
	mean		0.62	0.132	2.23	6.919	0.970
	Org-HS	NPK1	0.64	0.131	2.16	6.882	0.898
		NPK2	0.63	0.119	2.34	6.865	0.898
		NPK3	0.79	0.194	2.29	6.853	1.003
	mean		0.69	0.148	2.26	6.867	0.933
Mean I1 (6 days)			0.65	0.140	2.25	6.893	0.952
I3	Org_0	NPK1	0.59	0.113	2.16	6.893	1.005
		NPK2	0.56	0.093	2.29	6.895	1.006
		NPK3	0.52	0.094	2.18	6.886	1.001
	mean		0.55	0.100	2.21	6.891	1.004
	Org-HS	NPK1	0.65	0.098	2.18	6.935	1.005
		NPK2	0.63	0.122	2.28	6.875	1.005
		NPK3	0.66	0.116	2.41	6.890	1.002
	mean		0.65	0.112	2.29	6.900	1.004
Mean I1 (9 days)			0.60	0.106	2.25	6.896	1.004
Significance level LSD at 5%							
I (irrigation intervals)			0.053	0.015	Ns	Ns	Ns
Org (HS- compost)			0.031	0.009	0.032	Ns	Ns
NPK-rates			0.025	0.008	0.040	0.0158	Ns
Org*I			Ns	Ns	Ns	0.027	Ns
NPK*I			0.075	0.014	0.118	Ns	Ns
NPK*Org			Ns	0.012	0.084	Ns	0.034
NPK*Org*I			0.106	0.020	Ns	0.039	0.058

CONCLUSION

From previous results, we can concluded to maximize yield of roselle plant (*Hibiscus sabdariffa* L.) grown in Aswan governorate (Upper Egypt): fertilize plants with mineral fertilizers at rate of 56.25 kg N, 22.5 kg P_2O_5 & 27 kg K_2O per fed, along with application compost at rate 4 m^3 per fed (Handz soil-compost) and irrigation of plants every 6 days.

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إدارة إحتياجات نبات الكركديه من الأسمدة والرى المزروع تحت ظروف مصر العليا

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تعد مصر من الدول المنتجة لأفضل لكركديه في العالم وخاصة بصعيد مصر؛ وتعتبر إدارة التسميد والري من أهم العمليات الزراعية لنبات الكركديه (*Hibiscus sabdariffa* L.) لكونه نبات طبي؛ لذا تم إجراء تجربة حقلية خلال موسمي الزراعة الصيفي المتتاليين ٢٠١٧ و ٢٠١٨ بمحطة بحوث كوم أمبو الزراعية، محافظة أسوان ، مصر (٢٤ ° ٢٨ '٣٨,٦٠٤ "شمالاً و ٣٢ ° ٥٦' ٥٠,٦٧١" شرقًا)، لتقييم استجابة نبات الكركديه إلى معدلات من أسمدة النتروجين والفوسفور والبوتاسيوم (NPK) والسماد عضوي الصناعى "الكمبوست" والري عند فترات مختلفة؛ تم تنفيذ المعاملات فى تصميم قطع منشقة مرتين فى ثلاث مكررات؛ تمثلت فترات ري (ثلاث فترات كل ٣ ، ٦ و ٩ أيام) فى القطع الرئيسية ؛ وتمثلت معاملتي التسميد العضوي (بدون و ٤ مترمكعب كمبوست "هنزسويل" للفدان) فى القطع الشقية الأولى؛ وفى حين تمثلت معدلات السماد المعدنى (٣ معدلات: ١٠٠ % ، ٧٥% و ٥٠٪ من الموصى به NPK) فى القطع الشقية الثانية. أظهرت النتائج استجابة نمو نبات الكركديه معنويا لمعدلات التسميد المعدنى حتى معدل ١٠٠٪ من NPK والكمبوست والري كل ٣ أيام؛ فى حين أظهرت نتائج المحصول المتمثلة فى عدد الثمار ووزنها ومحصول سبلات الكركديه استجابة عكسية والتى تفوقت مع معلات التسميد الأقل عند معدلى ٧٥ و ٥٠٪ من NPK مع السماد العضوى والري كل ٦ أيام؛ وكما تأثر امتصاص النبات من NPK أيضًا ومحتوى السبلات من النيتروجين والأنثوسيانين والسيانيد بشكل كبير بتفاعل المعاملات من معدلات الأسمدة NPK مع السماد العضوي وفترات الري؛ هنا وقد خلصت النتائج أن معاملة التفاعل من تسميد النباتات بمعدل ٥٦,٢٥ كجم نيتروجين (N)، ٢٢,٥ كجم خامس اكسيد الفوسفور (P_2O_5) و ٢٧ كجم ثانى اكسيد البوتاسيوم (K_2O) للفدان (تمثل ٧٥٪ من الموصى به NPK) مع إضافة الكمبوست والري كل ٦ أيام كانت الأمثل لتعظيم محصول الكركديه وصفاته المزروع بمحافظة أسوان.