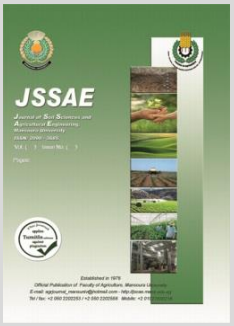
Journal of Soil Sciences and Agricultural Engineering

Journal homepage: www.jssae.mans.edu.eg
Available online at: www.jssae.journals.ekb.eg

Evaluate the Effect of Green Fertilizer and Two Sources of Potassium on Growth , Yield , some Chemical Constituents of Roselle Plants (Cv. Sabaheia 17) and the Availability of Macronutrients in Soil after Harvest

Hanan M. Abu El-Fotoh; Lamyaa A. Abd El-Rahman* and Samia M. S. El-Kalawy

Soils, Water and Environ. Res. Inst., Agric. Res. Center, Giza, Egypt



ABSTRACT

A field experiment was carried at El-Gemmeiza Agric. Res. Station, El-Gharbihya Governorate, Egypt during the two successive summer seasons of 2017 and 2018 to evaluate the effect of green fertilizer (faba bean) and two sources of potassium (mineral potassium sulphate (KS) 48 % K_2O) or natural feldspar (KF) 10.6 % K_2O with three levels 50, 75 and 100 % of the recommended rate (RR) beside untreated (control treatment) on growth, yield, sepals chemical constituents and the availability of macronutrients in soil after harvest of Roselle plants (cv. Sabaheia 17) under clay soil conditions. Fourteen treatments were carried out including the combinations of two levels of green fertilizers and six potassium fertilizes, while control treatments contain no fertilizers. A RCBD using a split plot was applied. Results revealed that growth and yield traits of Roselle plants including plant height, number of branches/plant, total dry weight/plant, fruit weight/plant, number of fruit/plant, seed weight/plant, sepals fresh and dry weight per plant and fed. and total yield of seeds/fed., leaf total chlorophyll and carotenoides, anthocyanin concentration, total carbohydrates, total acidity and P percentage in sepals were markedly improved when the green fertilizer combined with fertilizing with 75 % of the recommended Potassium rate (RR) in the form of feldspar (KF) (10.6 % K_2O) equal 530.65 kg /fed., was applied.The interaction between green fertilizer and fertilizing with 100 % RR in the form of KF possessed the greatest availability of N, P, K, pH and EC in the soil after harvest.

Keywords : Green Fertilizer , Potassium Fertilizer, Roselle plant

INTRODUCTION

Roselle (*Hibiscus sabdariffa* L.) belongs to the family Malvaceae. It is known commonly as "karkade" in Egypt and most Arab countries (Mohamed *et al.*, 2007).

The part of the flower used by customers is the dried and fleshly calyces which have large quantities of organic acids (that is, oxalic, malic, citric and tartaric acids). The calyces have, also, vitamin C and the properties of therapeutic and diuretic acids, in addition to two types of anthocyanin, namely: hibiscin (delphinidin) and gossyptin (cyanidin) (Peng-Kong *et al.*, 2002).

Green fertilizer is the plowing of cover crops while they are green or soon after they flower. Green fertilizer improves soil quality by increasing the organic matter content of soils (Duyar *et al*., 2007), acting as a source of nutrients (Dinnes *et al.* 2002), improving soil structure (Sullivan 2003), and increasing biological activity in the soil (Urzua *et al.* 2001).

Green fertilizer also, is the most important one amongest all the organic manures. It is a good management practice in agricultural production, because it can improve soil fertility and quality (Lee *et al.*, 2010) and also supply N, a primary limiting nutrient for crops (Elfstrand *et al.*, 2007).

Many researchers found that addition of organic fertilizers to plants could enhance its growth, yield and chemical constituents such as Roselle (El-Sherif and Sarwat, 2007; Akanbi *et al*., 2009; Mera *et al*., 2009; Hewidy *et al.*, 2018; Norhayati, *et al*., 2019), maize (Sangakkara *et al*., 2004; Yang *et al*., 2018), water melon (Aguyoh *et al.*, 2010), carrot (Jeptoo *et al*., 2013), cucumber (Tuzel *et al*., 2013) and tomato (Agbede *et al*., 2018).

Potassium is an important nutrient for plant meristematic growth and physiological functions, including regulation of water and gas exchange in plants, protein synthesis, enzyme activation, photosynthesis and carbohydrate translocation in plants. Potassium has favorable effects on metabolism of nucleic acids, proteins, vitamins and growth substances, energy transfer, phloem transport, cation-anion balance and enabling their ability to resist pests and diseases (Wang *et al*., 2013). In Egypt, large amounts of K- chemical fertilizers are used (such as potassium sulphate) to maximize crop yield per area unit and to compensate K-decreases in soils due to crop uptake , (Sheng and Huang 2002). The high price of these fertilizers is responsible for increasing production cost .

Fertilization of Roselle plants with potassium improving growth and yield of Roselle, in this regard Anyinkeng and Afui, (2011), Sakr *et al.* (2014), Ghasemi *et al.* (2015) , Abdel-Kader and Saleh (2017), Piri (2017) and Idris *et al.* (2018).

The use of natural potassium fertilizer and/or bio-fertilizer is low cost resources for providing plants with K which could alternate the expensive applied K-chemical

* **Corresponding author.**
E-mail address: lamyagad91@yahoo.com
DOI: 10.21608/jssae.2019.79579

fertilizers, also K-feldspar may be valuable as a slow releasing fertilizer and cheaper source of K (Labib *et al*., 2012). The use of potassium solbilizing bacteria as biofertilizer; i.e. silicate dissolving bacteria was suggested as a sustainable solution to improve plant growth, nutrition, root growth, plant competitiveness and responses to external stress factors (Dawwam *et al*., 2013). Moreover, potassium solbilizing bacteria play an important role in the formation of humus in soil, the cycling of other minerals tied up in organic matter (Zakaria, 2009). Also, it can be able to solubilize rock – K mineral powder, such as mica, illite and orthoclases (feldspar) through production and excretion of organic acids or chelate silicon ions to bring K into solution (Bennett *et al*., 1998).

Many authors reported that treated plants with K-feldspar increased growth and productivity, in this concern Shafeek *et al*. (2005) on pea , Bader (2006) on tomato, Abdel-Salam and Shams (2012) on potato, Abou-El-Seoud and Abdel-Mageed, (2012) on maize, Labib *et al*. (2012) on potato, Shams and Fekry, (2014) on sweet potato, Abou El-Khair and Mohsen (2016) on Jerusalem Artichoke and Merwad (2016) on maize.

The aim of this work was improving the soil health by using green fertilizer and feldspar which solubilized by silicate dissolving bacteria to reduce dependence of potassium chemical fertilizers (potassium sulphate) and to obtained high productivity and best sepals quality of roselle plants grown under clay soil.

MATERIALS AND METHODS

A field experiment was carried at El-Gemmeiza Agric. Res. Station, El-Gharbihya Governorate, Egypt (longitude 31 7^{o} E and latitude 30 43 ^{o} N) during the two successive summer seasons of 2017 and 2018 to evaluate the effect of green fertilizer and two source of potassium with three levels as soil application on growth, yield and leaf chemical constituents of Roselle plants (cv. Sabaheia 17) under clay soil conditions.

Particle size distribution and some chemical characteristics of the experimental Table 1. were determined according to the standard methods of Balck *et al*., (1965) and Jackson (1967).

Table 1. Soil physical and chemical analysis in 2017 and 2018 seasons

Parameter	Value	
1. Particle size distribution*	2017	2018
Corse sand (%)	3.88	5.08
Fine sand (%)	14.4	12.91
Silt (%)	40.11	42.01
Clay (%)	41.61	40.0
Textural class	clay loam	clay loam
2. Chemical analysis*		
EC dsm^{-1} (soil post extract)	2.20	2.11
pH (1: 2.5 soil : water suspension)	8.0	7.91
$CaCO_3$ (%)	2.9	2.1
Organic matter (%)	1.84	1.74
Available nitrogen (ppm)	30.0	27
Available phosphorus (ppm)	7.7	7.7
Available potassium (ppm)	400	385

*** According to Jackson (1967)**

Fourteen treatments were applied in this investigation including the combinations of green fertilizer (with or without) and two different sources of potassium each contains three levels (50, 75 and 100 % of the recommended rate (RR 75 kg K_2O) in the form of potassium sulphate (KS) 48 % K_2O) equal to 0, 78.12, 117.18 and 156.24 kg/fed. potassium sulphate, respectively and (50, 75 and 100 % of the recommended rate (RR) in the form of feldspar (KF) (10.6 % K_2O) equal to 353.77, 530.65 and 707.54 kg /fed., respectively, besides (zero) control treatment.

A randomized complete block design (RCBD) using split-plot with three replicates was applied. The main plot contains green fertilizer treatments (with or without), while source and levels of potassium were in the sub-plots. Each sub-plot was 8.4 m^2 including 3 ridges, each of 4m length and 70cm width.

The green fertilizer plant seeds of faba bean (*Vicia faba* L.) were sown on the first week of January in both seasons. Plants were incorporated into the soil after 45 days from the sowing in both seasons. After that, three samples of soil were taken monthly from March to estimate each C %, N %, C/N ratio, pH and Ec. The change in C. N, C/N ratio, pH and Ec during the composting period are show in Table 2

Table 2. The change in C. N, C/N ratio, pH and Ec during the composting period in 2017 and 2018 seasons

Composting time	C %		N%		C/N		pH (1:5)		EC (1:10 dSm$^{-1)}$	
	2017	2018	2017	2018	2017	2018	2017	2018	2017	2018
March	20.77	23.88	0.41	0.44	50.66	54.27	9.90	9.89	6.90	7
April	19.90	20.74	0.58	0.60	34.31	34.57	8.70	8.30	7.12	8.92
May	19.66	18.22	0.70	0.72	28.09	25.31	7.94	7.33	7.30	8.94
June	17.40	17.63	0.70	0.73	24.86	24.15	7.39	7.22	8.80	8.99

Seeds of Roselle (*Hibiscus sabdariffa* L.) were obtained from the Dept. Medicinal and Aromatic Plants, Hort. Res. Inst., Agric. Res. Center, Dokki, Ministry of Agric., Egypt. Sowing was on 2nd and 4th of May during the two successive seasons 2017 and 2018. The crop was sown on the top of the ridge 70 cm apart in holes at a spacing of 50 cm. Three seeds were placed in each hole which was then thinned to one plant per hill four weeks later.

Feldspar was mixed with silicate dissolving bacteria SDB *(Bacillus circulanc)* at 20 ml SDB per kg /feldspar (one ml of SDB contain 10^6 cells). The mixtures were regularly moistened and covered with plastic layer to keep the moisture content at about 60-70 % throughout the composting period for 90 days before application treatment according to Bader (2006). SDB was obtained by Central Lab. of Organic Agric. , Agric. Res. Center, Egypt.

K-feldspar is low grade rock potassium samples from a sedimentary rock materials deposit as raw mining after grinding to affine powder . Rock potassium as a feldspar and littlie powder contains (67. 94 SiO_2, 13.92 Al_2O_2, 0.09 Fe_2O_2, 0.32 CaO, 8.08 MgO, 10.6 % K_2O and 1.94% Na_2O**) .**

All plots received the recommended dose of N and P as urea (46 % N) and calcium superphosphate (15.5% P_2O_5) (at the rates of 75 kg N/fed., and 30 kg P_2O_5 /fed.,

respectively). All amounts of feldspar, phosphorus and one third of both nitrogen and potassium in the form of potassium sulphate were added during soil preparation, while the two third of nitrogen and potassium were divided into four equal portions, the first was applied after one month from sowing, whereas, the other three portions were applied every two weeks from the first beside plants. All the plots received normal agricultural practices whenever they needed.

Recorded data

Plant growth: At 170 days after sowing five plants were selected from the middle row of each plot in both seasons to estimate plant height (cm) and branch number /plant.

Leaf pigments: Disk samples from the fourth upper leaf were obtained in all plots to determined total chlorophyll (a+b) and carotenoids after 170 days from sowing in both seasons according to the method described by Wellburn (1994).

Yield and its components: After 200 days after sowing, when plants reached suitable maturity, the following data were taken : number and weight of fruits / plant, fresh seed yield / plant and per /fed., as well as fresh and dry weight of sepals /fed. (kg) were recorded**.**

Chemical constituents

Sepals were collected and dried for 48 h at 70°C to determine the total nitrogen which was determined by using semi-micro Kjeldahl method described by Bremner and Mulvaney (1982), Total phosphorus which was determined by using Spectrophotometer according to Olsen and Sommers (1982). Potassium content was determined photometrically using a flame photometer according to the method of Jackson (1970). Total carbohydrates were determined according to Dubois *et al.* (1956). Anthocyanin content was determined as described by Byamukama *et al.* (2014). Acidity of sepals was measured as described by A.O.A.C. (1990).

Statistical analysis:

Analysis of variance (ANOVA) was carried out (Snedecor and Cochranm, 1980) and the least significant differences (LSD) between treatments were estimated at at 0.05 level.

RESULTS AND DISCUSSION

Plant Growth and leaf pigments

Results in Table 3 show that, there were significant differences between green fertilizer levels on plant growth in both seasons.

Fertilizing Roselle plants grown under clay loam soil with green fertilizer recorded the greatest values of plant height, number of branches per plant and total dry weight per plant as compared to unfertilized ones in 2017 and 2018 seasons. Application of green fertilizer enhanced the plant total dry weight by 9.71 and 13.16% over unfertilized plants in the 2017 and 2018 successive seasons, respectively.

Increase in plant growth particularly after incorporated green fertilizer into soil due to improved the soil physical conditions and promoted microbial and soil organic matter, which in turn produced organic acids. These organic acids enhanced the promotive effect of auxin, which has direct effect on plant growth (Leopold, 1974). Green fertilizer also plays an important role to promote the root growth and enhance the nutrient absorption of plants as observed by Egharevba and Ogbomo (2007).

These results are in agreement with those of Akanbi *et al.* (2009) and Norhayati, *et al.* (2019) with Roselle Plant.

Effect of potassium sources and rates

Different sources and rates of potassium caused a significant increase in plant growth traits such as plant height, number of branches per plant and shoots dry weight per plant at 170 DAP than unfertilized treatment in both seasons (Table 3). However, in general fertilizing with K-feldspar (KF) was more effective than fertilizing with potassium shipmate (KS) in both grown seasons. In addition, increasing K_2O at the medium rates was the nest fir enhancing plant growth parameters. Increases in plant height, number of branches per plant and shoots dry weight per plant were obtained when plants were fertilized with K_2O at 75 % of the recommended rate (RR) in the form of feldspar, while the lowest values of above mentioned traits were recorded with zero PS or FS in the 2017 and 2018 seasons.

Table 3. Effect of green fertilizer and potassium sources and rates on plant growth of Roselle plants during 2017 and 2018 seasons

Treatments		Plant height (cm)		Number of branches/ plant		Total dry weight (g/ plant)	
		2017 season	2018 season	2017 season	2018 season	2017 season	2018 season
Effect of green fertilizer							
With		170.71	206.78	12.52	15.02	330.57	422.57
Without		166.95	197.43	10.95	12.73	301.29	373.41
LSD at 0.05 level		2.04	4.98	NS	1.61	10.19	8.87
Effect of potassium sources and rates							
0		158.66	177.33	8.88	9.23	295.00	337.67
Potassium sulpahte (KS)	50 %	163.16	197.00	10.61	12.73	307.00	371.00
	75 %	167.33	203.20	10.83	13.00	317.00	389.70
	100 %	167.83	203.80	11.05	13.27	308.00	410.79
Feldspar (KF)	50 %	172.67	209.00	12.72	15.26	298.50	386.29
	75 %	178.33	215.20	14.82	17.79	358.50	448.63
	100 %	173.83	209.19	13.23	15.87	327.50	441.88
LSD at 0.05 level		3.83	5.11	1.63	1.55	8.86	7.96

K_2O at 50 , 75 and 100 % of RR in the form of KS equal 78.12, 117.18 and 156.24 kg/fad, respectively

K_2O at 50 , 75 and 100 % of RR in the form of KF equal 353.77, 530.65 and 707.54 kg /fad. respectively

Total dry weight per plant was increased up to 21.52 and 32.86% in K2O (75% RR) in the form of FS, while it was up to 7.45 and 15.40% in K_2O (75% RR) in the form of PS than unfertilized plants in the 2017 and 2018 seasons, respectively.

The above-mentioned results may be attributed to the role of potassium element in metabolism and many processes needed to sustain and promote plant vegetative growth and development. Moreover, K plays a major role in many physiological and biochemical processes such as cell division and elongation, photosynthesis translocation of photosynthates and metabolism of carbohydrates and protein compounds (Marschner, 1995).

The use of potassium solbilizing bacteria as biofertilizer; i.e. silicate dissolving bacteria was suggested as a sustainable solution to improve plant growth, nutrition, root growth, plant competitiveness and responses to external stress factors (Dawwam *et al*., 2013). The increments in growth parameters due to inoculation with *Bacillus circulans* bacteria with feldspar might be attributed to bacteria that can solubilize them and provide faster and continuous supply of K for optimal plant growth (Priyanka and Sindhu, 2013). The previous positive action of potassium silicate on growth characters because it contains higher amounts of silicon (25 %) might be attributed to its important roles in protecting plants against (drought, cold, diseases and fungal attack), alleviating abiotic stress (heavy metals toxicity and salinity) and improving root development, uptake of water and nutrients and plant pigments (Qin and Tian 2009) as well as it contain magnesium as minor essentill macronutrient about 8% MgO.

These results are in general accordant with the findings of Abdel-Kader and Saleh (2017), Piri (2017) and Idris *et al.* (2018) on roselle with mineral potassium effect and Abdel-Salam and Shams (2012) on potato and Abd -El-Hakeem and Fekry (2014) on sweet potato and Merwad (2016) on maize with feldspar effect.

Effect of the interaction

Significant positive effects were noticed on the above mentioned growth characteristics (Table 4) concerning the interaction between green fertilizer fertilizing with different sources and rates of potassium comparing to untreated soil with manure or potassium .

The most favorable beneficial interaction treatment was attained in treated with green fertilizer interacted with fertilizing with KF at 75 % RR . Such interaction treatment recorded the tallest plants bearing the highest numbers of branches / plant with more total dry weight / plant comparing to all other interaction treatments during the two experimental seasons. While, the least vegetative growth was noticed in plants did not receive green fertilizer or any potassium source in the two successive seasons.

The combination between green manure and K_2O (75% RR) in the form of KF caused an increase in plant total dry weight up to 34.64 and 48.69%. On the other hand, it was up to 21.43 and 24.95% when green fertilizer and K_2O (75% RR) in the form of KS was applied over the control plants in the two successive seasons, respectively.

Table 4. Effect of the interaction between green fertilizer and potassium sources and rates on plant growth of Roselle plants during 2017 and 2018 seasons

Treatments			Plant height (cm)		Number of branches/ plant		Total dry weight (g/ plant)	
Green fertilizer	K source and rate		2017 season	2018 season	2017 season	2018 season	2017 season	2018 season
	0		157.67	183.47	9.11	13.33	310.00	350.52
		50 %	163.33	198.40	11.11	13.60	319.00	401.18
	KS	75 %	170.33	209.20	11.33	13.60	330.00	451.37
With		100%	170.33	209.20	11.33	16.67	321.00	419.69
		50 %	174.00	212.40	13.89	17.34	312.00	374.38
	KF	75 %	183.33	222.40	16.44	7.54	377.00	482.98
		100%	176.00	212.40	14.45	19.73	345.00	477.90
	0		159.66	171.19	8.66	12.13	280.00	324.82
		50 %	163.00	195.60	10.11	12.40	295.00	340.81
	KS	75 %	164.33	197.20	10.33	12.94	304.00	370.20
Without		100%	165.33	198.40	10.78	13.86	295.00	359.70
		50 %	171.33	205.60	11.55	14.41	285.00	398.20
	KF	75 %	171.66	205.99	12.01	15.85	340.00	405.85
		100%	171.66	205.99	12.01	15.85	295.00	405.85
LSD at 0.05 level			5.43	7.65	2.31	2.20	12.58	11.25

K_2O at 50 , 75 and 100 % of RR in the form of KS equal 78.12, 117.18 and 156.24 kg/fad, respectively
K_2O at 50 , 75 and 100 % of RR in the form of KF equal 353.77, 530.65 and 707.54 kg /fad. respectively

Roselle yield

Green fertilizer

Incorporated green fertilizer into soil resulted in significant increases in Roselle yield and its components compared to untreated soil in the two cultivated seasons Tables 5 and 6. Thus, the elevated values of fruit weight / plant (g), number of fruit / plant, Seed weight / plant (g), sepals fresh and dry weight / plant and per fad. and total yield of seeds / fad. were obtained with green fertilizer than untreated in the two growing seasons. Enhancement in sepals dry weight / fad. attained 23.17% and 19.37 % in plants treated with green fertilizer relative to dry weight of sepals / fad of plants untreated with green fertilizer during 1st and 2nd seasons, respectively.

Incorporation of green fertilizer into soil led to the enhancement of soil physical criteria including aeration, water holding capacity, nutrient availability and good balance between nutrients in the soil solution and improvement of nutrient exchange between the soils. Slow release of nutrients from the organic fertilizers during growth period and hence low leaching of the nutrients could also be other criteria, which improved vegetative growth and flower induction that are related to sepal's weight and the yield index as well as the growth promoting

agent released during green fertilizer degredation. (Gendy *et al*., 2012).

These results might be attributed to the favorable effect of green fertilizer during the growth period that resulted more vegetative plant growth (plant height, number of shoots / plant and total dry weight (Table 3) that induced more photosynthetic and minerals absorption rates. This in turn produced high carbohydrates in plant tissues that gave rise to more cell division and enlargement; this was reflected as producing more yields.

Results are in agreement with those mentioned by El-Sherif and Sarwat (2007), Akanbi *et al.* (2009), Mera *et al*. (2009) **Hewidy** *et al.* (2018) and Norhayati, *et al*. (2019) on Roselle. They found that treated plants with green fertilizers increased plant growth and leaf pigments than untreated.

Effect of potassium sources and rates

Data of the same Tables 5 and 6 showed that fertilizing Roselle plants with different sources and rates of potassium significantly increased yield and its components comparing to unfertilized control plants during 1st and 2nd seasons. More increases in yield parameters were found in plants received the moderate rate of KF comparing to those fertilized with KS in both seasons. Fertilized plants FS at 75 % RR recorded the best results for increasing fruit weight / plant (g), number of fruit / plant, Seed weight / plant (g), sepals fresh and dry weight per plant and per fad. and total yield of seeds / fed. than other treatments in the 2017 and 2018 seasons.

The sepals dry weight of sepals/fed. was raised up to 58.62 and 48.30% in plants fertilized with KF at 75% RR, 52.76 and 37.74% for KS at 75% RR over unfertilized plants with KS or KF during 1st and 2nd seasons, respectively.

Potassium promotes photosynthesis, fruit formation and activates enzymes and co-enzymes to metabolize carbohydrates and increases oil content in oil crops (Sakr *et al*., 2014).

These results are in accordance with those obtained by Sakr *et al.* (2014), Ghasemi *et al*. (2015) and Idris *et al.* (2018) on roselle with mineral potassium effect and Shams and Fekry, (2014) on sweet potato, Abou El-Khair and Mohsen (2016) on Jerusalem Artichoke and Merwad (2016) on maize with feldspar effect.

Table 5. Effect of green fertilizer and potassium sources and rates on yield and its components of Roselle plants during 2017 and 2018 seasons

Treatments		Fruit weight / plant (g)		Number of fruit / plant		Seed weight / plant (g)		Seed yield /fed. (kg)	
		2017 season	2018 season	2017 season	2018 season	2017 season	2018 season	2017 season	2018 season
Effect of green fertilizer									
With		601.67	633.03	128.36	152.32	57.44	68.24	565.03	611.22
Without		453.62	503.49	117.23	140.21	50.01	59.73	427.72	461.55
LSD at 0.05 level		10.64	6.14	4.61	2.04	3.06	3.22	14.19	13.48
Effect of potassium sources and rates									
0		381.84	375.80	82.06	93.20	36.20	40.04	370.97	388.01
KS	50 %	414.17	431.00	100.50	120.60	50.68	60.81	450.31	474.48
	75 %	435.50	462.60	109.88	131.86	55.54	66.65	559.60	609.97
	100%	584.67	635.60	123.89	148.67	61.89	74.26	484.16	527.74
KF	50 %	532.84	627.40	139.00	166.80	51.70	62.04	487.62	531.50
	75 %	705.17	786.20	156.50	185.40	62.40	74.88	608.62	663.40
	100%	639.34	659.20	147.77	177.33	57.69	69.23	513.39	559.59
LSD at 0.05 level		9.55	5.51	4.14	2.83	2.95	3.10	12.73	12.10

K_2O at 50 , 75 and 100 % of RR in the form of KS equal 78.12, 117.18 and 156.24 kg/fad, respectively
K_2O at 50 , 75 and 100 % of RR in the form of KF equal 353.77, 530.65 and 707.54 kg /fad. respectively

Table 6. Effect of green fertilizer and potassium sources and rates on fresh and dry yield of Roselle sepals during 2017 and 2018 seasons

Treatments		Fresh yield sepals /plant (g)		Dry yield sepals /plant (g)		Fresh yield sepals /fed. (Kg)		Dry yield sepals /fed. (Kg)	
		2017 season	2018 season	2017 season	2018 season	2017 season	2018 season	2017 season	2018 season
Effect of green fertilizer									
With		358.73	389.87	66.97	68.25	4053.64	4405.58	756.76	771.22
Without		300.29	357.01	54.37	57.18	3393.23	4034.21	614.38	646.09
LSD at 0.05 level		6.38	8.19	0.95	1.63	70.97	106.2	10.64	12.15
Effect of potassium source and rates									
0		214.95	245.28	43.16	48.66	2428.95	2771.62	487.70	549.80
KS	50 %	280.60	312.22	54.81	55.77	3170.80	3528.09	619.30	630.14
	75 %	357.00	403.40	65.93	67.02	4034.10	4558.42	745.01	757.27
	100%	337.50	383.00	66.08	64.30	3813.75	4327.90	746.70	726.59
KF	50 %	344.00	412.80	61.45	64.73	3887.20	4664.64	694.33	731.45
	75 %	403.00	453.00	68.46	72.16	4553.90	5118.90	773.60	815.35
	100%	369.50	404.40	64.81	66.37	4175.35	4569.72	732.35	749.98
LSD at 0.05 level		5.73	7.35	0.85	1.47	63.69	95.54	9.55	14.22

K_2O at 50 , 75 and 100 % of RR in the form of KS equal 78.12, 117.18 and 156.24 kg/fad, respectively
K_2O at 50 , 75 and 100 % of RR in the form of KF equal 353.77, 530.65 and 707.54 kg /fad. respectively

Effect of the interaction

The interaction treatments between soil treatment with green fertilizer and fertilization with potassium at different sources and rates had significant effects on yield and its components than untreated plants in both seasons (Tables 7 and 8). It was found that the most significant favorable beneficial interaction treatment for increasing fruit weight / plant (g), number of fruit / plant, seed weight / plant (g), sepals fresh and dry weight per plant and per fed. and total yield of seeds / fed. were obtained when Roselle plants treated with green fertilizer and fertilized with KF at 75 % RR, followed by the interaction between green fertilizer and fertilized with KS at 75 % RR, while the interaction between green fertilizer and FS at 100 % RR came in the third rank in both growing seasons. The lowest values of yield and its components were recorded with untreated plants with green fertilizer of potassium treatments.

The relative increases in dry weight of sepals / fad. were 89.02 and 78.29 % for treated with green fertilizer and fertilized with KF at 75 % RR, 79.32 and 65.42 % for the interaction between green fertilizer and fertilized with KS at 75 % RR over 0 green fertilizer and 0 potassium in the 1st and 2nd seasons, respectively.

Table 7. Effect of the interaction between green fertilizer and potassium sources and rates on yield and its components of Roselle plants during 2017 and 2018 seasons

Treatments			Fruit weight / plant (g)		Number of fruit / plant		Seed weight / plant (g)		Seed yield /fed. (kg)	
Green fertilizer	K source and rate		2017 season	2018 season	2017 season	2018 season	2017 season	2018 season	2017 season	2018 season
	0		461.67	423.20	88.78	99.34	41.63	45.16	395.39	398.28
	KS	50 %	505.67	486.80	104.11	124.93	51.89	62.27	463.92	505.67
		75 %	541.00	529.20	113.11	135.73	61.20	73.44	677.19	738.14
With		100%	689.33	707.20	127.44	152.93	63.32	75.98	543.33	592.23
	KF	50 %	582.00	686.40	149.11	178.93	53.33	64.00	521.81	568.77
		75 %	718.33	862.00	163.55	191.46	65.69	78.83	773.80	843.44
		100%	713.67	736.40	152.44	182.93	65.03	78.04	579.80	631.98
	0		302.00	328.40	75.33	87.07	30.77	34.92	346.54	377.73
	KS	50 %	322.67	375.20	96.88	116.26	49.47	59.36	436.69	443.29
		75 %	330.00	396.00	106.66	127.99	49.89	59.87	442.01	481.79
Without		100%	480.00	564.00	120.33	144.40	60.46	72.55	425.00	463.25
	KF	50 %	483.67	568.40	128.89	154.67	50.07	60.08	453.42	494.23
		75 %	692.00	710.40	149.44	179.33	59.11	70.93	443.44	483.35
		100%	565.00	582.00	143.11	171.73	50.36	60.43	446.97	487.20
LSD at 0.05 level			13.51	7.80	5.85	4.02	4.18	4.40	18.01	17.11

K_2O at 50 , 75 and 100 % of RR in the form of KS equal 78.12, 117.18 and 156.24 kg/fad, respectively
K_2O at 50 , 75 and 100 % of RR in the form of KF equal 353.77, 530.65 and 707.54 kg /fad. Respectively

Table 8. Effect of the interaction between green fertilizer and potassium sources and rates on fresh and dry yield of Roselle sepals during 2017 and 2018 seasons

Treatments			Fresh yield sepals /plant (g)		Dry yield sepals /plant (g)		Fresh yield sepals /fed. (Kg)		Dry yield sepals /fed. (Kg)	
Green fertilizer	K source And rate		2017 season	2018 season	2017 season	2018 season	2017 season	2018 season	2017 season	2018 season
	0		223.90	256.68	45.70	51.24	2530.1	2900.5	516.4	579.0
	KS	50 %	334.20	352.04	62.70	59.24	3776.5	3978.1	708.5	669.4
		75 %	408.00	439.60	72.84	76.21	4610.4	4967.5	823.1	861.2
With		100%	376.00	407.20	66.83	64.20	4248.8	4601.4	755.2	725.5
	KF	50 %	346.00	415.20	71.92	74.30	3909.8	4691.8	812.7	839.6
		75 %	439.00	465.60	76.78	82.14	4960.7	5261.3	867.6	928.2
		100%	384.00	392.80	72.02	70.42	4339.2	4438.6	813.8	795.7
	0		206.00	233.87	40.62	46.07	2327.8	2642.7	459.0	520.6
	KS	50 %	227.00	272.40	46.91	52.29	2565.1	3078.1	530.1	590.9
		75 %	306.00	367.20	59.02	57.82	3457.8	4149.4	666.9	653.4
Without		100%	299.00	358.80	65.33	64.40	3378.7	4054.4	738.2	727.7
	KF	50 %	342.00	410.40	50.97	55.16	3864.6	4637.5	576.0	623.3
		75 %	367.00	440.40	60.14	62.17	4147.1	4976.5	679.6	702.5
		100%	355.00	416.00	57.60	62.32	4011.5	4700.8	650.9	704.2
LSD at 0.05 level			8.10	10.40	1.21	2.08	90.07	135.11	13.51	20.19

K_2O at 50 , 75 and 100 % of RR in the form of KS equal 78.12, 117.18 and 156.24 kg/fad, respectively
K_2O at 50 , 75 and 100 % of RR in the form of KF equal 353.77, 530.65 and 707.54 kg /fad. Respectively

Leaf pigments and sepals quality

There were significant differences between the treatments of with or without green fertilizer to soil on leaf pigments and sepals quality during 2017 and 2018 seasons (Table 9).

The confirmed results showed that, treated Roselle plants with green fertilizer produced leaf with high pigments and sepals with best quality expressed as containing high values of total carbohydrates % , anthocynene concentration and total acidity % than untreated plants with green fertilizer in the 2017 and 2018 seasons.

Green fertilizer increased the availability and uptake of nutrients, which enhanced the higher

photosynthetic activity and in turn, corresponded to the higher amounts of anthocyanin.

These results are in line with Tuzel *et al*. (2013) on cucumber, Agbede *et al*. (2018) on tomato and Yang *et al*., (2018) on maize and Norhayati, *et al*. (2019) on Roselle

Potassium sources and rates

Different rates of Kf or Ks fertilization possessed a positive increase in leaf total chlorophyll and carotenoids and anthocyanin concentration, total carbohydrates % and total acidity % in sepals than unfertilized plants in 2017 and 2018 seasons (Table 9).

Table 9. Effect of green fertilizer and potassium sources and rates on plant growth and leaf pigments of Roselle plants during 2017 and 2018 seasons

Treatments		Total chlorophyll (mg/g FW)		Carotenoides (mg/g FW)		Total carbohydrates (%)		Anthocynene (mg/100 g)		Acidity (%)	
		2017 season	2018 season	2017 season	2018 season	2017 season	2018 season	2017 season	2018 season	2017 season	2018 season
Effect of green fertilizer											
With		2.76	2.82	1.52	1.69	15.29	17.97	18.76	19.38	4.95	4.99
Without		2.63	2.59	1.47	1.53	14.87	16.41	18.31	18.47	4.76	4.57
LSD at 0.05 level		0.06	0.09	0.04	0.07	0.15	0.62	0.35	0.56	0.14	0.11
Effect of potassium source and rates											
0		2.07	2.03	1.35	1.33	13.96	14.34	16.42	15.08	4.03	3.81
Potassium sulpahte (KS)	50 %	2.33	2.47	1.40	1.56	14.40	15.59	17.42	17.62	4.86	4.41
	75 %	2.51	2.65	1.44	1.63	14.85	17.63	18.23	18.96	4.94	4.80
	100 %	2.74	2.73	1.47	1.61	15.28	18.01	18.79	19.55	4.98	5.03
Feldspar (KF)	50 %	2.93	2.81	1.49	1.61	15.35	18.02	18.64	19.39	4.93	5.05
	75 %	3.23	3.23	1.70	1.83	16.16	18.92	20.79	21.63	5.16	5.19
	100 %	3.09	2.99	1.60	1.69	15.60	17.83	19.48	20.26	5.10	5.18
LSD at 0.05 level		0.06	0.08	0.03	0.07	0.14	0.21	0.31	0.48	0.08	0.07

K_2O at 50 , 75 and 100 % of RR in the form of KS equal 78.12, 117.18 and 156.24 kg/fad, respectively
K_2O at 50 , 75 and 100 % of RR in the form of KF equal 353.77, 530.65 and 707.54 kg /fad. respectively

Generally, Kf fertilization attained the greatest concentrations of leaf chlorophyll and carotenoids and produced sepals with the highest values of total carbohydrates, anthocyanin and total acidity than Ks fertilization. However, KF at 75% RR exhibited the greatest values of total carbohydrates, anthocyanin and total acidity.This may be due to kf contain other ions like Sio_2, Fe and Mg which affect.

The results are in conformity with the findings of Abdel-Kader and Saleh (2017), Piri (2017) and Idris *et al.* (2018) on roselle regarding mineral potassium effect and Abou El-Khair and Mohsen (2016) on Jerusalem Artichoke concerning feldspar effect.

Effect of the interaction

The interaction between green fertilizer and fertilization with potassium at different sources and rates had significant effect on leaf pigments and sepals quality than control treatment in 2017 and 2018 seasons (Table 10).

Interaction treatment of green fertilizer and fertilizing with KF at 75% RR attained maximum levels of Roselle leaf total chlorophyll and carotenoids and it gave the best sepals quality expressed total carbohydrates %, anthocyanin concentration and total acidity % than other interaction treatments. On the other hand, untreated plants with green fertilizer or potassium produced sepals with the lowest leaf pigments and sepals' quality during 2017 and 2018 seasons.

Chemical constituents of sepals

There were significant differences between two rates of fertilizer on N, P and K contents in sepals during 2017 and 2018 seasons (Table 11).

Table 10. Effect of the interaction between green fertilizer and potassium sources and rates on plant growth and leaf pigments of Roselle plants during 2017 and 2018 seasons

Treatments			Total chlorophyll (mg/g FW)		Carotenoides (mg/g FW)		Total carbohydrates (%)		Anthocynene (mg/100 g)		Acidity (%)	
Green fertilizer	K source	and rate	2017 season	2018 season	2017 season	2018 season	2017 season	2018 season	2017 season	2018 season	2017 season	2018 season
With		0	2.19	2.27	1.35	1.45	14.05	16.44	16.70	16.37	4.03	4.23
	KS	50 %	2.54	2.44	1.41	1.61	14.61	17.56	17.64	18.35	4.85	4.72
		75 %	2.69	2.59	1.45	1.65	15.01	18.06	18.35	19.08	5.05	4.97
		100%	2.81	2.71	1.48	1.68	15.44	18.31	18.93	19.69	5.04	5.19
	KF	50 %	2.86	2.94	1.53	1.73	15.65	18.42	18.91	19.67	5.12	5.11
		75 %	3.48	3.28	1.79	1.99	16.59	19.41	21.33	22.18	5.26	5.36
		100%	3.10	3.17	1.63	1.73	15.74	17.56	19.52	20.30	5.27	5.32
Without		0	180	1.94	1.34	1.21	13.88	12.24	16.14	13.79	4.03	3.38
	KS	50 %	2.41	2.21	1.38	1.52	14.20	13.61	17.20	16.89	4.86	4.10
		75 %	2.62	2.42	1.42	1.62	14.69	17.19	18.11	18.83	4.82	4.62
		100%	2.66	2.76	1.45	1.55	15.13	17.70	18.65	19.40	4.91	4.87
	KF	50 %	2.77	2.91	1.44	1.50	15.05	17.61	18.37	19.10	4.74	4.98
		75 %	2.89	3.00	1.56	1.66	15.74	18.42	20.26	21.07	5.06	5.01
		100%	2.89	3.00	1.56	1.66	15.46	18.09	19.44	20.22	4.93	5.03
LSD at 0.05 level			0.12	0.08	0.05	0.06	0.19	0.34	0.45	0.76	0.14	0.12

K_2O at 50 , 75 and 100 % of RR in the form of KS equal 78.12, 117.18 and 156.24 kg/fad, respectively
K_2O at 50 , 75 and 100 % of RR in the form of KF equal 353.77, 530.65 and 707.54 kg /fad. respectively

Table 11. Effect of green fertilizer and potassium source and rates on N,P and K contents of Roselle sepals during 2018 seasons

Treatments		N (%)		P (%)		K (%)	
		2017 season	2018 season	2017 season	2018 season	2017 season	2018 season
Effect of green fertilizer							
With		1.75	1.80	0.255	0.264	4.07	4.19
Without		1.49	1.50	0.201	0.202	3.54	3.59
LSD at 0.05 level		0.07	0.16	0.017	0.022	0.10	0.28
Effect of potassium source and rates							
	0	1.26	1.21	0.174	0.179	3.29	3.25
	50 %	1.47	1.47	0.189	0.185	3.52	3.59
KS	75 %	2.01	2.07	0.197	0.197	4.42	4.55
	100%	1.70	1.76	0.225	0.233	4.03	4.16
	50 %	1.51	1.57	0.233	0.241	3.40	3.50
KF	75 %	1.80	1.86	0.267	0.275	4.17	4.30
	100%	1.58	1.63	0.313	0.323	3.80	3.92
LSD at 0.05 level		0.06	0.09	0.015	0.029	0.09	0.16

K_2O at 50 , 75 and 100 % of RR in the form of KS equal 78.12, 117.18 and 156.24 kg/fad, respectively
K_2O at 50 , 75 and 100 % of RR in the form of KF equal 353.77, 530.65 and 707.54 kg /fad. respectively

Treated Roselle plants with green fertilizer gave the highest N, P and K contents in sepals than untreated plants with green fertilizer in the 2017 and 2018 seasons. This may be due to the increase in available N,P and K in soil related to green fertilizer.

These results are in line with Norhayati, *et al*. (2019) on Roselle

Effect of potassium sources and rates

Such data in the same Table showed that the used rates of both KS or KF possessed a significant effect on nitrogen, phosphorus and potassium percentage in sepals than unfertilized plants in both seasons.

Sepal contents of nitrogen, phosphorus and potassium were greater in the KF treatment than those of KS during the 2017 and 2018 seasons. However, the elevated values of nitrogen and potassium were obtained with 75 % RR in the form of KS, while the highest values of P% with KF at 75 % RR.

Potassium activates several enzymes especially in the metabolism of carbohydrates. The main effect of K_2O on carbohydrate, nitrogen and phosphorus percentages confirm that these percentages were raised as K_2O rate increased. Potassium percentage in plant leaves followed similar the above mention trend, but a significant linear relationship between increase in K_2O rate and increase in potassium percentage was detected (Liu *et al.,* 2010).

The results are in conformity with the findings of Abdel-Kader and Saleh (2017) on roselle regarding mineral potassium effect and Abou El-Khair and Mohsen (2016) on Jerusalem artichoke concerning feldspar effect

Effect of the interaction

The interaction between green fertilizer and fertilization with different sources and rates of potassium exhibited positive outcome for sepal chemical constituents in comparison with control treatment during the two cultivated seasons (Table 12).

Table 12. Effect of the interaction between green fertilizer and potassium sources and rates on N,P and K contents of Roselle sepals during 2017 and 2018 seasons

Treatments			N (%)		P (%)		K (%)	
Green fertilizer	K source and rates		2017 season	2018 season	2017 season	2018 season	2017 season	2018 season
	0		1.33	1.37	0.175	0.180	3.61	3.72
		50 %	1.60	1.65	0.198	0.204	3.86	3.98
	KS	75 %	2.30	2.37	0.200	0.206	4.77	4.91
With		100%	1.97	2.03	0.251	0.259	4.22	4.35
		50 %	1.53	1.58	0.254	0.262	3.73	3.84
	KF	75 %	1.87	1.93	0.312	0.321	4.30	4.43
		100%	1.63	1.68	0.401	0.413	4.00	4.12
	0		1.20	1.04	0.173	0.178	2.98	2.77
		50 %	1.35	1.29	0.181	0.166	3.19	3.19
	KS	75 %	1.72	1.77	0.195	0.187	4.07	4.19
Without		100%	1.44	1.48	0.200	0.206	3.85	3.97
		50 %	1.50	1.55	0.213	0.219	3.07	3.16
	KF	75 %	1.73	1.78	0.222	0.229	4.05	4.17
		100%	1.53	1.58	0.225	0.232	3.60	3.71
LSD at 0.05 level			0.09	0.14	0.022	0.046	0.14	0.26

K_2O at 50 , 75 and 100 % of RR in the form of KS equal 78.12, 117.18 and 156.24 kg/fad, respectively
K_2O at 50 , 75 and 100 % of RR in the form of KF equal 353.77, 530.65 and 707.54 kg /fad. respectively

Interaction treatment of green fertilizer X fertilizing with KS at 75 % RR resulted in sepals containing high N and K % comparing to other interaction treatments. While the interaction treatment with green fertilizer and fertilizing with KF at 75 % RR recorded sepals containing high P% in both seasons.

Availability of macronutrients in soil after harvest:

Effect of green fertilizer

Data presented in Table (13) show the values of available macronutrients such as N, P and K (mg/Kg) and EC in the studied soil were positively influenced by different green fertilizer, while pH of soil did not affected

by green fertilizer. Soil treated with green fertilizer had higher values of available N, P and K as well as EC in the soil than untreated treatment in both seasons.

Green fertilizer is the plowing of cover crops while they are green or soon after they flower, also green fertilizer improves soil quality by increasing the organic matter content of soils (Duyar *et al*., 2007), acting as a source of nutrients (Dinnes *et al.* 2002), improving soil structure (Sullivan 2003), and increasing biological activity in the soil (Urzua *et al*. 2001).

Table 13. Effect of green fertilizer and potassium source and rates on soil analysis after harvesting during 2017 and 2018 seasons

Treatments		Available N (ppm)		Available P (ppm)		Available K (ppm)		pH		Ec (dsm^{-1})	
		2017 season	2018 season	2017 season	2018 season	2017 season	2018 season	2017 season	2018 season	2017 season	2018 season
						Effect of green fertilizer					
With		39.08	41.25	9.22	9.59	475.60	481.92	8.14	8.13	2.048	2.048
Without		38.44	37.68	8.95	8.92	466.96	469.30	8.09	7.98	1.856	1.728
LSD at 0.05 level		0.51	0.98	0.16	0.42	7.09	9.81	NS	NS	0.01	0.02
						Effect of potassium source and rates					
0		36.17	35.16	8.01	7.94	437.96	440.15	7.96	7.82	1.408	1.408
KS	50 %	37.25	38.30	8.39	8.66	453.06	455.34	8.04	7.95	1.664	1.664
	75 %	38.07	39.22	8.74	8.97	461.16	464.71	8.12	8.02	1.792	1.728
	100%	39.40	40.80	9.09	9.33	477.46	479.72	8.16	8.10	1.92	1.92
KF	50 %	39.58	39.72	9.27	9.60	479.03	483.97	8.12	8.09	2.048	2.048
	75 %	40.10	41.25	9.83	9.99	488.42	495.20	8.18	8.17	2.304	2.176
	100%	40.75	41.83	10.28	10.32	501.90	510.19	8.22	8.25	2.56	2.432
LSD at 0.05 level		0.46	0.69	0.14	0.22	6.36	10.77	0.04	0.06	0.064	0.064

K_2O at 50 , 75 and 100 % of RR in the form of PS equal 78.12, 117.18 and 156.24 kg/fad, respectively
K_2O at 50 , 75 and 100 % of RR in the form of FS equal 353.77, 530.65 and 707.54 kg /fad. respectively

Effect of potassium sources and rates

Both KS or KF had reflected significant effect on the available of macronutrients such as N, P , K, pH and EC in the soil after harvest than untreated soil in both seasons , also increasing the rate of potassium to the soil up to 100 % RR increased the available of N, P and K as well as pH and EC in the soil than other rates (Table 13). However, the highest values of available of N, P and K as well as pH and EC were obtained with KF at 100 % RR, followed by KF at 75% RR, while KS at 100 RR came in the third rank. On the other, hand untreated soil gave the lowest values of above-mentioned traits.

Potassium solbilizing bacteria play an important role in the formation of humus in soil, the cycling of other minerals tied up in organic matter (Zakaria, 2009). Also, it can be able to solubilize rock – K mineral powder, such as mica, illite and orthoclases (feldspar) through production and excretion of organic acids or chelate silicon ions to bring K into solution (Bennett *et al*., 1998).

Effect of the interaction

The interaction treatments between green fertilizer and potassium treatments had significant effect on the available of N, P and K as well as pH and EC in the soil after harvest in 2017 and 2018 seasons (Table 14). The best interaction treatments for increasing the available of N, P and K in the soil were recorded with treated soil with green fertilizer and fertilizing Roselle plants with KF at 100 % RR.

Table 14. Effect of the interaction between green fertilizer and potassium source and rates on soil analysis after harvesting during 2017 and 2018 seasons

Treatments			Available N (ppm)		Available P (ppm)		Available K(ppm)		pH		Ec (dsm^{-1})	
Green fertilizer	K source and rates		2017 season	2018 season	2017 season	2018 season	2017 season	2018 season	2017 season	2018 season	2017 season	2018 season
With	0		36.45	38.14	8.02	8.12	442.20	452.14	7.98	7.88	1.472	1.408
	KS	50 %	37.40	40.42	8.46	9.17	456.30	460.15	8.09	8.02	1.792	1.728
		75 %	38.21	41.15	8.89	9.51	464.20	467.28	8.14	8.15	1.856	1.792
		100%	39.92	42.35	9.19	9.71	480.41	483.25	8.17	8.15	1.984	2.048
	KF	50 %	40.02	41.28	9.44	9.85	480.71	487.15	8.15	8.17	2.176	2.24
		75 %	40.49	42.27	10.02	10.12	495.11	501.22	8.21	8.22	2.496	2.432
		100%	41.10	43.15	10.55	10.65	510.30	522.23	8.25	8.32	2.56	2.624
Without	0		35.89	32.18	8.00	7.75	433.71	428.15	7.95	7.76	1.408	1.344
	KS	50 %	37.10	36.18	8.32	8.15	449.81	450.52	8.00	7.88	1.6	1.536
		75 %	37.94	37.28	8.59	8.42	458.12	462.14	8.10	7.89	1.728	1.6
		100%	38.89	39.24	8.99	8.95	474.51	476.18	8.15	8.04	1.92	1.792
	KF	50 %	39.15	38.15	9.10	9.35	477.35	480.79	8.10	8.01	1.984	1.856
		75 %	39.72	40.22	9.64	9.85	481.72	489.17	8.15	8.11	2.176	1.92
		100%	40.41	40.51	10.01	9.98	493.50	498.15	8.20	8.17	2.432	2.176
LSD at 0.05 level			0.65	0.98	0.20	0.32	9.00	15.22	0.06	0.08	0.064	0.128

K_2O at 50 , 75 and 100 % of RR in the form of PS equal 78.12, 117.18 and 156.24 kg/fad, respectively
K_2O at 50 , 75 and 100 % of RR in the form of FS equal 353.77, 530.65 and 707.54 kg /fad. respectively

CONCLUSION

In respect to results of this investigation, due to the high price of potassium fertilizer it could be concluded to the interaction between incorporation of faba bean into the soil after 45 days from the sowing (green fertilizer) and fertilizing with 75 % of the recommended rate (RR) in the form of feldspar (KF) (10.6 % K_2O) equal 530.65 kg /fed. was the most effective treatment to improve Roselle growth and yield, as it recorded the highest chemical constituents in sepals, while the interaction between green fertilizer and fertilizing with 100 % RR in the form of KF improving soil properties.

REFERENCES

A.O.A.C. Association of Official Agricultural Chemists, (1990). Official methods of analysis. 10th. Ed. A.O.A.C., Washington, Dc, USA.

Abd-El-Hakeem , S. S. and W.A. Fekry,(2014). Effect of K-Feldspar, potassium sulphate and silicate dissolving bacteria on growth, yield and quality of sweet potato plants. Zagazig J. Agric. Res., 41 (3): 467-477.

Abdel-Kader A.A.S. and F.E.M. Saleh (2017). Improvement of yield and quality of roselle (*Hibiscus sabdariffa* L.) plant by using natural sources of phosphorus and potassium in calcareous sandy soils. Scientific J. Flowers & Ornamental Plants, 4(3):233-244.

Merwad A.M.A. (2016). Efficiency of K-sulphate and K-feldspar Combined with Silicate Dissolving Bacteria on Yield and Nutrient Uptake by Maize Plants. *Egypt. J. Soil Sci*., 56 (2): 249- 259 .

Abdel-Salam M.A. and A.S. Shams (2012). Feldspar-K fertilization of potato (*Solanum tuberosum* L.) augmented by Biofertilizer. Amer.-Eurasian J. Agric. & Environ. Sci., 12 (6): 694-699.

Abou El-Khair E. E. and A. A. M. Mohsen (2016). Effect of natural sources of potassium on growth, mineral uptake and productivity of Jerusalem Artichoke grown in new reclaimed soil conditions . Middle East J. Agric., 5(3): 367-377.

Abou-El-Seouda B. and A. Abdel-Megeed (2012). Impact of rock materials and biofertilizations on P and K availability for maize (*Zea Maize*) under calcareous soil conditions. Saudi J. Biol. Sci., 19 (1): 55–63.

Agbede T. M., A.O. Adekiya, M. O.Ale , E. K. Eifediyi and C. A. Olatunji (2018). Soil properties, growth, fruit yield, mineral, lycopene and vitamin C contents of Tomato (*Lycopersicon esculentum* Mill) grown with green fertilizers and NPK Fertilizer. Agric. Conspec. Sci. 83 (4): 291-297.

Aguyoh J.N., W. Audi, M. Saidi and L. Gao-Qiong (2010). Growth, yield and quality response of watermelon (*Citrullus lanatus* CV. Crimson Sweet) subjected to different levels of tithonia manure. Inter. J. Sci. and Nature 1(1):7-11.

Akanbi, W.B, A.B. Olaniyan, A.O. Togun, Ilupeju, A.E.O and O.A. Olaniran (2009). The Effect Of organic and inorganic Fertilizer on Growth, Calyx Yield and Quality of Roselle (*Hibiscus Sabdariffa L.).* American-Eurasian Journal of Sustainable Agriculture, 3(4): 652-657.

Anyinkeng N. and M. M. Afui (2011). Soil nutrient supplementation on growth and biomass production of Roselle under tropical conditions. Agric. Biol. J. N. Am., 2(4): 603-609.

Bader, M.A. (2006). Efficiency of K-feldspar combined with organic materials and silicate-dissolving bacteria on tomato yield. *Journal of Applied Sciences Research*, 2, 1191-1198.

Bader, M.A., A. M.Shafei and S. H. Sharaf El-Deen (2006). The dissolution of K and P-bearing minerals by silicate dissolving bacteria and their effect on sorghum growth. Res. J. Agric. Biol. Sci., 2 (1), 5–11.

Bennett, P.C., W.J. Choi and J.R. Rogers (1998). Microbial destruction of feldspars. Mineral Mag., 62 A: 129-150.

Bin, J.(1983). Utilization of green fertilizer for raising soil fertility in China. *Soil Science*, 115:65-66.

Black , C . A. , D . D . Evans , J . L . White , L . E . Ensminger and F . E . Clark (1965) . Methods of soil analysis . Am. Soc . Agron . Inc. pub.Co. New York.

Bremner, J. M., and C. S. Mulvaney (1982)". Total nitrogen" In: Page, A. L., R. H. Miller, and D. R. Keeney (Eds)." Methods of Soil Analysis." Part 2, Amer.Soc. Agron. Madison, W. I. USA. pp. 595-624.

Byamukama R., M. andima, A. Mbabazi and B.T.Kiremire (2014). Anthocyanins from mulberry (*Morus ruba*) fruits as potential natural colour additives in yoghurt . African J. of Pure and Applied chemistry 8 (12): 182-190.

Dawwam, G.E., A. Elbeltagy, H.M. Emara, I.H. Abbas and M.M. Hassan (2013). Beneficial effect of plant growth promoting bacteria isolated from the roots of potato plant. Ann. Agric. Sci., 58 (2): 195-201.

Dinnes D.L., D.L. Karlen, D.B. Jaynes, T.C. Kapsar, J.L. Hatfield, T.S. Colvin, and C.A. Cambardella (2002) Nitrogen management strategies to reduce nitrate leaching in tile drained Midwestern soils. Agron J 94: 153–171.

Dubois, M., K.A. Gilles, J.H. Robers and F. Smith (1956). Colorimetric methods for determination of sugar and related substances.Anal. Chem., 28: 350-356.

Duyar H., Y. Tüzel and O.Kılıç (2007). Effects of green fertilizer fertilization on organic lettuce production in greenhouse. In: Proceedings of the Fifth National Horticulture Congress, 4–7 September 2007, Erzurum, pp. 45–49 (in Turkish).

Egharevba, R.K.A. & Ogbomo, L.K.E. (2007). Comparative effects of two nitrogen sources on the growth and yield of roselle (*Hibicus sabdariffa*) in the rainforest region: a case study of Benin-city, Edo State, Nigeria. *Journal of Agronomy*, 6(1): 142-146.

Elfstrand, S.; Båth, B. and Mårtensson, A. 2007. Influence of various forms of green fertilizer amendment on soil microbial community composition, enzyme activity and nutrient levels in leek. *Applied Soil Ecology*, 36:70-82.

El-Sherif, M.H. and Sarwat, M.I.(2007). Physiological and chemical variations in producing roselle plant (*Hibicus sabdariffa* L.) by using some organic farmyard manure. *World Journal of Agricultural Sciences*, 3(5): 609-616.

Gendy, A.S.H., H.A.H. Said-Al Ahl, and A.A. Mahmoud (2012). Growth, productivity and chemical constituents of Roselle (*Hibiscus sabdariffa* L.) plants as influenced by cattle manure and biofertilizers treatments. Austr. J. Basic and Appl. Sci., 6(5): 1-12.

Ghasemi, S., K. Abbaszadeh, M. Ghasemi, M. Salari and F. Zarei (2015). Effect of application of Nitrogen and Potassium fertilizers on some vegetative and reproductive traits in Roselle (*Hibiscus sabdariffa*). Inter. J. Agron. Agric. Res. 7(2): 75-79.

Gu R.S. and Q.X. Wen (1981). Cultivation and application of green manure in paddy field of China. In: Proc. Symp. on Paddy Soil. Pil 207-219. Science Press, Beijing; Springer-Verlag, New York

Hewidy M. , E. Sultan and M. Elsayed (2018). Water schedule of roselle (*Hibiscus sabdariffa* L.) under organic fertilization. Egypt. J. Hort. 45 (1): 53 – 64.

Idris M., A. Emmanuel, Oyebanji O. F., and H. Louis (2018). Effect of different levels of NPK fertilizer on the growth and yield of Roselle (*Hibiscus sabdariffa L)* in Yola Adamawa State of Nigeria. *Inter. Res. J. Environ. Sci.* 7(11): 37-41.

Jackson, M. L. (1967)." Soil Chemical Analysis", Prentice Hall, Inc., Englewood Cliffs, USA.

Jackson, M. L. (1970)." Soil Chemical Analysis". Prentic Hall, Englewood Ceiffs, N. J.

Leopold, A.C., B.W. Poovaiah, R.K. Dela Fuente, and R.J. Williams (1974). Regulation of growth with inorganic solutes. In: Plant Growth Substances, Tokyo: Hirokawa Publishing Coperation pp. 780-788

Jeptoo, A., J.N. Aguyoh, and M.Saidi (2013). Tithonia manure improves carrot yield and quality . *G.J.B.A.H.S.,Vol.2(4):136-142*.

Labib, B.F., T.K. Ghabour, I.S. Rahim and M.M. Wahba (2012). Effect of potassium bearing rock on the growth and quality of potato crop (*Solanum tubersoum*). J. Agric. Biotech. and Sustain. Dev., 4 (1): 7-15.

Lee, C. H.; K. D. Par; K. Y. Jung ; M. A. Ali ;D. Lee; J.Gutierrez, andP. J. Kimd(2010). Effect of Chinese milk vetch (*Astragalus sinicus* L.) as a green fertilizer on rice productivity and methane emission in paddy soil. *Agriculture, Ecosystems and Environment*, 138:343-347.

Liu, W., D. Zhu, D. Liu, X. Lu and M. Geny (2010). Comparative metabolic activity related to flavonoid synthesis in leaves and flowers of *Chrysanthemum morifolium* in response to K deficiency . Plant Soil 335:325-337.

Marschner, H., (1995)." Mineral Nutrition of Higher Plants". 2nd ed., Academi Press. Harcourt Brace. Jovanovich Publisher, pp. 674.

Mera U.M., B.R. Singh, M.D. Magaji, A. Singh, M. Musa and M.J.S. Kilgori (2009). Response of roselle (*Hibiscus sabdariffa* L.) to farmyard manure and nitrogen-fertilizer in the semi-arid savanna of Nigeria. Nigerian J. Basic and Appl. Sci. 17(2):246-251.

Mohamed, R., J. Fernandez, M. Pineda, and M. Aguilar (2007). Roselle (*Hibiscus sabdariffa* L.) seed oil is rich Source of Ǵ- Tocopherol. J. Food Sci., 72: 207-211.

Norhayati, Y., W.H. Ng, and M.A. Adzemi (2019). Effects of organic fertilizers on growth and yield of roselle (*Hibiscus sabdariffa* l.) on Bris soil. Malays. Appl. Biol. 48(1): 177–184.

Nur E-Elahi, M. (1991). Intercropping forage green fertilizer with a grain legume in the pre rice dry wet period for food, feed and organic nitrogen across irrigated and rain fed rice ecosystems. Rice Abstract, 15(2):92.

Olsen, S. R., and L. E. Sommers (1982)". Phosphorus". In: Page. A. L., R. H. Miller, and D. R.Keeney (Eds). Methods of Soil Analysis .Part 2 Amer. Soc. Agron. Madison, W. I. USA. pp. 403-430.

Peng-Kong, W., S. Yusof, H.M. Ghazali, and Y.B. Man, (2002). Physico-chemical characteristics of Roselle (*Hibiscus sabdariffa* L.). J. Nutr. Food Sci., 32: 68-73.

Piri H. (2017). Effect of different levels of nitrogen fertilizer, potassium and water on the quantitative and qualitative characteristics of Roselle. New Finding in Agriculture, 11(1): 17-31.

Priyanka, P. and S.S. Sindhu, (2013). Potassium solubilization by rhizosphere bacteria: influence of nutritional and environmental conditions. J. Microbiol. Res., 3 (1): 25-31.

Qin, Z. and S.P. Tian, (2009). Enhancement of bio control activity of *Cryptococcus laurentii* by silicon and the possible mechanisms involved. Phytopathology., 95:69- 75.

Sakr, W.R.A., H.M. Elbagoury, M.A.Sidky, and S.A. Ali, (2014). Production of organic roselle by natural minerals and biofertilizers. American-Eurasian J. Agric. & Environ. Sci., 14(10):985-995.

Sangakkara, UR;M. Liedgens ; A.Soldat iand P. Stamp (2004). Root and shoot growth of *(Zea mays*) as affected by incorporation of *Crotolaria juncea* and *Tithonia diversifolia* as green fertilizers. J. Agron. and Crop Sci. 190:330-346.

Shafeek, M. R.; O. A. H. EL- Zeiny and M. A. Ahmed (2005). Effect of phosphate and potassium fertilizer on growth, yield seed composition of pea plant in new reclaimed soil. Ass. J. plant. Sci., 4(6) : 608-612.

Shams, A. S. and W. A. Fekry (2014). Efficiency of applied K-feldspar with potassium sulphate and silicate dissolving bacteria on sweet potato plants. Zag. J. Agric. Res., 41(3): 467-477.

Sheng X.F.and Huang W.Y. (2002). Mechanism of potassium release from feldspar affected by the strain NBT of silicate bacterium. Acta Pedol. Sin., 39: 863–871.

Singhabutra, N.; S.Arunin, and Y.Anuluxtipan (1987). Experiment on two *Rhizobium* strains for inoculation into *Sesbania* spp. used as green fertilizer on the reclamation of saline soil. Paper presented at the 25th Annual Technical Meeting held from 2-6 Feb 1986. Kaset Start University, Bangkok.

Snedecor, G.W. and W.G. Cochran,(1980)." Statistical Methods".7th ed., Iowa State Univ., Press, Ames., Iowa, U.S.A.

Sullivan P. (2003). Overview of cover crops and green fertilizer. ATTRA, Fayetteville, AR, USA. Available at http: // attra. ncat. Org / attra-pub / covercrop.html, accessed 15.03.2011.

Tuzel, Y. , H. Duyar and G. B. Oztekin (2013). Effects of winter green fertilizer on organic cucumber production in unheated greenhouse conditions. Turk J Agric For. 37: 315-325.

Urzua H,JM. Urzua andR. Pizarro (2001) .Pre-selection of *Rhizobium leguminosarum* cv. Viceae strains in forage vetch for use as green fertilizer. Cien Inv Agr 28: 3–6.

Wang, M., Q. Zheng, Q. Shen and S. Guo (2013). The critical role of potassium in plant stress response. Inter. J. Molecular Sci., 14(4):7370–7390.

Wellburn, A.R.(1994). The spectral determination of chlorophyll *a* and *b*, as well as total carotenoids, using various solvents with spectrophotometers of different resolution. Journal of Plant Physiology 144: 307-313.

Yang L., B. Jinshun, J. Liu, N. Zeng and W. Cao (2018). Green fertilizer effect on changes of soil nitrogen fractions, maize growth, and nutrient uptake. Agronomy 8, 261:1-13

Zakaria, A.A.B.(2009). Growth optimization of potassium solubilizing bacteria isolated from biofertilizer. Bachelor of Cehm. Eng. (Biotech.) Fac. Cehm. Natural Resources Engl. Univ., Malaysia, Pahang, 40.

تقييم تاثير التسميد الاخضر و مصدرين للبوتاسيوم على النمو و المحصول و بعض الصفات الكيميائيه للكركديه و تيسر بعض العناصر الكبري فى التربه بعد الحصاد

حنان محمد ابو الفتوح ، لمياء عبد الحليم عبد الرحمن و ساميه محمد سعد الكلاوي

معهد بحوث الاراضى و المياه و البيئه – مركز البحوث الزراعيه – الجيزه – مصر

اجريت تجربه حقليه بمزرعه البحوث الزراعيه بالجميزه - محافظه الغربيه – مصر خط الطول 07. 31 شرقاً وخط عرض30 و43 درجة شمالاً خلال الموسمين الصيفيين المتعاقبين 2017 ، 2018 بهدف دراسه تأثير السماد الاخضر ، ومصدرين من البوتاسيوم (البوناسيوم المعدنى سلفات البوتاسيوم 48 % بو 2 أ ، الفلسبار 10.6 % بو2أ وثلاث مستويات منهما 50 ، 75 ، 100 % من الموصى به بجانب معامله المقارنه على النمو ، المحصول ، المكونات الكيماويه للسبلات وكذلك تيسير العناصر الكبرى فى التربه بعد الحصاد لنبات الكركديه (صنف صباحيه 17) تحت ظروف الارض الطينيه اللوميه . اشتملت التجربه على 14 معامله عبارة عن التفاعل بين مستويين من السماد الاخضر و 6 معاملات للتسميد البوتاسى بجانب معامله المقارنه ، وقد تم توزيع هذه المعاملات عشوائيا فى قطاعات منشقه فى ثلاث مكررات ، تم توزيع السماد الاخضر عشوائيا فى القطع الرئيسيه ، معاملات البوتاسيوم وزعت عشوائيا فى القطع تحت الرئيسيه . كانت أهم النتائج المتحصل عليها كالتالى ، سجلت معامله التفاعل بين دمج نبات الفول البلدى فى التربه بعد 45 يوم من الزراعه (كسماد أخضر) والتسميد بمعدل 75 % من البوتاسيوم الموصى به فى صوره فلسبار (10.6 % بو 2أ) أعلى القيم لارتفاع النبات ، عدد الافرع على النبات ، الوزن الجاف الكلى للنبات ، وزن الثمار للنبات ، عدد الثمار على النبات، كل من الوزن الطازج والجاف للسبلات للنبات وكذلك للفدان ، ومحصول البذور للفدان ، محتوى أنسجه الورقة من الكلوروفيل الكلى والكاروتنويدات ، تركيز الأنثوسيانين ، النسبه المئويه للكربوهيرات الكليه ، الحموضه الكليه % وكذلك محتوى السبلات من الفوسفور ، بينما سجلت معامله التفاعل بين السماد الاخضر ، والتسميد بمعدل 75 % من الموصى به من البوتاسيوم فى صورة سلفات البوتاسيوم أعلى القيم لمحتوى السبلات من النيتروجين والبوتاسيوم . التفاعل بين السماد الاخضر والتسميد بالبوتاسيوم بمعدل 100 % من الموصى به فى صوره فلسبار أعلى القيم النيتروجين والفوسفور والبوتاسيوم الميسر بالتربه بعد الحصاد