J. Agric. Sci. Mansoura Univ., 26 (11): 6991 - 7006, 2001.

GROWTH AND YIELD OF ROSELLE PLANTSAS INFLUENCED BY POTASSIUM FERTILIZATION LEVEL AND HARVEST TIMING

Harridy, I. M. A.; Mahassen M. A. Sidky and S. G. I. Soliman
Medicinal and Aromatic Plant Research Department, Horticulture Research Institute (HRI), Agricultural Research Center (ARC)

ABSTRACT

This experiment was conducted in South Tahreer Horticultural Research Station during the 1999 and 2000 seasons, with the aim of investigating the effect of different K fertilization levels (0, 50, 75 or 100 Kg K_2SO_4 fertilizer/fed.) and harvest timing (after 163, 170, 177, 184, 191 or 198 days from planting) on the growth, sepal and seed yields, as well as fixed oil content of roselle (*Hibiscus sabdariffa* L.) seeds. Potassium fertilization at 75 Kg K_2SO_4 fertilizer/fed. gave the best results in terms of the number of fruits/plant, fresh weight of fruits, fresh and dry weights of sepals, seed yield per plant and per feddan, seed index (weight of 100 seeds), seeds oil content (%), as well as the oil yield per plant and per feddan. Raising the K rate resulted in a steady increase in the K content of leaves, but reduced the anthocyanin content of sepals steadily. The tallest plants were those fertilized at 100 Kg K_2SO_4 fertilizer/fed. Moderate K fertilization (50 or 75 Kg K_2SO_4 fertilizer/fed.) gave the highest N content in the leaves. Delaying the harvest of fruits resulted in a steady increase in the seed yields per plant and per feddan, the N content (%) in leaves, and the anthocyanin content in sepals. All of these parameters gave their highest values after 198 days from planting. The highest oil yield (per plant and per feddan) was also obtained at the same harvest timing (198 days after planting). On the other hand, harvesting the fruits one week earlier (after 191 days from planting) gave the highest number of fruits/plant, as well as the highest values for fruits fresh weight, fresh and dry weights of sepals, and seed index. Maximum plant height was also recorded after 191 days from planting. The highest P and K contents in leaves were obtained after 163 and 184 days from planting, respectively, while the highest oil content in the seeds was recorded after 184 days from planting.

From the above results, it can be recommended that roselle plants should be fertilized with 75 Kg K_2SO_4 fertilizer/fed., and should be harvested after 191-198 days from planting.

INTRODUCTION

Roselle, *Hibiscus sabdariffa L.* (Fam. Malvaceae) is an annual medicinal plant cultivated in Egypt and many countries. The fleshy red calyx is used as a refreshing beverage (hot or cold) and for treatment of hypertension. Roselle seeds contain considerable quantities of an edible fixed oil.

In Egypt and other countries, the cultivation of roselle plant aims to produce the sepals only. However, relatively little information is known about the effect of cultural practices and growing conditions on the productivity of seeds and fixed oil by roselle plants. The aim of this study is to investigate the possibility of producing high yields of sepals as well as seeds and fixed

oil, by application of an appropriate level of K , and by harvesting at the proper stage of growth.

Regarding the suitable harvest stage, Osman and Hussein (1969) suggested that roselle sepals should be harvested 20-25 days after fruit set. Harridy (1980) found that the fresh weight of fruit and sepals was in fluctuation and reached its peak 35 days after fruit set.

Concerning K fertilization and its effects on plant growth and yield, many authors found that, K produces a significant increase in plant height [Ahmed (1989) on geranium plants]. A stimulating effect on the number of branches was found in fennel plants in response to K fertilization (Abd El-Kader, 1992).

Also, K fertilization had a positive effect on the dry weight of fennel (Abd El-Kader, 1992) and caraway plants (Faid, 1993).

Seed yield was increased in response to potassium application, as reported by Pankov (1977) on carrots, Abd El-Kader (1992) on fennel, Faid (1993) on caraway, and Soliman (1997) on black cumin.

The highest values of fixed oil content and yield (per plant) of black cumin were produced by the highest levels of potassium sulphate (Soliman, 1997).

As for fixed oil composition, Ismail and Mohamed (1997*)* found that oil content of some malvaceae plants (including roselle) ranged between 15.3-21.5%, and that the fatty acids were palmetic acid (15.27-34.33%), oleic acid (21.86-38.27%) and linoleic acid (23.63-49.75%). They added that fatty acid profiles were generally consistent with the fatty acid pattern found in cottonseed oil.

El-Sayed *et al.* (1998*)* reported that roselle seed oil contained 69.63% total polyunsaturated fatty acids. GLC analysis identified linoleic acid (49.30%), oleic acid (27.22%) and palmetic acid (18.17%) as the major fatty acids. It was suggested that roselle seeds might be a new source of edible oil.

MATERIALS AND METHODS

The present work was conducted in the experimental farm of South Tahreer Hort. Res. Station during the 1999 and 2000 seasons.

Roselle (*Hibiscus sabdariffa* L.) seeds were sown on May 1st in a sandy soil, in 2.4 x 2.5 m plots (6 square meters) on ridges 60 cm apart, at a spacing of 40 cm between hills.

Thinning was conducted when plants attained suitable growth (15 cm in height), leaving one plant per hill.

Agricultural treatments such as NP fertilization, irrigation, weed control and pest control were conducted according to the recommendations of the Egyptian Ministry of Agriculture.

Four potassium levels were used, *viz*. 0 (control), 50, 75 or 100 Kg potassium sulphate fertilizer/ fed. (equivalent to 0, 24, 36 or 48 Kg. K_2O/fed.). The fertilizer was added in two equal doses. The first dose was added on August 24th and the second on September 10th.

Two plants were harvested from each plot at weekly intervals starting from the 163rd day after planting (on October 10th) until the 198th day after planting (November 15th), with a total of six harvests. Data were recorded on growth characteristics (plant height, number of branches, number of fruits,as well as fresh and dry weights of fruits. Also, the fresh and dry weights of sepals per plant, the seed yield (gm./plant and Kg./fed.), as well as the weight of 100 seeds, were recorded.

The layout of the experiment was a randomized complete blocks design, with twenty-four treatments (4 K levels x 6 harvest stages) and 3 replicates.

The fixed oil content in dry roselle seeds, as well as the fixed oil yields per plant and per feddan, were determined using the method described by the A.O.C.S., 1964.

The fatty acid methyl esters were determined in the second season using an HP-5890 Gas Chromatograph (manufactured by the Hewlett Packard Co., Little Falls, MN), equipped with a flame-ionization detector. An HP free fatty acid phase (FFAP) column (25 m length, 0.30 µm film thickness, and 0.32 mm diameter) was used with helium (35 cm/s) as a carrier gas. The injector temperature was 250° C. The detector during analysis went from 50 to 240° C (7° C/min) after which the temperature was constant (240° C) for 30 min.

Total anthocyanin content in the sepals was determined according to Fuleki and Francis (1968), and to Du and Francis (1973). Dried leaf samples were also analysed chemically to determine their contents of total N (using the micro-Kjeldahl method, as described in A.O.A.C., 1984), P (according to King, 1951) and K (using an atomic absorption, flame emission spectrophotometer, Model AA-646, manufactured by Shimadzu, Japan).

Analysis of variance of the data was conducted, and the means were compared using the "Least Significant Difference" (L.S.D.) test at the 0.05 level, as recommended by Snedecor Cochran (1972).

RESULTS AND DISCUSSION

I- Effect of K levels and harvest timing on the growth and yield of roselle plants

1) Plant height (cm):

Data in Table (1) show that in both seasons, the tallest plants were those fertilized with the highest K rate (100 Kg potassium sulphate fertilizer/fed.). However, differences in height between plants receiving the different treatments were insignificant in the first season. In the second season, plants receiving the highest K rate were significantly taller than those fertilized at rates of 0 or 50 Kg/fed. Significant differences in height were also recorded between plants harvested at different timings. In both seasons, the tallest plants were those harvested after 191 days from planting, while the shortest plants were those harvested at the earliest harvest stage (after 163 days from planting). This means that the plants continued to grow vegetatively for 191 days after planting, after which they deteriorated slightly,

as indicated by the insignificant reduction in height that was observed at the last harvest stage, probably as a result of loss of plant turgidity and freshness. No significant interaction was detected in the first season between the effects of K fertilization rate and harvest timing. In the second season, the tallest plants were those fertilized with the highest K rate (100 Kg potassium sulphate fertilizer/fed.) and harvested after 191 days from planting. These results are in agreement with the findings of Ahmed (1989*)* on geranium.

2) Number of branches:

The number of branches/plant showed no significant response to potassium fertilization rates, whereas delaying the harvest resulted in a steady increase in the number of branches. However, this increase in the number of branches was insignificant (in both seasons) when harvesting was delayed from the first harvest stage (after 163 from planting) to the second date (after 170 days from planting), but when it was delayed from the first harvest stage to the third, fourth, fifth or sixth harvest stages, the number of branches increased significantly. In both seasons, the highest number of branches was recorded on plants harvest at the last stage (after 198 days from planting).

Regarding the interaction between the effects of potassium fertilization treatments and harvesting stages, the data recorded in the two seasons (Table 1) show that combining the highest potassium fertilization rate (100 Kg. potassium sulphate/fed.) with late harvesting of the plants (after 198 days from planting)
resulted in the highest number of branches/plant. In the first season, an equal number of branches was produced by plants receiving this treatment combination and those fertilized at 75 Kg. potassium sulphate/fed. and harvested at the same date (after 198 days from planting).

The above results are in agreement with those of Abd El-Kader (1992*)* on fennel plants.

3) Number of fruits/plant

Data in Table (2) show that fruiting in roselle plants was significantly influenced by potassium levels, harvest stage and the interaction between the two factors. In both seasons, the number of fruits/plant tended to increase gradually by raising the K levels up to the rate of 75 kg potassium sulphate/fed., which gave the highest number of fruits. A further increase in the fertilization rate to 100 kg potassium sulphate/fed. resulted in an insignificant reduction in the number of fruits/plant. Regarding the effect of the harvest stage on the number of fruits/plant, the data recorded in the two seasons showed that a gradual increase in the number of fruits was obtained as a result of prolonging the period from planting to harvesting of the fruits, up till the 191st day after planting. No additional fruits were obtained when harvesting was delayed by one more week (after 198 days from planting). The data in Table (2) also show that in both seasons, the best combination the K fertilization rate and the harvesting stage (in terms of the number of fruits/plant) was the application of 75 kg potassium sulphate/fed., and harvesting the plants after 198 days from planting.

Table (1) : Height and number of branches of roselle (*Hibiscus sabdariffa* L.) plants as affected by K fertilization and harvest timing.

Harvest stage (Days after planting)	Plant height					Number of branches				
	Fertilization rate (Kg potassium sulphate fertilizer/fed.)					Fertilization rate (Kg potassium sulphate fertilizer/fed.)				
	0	50	75	100	Means	0	50	75	100	Means
	First Season (1999)					First Season (1999)				
163	170.6	158.3	161.0	171.6	165.2	19.3	19.6	20.3	21.0	20.1
170	116.6	164.6	180.6	172.6	171.1	20.0	20.6	20.6	21.6	20.7
177	172.6	167.3	171.0	177.0	171.9	21.3	22.0	22.0	23.0	22.1
184	166.0	172.3	175.6	174.6	172.1	21.0	21.3	22.6	23.0	22.0
191	189.0	182.0	183.0	178.6	183.4	23.0	23.0	23.6	22.0	22.9
198	178.6	181.5	186.3	184.6	182.7	22.6	23.6	25.3	25.3	24.2
Means	173.9	171.0	176.0	176.4		21.2	21.7	22.4	22.6	
L.S.D. (0.05)										
K level (K)	N.S.					N.S.				
Harvest stage (H)	8.0					1.63				
K X H	N.S.					3.66				
	Second Season (2000)					Second Season (2000)				
163	169.3	151.0	166.3	177.6	166.5	19.6	19.0	20.0	21.0	19.9
170	167.0	169.0	172.3	178.0	171.5	21.0	21.0	21.6	21.0	21.2
177	164.3	171.3	180.0	174.0	172.4	21.0	22.3	22.6	23.3	22.3
184	176.3	163.3	178.6	173.3	172.9	21.3	22.0	23.0	23.3	22.4
191	179.6	180.0	182.3	185.6	181.8	22.0	23.3	23.0	23.0	22.8
198	175.3	176.0	184.3	182.0	179.4	22.3	23.0	24.0	24.6	23.5
Means	171.9	168.4	177.3	178.4		21.2	21.8	22.4	22.7	
L.S.D. (0.05)										
K level (K)	5.54					N.S.				
Harvest stage (H)	8.42					1.62				
K X H	27.55					3.43				

4) Fruits fresh weight (gm./plant):

The results recorded in the two seasons (Table 2) show that fruits fresh weight (gm./plant) was significantly increased in response to raising the potassium fertilization rates up to 75 Kg potassium sulphate/fed. Plants fertilized with this rate gave a significantly higher yield of fresh fruits, compared to those receiving any other K fertilization rate. Also, prolonging the time from planting till harvesting increased the fresh weight of fruits steadily, with the last harvest (after 198 from planting) giving the highest yield of fresh fruits. Regarding the interaction between the K fertilization rate and the harvesting stage, it was observed that in both seasons, the highest yield of fresh fruits was obtained when plants fertilized with 75 Kg potassium sulphate/fed. were harvested at the latest harvesting stage.

Table (2): Number of fruits and fruit fresh weight in roselle (*Hibiscus sabdariffa* L.) plants as affected by K fertilization and harvest timing.

Harvest stage (Days after planting)	Number of fruits/plant					Fruit fresh weight(gm/plant)				
	Fertilization rate (Kg potassium sulphate fertilizer/fed.)					Fertilization rate (Kg potassium sulphate fertilizer/fed.)				
	0	50	75	100	Means	0	50	75	100	Means
	First Season (1999)					First Season (1999)				
163	60.0	58.6	60.0	58.6	59.3	210.6	249.0	261.0	295.0	255.4
170	61.6	65.0	68.0	65.0	64.9	403.3	414.0	410.0	431.0	414.6
177	62.6	67.0	69.0	66.0	66.2	405.0	419.0	428.0	445.0	424.3
184	65.0	67.0	75.0	73.6	70.2	414.0	442.0	472.0	447.0	443.8
191	68.0	73.6	75.6	75.3	73.1	413.3	460.0	485.3	441.3	450.0
198	66.0	70.3	77.3	76.3	72.5	422.3	460.0	519.0	469.0	467.6
Means	63.9	66.9	70.8	69.1		378.0	407.3	429.2	421.4	
L.S.D. (0.05)										
K level (K)	3.84					16.64				
Harvest stage (H)	1.96					20.82				
K X H	14.3					55.7				
	Second Season (2000)					Second Season (2000)				
163	60.3	60.0	63.3	63.6	61.8	224.0	261.0	293.3	290.0	267.1
170	62.3	66.0	67.6	67.3	65.8	398.3	419.0	433.0	431.6	420.5
177	65.6	68.6	68.0	66.0	67.1	409.3	437.3	465.0	437.3	437.2
184	66.0	69.3	74.0	71.0	70.1	414.0	471.0	500.0	446.0	457.8
191	68.3	76.0	76.0	76.3	74.2	411.0	474.0	514.0	467.0	466.5
198	66.0	76.0	78.0	76.0	74.0	419.0	498.0	516.0	495.0	482.0
Means	64.8	69.3	71.2	69.0		379.3	426.7	453.5	427.8	
L.S.D. (0.05)										
K level (K)	8.3					20.1				
Harvest stage (H)	13.4					14.8				
K X H	15.9					83.0				

5) Sepals fresh weight gm./plant:

Sepals fresh weight (Table 3) was found to be significantly affected by K fertilization and harvesting stage. In both seasons, potassium sulphate at the rate of 75 Kg./fed. gave a significantly higher yield of fresh sepals than any other K fertilization rate that was tested. Also, the last harvest of roselle plants (after 198 days from planting) gave a significantly higher yield of fresh sepals in the first season, compared to harvesting at any earlier stage (in both seasons). In the second season, no significant difference was detected between the yields harvested at the last two satges (after 191 or 198 days from planting), with both these yields being significantly higher than those obtained with all earlier harvests.

Table (3) : Fresh and dry weights of sepals/plant in roselle (*Hibiscus sabdariffa* L.) plants as affected by K fertilization and harvest date.

Harvest stage (Days after planting)	Sepals fresh weight (gm/plant)					Sepals dry weight (gm/plant)				
	Fertilization rate (Kg potassium sulphate fertilizer/fed.)					Fertilization rate (Kg potassium sulphate fertilizer/fed.)				
	0	50	75	100	Means	0	50	75	100	Means
	First Season (1999)					First Season (1999)				
163	99.6	120.6	131.0	137.0	122.1	14.55	19.75	19.08	19.18	18.14
170	148.3	165.3	164.0	166.6	161.1	19.67	22.06	23.90	22.80	22.11
177	171.0	183.6	201.0	190.0	186.4	21.90	25.70	24.96	23.40	23.99
184	177.0	193.0	202.0	193.0	191.3	23.02	25.22	27.40	26.40	25.51
191	176.0	191.0	210.0	202.0	194.8	21.60	24.02	27.25	26.14	24.25
198	176.3	202.0	235.0	210.0	205.8	21.38	25.45	30.05	24.84	25.43
Means	157.5	175.9	190.5	183.1		20.35	23.70	25.44	23.80	
L.S.D. (0.05) K level (K) Harvest stage(H) K X H	6.77 4.25 22.39					0.837 0.61 3.97				
	Second Season (2000)					Second Season (2000)				
163	91.0	112.6	110.3	120.0	108.5	13.28	19.38	16.00	16.80	16.37
170	137.6	167.6	173.3	166.6	161.3	19.00	25.10	24.80	24.10	23.25
177	166.3	186.6	183.0	185.0	180.2	21.90	24.70	24.20	24.20	23.75
184	170.0	183.6	202.0	184.0	184.9	22.84	24.20	27.68	23.63	24.59
191	172.0	204.0	216.0	193.0	196.3	22.11	24.08	27.22	25.14	24.64
198	171.2	205.0	218.0	208.0	200.6	21.42	25.83	29.96	26.67	25.97
Means	151.4	176.5	183.8	176.1		20.09	23.88	24.97	23.42	
L.S.D. (0.05) K level (K) Harvest stage(H) K X H	6.52 6.66 26.94					1.00 0.96 2.85				

As with the fresh weight of fruits/plant, the highest yield of fresh sepals per plant was produced from combining K fertilization at the third level (75 Kg./fed. of potassium sulphate) with the last harvest stage (after 198 days from planting).

6) Sepals dry weight:

As with the sepals fresh weight/plant, the sepals dry weight was significantly affected by the K fertilization rate. In both seasons, plants fertilized at the rate of 75 Kg. potassium sulphate/fed. gave a significantly higher yield of dry sepals, compared to those receiving any other K fertilization treatment (Table 3). Also, the sepals dry weight showed a general steady increase with delaying the harvesting date. This trend was more evident in the second season, with the last harvest giving a significantly higher weight of dry sepals, compared to harvesting at any earlier stage.

Regarding the interaction between the K fertilization rate and the harvesting stage, the data in Table (3) show that in both seasons, the highest dry weight of sepals was obtained from plants fertilized with 75 Kg. potassium

sulphate/fed. and harvested at the last harvesing stage (after 198 days from planting).

The above results are in accordance with those of Osman and Hussein (1969) and Harridy (1980) on roselle. The effect of K showed the same response previously detected by Abd El-Kader (1992) on fennel, and by Faid (1993) on caraway.

7) Seed yield per plant and per feddan:

Concerning the production of seeds by roselle plant (Table 4), it was observed that plants fertilized with potassium sulphate at the rate of 75 Kg./fed. produced the highest seed yields (per plant and per feddan), compared to those supplied with any other rate of K fertilization. However, the differences between the seed yields obtained from K fertilization at the rates of 50, 75 or 100 Kg. potassium sulphate/fed. were insignificant.

The harvesting stage also had a considerable effect on the seed yield. In most cases, every delay of one week in the harvesting of roselle plants led to a significant increase in the seed yield (per plant or per feddan). Accordingly, seed yields harvested at the last stage (after 198 days from planting) were significantly higher than those harvested at any of the earlier stages.

Regarding the interaction between the K fertilization treatments and the harvesting stage, the best combination of these two factors (in terms of seed yield per plant or per feddan) was to supply the plants with 75 Kg. potassium sulphate/fed., and to harvest them after 198 days from planting. This led to the production of higher seed yields than any other combination of K fertilization rate and harvest stage.

8) Seed index (weight of 100 seeds):

Table (4) indicated that fertilization with 75 Kg. potassium sulphate/fed. gave the highest seed index, compared to the other K fertilization rates that were tested. However, differences were insignificant between all potassium levels in this respect. The obvious effect of K on seed production was similar to that obtained by Pankov (1977) on carrots, Abd El-Kader (1992) on fennel, Faid (1993) on caraway and Soliman (1997) on black cumin.

Regarding the effect of the harvest stages on the seed index, it was observed that delaying the harvest of roselle seeds resulted in a steady increase in the seed index, up to the fifth harvest stage (after 191 days from planting). However, one week later, at the last harvest stage (after 198 days from planting) an insignificant reduction was detected in the seed index, probably as a result of the loss of moisture within the seeds.

The results recorded with different combinations of K fertilization rates and harvest stages (Table 4) showed that within each K rate, delaying the harvest of seeds resulted in steady significant increases in the seed index (in most cases), until the fourth harvest stage (after 184 days from planting). Delaying the harvest of seeds by one or two more weeks caused only slight (insignificant) changes in the seed index, regardless of the K fertilization rate, i.e. there was no significant difference between the seed index of seeds harvested after 184, 191 or 198 days from planting. For plants fertilized at 0

(control), or 50 Kg. potassium sulphate/fed., the highest seed index was obtained when the seeds were harvested after 191 days from planting, whereas plants fertilized with 75 or 100 Kg. potassium sulphate/fed. gave the highest seed index when the seeds were harvested after 198 days from planting.

II- Fixed oil production

1) Fixed oil percentage (w/w) in roselle seeds:

The results shown in Table (5) indicated that fixed oil biosynthesis and accumulation in roselle seeds was influenced by potassium fertilization. The highest fixed oil content was obtained in the seeds of plants fertilized with 75 Kg. potassium sulphate/fed. It was also found that the oil percentage tended to increase steadily as the harvest date was retarded till the 184th day after planting. Any further delay in harvesting the seeds (to the 191st or 198th day after planting) resulted in a gradual reduction in the oil percentage.

These results hold true when the interaction between K fertilization and harvest timing is considered, with the highest fixed oil content resulting from fertilization of roselle plants with 75 Kg. potassium sulphate/fed. and harvesting the seeds after 184 days from planting.

2) Fixed oil yield (gm./plant):

The results presented in Table (5) indicated that the fixed oil yield (gm./plant) followed the same trend that was obtained for the fixed oil content in response to potassium fertilization levels. This is not true when harvest date was considered, as the highest fixed oil yield was obtained from those plants harvested at the last harvest (after 198 days from planting).

The interaction between the two factors (potassium fertilization and harvest timing) confirmed the previous results. The highest yield of fixed oil/plant was produced when plants were fertilized with 75 Kg. potassium sulphate/fed. and harvested after 198 days from planting.

This result was expected as fixed oil yield is a function of seed yield and fixed oil percent.

These results agreed with those of Soliman (1997) on black cumin. He found that the highest fixed oil content and yields (per plant) were produced by the highest level of potassium sulphate.

fertilization at the rate of 75 Kg. potassium sulphate/fed., and harvesting after 198 days from planting.

4+5

7000

3) Fixed oil yields (Kg./fed.):

The data in Table (5) show the effect of k levels and harvest dates on fixed oil yield (Kg./fed.). The results clearly indicate that the fixed oil yield per feddan followed the same trend previously observed for the fixed oil yield per plant, i.e., the highest fixed oil yield (Kg./fed.) was produced with K

4) Chemical composition of roselle seed oil:

Data in Table (6) and Fig. (1) show that the seed oil of roselle plants receiving 75 Kg. potassium sulphate and harvested after 198 days from planting was composed of 12 fatty acids, of which 8 were identified and comprised about 95% of the total fatty acids.

The identified saturated fatty acids were cabrylic, cabric, myristic, palmetic and arachidic. Their total percentage was 48%. Oleic, linoleic and linolenic were the identified unsaturated fatty acids, and comprised 45.71% of the fixed oil.

The above results indicate the importance of roselle seed oil, which can be valuable for use as an edible vegetable oil, since it contains two of the essential fatty acids (linoleic and linolenic), and a high amount of unsaturated fatty acids.

These results are in agreement with those results reported by Awatif and Mohamed (1997) and El-Sayed (1998).

Table (6): Chemical composition of roselle seed oil

No.	Fatty acids	Percentage
1	Unknown	0.34
2	Unknown	0.01
3	Unknown	0.19
4	Unknown	4.88
5	Cabrylic acid	15.89
6	Cabric acid	6.29
7	Oleic acid	20.30
8	Linoleic acid	19.49
9	linolenic acid	5.92
10	Myristic acid	6.66
11	Palmitic acid	16.51
12	Arachidic acid	3.50

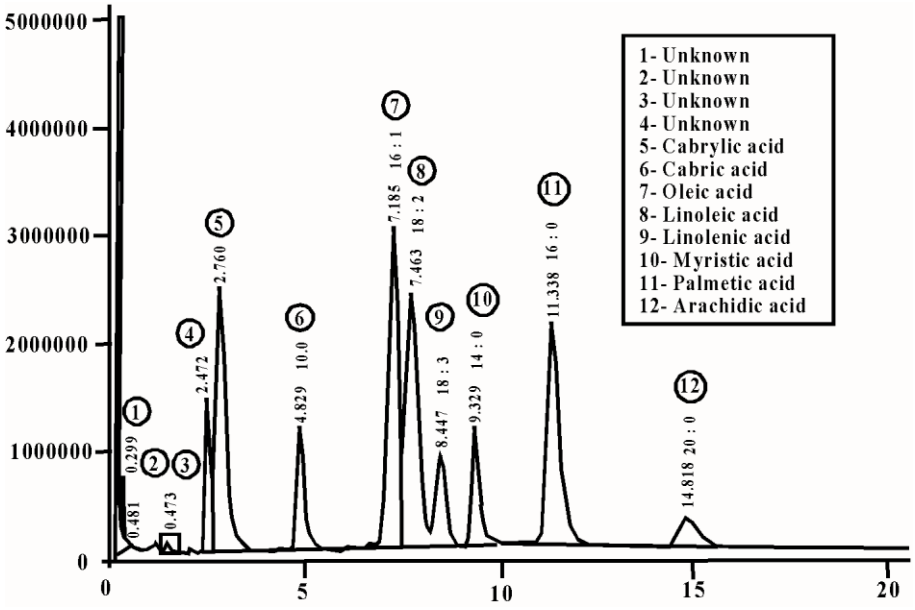

Fig. (1): Gas chromatogram of roselle seed oil

III-Plant chemical composition

A- Leaves

1) Nitrogen content:

The data in Table (7) indicate that the low and moderate levels of potassium (50 and 75 Kg. potassium sulphate/fed.) were the most effective in stimulating the nitrogen uptake in roselle plants. As for the harvest date, it was found that the nitrogen content tended to increase gradually till the last harvest timing (after 198 days from planting).

The interaction between potassium and harvest date tended to support these results, although the highest N content was obtained when plants receiving the highest K fertilization rate (100 Kg. potassium sulphate fertilizrer/fed.) were harvested at the last timing (after 198 days from planting).

2) Phosphorus content:

The phosphorus content was found to be slightly affected by both K level and harvest timing (Table 7). Values of phosphorus content in roselle leaves appear to be constant in plants receiving any rate of K fertilization (50, 75 and 100 Kg. of potassium sulphate/fed.). Also, slight differences were recorded between the P contents of plants harvested at any time after the 163rd day from planting.

Regarding the effect of different combinations of K fertlization rates and harvest timings on the P content, it appeared that plants receiving no K fertilization and harvested at the first harvest timing (after 163 days from planting) had a considerably lower P content than those receiving any other combination of the two factors. On the other hand, only slight differences

were recorded between the P contents obtained with all the other treatment combinations.

3) Potassium content:

The potassium uptake and accumulation by roselle plants was gradually stimulated as the K level was increased (Table 7). The highest content was recorded with the highest K level.

Regarding the harvest timing and its effects on the K content, it was clear that the K content tended to increase steadily with time, until the fourth harvest timing (after 184 days from planting), then it remained somewhat constant after that.

The data in Table (7) also show that combining the highest K fertilization level (100 Kg potassium sulphate fertilizer/fed.) with harvesting at the last timing (after 198 days from planting) gave the highest K content in the leaves.

B- Sepals

Total anthocyanin % of dry sepals

The data in Table (8) show that the mean anthocyanin content was decreased steadily with raising the K fertilization rate.

On the other hand, the anthocyanin content showed a gradual increase as the plant advanced in age. Hence, the highest values were recorded at the time of the last three dates.

An interesting interaction was detected between the effects of K fertilization and harvest timing. At the first four harvests (after 163, 170, 177 and 184 days from planting), the highest anthocyanin contents were recorded in plants receiving the lowest K fertilization rate (50 Kg. potassium sulphate/fed.). This behavior was mostly accompanied with low sepals content of k and may be attributed to the low k uptake under the 0 and 24 Kg. K_2o/fed. levels, which retarted carbohydrate translocation and allowed soluble sugars to accumulate. Hence, the anthocyanin (glycoside) formation tended to increase. However, At the last two harvests, the anthocyanin contents were decreased steadilty by raising the K fertilization rate, i.e., plants harvested after 191 or 198 days from planting, had the highest anthocyanin content when they received no K fertilization, and gave the lowest values when they were fertilized at the highest K rate (100 Kg. potassium sulphate/fed.).

Another interesting result was observed with plants receiving no K fertilization, which showed a steady reduction in their anthocyanin content with the delay in harvesting the sepals.

The data in Table (8) also show that the highest anthocyanin content was obtained when the plants were fertilized with 50 potassium sulphate/fed., and harvested after 177 days from planting.

7+8

RECOMMENDATIONS

From the above results, it can be recommended that roselle plants should be fertilized with 75 Kg K_2SO_4 fertilizer/fed., and should be harvested after 191-198 days from planting.

REFERENCES

Abd El-Kader, M. (1992). Physiological studies on fennel plant. M.Sc. Thesis, Fac. Agric., Zagazig University.

Ahmed, S. K. (1989). Physiological studies on geranium. Ph.D. Thesis, Fac. Agric., Zagazig Univ.

A.O.A.C. (1984). Official methods of analysis of the Association of Official Analytical Chemists. 14th Ed., Washington, D.C.

A.O.C.S. (1964). Official and Tentative Methods of American Oil Chemist Society, 2nd ed., puplished by the American Oil Chemists Society, 35, East Wacker Drive, Chicago, Illinois.

Du, C. T. and F.J. Francis (1973). Anthocyanin of roselle. Food Sci., 38 (5): 810-12.

El-Sayed, H.; S.T. Kheir and M.B. Atta (1998). Some physicochemical characteristics and fatty acid composition of roselle (*Hibiscus sabdariffa* L.) seed oil. Assuit J. Agric. Sci., 29(5): 103-113.

Faid, A. M. (1993). Physiological studies on caraway. M.Sc. Thesis, Fac. Agric., Zagazig Univ.

Fuleki, T. and F. J. Francis (1968). Quantitative methods of anthocyanins 1- Extraction and determination of anthocyanin in cranberries. J. Food Sci., 3 (1): 72.

Harridy, S. M. M. (1980). Studies on the biochemical constituents of roselle plants. M.Sc. Thesis, Fac. Agric., Ain Shams Univ.

Ismail, Awatif I. and H.M.A. Mohamed (1997). Characteristics and fatty acid content of oil of some seeds of malvaceae. Egypt. J. Agric. Res., 1997 75 (3): 769 – 787, 24 ref.

King E. J. (1951). Microanalysis in Medical Biochemistry. 2nd Ed., Churchill, London.

Osman A. E. and M. H. Hussein (1969). Post harvest technological treatments suggested for improvement the flavor and handling of roselle. Agric Res. Rev. Min. Agric., 47: (145-158).

Pankove V. V. (1977). The effect of potassium on the chemical composition and productivity of carrots. Hort. Abst., (1978) 48. 2471.

Soliman, M. Th. M. A. (1997). physiological studies on black cumin (*Nigella sativa*). M.Sc. Thesis, Fac. Agric., Zagazig Univ.

Snedecor G. W. and W. G. Corchran (1972). Statistical Methods, 6th ed., Iowa State Univ. Pres., Ames, Iowa, U.S.A., p. 953.

تأثير مستويات البوتاسيوم ومواعيد الحصاد على النمو والمحصول لنبات الكركديه

إبراهيم محمد أحمد هريدى و محاسن محمد عبد الغنى صدقى و سعيد جبر إبراهيم سليمان
قسم بحوث النباتات الطبية والعطرية - معهد بحوث البساتين - مركز البحوث الزراعية

تم إجراء هذا البحث في محطة بحوث البساتين بجنوب التحرير وذلك أثناء موسمى ١٩٩٩ ، ٢٠٠٠ بهدف دراسة تأثير المستويات المختلفة للتسميد بالبوتاسيوم (صفر، ٥٠ ، ٧٥ أو ١٠٠ كجم سلفات البوتاسيوم للفدان) وميعاد الحصاد (بعد ١٦٣ ، ١٧٠ ، ١٧٧ ، ١٨٤ ، ١٩١ أو ١٩٨ يوم بعد الزراعة) على النمو ومحصول كل من السبلات والبذرة وكذلك المحتوى من الزيت الثابت لبذور الكركديه. و أدى التسميد بمعدل ٧٥ كجم سلفات بوتاسيوم للفدان إلى أفضل النتائج من حيث عدد الثمار/نبات، الوزن الطازج للثمار، الأوزان الطازجة و الجافة للسبلات، محصول البذور للنبات و للفدان، وزن المائة بذرة، محتوى البذور من الزيت (%)، بالإضافة إلى محصول الزيت للنبات و للفدان. و أدى رفع معدل التسميد البوتاسى إلى زيادة طردية فى محتوى الأوراق من البوتاسيوم، إلا أنه قلل محتوى السبلات من الأنثوسيانين طردياً. كذلك فإن معدل البوتاسيوم المرتفع (١٠٠ كجم سلفات البوتاسيوم للفدان) أعطى أطول النباتات، بينما المستويات المتوسطة من التسميد (٥٠ أو ٧٥ كجم سلفات البوتاسيوم للفدان) أعطت أعلى محتوى من النتروجين فى الأوراق. هذا و أدى تأخير جمع الثمار إلى زيادة طردية فى محصول البذرة للنبات و للفدان، و محتوى النتروجين فى الأوراق، و الأنثوسيانين فى السبلات، حيث أعطت هذه الصفات أعلى قيم لها بعد ١٩٨ يوم من الزراعة. كذلك تم الحصول على أعلى محصول زيت للنبات و للفدان عند نفس توقيت الجمع (بعد ١٩٨ يوم من الزراعة). و من جهة أخرى، فإن جمع الثمار قبل ذلك بأسبوع (بعد ١٩١ يوم من الزراعة) أعطى أعلى عدد من الثمار للنبات، و أعلى قيم للوزن الطازج للثمار، و الأوزان الطازجة و الجافة للسبلات، و وزن المائة بذرة. كذلك تم تسجيل أقصى إرتفاع للنباتات بعد ١٩١ يوم من الزراعة. هذا و تم الحصول على أعلى محتوى من الفوسفور و البوتاسيوم فى الأوراق بعد ١٦٣ يوم و بعد ١٨٤ يوم من الزراعة، على التوالى، فى حين تم الحصول على أعلى محتوى من الزيت فى البذور بعد مرور ١٨٤ يوم من الزراعة.

من النتائج السابقة، يمكن التوصية بتسميد نباتات الكركديه بمعدل ٧٥ كجم سلفات بوتاسيوم للفدان، و أن تجمع الثمار بعد ١٩١-١٩٨ يوم من الزراعة.

Table (4) : The dry weight of seeds per plant and per feddan in roselle (*Hibiscus sabdariffa* L.) plants as affected by K fertilization and harvest date.

Harvest stage (Days after planting)	Seed weight/plant (gm)					Seed yield/fed. (kg)					Seed index (weight of 100 seeds, gm)				
	Fertilization rate (Kg potassium sulphate fertilizer/fed.)					Fertilization rate (Kg potassium sulphate fertilizer/fed.)					Fertilization rate (Kg potassium sulphate fertilizer/fed.)				
	0	50	75	100	Means	0	50	75	100	Means	0	50	75	150	Means
163	12.00	12.50	13.50	13.00	12.75	204.0	212.5	229.5	221.0	216.8	0.993	1.091	1.411	1.241	1.184
170	21.40	18.50	26.90	27.70	23.62	363.8	314.5	457.3	472.6	402.1	1.528	1.678	2.171	1.910	1.822
177	34.90	32.30	34.80	29.20	32.80	593.3	549.1	591.6	496.4	557.6	2.363	2.576	2.759	2.601	2.574
184	32.30	39.80	41.00	39.00	38.02	549.1	676.6	697.0	663.0	646.4	3.260	3.232	3.310	2.885	3.172
191	39.80	38.70	45.40	44.50	42.00	677.2	657.9	771.8	754.2	715.3	3.378	3.465	3.269	3.256	3.342
198	45.70	55.60	62.40	51.00	53.67	776.9	945.2	1064.2	867.0	913.3	3.066	3.410	3.330	3.339	3.286
Means	31.01	32.90	37.33	34.06		527.4	559.3	635.2	579.0		2.431	2.575	2.708	2.539	
L.S.D. (0.05)															
K level (K)	4.78					79.14					0.312				
Harvest stage (H)	2.86					73.81					2.577				
K X H	15.98					269.27					0.472				

Table (5) : The fixed oil content (%) and fixed oil yield (per plant and per feddan) in roselle (*Hibiscus sabdariffa* L.) plants as affected by K fertilization and harvest date.

Harvest stage (Days after planting)	Fixed oil content (%)					Fixed oil yield/plant (gm)					Fixed oil yield/feddan (Kg)				
	Fertilization rate (Kg potassium sulphate fertilizer/fed.)					Fertilization rate (Kg potassium sulphate fertilizer/fed.)					Fertilization rate (Kg potassium sulphate fertilizer/fed.)				
	0	50	75	100	Means	0	50	75	100	Means	0	50	75	150	Means
163	4.09	5.93	6.95	5.10	5.52	0.49	0.74	0.94	0.66	0.71	8.4	12.6	16.0	11.3	12.0
170	5.84	9.13	10.69	6.74	8.10	1.25	1.69	2.87	1.87	1.92	21.3	28.7	48.9	21.8	32.6
177	17.49	13.13	16.49	10.39	15.37	6.10	4.24	5.74	4.20	5.07	103.8	72.1	97.5	71.4	86.2
184	17.39	18.39	19.87	15.05	17.67	5.62	7.32	8.15	5.87	6.74	95.5	124.4	138.5	99.8	114.5
191	17.61	16.45	16.50	16.98	17.01	7.01	6.56	7.49	7.56	7.15	119.2	111.5	127.4	128.5	121.6
198	14.48	15.40	16.32	16.32	15.63	6.62	8.57	10.18	8.32	8.42	112.5	145.6	173.1	141.5	143.2
Means	12.81	13.15	14.46	12.42		4.51	4.85	5.90	5.00		76.8	82.5	100.2	85.0	

Table (7) : The effect of K fertilization and harvest timing on the N, P and K contents in roselle (*Hibiscus sabdariffa*) leaves.

Harvest stage (Days after planting)	N content (%)					P content (%)					K content (%)				
	Fertilization rate (Kg potassium sulphate fertilizer/fed.)					Fertilization rate (Kg potassium sulphate fertilizer/fed.)					Fertilization rate (Kg potassium sulphate fertilizer/fed.)				
	0	24	36	48	Means	0	24	36	48	Means	0	24	36	48	Means
163	3.10	3.20	3.30	2.70	3.08	0.26	0.42	0.34	0.38	0.35	1.70	2.40	2.72	2.96	2.45
170	3.33	3.20	3.00	2.65	3.05	0.39	0.42	0.45	0.41	0.42	1.90	2.40	2.85	2.90	2.51
177	3.70	3.20	2.70	2.30	2.98	0.42	0.43	0.43	0.45	0.43	1.98	2.48	2.95	2.96	2.59
184	2.82	3.24	3.26	3.10	3.11	0.39	0.42	0.45	0.43	0.42	2.30	2.72	2.90	3.15	2.77
191	2.80	3.56	3.60	3.56	3.38	0.39	0.40	0.41	0.40	0.40	2.30	2.70	2.98	3.00	2.74
198	2.86	3.82	3.90	3.98	3.64	0.40	0.40	0.42	0.42	0.41	2.22	2.80	2.98	3.21	2.80
Means	3.10	3.37	3.29	3.05		0.38	0.42	0.42	0.42		2.07	2.58	2.90	3.03	

Table (8): Effect of k levels and harvest dates on the total anthocyanin % in dry sepals of roselle (*Hibiscus sabdariffa*) plants.

K levels (Kg potassium sulphate fertilizer/fed.)	Harvest stage (Days after planting)						Means
	163	170	177	184	191	198	
0	2.100	2.305	2.511	2.775	3.028	3.351	2.678
50	3.174	3.375	3.585	3.223	2.863	2.650	2.548
75	2.160	2.344	2.550	2.550	2.571	2.625	2.467
100	1.800	1.930	2.136	2.361	2.619	2.470	2.219
M	2.308	2.488	2.695	2.727	2.770	2.774	

J. Agric. Sci. Mansoura Univ., 26 (11): 6991 - 7006, 2001.