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Effect of Foliar Application of NPK on Some Growth Characters of Two Cultivars of Roselle (*Hibiscus sabdariffa* L.)

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ABSTRACT

Roselle is a promising crop which has a number of uses and prospects for industrial potential. This experiment was conducted to evaluate the effect of foliar application of NPK fertilizer (Pro. Sol. USA) at 0, 1 and 2 g L^{-1} of this fertilizer on some growth characters, yield component and chemical constituents of calyces of two cultivars of Roselle (*Hibiscus sabdariffa* L.); red and lined. The results show that plant height, number of branches per plant, total number of fruits and dry calyces yield were increased due to foliar application of NPK. Also, all chemical constituents were positively affected by NPK application. The higher rate of NPK, 2 g L^{-1}, was more effective than the lower rate. In addition, red cultivar was superior in response to treatments. Interaction between NPK rates and cultivar show that the combination treatment of red cultivar and 2 g L^{-1} gave the best results in all plant characters measured.

Key words: Roselle, NPK, calyces yield, fiber, carbohydrate, vitamin C

INTRODUCTION

Roselle (*Hibiscus sabdariffa* L.) is an annual shrub belongs to malvaceae family. It is cultivated in tropical and subtropical regions for its popular edible calyces, stem fibers, leaves and seeds (Babajide *et al*., 2004; Mahadevan *et al*., 2009). It is a popular plant in Middle Eastern countries and it is known with different names such as roselle, sorrel, mesta and karkade (Abu-Tarboush and Ahmed, 1996). However, it is native to India where it is commonly cultivated, but was introduced to other parts of the world such as Central America, West Indies and Africa (Babajide *et al*., 2004; Fasoyiro *et al*., 2005).

Roselle has a lot of potential as an industrial crop. It is now considered one of the competitive beverages in the world (Schippers, 2000). Red calyces are utilized as coloring reagent for jelly, jam, beverages, sauces and food preserves (Mahadevan *et al*., 2009; Tsai *et al*., 2002; Abo-Baker and Mostafa, 2011). It contains higher amount of ascorbic acid and it is rich in riboflavin, niacin, calcium and iron (Babalola *et al*., 2000; Wong *et al*., 2002; Fasoyiro *et al*., 2005; Qi *et al*., 2005). Calyx presents antimicrobial as well as antioxidant activities due to its phenolic compounds (Fasoyiro *et al*., 2005; Anokwuru *et al*., 2011). Seeds of this plant have been found to be a good source of protein (Halimatul *et al*., 2007; Mukhtar, 2007). Roselle is one of the most important and popular medicinal plants and it has several properties such as; antiseptic, aphrodisiac, cholagogue, digestive and stomachic (Akindahunsi and Olaleye, 2003; Azooz, 2009). Fertilization is a major factor affecting crops production. Foliar fertilizer is being used widely as an alternative to soil

nutrition supply or as a complementary practice (George, 2003). It is preferred over other methods of application due to the use of less amount of the fertilizer, avoid soil problems, less ground water pollution in addition to the profound effect on plant growth and components (Sabir *et al*., 2002a,b; Hamayun *et al*., 2011). Foliar application of NPK has been found to increase grain yield of wheat (Jamal *et al*., 2006; Shaaban *et al*., 2009), yield components of lentil (Hamayun *et al*., 2011), vegetative characters of maize (Liang and Silberbush, 2002). NPK application alone or in combination with microbial inoculums or humic substances improves cow pea plant growth and nodulation (Abdelhamid *et al*., 2011). For roselle, high productive potentials has been reported when plant grown under adequate nitrogenous fertilizer (Babatunde *et al*., 2002). Also, it was found that a mixture of biofertilizer combined with chemical fertilizer improved growth characters and increased sepal yield in addition to other chemical constituents of sepals (Hassan, 2009; Abo-Baker and Mostafa, 2011). Oyewole and Mera (2010) mentioned that plant height responded significantly to both nitrogen and phosphorus fertilization and calyx and seed yields increased with increasing rates of N and P fertilizers. The aim of this study was to investigate the effect of NPK foliar application on the growth characters, yield component and some calyx chemical constituents of two cultivars of *Hibiscus sabdariffa* L. plant.

MATERIALS AND METHODS

Field trial was carried out in the season of 2010 at the Diwaniya Station for Roselle Cultivation and Development, Qadisiya Province, Iraq, to investigate the response of two roselle cultivars to foliar application of NPK fertilizer (Pro. Sol. USA). Certified seeds of the two cultivars were obtained from the above mentioned station. Treatments consisted of three rates of the fertilizer; 0, 1 and 2 g L^{-1} distilled water and two cultivars; red and lined, in addition to the interaction between the fertilizer levels and the cultivars. Soil samples were collected for analysis for chemical and physical properties before planting (Table 1). Treatments were laid out in a randomized complete block design as a split plot experiment with three replications.

The land was ploughed twice; harrowed and leveled of. Land was divided into blocks and each block has subplot measuring 3×3 m. Each subplot consists of four rows, 0.75 cm in between. Three to five seeds were planted per hill on a depth of 3-4 cm on April 1, 2010 and the distance between the hills was 50 cm. The crop was thinned to one plant per hill bringing the plant population to four plant per square meter. Weed control was carried out manually and all other practices were done as needed.

Foliar fertilizer was applied twice; the first one after thirty days of planting and the second one after sixty days of planting. Measurements were done on ten plants which were taken from each experimental unit at harvest time on October 13. Plant height, number of branches per plant, number of fruits per plant and dry calyces yield per plant were determined. The calyces were air dried and the dry powder of sepals was taken for determination of total anthocyanin as percentage according to Du and Francis (1973). Total carbohydrate percentages were determined in the dried leaves as previously described by Herbert *et al*. (1971). Vitamin C and titratable acidity was done according to AOAC (1990).

Table 1: Chemical and physical properties of the experiment soil

Character	Sand (%)	Silt (%)	Clay (%)	Texture	EC	PH	Organic matter (%)	Total N (%)	P (mg kg^{-1})
Value	14.3	56.5	29.2	Silty clay	2.5	7.8	0.84	0.025	3.7

Statistical analysis: Statistical analysis of experimental data was accomplished by standard analysis of variance (ANOVA) in randomized complete block design. The treatment means were separated using LSD at 5%.

RESULTS AND DISCUSSION

It is evident from data in Table 2 that both plant height and number of branches per plant were significantly increased as a result of foliar application of NPK fertilizer in comparison to untreated control. Plant height reached 55.00 and 67.33 cm of lined and red cultivar, respectively at the higher rate of foliar fertilizer compare to 38.67 and 39.67 cm for the control treatment. For number of branches the highest number was obtained at the higher rate of the fertilizer (9.67 and 13.67 for the lined and red cultivar, respectively). However, there were no significant differences between the two rates of fertilizer in their effect on number of branches per plant in lined cultivar. Also, the results show that the red cultivar was superior in plant height rather than number of branches which show no significant differences between the two cultivars. It is well known that chemical fertilizers could enhance plant growth due to the role of nitrogen in nucleic acids and protein synthesis, and phosphorus as an essential component of the energy compounds (ATP and ADP) and phosphoprotein, in addition to the role of potassium as an activator of many enzymes (Helgi and Rolfe, 2005). The present results come in agreement with the results reported earlier when roselle plants treated with NPK fertilizers (Harridy and Amara, 1998) or biofertilizers alone or combined with chemical fertilizers (Hassan, 2009). Also, it was found that plant height and stem diameter of guava plant grown under nursery conditions were positively affected by the foliar application of NPK (Al-Qurashi, 2005). Other investigators showed that inoculation of seeds with *Azotobacter* and *Azospirillum* in the presence of chemical fertilizers resulted in improving both growth and yield of anise (Gomaa and Abou-Aly, 2001) *Foeniculum vulgare* (Mahfouz and Sharaf-Eldin, 2007) and *Nigella sativa* (Shaalan, 2005).

With regard to the interaction, it was clear that the combination treatment of red cultivar with 2 g L^{-1} of NPK gave taller plants and higher number of branches per plant (67.33 and 13.67 cm, respectively) whilst the combination treatment of lined cultivar with 0 g L^{-1} fertilizer gave the lowest values of plant height and the combination treatment of red cultivar with 0 g L^{-1} fertilizer gave the lowest values of number of branches per plant. It was found earlier that foliar application of benzyladenine, NPK fertilizer or their combinations influenced the vegetative growth of croton plants (Abd El-Aziz, 2007). The general significant positive response of plant height and number

Table 2: Effect of cultivar, NPK fertilizer and their interaction on plant height and number of branches of roselle

	Plant height (cm)				No. of branches per plant			
	Rate of fertilizer (g L^{-1})				Rate of fertilizer (g L^{-1})			
Cultivar	0	1	2	Mean	0	1	2	Mean
Lined	38.67	46.33	55.00	46.66	8.33	11.66	9.67	9.88
Red	39.67	55.00	67.33	54.00	6.66	10.00	13.67	10.11
Mean	39.17	50.66	61.16		7.49	10.83	11.67	

LSD at 5%	Cultivars	Foliar fertilizer	Interaction
Plant height	6.27	8.13	10.58
No. of branches	NS	3.44	4.13

Table 3: Effect of cultivar, NPK fertilizer and their interaction on fruit number and total yield of dry calyces (g) of roselle

	Fruit No.				Calyces dry weight			
	Rate of fertilizer (g L^{-1})				Rate of fertilizer (g L^{-1})			
Cultivar	0	1	2	Mean	0	1	2	Mean
Lined	18.67	34.66	44.33	32.55	7.60	17.40	14.83	13.27
Red	18.00	38.66	54.33	36.99	6.23	15.13	20.50	13.95
Mean	18.33	36.66	49.33		6.91	16.26	17.66	
LSD at 5%		Cultivars		Foliar fertilizer				Interaction
Fruit number		4.05		6.81				9.63
Total yield		NS		4.25				5.51

of branches of roselle to nitrogen is an indicative of not only its importance but also to its association with vegetative growth (Sabir *et al*., 2002a,b; Okosun *et al*., 2006a; Sanoussi *et al*., 2010).

Data analysis show significant ($p<0.05$) influence of NPK foliar application on both fruit number and calyces dry weight (Table 3). Number of fruits at the higher concentration of foliar fertilizer increased by 137 and 200% over the control in the lined and red cultivar, respectively. Calyces dry weight recorded its highest value at a fertilizer rate of 1 gL^{-1} (17.40 g) for the lined cultivar, while for the red cultivar the highest value for the calyces dry weight was recorded at the fertilizer rate of 2 g L^{-1} (20.50 g). The least fruit number and calyces dry weight were observed in control treatment. These results come in agreement with the findings of Okosun (2000), Babatunde (2001), Babatunde *et al*. (2002) and Okosun *et al*. (2006a) who reported an increase in calyces yield as a result of manure or nitrogen fertilization. They attributed that to increase in crop photosynthetic ability, as a result of good vegetative growth induced by these treatments. Also, several other workers have found that a combination of chemical fertilizers and biofertilizers improved the plant growth and increased sepal yield due to the direct effect of chemical fertilizers or indirect through the microbial propagation activation, Shaalan *et al*. (2001) on roselle, Shaalan (2005) on *Nigella sativa* and Hassan (2009) on roselle.

The two rates of NPK fertilizer were significantly differed in their effect on fruit number but not for calyces dry weight. The increase in fruit number due to the use of fertilizer may be a reflection of the greater vigor in vegetative growth and higher growth rates. Oyewole and Mera (2010) found that calyx yield, pods/plant and seeds/pod responded significantly to nitrogen application. In contrast, it was found that nitrogen treatment had no effect on calyx yield in three ecotypes of roselle (Sanoussi *et al*., 2010). Fruit number of roselle, as in the case of plant height, also showed a positive response to cultivar. It was mentioned earlier that the differences in the response of two cultivars of roselle, Sokoto red Sokoto white cultivar, was probably due to the differences in their vegetative growth (Okosun *et al*., 2006b). Combination treatments show pronounced differences. Treatment of red cultivar along with 2 g L^{-1} of NPK gave the higher fruit number and calyces dry weight.

Foliar application of NPK increased the percentage of total carbohydrates and fiber in roselle calyces compares to control (Table 4). The effect of 2 g L^{-1} of NPK was more appeared on total carbohydrates than 1 g L^{-1}. In comparison between the two cultivars, the higher carbohydrate percentage (29.88%) was obtained in red cultivar compare to lined cultivar (22.06%). Increasing the total carbohydrate may be due to the promotion effects of NPK fertilizer on the photosynthetic pigments. Similar findings were obtained by Harridy and Amara (1998), Shaalan *et al*. (2001) and Hassan (2009). For fiber, the two rates of fertilizer increased the fiber percentage significantly

Table 4: Effect of cultivar, NPK fertilizer and their interaction on total carbohydrate and fiber percent in calyces of roselle

	Total carbohydrate (%)				Fiber (%)			
	Rate of fertilizer (g L^{-1})				Rate of fertilizer (g L^{-1})			
Cultivar	0	1	2	Mean	0	1	2	Mean
Lined	20.20	22.00	24.0	22.06	3.47	5.70	5.74	4.97
Red	26.00	30.00	33.0	29.88	3.38	3.52	3.99	3.63
Mean	23.43	26.66	28.5		3.42	4.61	4.86	
LSD at 5%		Cultivars		Foliar fertilizer				Interaction
Carbohydrate		1.49		1.82				2.69
Fiber		1.23		0.94				1.55

Table 5: Effect of cultivar, NPK fertilizer and their interaction on vitamin C, titratable acidity and anthocyanin content in calyces of roselle

	Vitamin C (mg/100 g fresh weight)				Titratable acidity (%)				Total anthocyanin (%)			
	Rate of fertilizer (g L^{-1})				Rate of fertilizer (g L^{-1})				Rate of fertilizer (g L^{-1})			
Cultivar	0	1	2	Mean	0	1	2	Mean	0	1	2	Mean
Lined	40.00	44.00	47	43.66	3.6	3.93	4.50	4.01	5.40	6.60	7.33	6.44
Red	55.33	57.33	61	57.88	4.73	5.16	5.80	5.23	8.30	8.70	10.13	9.04
Mean	47.66	50.66	54		4.16	4.54	5.15		6.85	7.65	8.73	
LSD at 5%		Cultivars		Foliar fertilizer				Interaction				
Vitamin C		1.02		1.25				3.21				
Total acidity		0.14		0.17				0.22				
Anthocyanin		0.25		0.18				0.15				

compare to control, although, they were not differ from each other. The positive effect of fertilizer on fiber may be due to the overall promotion effect on general metabolic activities. However, Changdee *et al.* (2009) have shown that stress treatment such as waterlogging significantly decreased fiber yield of three fiber crops by 51.2% compared to control. Lined cultivar shows higher fiber content (4.97%) than red cultivar (3.63%). These differences may due to cultivar difference. In accordance of these results, it was found that crude fiber and ascorbic acid of green colored calyx were significantly higher than red and dark red roselle (Babalola *et al.*, 2000).

Also, combination treatment of red cultivar and 2 g L^{-1} NPK gave the highest value of carbohydrate (33.00%), whilst the combination treatment of lined cultivar and 2 g L^{-1} NPK gave the highest value of fiber content (5.74%). It was found that foliar application of benzyladenine, NPK fertilizer or their combinations influenced the vegetative growth, chlorophyll, carotenoids content and total carbohydrate percentage of croton plants, especially when plants were sprayed with BA combined with NPK (Abd El-Aziz, 2007).

Data in Table 5 revealed that Vitamin C, titratable acidity and total anthocyanin all increased as a result of NPK foliar application. The highest values of these parameters were obtained at the higher rate of foliar fertilizer. For lined cultivar, they were; 47.00 mg 100 g fw, 4.5 and 7.33% for vitamin C, titratable acidity and total anthocyanin, respectively. For the red cultivar, these values were 61.00, 5.80 and 10.13, respectively. The growth promotion caused by adding the NPK fertilizer could be reflected in increasing the chemical constitutes of plant sepals. This result comes

in agreement with Hassan (2009) results who was found that applying biofertilizers alone or combined with chemical fertilizers significantly improved growth characters and as a result, total anthocyanin content, total carbohydrates, and chlorophyll content were increased also. It was mentioned earlier that the synthesis of anthocyanins and other constituents in the fruit calyx of *Hibiscus sabdariffa* was significantly stimulated by the proper treatments such as adequate irrigation water (Mandour *et al*., 1979).

Also, as shown with the other characters, red cultivar calyces were richer than the lined cultivar in vitamin C and anthocyanin in addition to having higher acidity. The increase in the values of these three characters were 32.6, 30.6 and 40.5% in red cultivar over the lined cultivar. In accordance with these results, it was found that crude fiber and ascorbic acid of green coloured calyx were significantly higher than red and dark red roselle (Babalola *et al*., 2000).

With regard to the interaction between cultivars and NPK rates it was evident that the combination of higher rate of NPK and red cultivar always gives the higher values of Vitamin C, titratable acidity and anthocyanin. In contrast, combination of lined cultivar with 0 g L^{-1} of NPK gives the least values.

CONCLUSION

The present study shows clearly that NPK foliar application has positive effect on vegetative characters and calyces chemical constituents. The 2 g L^{-1} rate of fertilizer was more effective in obtaining better plant characteristics. Red cultivar was superior in most characters measured in compare to lined cultivar.

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