INNSPUB

International Journal of Agronomy and Agricultural Research (IJAAR)
ISSN: 2223-7054 (Print) 2225-3610 (Online)
http://www.innspub.net
Vol. 7, No. 2, p. 75-79, 2015

RESEARCH PAPER OPEN ACCESS

Effect of application of Nitrogen and Potassium fertilizers on some vegetative and reproductive traits in Roselle (*Hibiscus sabdariffa*)

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Article published on August 04, 2015

Key words: Roselle, Nitrogen, Potassium, Vegetative, Reproductive.

Abstract

A pot experiment was carried out to examine the effect of application of nitrogen and potassium fertilizers on some vegetative and reproductive traits in Roselle *(Hibiscus sabdariffa)*. Treatments were included control with no fertilizer (T_1); 70 mg N per kg soil (T_2); 50 mg K_2O per kg soil (T_3); and combination of T_2 and T_3 (T_4) that applied on 30 day old seedlings. In the end of experiment (30 days after flowering), the parameters stem height, stem diameter, number of leaves and flowers, flower diameter, calyx length, number of shoots, fresh and dry weight of organs and vitamin C were evaluated. The results showed that were significant differences in some parameters among applied treatments. Treatments 3 and 4 showed no significant differences in studied parameters. Application of nitrogen fertilizer decreased the levels of vitamin C while potassium fertilizer and integrated use of N and K increased the levels of vitamin C. The traits stem height, stem diameter, number of leaves, number of flowers, number of shoots, biomass of leaves and flowers were not significantly affected by fertilizer treatments. The highest flower diameter (2.63 cm), calyx length (2.91 cm) and flower dry weight (10.56 g), were obtained at treatment of 50 mg K_2O kg^{-1} soil. The results showed that the treatments K alone and combination of N with K were more efficient than either N or no fertilizer in improving traits of Roselle.

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Introduction

The Roselle (*Hibiscus sabdariffa* L.) is an annual plant belonging to the family Malvaceae (Tindal, 1986). This plant has spread eastwards across Africa to India and westwards to West Indies and Jamaica (Mclean, 1973). The plant is cultivated mainly for the calyces. It has reported that calyces of Roselle are important for nutritional and medicinal value (Purseglove, 1991). Calyces are very rich in β-carotene, vitamin A, C and some mineral elements such as phosphorus, iron, and calcium (Babalola, 2000., FAO, 1988), therefore are used as a beverage. It has reported that concentration of ascorbic acid (vitamin C) of water extract of calyces was 7.12mg.100 g^{-1}(Ibrahim *et al*., 1971). This plant can grow on a wide range of soil conditions but for economic production, soil should well supplied by essential minerals (Adanlawo and Ajibade, 2006., Tindal, 1986). Mineral elements can improve properties of Roselle such as calyces yield, quality of vitamins and antioxidants. Nitrogen and Potassium are two major limiting nutrients for plant growth and yield. Nitrogen is needed for normal growth and the synthesis of proteins in plants (Worthington, 2001). Potassium is also essential for plant growth and development. This element has important duties such as cell division and enlargement, regulation of opening and closing of the stomata, water relations, osmotic regulation, improvement of photosynthesis, protein synthesis, development of the root system and increase of disease resistance and stress tolerance (Sakr *et al*., 2014., Abd-El-Moez, 1996). Potassium also promotes photosynthesis, fruit formation and activates enzymes and co-enzymes to metabolize carbohydrates and increases oil content in oil crops (Sakr *et al*., 2014). Despite the importance of Roselle, its production in Iran is limit. Processing and preservation of the products and calyx extracts in Iran are important restriction for production. Attention to cultivation and exporting the calyx of this plant can be economically important for our country. Therefore evaluation of effect of mineral elements on growth traits and quality of this plant is useful. The goal of this research was to understand effect of nitrogen and potassium fertilizers on some properties of Roselle plant.

Materials and methods

The study area

This research was set-up in the greenhouse of Agricultural faculty, Hormozgan university, Bandar Abbas, Iran, during the period from January to May 2015.

Experiment set-up and Fertilizer treatments

About 4 seeds of *Hibiscus sabdariffa* were planted in a pot filled with 10 kg soil and at 2 weeks after emergence the seedlings were thinned to one plant per pot. The Complete Randomised Design (CRD) was applied using four levels of fertilization. Fertilizer treatments were included control or no fertilizer (T_1); 70 mg N per kg soil (T_2); 50 mg K per kg soil (T_3), and combination of T2 and T3 (T_4). Each treatment had replicated six times or 6 pots. All treatments applied on 30 day old seedlings.

Measurements

In the end of experiment (30 days after flowering), stem height, stem diameter, number of leaves and flowers, flower diameter, calyx length, number of shoots, fresh and dry weight of organs and vitamin C contents were evaluated. For determination of ascorbic acid (vitamin C) concentration, calyces were dried and method of Ibitoye (2005) was used.

Statistical analysis

Treatments effects were evaluated using ANOVA using SPSS software. The Duncan's Multiple Range Test (DMRT) was used for comparison of means.

Results and discussion

Roselle was affected by the applied treatments. Results showed that there were significant differences in some parameters among fertilizer treatments. Application of potassium fertilizer alone and also combination treatments of nitrogen and potassium showed no significant differences in studied parameters.

Analysis of variance of studied traits

The results of variance analysis of effects of fertilizer treatments on some traits of Rosselle are shown in Table 1. The determination of the effects of fertilizer treatments showed that the traits stem height, stem diameter, number of leaves, number of flowers, number of shoots, biomass of leaves and flowers were not significantly affected by fertilizer treatments, while flower diameter, calyx length, fresh and dry weight of shoots, root fresh and dry weight and also vitamin C significantly affected by fertilizer treatments.

Table 1. Analysis of variance of effect of fertilizer treatments on some parameters in *Hibiscus sabdariffa*.

		Mean Square							
Source of variation	df	Stem height	Stem diameter	Number of leaves	Number of flowers	Flower diameter	Calyx length	Number of shoots	Shoot fresh weight
Fertilizer	3	202.500^{ns}	0.027^{ns}	9.042^{ns}	15.444^{ns}	0.565**	0.887*	0.486^{ns}	25.395*

Table 1. Continued.

		Mean Square						
Source of variation	df	Shoot dry weight	Leaf Fresh weight	Leaf dry weight	Root fresh weight	Root dry weight	Calyx and seeds fresh weight	Calyx and Seeds dry weight	Vitamin C
Fertilizer	3	1.584*	12.247^{ns}	0.175^{ns}	98.78*	1.506*	201.58^{ns}	19.927^{ns}	0.007**

ns,* and ** are insignificant, significant at 0.05 and 0.01 level, respectively.

Effect of fertilizer treatments on some qualitative and quantitative traits

The results of comparison of means are showed in Table 2. Based on the results, stem height of plants varied from 39.66 cm in no fertilizer treatments to 52.83cm in plants that received alone potassium fertilizer (Table 2).

Table 2. Comparison of effect of fertilizer treatments on some qualitative and quantitative traits in *Hibiscus sabdariffa*.

Treatments	SH (cm)	SD (cm)	NL	NF	FD (cm)	CL (cm)	NS	SFW (g)	SDW (g)
T_1 (No fertilizer)	39.66 a	0.666 ab	12.33 a	13.33 a	1.916 b	2.133 b	1.83 a	9.56 b	2.45 b
T_2 (70 mg N /kg soil)	49.6 a	0.616 b	12.16 a	11.166 a	2.083 b	2.383 ab	1.66 a	13.17 a	3.35 ab
T_3 (50 mg K/kg soil)	52.83 a	0.733 ab	13.83 a	13.833 a	2.633 a	2.916 a	1.50 a	14.12 a	3.55 a
T_4 (70 mg N+50mg K/kg soil)	50.66 a	0.766 a	10.83 a	15 a	2.25 ab	2.883 a	1.16 a	11.06 ab	2.75 ab

Table 2. Continued.

Treatments	SDW(g)	LFW (g)	LDW (g)	RFW (g)	RDW (g)	CSFW (g)	CSDW (g)	Vitamin C (mg. g dry weight^{-1})
T_1 (No fertilizer)	2.45 b	9.535 a	1.2 a	6.98 b	0.928 b	36.08 a	7.19 ab	0.0715 b
T_2 (70 mg N /kg soil)	3.35 ab	8.38 ab	1.071 ab	14.52 a	1.9 a	30.39 a	6.42 b	0.0498 b
T_3 (50 mg K/kg soil)	3.55 a	7.325 ab	0.966 ab	15.71 a	1.91 a	44.49 a	10.56 a	0.1168 a
T_4 (70 mg N+50mg K/kg soil)	2.75 ab	6.198 b	0.803 b	9.94 ab	1.21 ab	36.51 a	7.42 ab	0.1203 a

1.Significant differences within the same column are indicated by different letters (P = 0.05, Duncan test).

2. Abbreviations: SH=Stem height, SD=Stem diameter, NL= Number of leaves per plant, NF= Number of flowers per plant, FD=Flower diameter, CL= Calyx length, NS= Number of shoots per plant, SFW= Shoot fresh weight, SDW= Shoot dry weight, LFW= Leaf fresh weight, LDW= Leaf dry weight, RFW= Root fresh weight, RDW= Root dry weight, CSFW= Calyx and seeds fresh weight, CSDW= Calyx and seeds dry weight).

It means that application of potassium fertilizer produced taller plants than what was observed in other treatments. Stem diameter varied from 0.616 cm in nitrogen treatment to 0.766 cm in combination treatment (T_4). In case of number of leaves per plant also the maximum (13.83) and the minimum (10.83) number were obtained in the treatments potassium and combination of nitrogen and potassium, respectively. The highest number of flower per plant (15) was obtained in the combination treatment of nitrogen and potassium. Flower diameter significantly affected by fertilizer treatment. The highest content of flower diameter was observed at treatment of potassium fertilizer (2.633 cm) and showed significant difference with the treatments control (1.916 cm) and nitrogen treatment (2.083 cm). Calyx length also was varied between 2.133 cm and 2.916 cm that were obtained in no fertilizer and potassium treatments, respectively. Number of shoots per plant decreased with fertilization but this reduction was not statically significant. The highest contents of fresh weight (14.12 g) and dry weight (3.55 g) of shoots also recorded in potassium treatment and the lowest contents of both parameters were obtained in no fertilizer treatment. Fertilizer treatments reduced dry and fresh weight of leaves but these effects were not statically significant. In case of fresh and dry weight of roots, the maximum contents (15.71 - 1.91 g, respectively) recorded in potassium treatment, while the lowest contents of both parameter were belonged to no fertilizer treatment. The highest fresh weight and dry weight of flowers plus seeds were 44.49 g and 10.56 g, respectively that recorded in potassium treatment. Contents of vitamin C affected significantly by fertilizer treatments. The lowest content of vitamin C was obtained by application of nitrogen fertilizer (–0.0498 mg per g dry matter), although had no significant difference with obtained content in control (0.0715 $mg.g^{-1}$). The highest content of vitamin C (0.1203 $mg.g^{-1}$) was obtained by combination application of nitrogen and potassium, although had no significant difference with potassium treatment (0.1168 $mg.g^{-1}$). There are many reports about effects of fertilizer treatments on *Hibiscus sabdariffa* in other countries. In report of Abo-Baker and Mostafa (2011), seed inoculation of *Hibiscus sabdariffa* with the compound of bio-fertilizers combined with 50 or 100% NPK increased shoot fresh weight. Abbas and Ali (2011) applied NPK as foliar spray on Roselle and reported fertilization, improved growth parameters. Akanbi *et al.* (2009) also evaluated effect of inorganic fertilizer, organic manure and combination of both on growth, calyx yield and quality of Roselle. Their results revealed that combination of inorganic together with mineral fertilizers had more efficient than either organic or inorganic fertilizer alone.

They stated that use of 5.0 t. /ha cassava peel compost plus with 150 kg /ha NPK resulted in the highest calyx yield (22.2 t. ha) and increased contents of essential proximate and nutritional quality of Roselle calyx. Sakr *et al.*, (2014) also stated that fertilization treatments significantly enhanced height, number of branches, leaf area, root length, fresh and dry weights of leaves and roots of Roselle. In research of Musa and Ogbadoyi (2012) on this plant also application of nitrogen fertilizer significantly reduced vitamin c content that was accordance with our results. In their evaluation, vitamin C contents at fruiting stage were 16.08 and 13.08 $mg.100\ g^{-1}$ in control and nitrogen treatments, respectively. It has reported that reduction of vitamin C content with nitrogen application can be due to reduction of carbohydrates biosynthesis. Because vitamin C is formed from carbohydrates (Worthington, 2001).

Conclusion

In Roselle, calyx yield and concentration of vitamin C are important parameters. Application of fertilizer has effect on the quality and yield components. The results revealed that application of 50 mg K_2O per kg soil and also the treatment of combination of 70 mg N per kg soil with 50 mg K_2O per kg soil were more efficient than either N or no fertilizer in improving traits of Roselle. Most of evaluated parameters were least in no fertilizer treatment. More studies are required to determine suitable fertilizer compound for this plant.

Acknowledgement

We would like to thank Hormozgan University for providing facilities of this study.

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