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RESEARCH ARTICLE

# Influence of foliar applied nitrogen, phosphorus and potassium on the vegetative and reproductive attributes of Roselle *(Hibiscus sabdariffa)*

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**Abstract**
An experiment was conducted to study the influence of foliar application of nitrogen, phosphorus and potash (NPK) on the vegetative and reproductive attributes of Roselle. The experiment was designed using Randomized Complete Block Design (RCBD) with one factor i.e., NPK treatments (0, 3, 4, 5, 6 g $l^{-1}$). Treatments were repeated four times. The experiment was carried out in Ornamental Horticulture Nursery, Department of Horticulture, The University of Agriculture, Peshawar during the year 2020. Data were recorded on plant height (cm), stem diameter(mm), number of branches $plant^{-1}$, number of leafs $plant^{-1}$, leaf area($cm^2$), days to first flowering, days to last flowering, number of calyces $plant^{-l}$, calyx diameter, calyces fresh weight $plant^{-l}$, pod size, number of seeds $pod^{-l}$ . Foliar application of NPK had significant effect on most of the studied attributes. Maximum plant height (104.75 cm), stem diameter (2.23 mm), number of branches $plant^{-1}$ (13.5), number of leaves $plant^{-1}$ (301), and leaf area (118.25$cm^2$), minimum days to first flowering (106.50), maximum days to last flowering (128), calyx diameter (27.275 mm), calyces fresh weight $plant^{-1}$(219.88 g), pod size(21.532 mm) and number of seeds $pod^{-1}$ (25.68) were recorded in plants sprayed with NPK @ 6g $L^{-1}$. Minimum plant height (67.50 cm), stem diameter (0.7775 mm), number of branches (4.000), number of leaves (58.50), and leaf area (113.00$cm^2$), maximum days to first flowering (109.00), minimum days to last flowering (114.75), calyx diameter (23.835mm), calyces fresh weight $plant^{-1}$ (89.84 g), pod size (19.617mm) and number of seeds (21.688) were recorded in control plants (Sprayed with distilled water). It is concluded that plants treated with foliar applied NPK at 6g $L^{-1}$ improved most of the vegetative and reproductive variables of Roselle and hence could be recommended for better growth and production of Roselle under the agro-climatic conditions of Peshawar.

**Keywords:** Micronutrient; foliar spray; vegetative attributes; Flowers and seed production

## Introduction

Roselle (*Hibiscus sabdariffa* L.) is a herbaceous shrub that belongs to the family *Malvaceae*. It is native to Asia and tropical Africa. The plant is mainly grown in tropics such as Africa, Australia, Brazil, Caribbean, Central America, Florida, India, Hawaii and Philippines (Gautam, 2004). The crop is grown mainly in traditional farming system, mostly under rain fed conditions in many tropical and subtropical countries (Cobley, 1975).

It is mostly grown for attractive edible calyces (Purseglove, 1991). It is known by many names such as 'Florida roselle'and 'Florida cranberry' in Florida, USA; 'bisap' in Senegal and 'Sobo' in Nigeria (Wong *et al.*,2002).The warm and humid tropical climate is suitable for Roselle plants as it is exceptionally susceptible to frost and mist (Ahmed *et al.*,1981). Roselle can be growth best in areas with temperature ranges from 18 to 35ºC, with an optimum of 25ºC. Growth of the plant ceases at 14ºC (Mc-Clintock *et al*., 2004). The plant grows well in most of the soils but it should be well-drained. It can tolerate poor soils as well and is often grown as a supplementary rather than primary crop (Hacket and Carolene, 1982).

*Hibiscus sabdariffa* is an annual, erect, bushy, herbaceous shrub that can grow up to 8 ft (2.4 m) tall, with smooth or nearly smooth, cylindrical, typically red stems. The leaves are alternate, 3 to 5 in (7.5–12.5 cm) long, green with reddish colour veins and long or short petioles. The leaves of young seedlings and upper leaves are simple; lower leaves are deeply 3 to 5 or even 7 lobed; the margins are toothed. Flowers, borne singly in the leaf axils, are up to 12.5 cm wide, yellow or buff with a rose or maroon eye, and turn pink as they wither at the end of the day. At this time, the typically red calyx, consisting of 5 large sepals with a collar (epi-calyx) of 8 to 12 slim, pointed bracts (or bracteoles) around the base, begins to enlarge, becomes fleshy, crisp but juicy. The capsule turns brown and splits open when mature and dry. The calyx, stems and leaves are acidic in nature and closely resemble with the cranberry in flavor (Morton, 1987; Ross, 2003).

Roselle is a short-day plant that is very sensitive to the photoperiod. In the first 4-5 months of its growth, Roselle requires a daily light phase of 13 hours (Mc-Clintock *et al.,* 2004). Roselle plants prefer well-drained, humus and rich-fertile soils with a pH of 5.5 to 8.0 (Augstburger, 2009). Roselle is resistant to relatively high temperatures throughout the growing and fruiting times in open field. Nutritionally, the calyces have sufficient amounts of vitamins A, C, phosphorous, iron and calcium but tiny protein (FAO, 2004). The commercially important part of the plant is the fleshy calyx (sepals) surrounding the fruit (capsules). The whole plant can be used as beverage, or the dried calyces can be soaked in water to prepare a colorful cold drink, or may be boiled in water and taken as a hot drink. It also has some medicinal properties. The seeds contain 17.8–21% non-edible oil (Ahmed, (1980) and 20% protein, and are sometimes used for animal feed (Ahmed and Nour, (1981). The seeds are source of highly valued vegetable oil with properties similar to that of crude olive. In terms of their oil content, the seeds of Roselle are richer in lipids (22%) than most well-known seed oil such as those derived from Cotton (13%), Soybean (14%) and Palm fruit (20%) (Nzikou *et al.,* 2012).

Liquid form of Nitrogen, Phosphorus and potassium (NPK) is a fertilizer that is formulated to provide nitrogen, phosphorus and potassium in highly efficient way. Nitrogen promotes growth and development of plant and is essential for almost all crops. NPK, are the "Big 3" primary nutrients in commercial fertilizers required by plants in relatively higher quantity. Nitrogen is considered to be the most important nutrient, and plants absorb more nitrogen than any other element. Nitrogen is essential for healthy growth of plants. It is essential in the formation of protein, and protein makes up much of the tissues of most living things. Phosphorus, is linked to a plant's ability to use and store energy, including the process of photosynthesis. It's also needed to help plants grow and develop normally. Phosphorus in commercial fertilizers comes from phosphate rock. Potassium is the third major nutrient. It helps strengthening the plants' abilities to resist disease and plays an important role in increasing crop yields and overall quality. It regulates the opening and closing of Stomata. Potassium also protects the plant when the weather is cold or dry, strengthening its root system and preventing wilt (Carvajal, *et al.,* 2018).

NPK are most essential nutrients required for the gowth and development of plants. The application of fertilizers is a major factor determining the crop productivity. Foliar fertilizer is being used widely as an alternative to soil nutrition supply or as a complementary practice (Jullien *et al.,* 2001; George, 2003; Akanbiat *et al.,*2009). Foliar spray is preferred over other methods of application due to the use of less amount of fertilizer, avoide soil problems, less ground water pollution in addition to the profound effect of plant growth, yield and yield related

components (sabir e*t al* ., 2002; Hamayun *et al.*, 2011). Keeping in view the importance of NPK and the application of these macro-nutrients via foliar spray on Roselle for better nutrient use efficiency a project was design with the objective: To investigate the effect of foliar applied NPK on the vegetative and reproductive performance of Roselle.

## Materials and methods

The experiment on "Influence of foliar applied nitrogen, phosphorous and potassium on the vegetative and reproductive attributes of roselle "*hibiscus sabdariffa*" was carried out at the Ornamental Horticulture Nursery, The University of Agriculture, Peshawar during the year 2020.

## Experimental design and field preparation

The experiment was conducted in Randomized Complete Block Design (RCBD) based on single factor. The factor was NPK foliar application, having five concentrations. The plant to plant and row to row distance was kept 30 cm and 60 cm respectively.

The field was thoroughly ploughed and leveled. The seeds were planted 2.5 cm deep. Crop management practices such as Irrigation, weeding, hoeing and pest management etc were done equally to all treatments throughout experiment when needed. Seeds of Roselle (*Hibiscus sabdariffa* L.,) were obtained from Department of Horticulture, The University of Agriculture Peshawar Pakistan. The plants were relatively weak then normal growth.. Data were recorded on plant height, number of branches plant$^{-1}$, number of leaves plant$^{-1}$, stem diameter, leaf area plant$^{-1}$, days to first flowering, days to last flowering, number of calyces plant$^{-1}$, calyx diameter, calyces fresh weight plant$^{-1}$, pod size, number of seeds pod$^{-1}$.

## Statistical Analysis

Data were subjected to analyses of variance. Software Statistix8.1 was used for computing analysis of variance and then least significant difference (LSD) test was used for significant findings.

## Results and Discussion

### Plant height (cm)

Data of plant height are given in Table 1. Tallest plants having height (104.75 cm) was observed in plots where plants were sprayed with NPK at 6g l$^{-1}$ that was statistically similar to plant height (95.50 cm) recorded in plants that received NPK at 5 gl$^{-1}$. However, minimum plant height (78.00cm) was recorded in plants sprayed with distilled water (Control). It is clear from mean data that there was an increase in plant height with an increase in the concentration of foliar applied NPK up to 6 g l$^{-1}$. It might be due to the reason that NPK are primary essential nutrients required for the growth and development. Plants that received foliar applied NPK were healthy due to optimum growth and hence attained maximum height (Drostkar *et al*., 2016).

**Number of branches plant$^{-1}$**

Data of number of branches plant$^{-1}$ are given in Table 1. Maximum number of branches plant$^{-1}$ (13.500) was observed in plants that received foliar applied NPK at 6 gl$^{-1}$ followed by no. of branches (11.75) observed in plants sprayed with NPK at 5gl$^{-1}$. However, the minimum number of branches plant$^{-1}$ (4.00) was recorded in plants sprayed with distilled water (Control). Mean data pertaining to NPK showed that highest no. of branches (13.50) were recorded in plants sprayed with 6 gl$^{-1}$ NPK. At the same concentration tallest plants were produced and hence those plants resulted in more number of leaves. Plants that received foliar applied NPK were healthy due to optimum growth and hence attained maximum number of branches (Kwon *et al. 2 019*).

**Number of leaves plant$^{-1}$**

Data pertaining to number of leaves plant$^{-1}$ are given in Table 1. Maximum number of leaves plant$^{-1}$ (301.25) was observed in plants sprayed with NPK at of 6 g l$^{-1}$. However minimum number of leaves plant$^{-1}$ (58.50) was recorded in plants sprayed with distilled water (control). The major nutrients (NPK) are reported to enhance plant vegetative growth. Nitrogen, phosphorus and potassium have a significant effect on leaf and flower quality of Roselle plant (Singh *et al.*, 2004). NPK applications have direct impact on the number of leaves (Anamika and Lavania, 1990).

**Stem diameter (mm)**

Data of stem diameter are given in Table 1. Highest stem diameter (2.23 mm) plant$^{-1}$ was measured in plots where plants were sprayed with NPK at 6 g l$^{-1}$ followed by (1.40 mm) recorded in plots where NPK was sprayed at the rate of 5gl$^{-1}$, However minimum stem diameter plant$^{-1}$ (0.77 mm) was recorded in plants sprayed distilled water (control). Plants that received optimum NPK produced more no. of leaves with good photosynthesis and resulted in an increase in stem diameter (Kwon, *et al.*, 2019).

**Leaf area plant$^{-1}$ (cm$^2$)**

Data of leaf area are given in Table 1. Maximum leaf area plant$^{-1}$ (119.75) was observed in plots where plants sprayed at 5g l$^{-1}$ of NPK that was statistically similar to leaf area recorded in plants treated with 6g l$^{-1}$ of NPK. However minimum leaf area (113.0) was recorded in plants sprayed with distilled water (control). Foliar application resulted in an increase in leaf area. NPK has significant role to augment cell division and cell expansion in plants (Marschner & Possingham, 1975; Mengel, 1977).

**Days to First Flowering**

Data of days to first flowering are given in Table 2. Mean data revealed that minimum days to first flowering (106.50) were noted in plants sprayed with NPK at 6g l $^{-l}$. However maximum days to first flowering (109.00) were recorded in plants sprayed with distilled water (control). The results showed that flowering was delayed with the application of NPK as compared to control plants. It might be due to the reason that NPK contain nitrogen that enhance the vegetative growth of the plant and that's why resulted in maximum days to first flower opening. The findings are in agreement with that of Qasim, et al. (2008) who reported a delay in flowering in response to the application of NPK.

**Table1.** Vegetative attributes of Roselle as affected by foliar applied NPK

| NPK ($g\ L^{-1}$) | Plant height (cm) | No. of branches | No. of leaves | Stem diameter (mm) | Leaf area per plant ($cm^2$) |
|---|---|---|---|---|---|
| Control (Distilled water) | 67.50 c | 4.00 c | 58.50 e | 0.77 d | 113.00 b |
| $3gl^{-1}$ | 78.00 bc | 4.75 c | 99.25 d | 1.01 cd | 113.25 b |
| $4g\ l^{-1}$ | 83.00 b | 7.75 b | 117.00 c | 1.06 c | 114.75 ab |
| $5g\ l^{-1}$ | 95.50 a | 11.75 a | 139.50 b | 1.40 b | 119.75 a |
| $6g\ l^{-1}$ | 104.75 a | 13.50 a | 301.25 a | 2.23 a | 118.25 ab |
| LSD ($P \leq 0.01$) | 11.36 | 2.02 | 15.77 | 0.26 | 5.66 |

Means followed by different letters are significantly different from one another at 1% level of significance.

**Days to Last Flowering**

Data of days to last flowering are given in Table 2. Mean data revealed that maximum days to last flowering (128.00) were noted in plants sprayed with NPK at $6g\ l^{-1}$ followed by (118.75) recorded in foliar sprayed at the rate of $5g\ l^{-1}$, while the minimum days to last flowering (114.75) was recorded in plants sprayed with distilled water (control).The results showed that flowering was delayed in plants sprayed with NPK foliar application as compared to control plants. It is due to the reason that NPK contain nitrogen that enhanced the vegetative growth of plants and hence resulted in maximum days to last flower opening (Akbari, *et al.,* 2018).

**Number of Calyces plant$^{-1}$**

Data regarding number of calyces plant$^{-1}$ are given in Table 2. Maximum number of calyces plant$^{-1}$ (33.75) was observed in plants with foliar application of NPK at the rate of $6g\ l^{-1}$ followed by no. of calyces (23.50) observed in plants sprayed with NPK at the rate of $5\ gl^{-1}$. However minimum number of calyces plant$^{-1}$ (9.75) was recorded in plants sprayed with distilled water (control). Calyx number was found higher with application of NPK because resulted in more plant height with a significant increase in leaf area and no. of branches and hence produced maximum no. of calyces as compared to the plants that were sprayed with distilled water (Babajide *et al.,* 2007; Abbas & Ali 2011).

**Calyx Diameter**

Data of calyx diameter are given in Table 2. Maximum calyx diameter (27.275 mm) plant$^{-1}$ was recorded in plants that received foliar applied NPK at the rate of $6\ g\ L^{-1}$ followed by (26.64 mm) recorded in plants sprayed with NPK at the rate of $5g\ L^{-1}$, while the minimum calyx diameter plant$^{-1}$ ( 23.835 mm) was recorded in plants sprayed with distilled water (control). NPK enhanced the plant height with better growth and development and resulted in a significant increase in the calyx diameter (Akanbi, 2002; Stefano et al., 2004)

**Calyces Fresh Weight plant$^{-1}$**

Data of calyces fresh weight plant$^{-1}$ are given in Table 2. Maximum calyces fresh weight plant$^{-1}$ (219.88 g) was recorded in plants sprayed with NPK at 6g L $^{-1}$ followed by (170.50 g) recorded in foliar application of NPK at 5g L$^{-1}$, however minimum calyces fresh weight plant$^{-1}$ (89.94 g) was recorded in plants sprayed with distilled water(control). Egharevba and Law-Ogbomo reported that yield of Roselle was increased with the application of NPK. The plants yield is significantly increased with the application of NPK (Okosun et al., 2006).

**Pod Size (mm)**

Data of pod size are given in Table 2. Largest pod size (21.532 mm) was recorded in plants sprayed with NPK at 6 g L$^{-1}$ followed by (20.808 mm) recorded in plants sprayed with NPK at the rate of 5g L$^{-1}$, while the minimum pod size (19.617 mm) was recorded in plants sprayed with distilled water(Control). NPK fertilization enhances flowering parameters, fruits size and seeds production of various medicinal and herbaceous plants (Abd-Elmalik, 1996)

**Number of Seed Pod$^{-1}$.**

Data of number of seed pod$^{-1}$ are given in Table 2. Maximum number of seeds pod$^{-1}$ (25.688) was recorded in plants sprayed with NPK at 6g l $^{-1}$ followed by (24.813) observed in plants sprayed with NPK at 5g l $^{-1}$, however least number of seeds plant$^{-1}$ (21.688) was observed in plants sprayed with distilled water (Control). NPK cause to enhance root growth, flower initiation, seed and fruit development (Sharpley *et al.,* 1996).

**Table 2.** Mean values of reproductive attributes in Roselle as affected by foliar applied NPK

| NPK(g L$^{-1}$) | Days to First Flowering | Days to Last Flowering | Number of calyces plant$^{-1}$ | Calyx Diameter | Calyces Fresh Weight plant$^{-1}$ | Pod Size | Number of Seed Pod$^{-1}$ |
|---|---|---|---|---|---|---|---|
| Control (Distilled water) | 109.00 a | 114.75 c | 9.75 e | 23.835 c | 89.94 d | 19.61 c | 21.68 c |
| 3gl$^{-1}$ | 108.00 b | 115.75 bc | 12.50 d | 25.62 b | 92.31cd | 20.15 bc | 24.06 b |
| 4g l$^{-1}$ | 107.00 c | 116.00 bc | 15.50 c | 25.63 b | 96.50 c | 20.53 b | 24.50 b |
| 5g l$^{-1}$ | 107.00 c | 118.75 b | 23.50 b | 26.64 a | 170.50 b | 20.80 ab | 24.81 ab |
| 6g l$^{-1}$ | 106.50 c | 128.00 a | 33.75 a | 27.27 a | 219.88 a | 21.53 a | 25.68 a |
| LSD (P≤ 0.01) | 0.88 | 3.98 | 1.7745 | 6.12 | 6.12 | 0.74 | 1.07 |

Means followed by different letters are significantly different from one another at 1% level of significance.

## Conclusions

The application of NPK at the rate of 6 g $L^{-1}$ resulted in taller plants, stem diameter, number of branches, number of leaves and leaf area minimum days to first flowering with maximum days to last flowering, number of calyces $plant^{-1}$, calyx diameter, calyces fresh weight $plant^{-1}$, pod size and number of seeds $pod^{-1}$. Minimum plant height, stem diameter, number of branches, number of leaves and leaf area, least days to first flowering with early days to last flowering, minimum number of calyces $plant^{-1}$ ,calyx diameter , calyces fresh weight $plant^{-1}$, pod size and number of seeds $pod^{-1}$ were noted in plants sprayed with distilled water (Control plants). Foliar application of NPK at the rate of 6g $L^{-1}$ is recommended for better vegetative and reproductive attributes of Roselle.

***Declaration***

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**Data availability:** From the author

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