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The Effect of Nitrogen and Phosphorus on Growth and Yield of Roselle (*Hibiscus sabdariffa* var. *sabdariffa* L.) In a Semi Arid Agro-Ecology of Nigeria

L.A. Okosun, M.D. Magaji and A.I. Yakubu
Faculty of Agriculture, Department of Crop Science,
Usmanu Danfodiyo University, P.M.B. 2346, Sokoto, Nigeria

Abstract: Two field experiments were conducted during 1998 and 1999 rainy seasons at the Usmanu Danfodiyo University Sokoto Dry Land Farm, Sokoto (Latitude 13° 09′N and Longitude 5° 18′E), with a view to studying nitrogen and phosphorus fertilization on growth, yield components and calyx/seed yields of roselle. Treatments consisted of four levels each of N (0, 20, 40 and 60 kg N ha^{-1}) and P (0, 10, 20 and 30 kg P ha^{-1}), which were combined factorially in a randomized complete block design, replicated three times. Data were collected on plant height, calyx and seed yield of roselle. Results showed that plant height responded significantly to both nitrogen and phosphorus fertilization. Plants treated with 40 and 60 kg N ha^{-1} were significantly taller than plants that were fertilized at 0 and 20 kg N ha^{-1}, whereas P rates at 10 and 20 kg ha^{-1} produced the tallest plants than the other P rates. Calyx and seed yields increased with increasing rates of N and P fertilizers up to 60 kg N and 30 kg P ha^{-1}.

Key words: Nitrogen, phosphorous, growth, yield, roselle, semi-arid

Introduction

Roselle (*Hibiscus sabdariffa* L.), is a tropical annual shrub that produces fruit-like structures with often elaborate calyces containing edible pigments (Ghazali, 1999). A member of the Malvacae family, it is a native to India and Malasia where it is commonly cultivated and must have been carried at an early date to Africa (Babajide *et al.*, 2004). In Nigeria, the cultivation and intense utilization of the red and purple genotypes are found mainly in the Guinea and Sudan Savanna ecological zones of the country while the green genotype, hitherto ascribed little utility value, is found in the Southwest (Alegbejo, 2000). Generally the utility of roselle varies among different people the world over (Babajide *et al.*, 2004). In Nigeria, the calyx of the green type is used for making soup and is locally referred to as “Yakwa” and “Ishapa” in Hausa and Yoruba languages, respectively. The calyx of the red type is boiled in hot water, the purple/red coloured extract is stained, sweetened and flavoured as a beverage drink, “Zoborodo” (Alegbejo, 2000). It has a number of uses and promising prospects for industrial purposes (Adekpe and Adigun, 2000). The tender leaves and shoots are eaten in salads and soups. Traditionally, preparations from various parts of the roselle plant such as flower (calyx and corolla) and leaves are used as remedy for various illnesses. The drink is a readily available and inexpensive source of vitamin C in addition to various medicinal values (Babajide *et al.*, 2004).

Corresponding Author: Yakubu, A.I., Faculty of Agriculture, Department of Crop Science, Usmanu Danfodiyo University, P.M.B. 2346, Sokoto, Nigeria

Work initiated at the Institute for Agricultural Research (IAR), Zaria, Nigeria resulted in screening of a number of roselle germplasms and preliminary studies on effects of nitrogen and phosphorus on yield and yield components of the crop (Alegbejo, 1998). By way of research very limited nutrition studies had been carried out on roselle in the study area. Work done so far is limited to northern Guinea savanna zone (Alegbejo, 1998; Lamido, 1998) excluding the Sudan savanna zone where roselle is predominantly being grown as a dividing hedge between farms and a lot of variants of roselle are found.

In view of the afore-mentioned, the study was undertaken to investigate the effects of N and P on growth and yield of roselle as well as to determine their optimum rates of application.

Materials and Methods

Two field trials were conducted during the 1998 and 1999 rainy seasons at the Usmanu Danfodiyo University Dry Land Farm, Sokoto (Latitude 13°09′N and Longitude 5°9′E). Soil samples were collected for analysis before planting, while the weather data were monitored throughout the duration of the experiment. The treatments consisted of a factorial combination of four levels each of nitrogen (0, 20, 40 and 60 kg N ha^{-1}) and phosphorus (0, 10, 20 and 30 kg P ha^{-1}) laid out in a randomized complete block design with three replications. Nitrogen was applied in form of urea (46%) while phosphorus was applied as single super-phosphate (7.87% P). The gross and net plot areas were 6 m × 4.8 m and 4.8 m × 3.6 m made up of eight and six rows, respectively.

The land was ploughed and harrowed and the blocks and plots were laid out, which were separated by 1 m and 0.5 m paths, respectively. Three to five seeds of Sokoto Red roselle were planted per hill on the flat at a spacing of 60×45 cm on 15-7-98 for 1998 and 19-7-99 for 1999 rainy seasons, respectively. Nitrogen fertilizer was applied in two equal doses as per treatment. The first dose was applied as a basal dressing along with all of the phosphorus at land preparation while the second dose of nitrogen was applied as a band on one side of roselle row using a furrow 6 cm away from the plant at 6 weeks after planting (WAP). The crop was thinned to one plant per stand at 2 WAP bringing the plant population to 4 plants m^{-2}. Weed control was carried out manually with the first weeding at 2 WAP, which was later followed by two additional weeding at 4 and 6 WAP.

Data were collected on plant height at fortnightly intervals beginning from 4 WAP by cutting two plants at ground level from each net plot area. Plant height was then measured from the base of the stem to the apex of the last leaf. Number of pods/plant was determined when the crop was at 16 WAP by counting the number of pods present in 4 randomly selected plants in the net plot area from which the number of pods/plant was derived. The dry calyx yield/plant was determined at 16 WAP by dividing total dried yield from four randomly selected plants from each plot area with the number of plants harvested. Calyx yield ha^{-1} was determined at 16 WAP by harvesting the fresh calyx in the net plot area. The calyces were air dried and weighed. The calyx yield per net plot was expressed in kg ha^{-1}. Seed yield per plant per hectare were also obtained by the same procedure as described for the calyx.

The data were analyzed using Analysis of Variance (ANOVA) technique. The treatment means were separated using Duncan's Multiple Range Test (Gomez and Gomez, 1984).

Results

The texture of the soil was found to be loamy sand and the soil was deep, loose and well drained, classified as Typic Psammants (USDA, 1988). Chemical analysis showed that the soil was slightly acidic, very low in organic-C and total-N content, moderate in exchangeable cations, low in cation exchange capacity and available-P but medium in K, Na, Ca and Mg contents. The number of rainy days during the two experimental seasons were observed to be 28 and 31 days in 1998 and 1999 rainy seasons, respectively with annual rainfall of 550.7 and 597.1 mm, respectively. The Temperature and Relative Humidity were normal for the long-range averages.

Plant height was significantly affected by nitrogen except at 4 WAP in 1998. Also plant height was significantly highly influenced ($p<0.01$) by phosphorus at 8, 10, 12 and 14 WAP but only significant ($p<0.05$) at 6 WAP. Phosphorus effect was not significant at 4 WAP. At 6 WAP there was significant response to applied N on plant height at 20, 40 and 60 kg N ha^{-1} when compared with control. However, the response to N at 20 and 40 kg N ha^{-1} were similar and higher than that of 60 kg N ha^{-1}. At 8 WAP, the response to N at 20 and 60 kg N ha^{-1} was not statistically different from the control but at 40 kg N ha^{-1} the response was higher than that obtained from the control. At 10, 12 and 14 WAP, there were significant responses to N at 20, 40 and 60 kg N ha^{-1} but the responses at 20 and 60 kg N ha^{-1} were statistically not different (Table 1).

In the case of phosphorus, at 6 WAP, there were significant but similar responses to applied P at 10, 20 and 30 kg P ha^{-1}. At 8 WAP, there were no responses to applied P at 10 and 20 kg P ha^{-1} but showed negative response on plant height at 30 kg P ha^{-1}, that is lower than the control treatment. At 10 WAP, addition of 10 kg P ha^{-1} resulted in no response to applied P but there were negative responses with subsequent addition at 20 and 30 kg P ha^{-1}. At 12 and 14 WAP, there were negative responses to P at 10 and 30 kg P ha^{-1} but showed no response at 20 kg P ha^{-1} (Table 1).

In 1999, the response of plant height to applied N and P fertilizers was similar to that of 1998 except for the response that occurred at 4 WAP and the non response to applied N at 6 and 8 WAP, (Table 2).

Yield and yield components of roselle responded significantly to nitrogen and phosphorus in the two seasons (Tables 3 and 4). With respect to number of pods/plant, in 1998, there were significant responses at 20 and 40 kg N^{-1} ha^{-1} but showed no significance response from the control at 60 kg N^{-1} ha^{-1}. In 1999, additions of 20 and 60 kg N ha^{-1} resulted in significant response to applied N on number of pods when compared with 0 kg N ha^{-1} but showed no response at 40 kg N ha^{-1}. In the case of phosphorus, in 1998, there were significant responses to applied P at 10 and 20 kg P ha^{-1} but at 30 kg P ha^{-1} the response was negative. In 1999, the trend in response of applied P on number of pods was similar except that there was no response at 30 kg P ha^{-1}.

Table 1: Mean plant height (cm) of roselle as affected by the nitrogen and phosphorus effects during the 1998 season

	Weeks after planting					
Treatment	4	6	8	10	12	14
Nitrogen (kg ha^{-1})						
0	19.92	32.33c	53.42b	77.25c	122.8c	135.58c
20	20.83	37.42a	55.75b	86.58b	126.8b	147.33b
40	21.33	37.92a	60.50a	90.50a	132.3a	153.52a
60	18.25	34.92b	55.33b	86.83b	128.4b	148.75b
Sig.	ns	**	**	**	**	**
SE±	0.888	0.624	0.907	0.786	0.786	0.897
Phophorus (kg ha^{-1})						
0	20.08	33.92b	59.17a	89.25a	131.8a	149.50a
10	21.58	36.67a	56.50a	88.58a	126.8b	145.08b
20	20.58	36.25a	56.67a	82.83b	130.2a	148.67a
30	18.08	35.75a	52.67b	80.50c	121.4c	141.92c
Sig	ns	*	**	**	**.	**
SE±	0.888	0.624	0.907	0.786	0.786	0.897
N×P	ns	**	**	**	**	**

ns and *, ** - not significant and significant at 5% and 1%, respectively, Means followed by the same letter within a treatment group are not different statistically by DMRT at 5% level

Table 2: Mean plant height (cm) of roselle as affected by nitrogen and phosphorus during the 1999 season

	Weeks after planting					
Treatment	4	6	8	10	12	14
Nitrogen (kg ha^{-1})						
0	23.42a	37.42	56.67	81.08d	121.2c	136.75d
20	22.50a	38.83	57.75	88.50b	129.6b	145.08b
40	22.00ab	39.25	59.67	91.50a	131.7a	141.42c
60	20.42b	37.00	57.33	85.33c	130.8ab	149.83a
Sig.	*	ns	ns	**	**	**
SE±	0.681	0.675	0.803	0.653	0.653	0.701
Phosphorus (kg ha^{-1})						
0	22.67	39.17	60.50a	87.58a	131.6a	144.75b
10	22.75	37.75	57.75b	87.50a	128.1b	148.72a
20	22.00	38.17	57.08b	84.33b	130.3a	139.08c
30	20.92	37.42	56.08b	87.00a	123.3c	140.33c
Sig	ns	ns	**	**	**	**
SE±	0.681	0.675	0.803	0.653	0.653	0.701
N×P	*	**	**	**	**	**

ns and *, ** - not significant and significant at 5% and 1%, respectively, Means followed by the same letter within a treatment group are not different statistically by DMRT at 5% level

Table 3: Mean yield and yield components of roselle as affected by N and P in 1998 season

Treatment	Pod/plant	calyx/plant	calyx/ha (kg)	Seed/pod	Seed/ha (kg)
Nitrogen (kg ha^{-1})					
0	47.25c	13.73ab	549.00	14.93b	597.33b
20	55.33a	15.11a	604.00	19.25a	770.00a
40	48.33b	13.71ab	548.33	15.88b	635.00b
60	47.17c	12.49b	524.70	16.74b	665.67b
Sig.	**	*	Ns	**	**
SE±	0.811	0.627	27.305	0.639	26.195
Phosphorus (kg ha^{-1})					
0	47.08c	13.86	554.00	15.64b	621.50b
10	51.92b	13.91	556.67	18.15a	725.83a
20	56.50a	13.88	580.33	17.73a	709.33a
30	42.58d	13.38	535.33	25.28b	611.33b
Sig.	**	Ns	Ns	**	**
SE±	0.811	0.627	27.305	0.639	26.195
N×P	**	**	**	**	**

ns and *,** - not significant and significant at 5% and 1%, respectively, Means followed by the same letter within a treatment group are not different statistically by DMRT at 5% level

Table 4: Mean yield and yield components of roselle as affected by N and P in 1999 season

Treatment.	Pod/plant	calyx/pl	calyx/ha (kg)	Seed/pod	Seed/ha (kg)
Nitrogen (kg ha^{-1})					
0	52.33c	14.66b	586.30b	17.03c	681.33c
20	74.17a	16.03a	641.33a	21.72a	868.33a
40	53.58c	12.97c	518.67c	19.04b	761.67b
60	57.42b	16.72b	668.67a	19.71b	788.67b
Sig.	**	*	**	**	**
SE±	1.042	0.470	18.787	0.526	21.044
Phosphorus (kg ha^{-1})					
0	55.08b	12.10c	484.00c	15.77d	630.67d
10	62.08a	15.00b	600.00b	24.04a	961.67a
20	64.92a	15.27b	610.67b	19.94b	797.67b
30	55.42b	18.01a	720.33a	17.76c	710.33c
Sig.	**	**	**	**	**
SE±	1.042	0.470	18.787	0.526	21.044
N x P	**	**	**	ns	**

ns and *,** - not significant and significant at 5% and 1%, respectively. pl= plant., Means followed by the same letter within a treatment group are not different statistically by DMRT at 5% level

With respect to calyx yield/plant (Tables 3 and 4); in 1998, there was no response to applied N when compared with the control. In 1999, there was significant response to N at 20 kg N^{-1} ha^{-1} while the response was negative at 40 kg N^{-1} ha^{-1} and showed no response at 60 kg N ha^{-1}. With regards to P effects in 1999, addition of applied P on calyx yield/plant resulted in significant responses when compared with control P.

Considering calyx yield ha^{-1}, in 1999, there were significant responses to applied N at 20 and 60 kg N ha^{-1} and at 40 kg N ha^{-1} the response was negative. In the case of phosphorus, the addition of 10 and 20 kg P ha^{-1} showed no response to applied but subsequent addition at 30 kg P resulted in significantly higher response than at control P.

With seed yield/plant (Tables 3 and 4); in the two years, application of 20 kg N ha^{-1} resulted in significant response to applied N but there were no responses with addition to 40 or 60 kg N ha^{-1}. There were significant responses in 1998 to applied P on seed yield/plant at 10 and 20 kg P ha^{-1} but there was no response at 30 kg P ha^{-1} when compared with control P. In 1999, there were significant responses on seed yield/plant at 10, 20 and 30 kg P ha^{-1} when compared with 0 kg P ha^{-1}.

Considering calyx yield/ha, in 1998, there was significant response to applied N at 20 kg N ha^{-1} whereas there were no responses at 40 and 60 kg N ha^{-1} when compared with control N. In 1999, there were significant responses to N at 20, 40 and 60 kg N ha^{-1} when compared with 0 kg N ha^{-1}. In 1998, additions of 10 and 20 P ha^{-1} resulted in significant responses to applied P on seed yield/ha but there was no response with further addition at 30 kg P ha^{-1}. In 1999, there were significant responses at applied P levels when compared with control.

Discussion

The general significant positive response of plant height of roselle to nitrogen is indicative of not only its importance but to also its association with vegetative growth. Similar observations were made by Tisdale and Nelson (1996) that nitrogen was linked with vigorous vegetative growth in crop plants. Selim *et al*. (1993) also reported significant response of plant height of roselle to nitrogen. However, the lack of significance at the initial growth stage may be due to time lag for the roselle root system to develop sufficiently to take up the available nitrogen in soil solution, urea being a highly soluble fertilizer.

The similarity in plant height in the two seasons may prove that it is a trait under genetic control rather than a trait moderated by environment, otherwise, plants in the 1999 season failed to respond favourably to the better rainfall distribution in that year. The plant height of 153.52 cm at 40 kg N $ha^{-1}$and 149.83 cm at 60 kg N ha^{-1}at 14 WAP in 1998 and 1999, respectively, is in close agreement with the findings of Slim *et al*. (1993) who reported plant height of roselle of 160 cm at the highest nitrogen level of 180 kg N^{-1} ha^{-1}

Phosphorus also proved to be significant which showed its importance in vegetative growth of roselle. The lack of response to the nutrient in plant height at the early growth stage of roselle crop in spite of low native soil phosphorus status, may be due to the small root system which might have been inadequate to take up the available phosphorus in soil solution. In addition, it might have been due to the low soluble nature of single super phosphate fertilizer. Although its effect is long lasting as a result of its residual effect, it takes considerable time for single super phosphate fertilizer to enter into soil solution. This explained the initial purpling of leaves observed in few plants that cut across phosphorus treatments which disappeared with time, with more rains which might have caused more of the phosphorus to be released and therefore available for the roselle plant.

Calyx yield per plant responded positively to nitrogen in both seasons. The highest calyx yield per plant was 16 g at 20 kg N ha^{-1}. Selim *et al*. (1993) also reported the highest calyx yield per plant of 49.4 g at 160 kg N ha^{-1}. Their higher dry calyx yield per plant may have to do with their higher rates of fertilizer applied or with the cultivar of roselle. In general, it may be inferred that dry calyx yield per plant tended to follow the same trend as the number of pods per plant and calyx harvest index.

Calyx yield/plant responded positively to phosphorus only in 1999 season. It showed the importance of phosphorus in determining calyx yield/plant. Calyx yield per hectare responded positively to nitrogen and phosphorus also only in 1999. The highest calyx yield per hectare was 669 kg ha^{-1} at 60 kg N and 720 kg ha^{-1} at 30 kg P ha^{-1}. The high calyx yield ha^{-1} at 60 kg N ha^{-1} was not reflected in any of its calyx yield components or calyx harvest index. Calyx harvest index seemed not relevant also to high calyx yield per hectare at 30 kg P ha^{-1} instead it seemed to have been brought about by the high calyx yield per plant at 30 kg P ha^{-1}.

Calyx yield/ha responded positively to nitrogen and phosphorus in the combined analysis. With both nutrients the optimum levels may not have been reached because even at their highest levels calyx yield/ha was still increasing.

Seed yield/plant responded positively to nitrogen rates in both seasons. The highest seed yield/plant was at 20 kg N $ha^{-1}$and it may be associated with its high number of pods per/plant and high seed harvest index. Seed yield/plant of roselle also responded positively to phosphorus in both seasons. The high seed yield/plant at 10 kg P ha^{-1} may not have been due to the influence of number of pods/plant but instead may have been mediated by the high seed harvest index.

Seed yield/ha showed positive response to nitrogen. The highest seed yield/plant was at 20 kg N $ha^{-1}$and it may have been mediated by its high seed yield/plant, Seed yield/ha responded positively to phosphorus in both seasons. The high seed yield/ha at 10 kg P ha^{-1} could have been due to a combination of high pods/plant, seed/plant and seed harvest index.

From the results obtained, it could be concluded that both Nitrogen and phosphorus are important for the growth and yield of the roselle plant, just as with most crop plants. But the rates of these nutrients to be used depend on the on the characteristic of the crop in question.

References

Adekpe, D.I. and J.A. Adigun, 2000. Evaluation of herbicides for weed control in roselle at Samaru-Zaria. In Proceedings: 18th Horticultural SWociety of Nigeria Conference, IAR/ABU Zaria, pp: 170-173.

Alegbejo, M.D., 1998. The potentials of roselle as an industrial crop in Nigeria. Noma Magazine, 14: 43-45

Alegbejo, M.D., 2000. Processing, utilization and nutritional values of okra and roselle. Noma Magazine, 14: 43-45

Babajide, J.M., J.G. Bodunde and A.A. Salami, 2004. Quality and sensory evaluation of processed calyces of six varieties of roselle (*Hibiscus sabdariffa* L.). Nigerian J. Hortic. Sci., 9: 110-115.

Ghazali, M., 1999. Characterization and utilization of roselle. Food Science and Biotechnology Online, University of Putra, Malaysia.

Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedure for Agricultural Research (2nd Edn.,). John Willey and Sons Limited, USA., pp: 98-108.

Lamido, A., 1998. Roselle production (*Hibiscus sabdariffa* L.). Production as affected by pruning and sowing date. J. Agric. Technol., 6: 16-20.

Selim, S.M.A., A.M. Rokba, M.R. Hassan and M.A. Hassan, 1993. Effects of sowing dates, nitrogenous and potassium fertilization on roselle plant. Egypt J. Hortic., 20: 87-96.

Tindale, S.L. and L.Nelson, 1996. Soil Fertility and Fertilizers. The Macmillan Company, London, 3rd Edn., pp: 66-104.

United States Department of Agriculture (USDA), 1988. Soil Taxonomy. A Basic System of Soil Classification for Making and Interpreting Soil Surveys. Robert E. Krieger Publishing Company, Inc. pp: 179-209.