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Effect of Nitrogen Fertiliser on the Growth and Calyx Yield of Two Cultivars of Roselle in Northern Guinea Savanna

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Abstract: Yield experiments were carried out during the 2000 and 2001 rainy seasons on the field of National Horticultural Research Institute at Bagauda (latitude 11°33' N and longitude 8°23'E of the equator). The experiment was aimed at evaluating the response of roselle cultivars to different levels of N in combination with 50 kg P/ha and establishing an optimum N fertilizer requirement by roselle. Five rates of nitrogen (0, 30, 60, 90 and 120 kg N ha^{-1}) were factorially combined with deep red and pure white cultivars of roselle in a randomized complete block design arrangement with three replications. Application of N significantly ($p<0.05$) increased plant height, number of leaves, branches, pods, calyx and seed yields o roselle. Application of 50 kg P/ha as basal dressing significantly ($p<0.05$) influenced the production of calyces among the cultivars. In Nothern Guinea savanna, calyx yield of 2.38 t/ha fresh weight with a corresponding dry matter of 1.02 t/ha were significantly different ($p<0.05$) when 30 kg N/ha was applied to deep red cultivar and second season (2001) was better than the first season (2000). Similarly, significantly differences ($p<0.05$) were recorded in the seed yields of roselle cultivars in 2001 season and 60 kg N/ha produced optimum levels of 690.0 kg/ha for deep red and 550.0 kg/ha for pure white cultivars seed yields in Northern Guinea savanna.

Key words:

INTRODUCTION

Roselle (*Hibiscus sabdariffa* L.) is a native of tropical Central and West Africa and is widely distributed throughout many tropical areas [1]. Roselle popularly called "Yakuwa" (Hausa) and 'Isapa' (Yoruba) is adapted to a wide range of soil conditions. It is often grown on relatively infertile soils but economic yields are only obtained on soils which are well supplied with organic material and essential nutrients. Roselle is tolerant to relatively high temperatures throughout the growing and fruiting periods [2]. The plant has an overall growing period of 4-6 months from planting of the seeds to harvesting of the calyx. The production of roselle in the savanna is now on the increase. It plays an important role in the lives of people ranging from rural dwellers to urban settlers. It serves as a source of food, income, employment, raw material and foreign exchange earner if production is well packaged. Muoneke and Akingbade [3] reported hat the land area devoted for roselle cultivation in Nigeria has increased over the years because of the increased awareness of the potential refreshing and medicinal value of the "zobarodo" drink [4].

Roselle is cultivated for its fleshy fruits, leaves, stems, flowers (calyces), seeds and fibre [5]. Roselle is described as an emerging crop of economic importance whose extracts from the coloured calyces are used in the preparation of beverage drinks. There is however, little available research information and documentation that could help in an organized cultivation [6].

Nitrogen is undoubtedly the most limiting nutrient in Nigerian soils, particularly in the savanna zone where the soils are predominantly coarse textured and characteristically low in organic matter [7]; it limits crop production in the tropics [8]. Its deficiency is usually recognized first by pale green or yellowish-green colour of the leaves, followed by premature necrosis of the old leaves. Most soils in Nigeria are potentially low in natural fertility and, therefore, cannot sustain high crop yields under continuous cultivation [9].

Kumar *et al*. [10] noted that there has practically been no research work so far done on the agronomy of roselle

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in Northern Nigeria. It is thus the focus of this study, to determine the N in combination with 50 kg P fertilizer requirements of roselle as one of the major agronomic practices to increase its productivity in Northern Guinea savanna of Nigeria.

MATERIALS AND METHODS

Three seeds of roselle were sown per hole on the 20th/06/2000 and 27th/06/2001 respectively at the farm of NIHORT, Bagauda. Seedling emergence commended three days after sowing and thinning of seedlings to only one plant per hole followed immediately after the first weeding. To understand the response of roselle cultivars to N and P, a uniform application of 50 kg P/ha as basal application was done to all plots before the application of nitrogen. Five different levels of nitrogen namely, 0, 30, 60, 90 and 120 k N ha^{-1} were applied on two cultivars of roselle at 6 WAS after thinning of seedlings. Hand weeding with a simple how was done at different intervals in the seasons. The experiment was a 2×1×5 factorials arranged in randomized complete block design with three replications. Data were collected on the growth parameters such as plant height (cm), number of leaves, branches, pods, stem girth at 10 cm above the ground surface (cm) and leaf area index. Destructive and non-destructive samplings of three leaves/plant were conventionally measured at the base and middle of the petiole and some were traced on graph sheets and mean value determined according to Wiersima and Bailey [11] and Gamiely *et al*. [12]. Yield data were determined on total weight of plants, fresh and dry matter and seed yields.

RESULTS AND DISCUSSION

The chemical and physical properties of the soils collected at different depths of 0-15 cm and 15-30 cm at Bagauda in Table 1 shows that the organic carbon, total nitrogen, available phosphorus, exchangeable cations and base saturations were low and the soil test values revealed that silt and clay were highest at 15-30 cm. Rainfall, humidity and temperature were among the weather variables (Table 2) that determined the growth and yield of deep red and pure white cultivars of roselle at Bagauda.

Table 1: Results for soil analyses for the site of NIHORT Bagauda in Northern Guinea savanna of Nigeria

Variables	0-15 cm	15-30 cm
pH (H_20)-1:2	5.00	5.00
Org. C (g kg^{-1})	0.38	0.29
Total N (g kg^{-1})	0.08	0.06
Av. P. (mg kg^{-1})	0.56	0.34
Exchangeable Bases (C mol kg^{-1})		
Ca	0.27	0.55
Mg	0.08	0.10
Na	0.30	0.43
K	0.19	0.20
Ex. Ac	0.24	0.16
CEC	1.08	1.44
Physical properties of soil		
Sand (g kg^{-1})	784.00	584.00
Silt (g kg^{-1})	114.00	274.00
Clay (g kg^{-1})	102.00	142.00

Plant Height, Number of Leaves and Number of Branches: Plant height was significantly ($p<0.05$) influenced by the application of N in combination with 50 kg P ha^{-1} cultivars of roselle. The best performing cultivar in relation to plant height at different N rates was deep red cultivar at 20 WAS (Table 3). The application of 60 kg N and 50 kg P ha^{-1} to cultivars of roselle recorded the highest plant height of 89.8 cm while pure white cultivar was best at 30 kg N/ha. Increasing the levels of N to 90 and 120 kg ha^{-1} on the two cultivars of roselle did not have any significant ($p<0.05$) change on plan height at Bagauda (Table 3).

The number of leaves per plant of roselle was significantly ($p<0.05$) affected by the application of 30 kg N + 50 kg P/ha on deep red cultivar and optimum number of 195.4 leaves/plant was recorded from the application of 60 kg N/ha on pure white cultivar (Table 3). The highest number of leaves per plant was recorded at 16 WAS and the best cultivar with the highest number of leaves/plant was pure white. Drastic leaf drop was recorded at 20 WAS and N rates applied to cultivar were not significant ($p<0.05$).

Progressive increase in the number of branches/plant of roselle cultivars was observed at different N rates + 50 kg P/ha (Table 4). The highest mean branches plant^{-1} was obtained from 120 kg N + 50 kg P/ha and this significantly differed ($p<0.05$) from the lowest mean obtained from the control. However, optimum number of branches/plant of 10.8 (deep red) and 18.2 (pure white) for roselle cultivars were obtained from the application of 30 kg N + 50 kg P/ha and lowest number of branches/plant was generally obtained from no nitrogen fertilizer application (Table 4).

Number of Flower Pods, Stem Girth and Leaf Area Index/plant: N applied at 50 kg P ha^{-1} on two cultivars of

Table 2: Summary of relative humidity, rainfall and temperature for 2000 and 2001 seasons at Bagauda

Month and Year	Relative Humidity %	Daily Rainfall (mm)	Max. Temp. (°C)	Min. Temp. (°C)	Soil temperatures 5cm °C	10cm °C	30cm °C	50cm °C
May 2000	50	16.6	38	24	41.7	42.1	35.4	34.5
May 2001	60	85.6	36	25	42.0	38.4	33.8	32.3
June 2000	59	52.2	32	22	33.7	37.8	30.0	29.9
June 2001	65	37.3	34	23	35.3	40.3	31.1	30.8
July 2000	73	123.4	31	22	32.7	38.5	29.0	29.7
July 2001	72	226.7	34	22	31.8	38.9	29.6	29.4
Aug. 2000	80	176.1	30	21	27.9	36.8	27.3	27.4
Aug. 2001	80	116.4	31	22	29.5	37.5	27.9	27.6
Sept. 2000	71	113.6	32	22	32.2	38.8	29.5	29.4
Sept. 2001	75	0.0	32	22	32.3	38.5	29.3	28.9
Oct. 2000	56	15.4	33	20	37.3	40.6	30.2	30.2
Oct. 2001	46	0.0	33	19	38.4	40.0	30.2	30.1
Nov. 2000	33	0.0	32	14	34.5	37.2	27.5	27.8
Nov. 2001	38	0.0	33	15	36.4	36.4	27.8	27.8

Source: NIHORT, Bagauda Meteorological Station, Kano State

Table 3: Plant height (cm) and number of leaves/plant of roselle cultivars as influenced by N + 50 kg P/ha at Bagauda

		Plant height (cm)			Number of leaves		
		Weeks after sowing					
Cultivar	N kg ha^{-1}	12	16	20	12	16	20
Deep red	0	46.4	60.1	68.2c	83.7	108.4	20.9
	30	47.2	61.8	69.0b	133.9	179.4ab	16.4
	60	50.1	77.0	89.8a	112.7	186.4a	28.1
	90	43.9	67.3	84.1a	109.0	153.9c	17.7
	120	47.3	69.9	85.8a	73.8	110.7d	25.4
Pure white	0	33.7	54.3	60.6c	51.5	79.6d	21.4
	30	43.3	71.3	80.4a	76.6	157.9c	46.6
	60	37.4	69.2	80.0b	82.6	195.4ab	40.1
	90	42.5	70.8	78.9b	132.2	205.6a	29.4
	120	44.7	75.8	88.2a	85.3	159.4c	22.5
	SE	4.2	5.9	7.3	40.4	46.5	ns

DMRT<0.05 = Treatments with the same alphabets do not differ significantly

Table 4: Number of branches and flower pods of roselle as influenced by different levels of N + 50 kg P/ha at Bagauda

		Number of branches/plant			Number of flower pods/plant		
		Weeks after sowing					
Cultivar	N kg ha^{-1}	12	16	20	12	16	20
Deep red	0	5.7	7.0	7.8d	19.7	31.4	45.6e
	30	7.3	10.1	10.8c	34.1	95.8	112.9a
	60	9.0	11.2	11.7c	39.9	47.5	101.6ab
	90	8.5	11.3	13.1b	36.8	46.1	76.2c
	120	7.8	9.6	18.8a	17.6	36.6	59.7d
Pure white	0	5.0	7.1	8.3b	12.2	20.1	39.1e
	30	7.8	10.6	18.2a	31.8	35.5	62.0d
	60	7.7	10.6	18.9a	35.3	60.8	105.3a
	90	9.2	10.8	12.5b	45.7	56.7	79.6bc
	120	8.1	10.7	19.0a	25.2	53.0	82.7b
	SE	0.9	1.1	1.9	7.8	12.1	15.7

DMRT<0.05 = Treatments with the same alphabets do not differ significantly

roselle significantly ($p<0.05$) influenced the number of flower pods plant^{-1} at Bagauda. Mean flower pods plant^{-1} increased significantly ($p<0.05$) at 20 WAS with different N rates. The highest number of pods/plant among the cultivars was obtained at 30 kg N + 50 kg P/ha while the lowest mean was recorded from 0 kg N/ha. Production of pods plant^{-1} in deep ed cultivar was highest at 30 kg N/ha with 112 pods/plant while pure white cultivar responded best to 60 kg N/ha with the highest number of 105.3 pods/plant and these means differed significantly ($p<0.05$) from the controls (Table 4).

Table 5: Stem girth (10 cm above ground surface) and leaf area index of roselle cultivars as influenced by different levels of N + 50 kg P/ha at Bagauda

		Stem girth at 10 cm above ground surface (cm)			Leaf area index		
		Weeks after sowing					
Cultivar	N kg ha^{-1}	12	16	20	12	16	20
Deep red	0	1.9	2.7	3.1c	0.26	0.50	1.11d
	30	3.1	3.5	3.9ab	0.40	0.81	1.92b
	60	2.8	3.9	4.4a	0.50	0.90	2.16a
	90	2.5	3.6	4.3a	0.40	0.75	1.65c
	120	2.6	3.9	4.6a	0.45	0.90	1.98b
Pure white	0	1.9	2.8	3.2cd	0.31	0.59	1.32e
	30	3.8	4.0	5.1a	0.59	1.14	2.70a
	60	3.3	4.3	5.4a	0.40	0.89	1.92cd
	90	3.2	4.4	5.1a	0.43	1.01	2.20c
	120	3.3	4.0	4.7ab	0.57	1.13	2.50a
	SE	0.3	0.4	0.6	0.08	0.16	0.34

DMRT<0.05 = Treatments with the same alphabets do not differ significantly

Stem girth of roselle cultivars was significantly ($p<0.05$) influenced by the application of 30 kg N ha^{-1} in combination with 50 kg P ha^{-1}. Increased application of N to higher rates did not produce significant differences ($p<0.05$) in the stem girths of deep red and pure white cultivars. However, it was observed that the best response of roselle cultivars were significantly different ($p<0.05$) from the lowest means obtained from the control (Table 5). Cultivar performance recording the highest stem girth of 5.1 cm was obtained in pure white cultivar at 20 WAS from the best N rate of 30 kg in combination with 50 kg P/ha.

The highest LAI obtained from the cultivars of roselle was influenced by the application of 60 kg N ha^{-1} on deep red while pure white showed the highest response at 30 kg N/ha and the lowest mean was recorded when no nitrogen fertilizer was used. Cultivar performance in relation to LAI was recorded highest in pure white cultivar (Table 5). Generally, it was observed that leaf area index of roselle cultivars increased from 12 to 20 WAS at different N rates irrespective of cultivar variations. Growth parameters of roselle cultivars were significantly ($p<0.05$) influenced by N applications at Bagauda. Aloe *et al*. [13] and El Gamal *et al*. [14] reported that increased dosage of N either singly or in combination with K stimulated vegetative growths of maize and roselle plans. Menzel *et al*. [15] and Aiyelaagbe *et al*. [16] reported that 120 kg N ha^{-1} was suboptimal for the growth of passion fruit and further increased application of 240 kg N ha^{-1} favoured increased number of branches/plant as well as plant growth and this contrasted with the N requirement by roselle.

Yield and Yield Components: Total weights of plants, number of pods and weight of pods/ha were significantly ($p<0.05$) affected by the application of nitrogen in combination with 50 kg P/ha. The best response of deep red cultivar in the two seasons was obtained from the application of 30 kg N + 50 kg P/ha on pure white cultivar recorded the best yields and the lowest mean was recorded from the control in 2000 season. Season showed significant differences ($p<0.05$) in the means of roselle cultivars and 2001 season recorded highest yields. Similar trend was observed in the number of pods as affected by the application of 30 kg N + 50 kg P/ha and cultivars of roselle were significantly ($p<0.05$) affected by N in the two seasons (Table 6). Weights of fresh pods/ha for roselle cultivars were significantly ($p<0.05$) influenced by the application of 30 kg N + 50 kg P/ha (Table 7) and best season for significantly ($p<0.05$) higher yield was 2001 while 2000 was recorded as the lowest yielding season (Table 6).

The response of seed yield of roselle cultivars to N in combination with 50 kg P ha^{-1} applied was significantly different ($p<0.05$) in the two seasons. The mean seed yield of roselle responded significantly ($p<0.05$) to the application of 60 kg N + 50 kg P/ha. The highest seed yield of 690.0 kg/ha recoded from the effect of N + 50 kg P/ha was obtained from 60 kg/ha in 2001 season while the lowest mean of 80.0 kg/ha was recorded from no fertilizer

Table 6: Total weight of plants and total number of plants/ha of roselle cultivars as affected by N + 50 kg P/ha at Bagauda

		Total weights of plants		Number of pods	
		Yield (t/ha)			
Site	N kg ha^{-1}	2000	2001	2000	2001
Cultivar	0	2.43d	2.65c	16.97b	840.0a
Deep red	30	3.30c	6.20a	1712.5b	782.5a
	60	4.34ab	4.71b	1760.0b	797.5a
	90	4.82a	7.59a	2320.0a	557.5c
	120	5.84a	6.33a	1007.5	697.5b
Pure white	0	1.91cd	1.75d	1730.0a	487.5d
	30	3.55b	3.79c	1935.0a	690.0a
	60	4.92a	4.02b	1582.5b	620.0b
	90	4.33a	5.79a	1377.5b	570.0c
	120	5.32a	6.82a	1642.5a	785.0a
	SE	1.22	1.69	366.3	138.3

DMRT<0.05 = Treatments with the same alphabets do not differ significantly

Table 7: Weight of fresh pods (t ha^{-1}) and seed yield (kg/ha) of roselle as affected by the application of N + 50 kg P/ha at Bagauda

		Fresh pods		Seed yield	
		Yield (t/ha)			
Site	N kg ha^{-1}	2000	2001	2000	2001
Cultivar	0	1.30c	1.85c	120.0d	330.0c
Deep red	30	2.58a	3.79b	180.0c	440.0b
	60	1.62b	3.59b	230.0b	690.0a
	90	1.61b	4.71a	200.0b	480.0b
	120	2.76a	4.42a	390.0a	540.0a
Pure white	0	1.36c	1.65c	80.0cd	230.0d
	30	2.78a	2.36b	160.0b	450.0c
	60	1.71b	2.86b	220.0a	550.0b
	90	1.61b	4.08a	180.0b	630.0a
	120	2.18a	4.83a	250.0a	690.0a
	SE	0.62	1.04	110.0	140.0

DMRT<0.05 = Treatments with the same alphabets do not differ significantly

application in 2000 season (Table 7). Magaji [17] reported that seed yield of paddy rice increased with increase in N level up to 45 kg N ha^{-1} but Olugbemi [18] disagreed by reporting that increasing the N level from 100-150 kg N ha^{-1} increased significantly ($p<0.05$) the grain yield of wheat.

Calyx Yield: Fresh and dried calyx yields of roselle cultivars were significantly ($p<0.05$) influenced by the applications of 30 and 60 kg N + 50 kg P/ha in the two seasons (Table 8). Cultivar variation showed that fresh calyx yield and corresponding dry matter of deep red cultivar recorded best means at 30 kg N/ha while the lowest mean was obtained from 0 kg N/ha. Higher N rate up to 90 kg N + 50 kg P/ha was required by pure white cultivar for a significantly different ($p<0.05$) fresh calyx, however, the corresponding dry matter responded best to 60 kg N + 50 kg P/ha and lowest mean was obtained from

Table 8: Fresh and dried calyx yields of roselle cultivars as affected by N + 50 kg P/ha application at Bagauda

		Fresh Calyx		Dried matter	
		Yield (t/ha)			
Site	N kg ha^{-1}	2000	2001	2000	2001
Cultivar	0	0.26cd	1.38c	0.14d	0.36cd
Deep red	30	0.76b	2.38a	0.19c	1.02a
	60	0.81b	1.92b	0.26b	0.86b
	90	0.73b	2.71a	0.24b	0.96a
	120	1.28a	2.41a	0.48a	1.00a
Pure white	0	0.23c	0.44d	0.10d	0.16cd
	30	0.62b	1.02c	0.21c	0.40b
	60	0.77b	1.23c	0.28b	0.51b
	90	0.78b	2.29b	0.23c	0.97a
	120	1.14a	2.92a	0.39a	1.22a
	SE	0.24	0.53	0.08	0.27

0 kg N/ha. The highest yielding cultivar was pure white at high N rate of 120 kg/ha but deep and exhibited the best response of 1.02 t/ha dried calyx yield at 30 kg N + 50 kg P/ha in 2001 season (Table 8). The effects of N on roselle cultivars showed that N increased fresh calyx yield and this finding was supported by Olaniyi [19] who reported significant ($p<0.05$) increases in the yields of melon cultivars as a result of increased level of N.

CONCLUSION

Two cultivars of roselle namely deep red and pure white were tested against five levels of N in Northern Guinea savanna. Analysed data showed that plant height increased with increased level of N, number of leaves responded better to 30 kg N ha^{-1}, overall response of branches was highest at 60 kg N/ha and deep red roselle had the highest number of flower buds plant^{-1}. The overall effect of nitrogen on the leaf and its components showed that leaf area index was induced by 60 kg N ha^{-1} while stem girth decreased from 0 to 10 cm above ground surface but significant differences ($p<0.05$) at 60 + 50 kg P ha^{-1} across the cultivars were recorded. The calyx yield of roselle in 2000 and 2001 seasons showed that deep red cultivar yielded better than pure white cultivar. The optimum and highest seed yields of 690.0 (deep red) and 550.0 (pure white) kg/ha were recorded from 60 kg N + 50 kg P/ha respectively.

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