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Full Length Research Paper

Response of roselle (*Hibiscus sabdariffa* L.) to rates of inorganic and farmyard fertilizers in the Sudan savanna ecological zone of Nigeria

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Field trials conducted in two rainy seasons at the Usmanu Danfodiyu University, Sokoto, Nigeria, were used to investigate the response of Roselle to organic manure (2.5, 5.0 and 7.5 tons/ha cow dung) and nitrogen (N) fertilizer (25, 50, and 75 kg/ha as urea) applications. The results of the analysis of the experimental data show that calyx yield, pods/plant and seeds/pod responded significantly ($P < 0.05$) to manure and nitrogen applications in both years (2005 and 2006), while days to 50% flowering did not respond significantly to manure or N-fertilization. However, days to 50% flowering increased with manure, or N-application. For calyx, pod and seed production, application of manure at 7.5 t/ha or N at 75 kg N/ha gave the best result.

Key words: Roselle, manure, nitrogen fertilizer, calyx yield, pods/plant and seeds/pod.

INTRODUCTION

Roselle with two popular varieties: *Sabdariffa* (edible-fruited type) and *Altissima* (fibre type) belongs to the family *Malvaceae*. The major areas of Roselle cultivation in Africa include Benin, Sudan, Cote D' Ivoire, Ghana, Niger, Burkina Faso and Nigeria. The crop finds readily available market in Europe and the Middle East, where the red acid succulent calyx is usually boiled with sugar to produce 'sorrel' drink, in addition to being made into jellies, sauces and chutneys (Gibbon and Pain, 1985). The tender leaves and stalks are also eaten as salad. In Asia, it is used as a substitute to jute and its pulp is suitable for the manufacture of newsprint. In the Caribbean and Northeast Africa, the dried red calyces found a use as tea; drank hot or more commonly cold, after adding some sugar. The seed contains edible oil, which can also be used as an ingredient for making paints, while its medicinal uses have been well-documented (Alegbejo, 1998; Onyenekwe, 1998). In spite of the crop's economic prospect and medicinal importance, particularly in the treatment of high blood pressure, the level of research on Roselle does not compare to the works done on its closely related species, such as cotton (Kumar et al., 1986; Dike, 1987).

High cost of fertilizers in Nigeria coupled with the problem of product availability justifies a study into maximization of this resource. An investigation into alternative sources of nutrients, this time, farmyard manure, which are more readily available and cheaper, particularly in the experimental area where animal production is part of the farming systems, may alleviate the problem of nutrient deficiency. More importantly, in developed countries increasing awareness and availability of information on man's dietary habits has led to strong steady growth in the sale and consumption of organic foods. Organic farming has become the most highly valued method of sustainable production in agriculture and food trade (Bavec and Bavec, 2007).

It was observed that due to consumer fear, caused by the increasing potential for agricultural products to carry diseases or contain harmful additives, there is an ever increasing demand for healthy, high quality food. Furthermore, is was stressed that the concept of organic

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Table 1. Pre-sowing soil analysis of the experimental site in 2005 and 2006 cropping seasons.

Soil characteristics	Cropping season	
	2005	2006
Sand (%)	96.2	96.3
Silt (%)	0.5	0.4
Clay (%)	3.3	3.3
Total N (%)	0.021	0.023
Available phosphate (µg/g)	0.23	0.25
Exchangeable base (c mol.kg^{-1})		
Na	0.31	0.34
K	1.81	1.89
Ca	0.22	0.23
Mg	1.60	1.64
CEC (meq/100 g)	4.80	4.92
Organic C (%)	0.04	0.06
Soil pH (H_2O 1:1)	6.3	6.2

farming is founded on the idea that soil with sufficient organic matter content, good soil structure, rich and variegated living organisms can provide a base for healthy crops. Soil cultivation is therefore a central component of organic farming, where plant nutrient supply is based on previous input of organic matter in the soil, which is decomposed and mineralized by soil organisms (Bavec and Bavec, 2007).

This trial thus investigated the response of Roselle to different rates of farmyard manure and nitrogen fertilizer with the aim of recommending the most appropriate fertilizer requirement for the crop in the Sudan savanna ecological zone of Nigeria. The research focused on determining the optimum rates of manure and nitrogen fertilizer for sustainable production of Roselle under the semi-arid dry land conditions of the Sudan savanna ecological zone.

MATERIALS AND METHODS

Field trials carried out in the rainy seasons of 2005 and 2006 cropping seasons at the Teaching and Research Dry land Farm, Usmanu Danfodiyo University, Sokoto, Nigeria (Latitude 13°01'N and Longitude 5°15'E, 320 m above sea level) was used to investigate the response of Roselle to rates of farmyard manure and N-fertilizer. The treatment which consisted of three rates each of farmyard manure (2.5, 5.0 and 7.5 tons/ha) and N-fertilizer (25, 50 and 75 kg N/ha as urea) in addition to control treatment, were apportioned in a randomized complete block design (RCBD) with three replications. Seeds were sown on the flat into subplots measuring 3 x 3 m^2 each, separated by 1 m leeway, enforced by two high ridges. Land preparation was manually accomplished using hand hoes. Two seeds were sown per hole at 50 x 50 cm, later thinned to one plant per stand at two weeks after sowing (2 WAS). Weeding was at 2, 6 and 9 WAS. N-fertilizer and manure application were as in the treatment. N was however, applied in split doses, at 2 and 6 WAS, while manure was applied 2 weeks prior to land preparation and later incorporated at land preparation. Plots treated to N-fertilizer also received 30 (as muriate of potash) and 60 kg P/ha [as single super phosphate (SSP)].

Crop was observed for plant height, number of leaves per plant, days to 50% flowering, calyx yield, number of pods/plant, number of seeds/pod, among other parameters. Plant height was a measure of the plant from soil level to the tip of the tallest branch, while number of leaves was taken as average of the leaves in five randomly sampled plants in the net plot (2 x 2 m^2). 50% flowering was attained when half the plant population in the net plot had flowered. While the plants sampled for determination of plant height were also observed for number of pods/plant and ten randomly sampled pods from such plants were used in the determination of the number of seeds/pod and 1000-seed weight; a measure of the weight in grams of 1000 seeds. At maturity, calyces in the net plot were harvested for the determination of calyx yield. Statistical analysis of experimental data was accomplished by standard analysis of variance (ANOVA) in RCBD (Gomez and Gomez, 1984). Experimental means found to be statistically significant were separated using the Fisher's least significant difference (LSD) at 5% probability level as described for RCBD.

RESULTS AND DISCUSSION

Meteorological data and soil characteristics of the experimental site

The experimental area has extremes of temperatures (15 - 45°C); the low temperatures occurring in November - February and the high in April - May. Annual rainfall recorded was 705.9 and 610.4 mm, respectively in 2005 and 2006 cropping seasons. Results of soil analysis in the experimental years revealed that the surface soil (0 – 30 cm) was slightly acidic, predominantly sandy with low levels of organic matter and essential nutrients (Table 1).

Crop growth and productivity depend on the interaction with its environment. Of significant importance are climatic and soil factors in determining crop growth and productivity. Conditions of temperature, precipitation and humidity may promote or discourage the growth of fungus and diseases, which may be injurious to crops (Nnaemeka, 2001), while soil is the region of plant forage for nutrients required for growth and productivity. The poor nutrient status of the experimental plot had negative implications for crop growth, development and crop yield, except when the nutrient status was complemented with other readily available nutrient sources. Havlin et al. (2005) observed that microbial activity and the recycling of nutrient through soil organic matter (OM) substantially impacts plant nutrient availability. They however stressed the importance of the soil solution concentration of N, S, P and several micronutrients in the organic fraction in soils, while climate plays important role in OM (organic matter) decomposition and eventually, the nutrient uptake by plants.

Table 2. Effect of manure and nitrogen application on days to 50% flowering in 2005 and 2006 cropping seasons in the Sudan savanna ecological zone of Nigeria.

Treatment	Days to 50% flowering		
	2005	2006	Combined
Manure (ton/ha)			
0	100	102	101
2.5	102	103	103
5.0	103	104	104
7.5	104	106	105
LSD (0.05)	NS	NS	NS
Nitrogen (urea kg/ha)			
0	100	102	101
25	103	103	103
50	104	105	105
75	105	106	106
LSD (0.05)	NS	NS	NS

NS = Non-significant at 5%.

Table 3. Effect of manure and nitrogen on dry calyx yield (kg/ha) in 2005 and 2006 cropping seasons in the Sudan savanna ecological zone of Nigeria.

Treatment	Dry calyx yield (kg/ha)		
	2005	2006	Combined
Manure (ton/ha)			
0	249.5^{c}	313.0^{d}	281.3^{c}
2.5	338.8^{b}	421.6^{b}	380.2^{ab}
5.0	318.6^{b}	467.0^{a}	392.8^{ab}
7.5	388.3$_{a}$	413.9^{c}	401.1^{a}
LSD (0.05)	12.57	6.41	16.99
Nitrogen (urea kg/ha)			
0	249.5^{b}	313.0^{d}	281.3^{c}
25	344.8^{a}	385.0^{c}	364.9^{b}
50	355.4^{a}	412.3^{b}	383.9^{a}
75	355.4^{a}	419.4^{a}	387.4^{a}
LSD (0.05)	12.57	6.41	16.99

Means in a column within the same treatment followed by the same letter(s) do not differ significantly at $P < 0.05$.
Means in a column within the same treatment followed by the same letter(s) do not differ significantly at $P < 0.05$.

Effect of nutrient application on days to flowering

Analysis of the data showed that increase in the soil fertility either by the application of farmyard manure or N-fertilizer increased days to 50% flowering, however, not significantly ($P > 0.05$) when compared to the control (Table 2). The highest amounts of farmyard manure (7.5 ton/ha) or nitrogen (75 kg N/ha) were always the last to reach 50% flowering. The longer time period taken by plots treated with farmyard manure, or N-fertilizer to attain 50% flowering could largely be due to the contribution made by the treatments to the fertility status of the soil. Manure application has been reported to promote vegetative growth in plants (Udoh et al., 2005), while nitrogen has also been observed to elongate the juvenile stage in plant, thus delaying crop maturity. Thus, the increase in time to the attainment of flowering with increase in application of N-fertilizer may be attributed to the role of nitrogen in crop vegetative development as reported by Selim et al. (1993). The authors had observed, while working on the effect of nitrogen and potassium on vegetative growth and flowering in Roselle, that the highest level of nitrogen (180 kg N/ha) when combined with the lowest or medium rates of potassium (30 or 60 kg k/ha) delayed flowering in Roselle. They concluded that high nitrogen level significantly prolonged vegetative stages in Roselle. The same is also true for manure application, which just as in N-fertilization, increases soil fertility, which in turn prolonged vegetative growth period and time of final plant maturity (Tisdale and Nelson, 1975).

Effect of nutrient application on calyx yield

In both seasons, as well as in the combined result, data analysis show significant ($P < 0.05$) influence of nutrient application, either in the form of farmyard manure or nitrogen on dry calyx yields (Table 3). The least calyx yield was observed in the control treatment, which increased with increase in farmyard manure, or N-fertilization. The positive response of dry calyx yield to manure and fertilizer application confirmed the findings of Tindall (1983) who reported that economic yield of Roselle were only obtained on soils which were well supplied with organic materials and essential nutrients and those of Mahran et al. (1978), Gibbon and Pain (1985), Okusanya et al. (1999), Okosun (2000) and Babatunde (2001) who observed increase in calyx yield as a result of manure or nitrogen fertilization, which was attributed to increase in crop photosynthetic ability, as a result of good vegetative growth induced by these treatments. In both cropping seasons, the response of farmyard manure compared favorably with results obtained from the application of N-fertilizer.

Effect of nutrient application on pod and seed yield

Application of farmyard manure or nitrogen fertilization significantly ($P < 0.05$) influenced number of pods produced per plant (Table 4) in both cropping seasons. Application of manure at 7.5 ton/ha gave the highest

Table 4. Effect of manure and nitrogen on the number of pods produced per plant in the Sudan savanna ecological zone of Nigeria.

Treatment	Number of pods per plant		
	2005	2006	Combined
Manure (ton/ha)			
0	33.8d	33.7d	33.8d
2.5	38.8c	40.6c	39.7c
5.0	42.2b	47.0a	44.6b
7.5	48.3a	48.4a	48.4a
LSD (0.05)	0.94	0.70	0.29
Nitrogen (urea kg/ha) (N)			
0	33.8d	33.7d	33.8d
25	34.2c	41.6c	37.9c
50	41.7b	44.3b	43.0b
75	50.8a	49.0a	49.9a
LSD (0.05)	0.94	0.70	0.29

Means in the column within the same treatment followed by the same letter(s) do not differ significantly at P < 0.05.

Table 5. Effect of manure, nitrogen and their interaction on the number of seeds/pod in the Sudan savanna ecological zone of Nigeria.

Treatment	Number of seeds/pod		
	2005	2006	Combined
Manure (ton/ha)			
0	23.3^{b}	24.5^{c}	23.9^{b}
2.5	25.0^{a}	24.8^{c}	24.9^{b}
5.0	25.4^{a}	26.5^{b}	26.0^{a}
7.5	26.6^{a}	28.4^{a}	27.5^{a}
LSD (0.05)	0.34	0.42	0.35
Nitrogen (urea kg/ha)			
0	23.3^{b}	24.5^{c}	23.9^{b}
25	23.6^{b}	24.6^{c}	24.1^{b}
50	25.6^{a}	26.7^{ab}	26.2^{a}
75	26.8^{a}	27.8^{a}	27.3^{a}
LSD (0.05)	0.34	0.42	0.35

Means in a column within the same treatment followed by the same letter(s) do not differ significantly at P < 0.05.

number of pods in both cropping seasons, while consistently, the lowest pods/plant was in the control plot. For N-fertilizer, application of 75 kg N/ha gave the highest pods/plant in both cropping seasons, while the control treatment gave the least number of pods/plant in both years and in the combined analysis. In addition results of the statistical analysis revealed that number of seeds produced per pod were significantly (P < 0.05) influenced by manure and nitrogen fertilizer application in both years compared to the control (Table 5). Application of manure at 7.5 ton/ha gave the highest number of seeds/pod in both years, while application of 75 kg N/ha recorded the highest number of seeds/pod in both years for nitrogen fertilizer treatments though not significantly different from 50 kg N/ha treatment.

Conclusion

Trials conducted in 2005 and 2006 rainy seasons at the Usmanu Danfodiyu University, Sokoto, Nigeria, were used to investigate the response of Roselle to organic manure (2.5, 5.0, and 7.5 tons/ha cow dung) and nitrogen fertilizer (25, 50, and 75 kg/ha as urea) applications. Calyx yield, pods/plant and seeds/pod responded significantly (P<0.05) to manure and nitrogen applications, while days to 50% flowering was not significantly influenced by manure or N-fertilization, though increase in number of days to 50% flowering was observed as farmyard manure and N-fertilizer were increased. For the purpose of calyx, pod or seed production, application of manure at 7.5 t/ha or N at 75kg N/ha is recommended for the study area or other environments with similar soil nutrient status. These rates were observed to give the best response for calyx, pod and seed yield. The low nutrient status of the soil implies that adequate fertilization or manure application is needed to ensure plant response. Thus, responses to either farmyard manure or N-fertilization were more profound at higher rates for most observations reported.

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