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Response of roselle (*Hibiscus sabdariffa* L.) varieties to fertilizer type and rates in two agro-ecologies of southwest Nigeria

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ABSTRACT

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Roselle is an important traditional vegetable that is drought resistant and tolerant to wide range of soil conditions. It responds well to fertilizer application for optimum productivity. Field trials were conducted simultaneously in Abeokuta and Ibadan in 2014 to evaluate the effect of different types and rates of fertilizer on the performance of roselle. The trials had fourteen treatment combinations fitted into split plot design with three replicates. Seven fertilizer rates made up of three organic fertilizer (2.5, 5.0, and 7.5t ha^{-1}) Alesinloye organic fertilizer (AOF) and three NPK 15-15-15 fertilizer rates (200, 300 and 400kg ha^{-1}); no fertilizer (control) was applied on white and red roselle varieties. Data on plant height, number of leaves and branches, shoot dry weight, number of calyx/plant, and weight of dry calyx were collected. Application of 7.5t ha^{-1} AOF gave significantly (p<0.05) higher number of leaves (126.0 and 115. 1) for white roselle as compared to red with (91.7 and 80.8) at the two locations. Also, the 7.5t ha^{-1} AOF produced significantly (p<0.05) higher dry calyx yield (425.6 and 386.7kg ha^{-1}) for white roselle relative to red (329.0 and 291.6kg ha^{-1}) in Abeokuta and Ibadan, respectively. The 7.5t ha^{-1}AOF did better than other fertilizer treatments in this trial, hence recommended for optimum performance of roselle in southwest Nigeria.

Keywords: Roselle, Organic, fertilizer type, calyx yield

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INTRODUCTION

Roselle (*Hibiscus sabdarjffa* L.*)* is an annual or biennial plant that belongs to the family *Malvaceae*. It is most suited for tropical climate with high humidity and temperature range of 25 to 35°C (Rao 1996). In Africa, roselle has two main uses: as a vegetable and as an ingredient of a beverage. Young roselle shoots, leaves, and calices are either used as cooked vegetable or are finely cut and used to make sauces (Babatunde 2003). The stewed calyces of the green types are added as a condiment to rice dishes in Senegal. Roselle tea is used to suppress high blood pressure. The leaves are a source of mucilage used in pharmacy and cosmetics. Extracts are often used medicinally to treat colds, toothache, urinary tract infections, and hangovers (Diouf et al 1999). Leaf juice is used to treat conjunctivitis in Senegal. Leaves are applied as a poultice to treat sores and ulcers. A root decoction can be used as a laxative.

Conventional farming relies heavily on the use of external inputs particularly, herbicides, pesticides, mineral fertilizers, hormones, and other toxic chemicals to achieve optimum crop performance. These lead to increasing levels of environmental pollution and health hazards like cancer, chronic kidney diseases (Gunatilake et al 2014), and death. Consequently, there is a quest for eco- friendly alternatives to dependency on synthetic chemicals. Furthermore, the cost of inorganic fertilizers is increasing enormously to an extent that they are out of reach of small and marginal farmers (Gma 2015). Also, the current global scenario firmly emphasizes the need to adopt eco- friendly agricultural practices for sustainable food production. High cost of inorganic fertilizers, their untimely availability and adulteration are setbacks that lead to soil nutrient imbalance. Authors (Hacket & Carolene 1982, Babatunde & Akinsete 2001) are unanimous on the need for comprehensive studies on suitable agronomic practices that can lead to profitable production of Roselle. Integrated use of organic fertilizer with or without mineral fertilizer and pests and diseases control at different phenological stages have been suggested as a panacea to achieving sustainable production of this crop. This study was therefore undertaken to determine the optimum rates of organic and inorganic fertilizer for sustainable production of roselle under the ecology of southwest Nigeria.

MATERIALS AND METHODS

Description of Experimental Site

The experiment was conducted at the Teaching and Research Farm of the Institute of Food Security, Environmental Resources and Agricultural Research (IFSERAR), Federal University of Agriculture, Abeokuta (latitude 7°15'N and longitude 3°25'E) 100m above sea level and at National Horticultural Research Institute (NIHORT) Ibadan, (latitude 7°22' and longitude 7°25'E). IFSERAR has an average annual rainfall of about 1062.5mm with bi-modal distribution, temperature range of 24.7°C-36.4°C and relative humidity of 88.5%. The area of land lies within the forest savanna transition zone (Aiboni 2011), while NIHORT is located in Guinea savannah Agro-ecology (NIHORT Meteorological station 2015). NIHORT has an annual rainfall of 1400-1500mm with bi-modal distribution, temperature of 25.7°C-30.2°C, and

relative humidity of 70-85%. In both locations, the soil samples of the plots were collected with the aid of soil auger after which the soil analysis was carried out in line with standard procedure to determine physico-chemical properties.

Treatment consisted of factorial combinations of four rates of manure (0, 2.5, 5.0 and 7.5t ha^{-1} Alesinloye Organic Fertilizer (AOF) and three rates of NPK 15-15-15 fertilizer (200, 300 and 400kg ha^{-1}) and Two cultivar of Roselle (White and red). These were arranged randomly in split-plot design. Three seeds per hill were sown (latter thinned to two at 2 weeks after germination) at an inter and intra-row spacing of 50cmx60cm in a 5.0mx4.5m plots size with 2m alley between plots and blocks in the month of July and August 2014 at Abeokuta and Ibadan, respectively. The Alesinloye Organic fertilizer (Composted cow-dung plus sorted city refuse) was applied one week after planting while NPK fertilizer was applied 4 weeks after sowing (WAS). Weeding was done as at when due, from 3WAS. Data on number of leaves, number of branches, and plant height (cm) at maturity were collected. Calyx dry matter, number of calyx per plant, dry calyx yield, and yield components were also recorded.

Data Analyses

All data generated were subjected to analyses of variance procedure in split-plot design of Statistical Analyses Software (SAS version 9.1). Significant treatment means were separated and compared using LSD, Duncan's multiple range test (DMRT), and Standard error at 5% levels of probability where appropriate.

RESULTS AND DISCUSSION

Physical and Chemical Properties of Soil and Organic Fertilizer

The results of soil analyses for both locations indicated low nutrient compositions (Table 1). The soils were sandy loam with a pH range of 5.2 (Ibadan) and 6.3 (Abeokuta) which made it slightly acidic. The major nutrients (N, P, K, Ca and Mg) needed for optimum production of roselle were very low. The total N was 0.82 and 0.06%, available P was 8.0mg kg^{-1} and 6.3, and the available K cmol kg^{-1} was 0.43 and 0.18 in Abeokuta and Ibadan, respectively. These values were less than the critical range of 1.5-2.0g kg^{-1} for N (Singh and Uriyo 1980), 10mg kg^{-1} for P (Adeoye & Agboola 1985), and 0.1-0.2 $cmolkg^{-1}$ for K (Ayodele 1984) believed to be optimal for crop production. In Table 1, soils Ca and Mg values were low in both soils. The Alesinloye Organic fertilizer (AOF) used for the experiment is rich in plant nutrient being adequate for quick nutrient release with 2.56% N, 1.10% P and 0.68% K, respectively (Table 1).

Growth and Yield Parameters

Effect of different rates of fertilizer on growth parameters of roselle (Table 2), showed that white roselle had significantly (p<0.05) taller plants (105.12cm and 99.09cm) as compared to red roselle (88.79cm and 84.122cm) in Abeokuta and Ibadan, respectively. Furthermore, white roselle had significantly higher number of leaves (91.72 and 80.80) as compared to red roselle (73.75 and 68.79) in Abeokuta and Ibadan, respectively. There was no significant difference in the number of branches of white and red roselle in both locations (Table 2).

Roselle Plant Roselle Capsules

Roselle Plantation

Table 1. Physical and chemical properties of soil and organic fertilizer used for the experiment in Abeokuta and Ibadan Southwest Nigeria

Parameter	Abeokuta	Ibadan	Nutrient contents of Organic Fertilizer	
	Values		Parameters	Values
pH	6.3	5.2	N (%)	2.58
Org. C (g kg^{-1})	3.8	0.83	P (%)	1.10
Total N (g kg^{-1})	0.82	0.06	K (%)	0.68
P (mg kg^{-1})	8.0	6.29	Ca (cmol kg^{-1})	3.62
K (cmol kg^{-1})	0.43	0.18	Mg (cmol kg^{-1})	0.18
Ca (cmol kg^{-1})	5.02	5.28	C/N ratio (g kg^{-1})	8.97
Mg (cmol kg^{-1})	0.31	0.67	Na (cmol kg^{-1})	1.75
Na (cmol kg^{-1})	0.1	0.25	Fe (mg kg^{-1})	4.42
Al (cmol kg^{-1})	0.08	0.09	Mn (mg kg^{-1})	3.70
Zn [mg kg^{-1}]	9.51	6.1	Cu (mg kg^{-1})	11.45
Cu [mg kg^{-1}]	3.42	1.45	Zn (mg kg^{-1})	3.60
Mn [mg kg^{-1}]	114	78.4	Mo (mg kg^{-1})	0.12
Fe [mg kg^{-1}]	210	11.2	B (mg kg^{-1})	0.06
ECEC (cmol kg^{-1})	5.94	6.47		
Base saturation %	98.65	98.61		
Sand [g kg^{-1}]	760	88.6		
Silt [g kg^{-1}]	110	5.4		
Clay [g kg^{-1}]	130	6.0		

Response of roselle varieties to fertilizer type

Application of 7.5t ha^{-1} Alesinloye Organic Fertilizer (AOF) resulted in significantly (p<0.05) taller plants (109.28 and 100.72cm), more number of leaves (126.0 and 115.05), and number of branches (22.97 and 21.68) for Abeokuta and Ibadan, respectively, as compared to other fertilizer treatments. The least performance in terms of number of leaves and branches were observed in roselle plant with no fertilizer treatment (control) (Table 2).

Table 2. Effect of variety, fertilizer type and rate on plant height (cm), number of leaves and number of branches of roselle in Abeokuta and Ibadan

Treatment	Plant Height (cm)		Number of Leaves		Number of branches	
	Abeokuta	Ibadan	Abeokuta	Ibadan	Abeokuta	Ibadan
Variety (V)						
white roselle	105.12	99.09	91.72	80.80	20.15	19.20
red roselle	88.79	84.12	73.75	68.79	18.73	17.87
LSD (p<0.05)	1.24	1.85	3.58	1.08	0.36	0.34
Fertilizer rate and type (F)						
2.5t ha^{-1} AOF	84.95d	99.73b	64.0cd	61.83c	17.52c	16.48c
5.0t ha^{-1} AOF	85.10d	80.98e	100.0a	95.63a	22.23a	21.67a
7.5t ha^{-1} AOF	109.28a	100.72a	126.0a	115.05a	22.97a	21.68a
200kg ha^{-1} NPK	98.50b	92.82b	68.8c	53.33d	18.03c	17.33c
300kg ha^{-1} NPK	93.63c	88.23c	73.5b	70.75b	19.82b	19.12b
400kg ha^{-1} NPK	110.78a	106.33a	90.0ab	76.77b	20.43b	19.18b
Control	83.43d	95.72b	56.3d	50.18d	15.08d	14.33d
SE ±	2.31	3.46	6.27	2.03	0.67	0.63
V x F	3.27	4.29	9.47	2.87	7.68	5.43

*Means followed by the same letter(s) within a column are not significantly different at the p<0.05% level according to DMRT. AOF= Alesinloye Organic Fertilizer

Yield parameters of roselle followed similar trend as observed in growth parameters (Table 3). White roselle variety had significantly (p<0.05) higher shoot dry weight (1050.6 and 957.8kg ha^{-1}) as compared to red roselle (839.3 and 754.0kg ha^{-1}) in Abeokuta and Ibadan, respectively. Similarly, significantly (p<0.05) higher number of calyx (94.56 and 82.83) were observed in white roselle variety as compared to red roselle (86.76 and 73.57) in Abeokuta and Ibadan, respectively. White roselle also had significantly higher dry calyx weight (329.54 and 291.26kg ha^{-1}) relative to red roselle (295.86 and 260.86kg ha^{-1}) in Abeokuta and Ibadan, respectively (Table 3).

Roselle plants grown with 7.5t ha^{-1} AOF had significantly higher shoot dry weight (1546.3 and 1415.4kg ha^{-1}), number of calyx per plant (97.25 and 92.07), and dry calyx yield (407.83 and 373.32kg ha^{-1}) in Abeokuta and Ibadan, respectively, as compared to other fertilizer treatments. Generally, roselle plants grown in Abeokuta performed better in terms of all the growth and yield parameters measured than those grown in Ibadan.

Table 3. Effect of variety, fertilizer type and rate on shoot dry weight, number of calyx and calyx dry weight of roselle in Abeokuta and Ibadan production locations

Treatment	Shoot dry weight (kg ha^{-1})		Number of calyx Per plant		Calyx dry weight (kg ha^{-1})	
	Abeokuta	Ibadan	Abeokuta	Ibadan	Abeokuta	Ibadan
Varieties (V)						
white roselle	1050.6	957.8	94.56	82.83	329.54	291.26
red roselle	839.3	754.0	86.76	73.57	295.86	260. 29
LSD (p<0.05)	15.33	18.37	1.36	2.53	3.19	3.16
Fertilizer rate & type (F)						
2.5t ha^{-1} AOF	730.5d	670.1e	78.83c	30.35d	275.33e	229.30d
5.0t ha^{-1} AOF	1298.4b	1157.4b	87.75b	76.58c	377.17c	347.21b
7.5t ha^{-1} AOF	1546.3a	1415.4a	97.25a	92.07a	407.83a	373.32a
200kg ha^{-1}NPK	778.8d	689.5d	75.27c	71.32c	241.23f	210.54d
300kg ha^{-1}NPK	915.2c	844.6c	74.38c	72.65c	328.83d	292.85c
400kg ha^{-1}NPK	960.5c	872.4c	92.37a	89.83b	383.67b	362.36b
Control	385e	341.8f	24.33d	22.43e	206.33g	178.00e
SE ±	28.68	34.36	0.56	0.99	3.55	5.92
V x F	40.57	48.6	0.79	1.41	5.02	8.37

Means followed by the same letter (s) within a column are not significantly different at p<0.05% level according to DMRT. AOF= Alesinloye Organic Fertilizer

White roselle variety generally performed better than red roselle in terms of growth and yield parameters due to varietal differences and the innate ability of white roselle to adapt better to the southwest agro-ecology zone of Nigeria than red variety. This is in accordance with the findings of Bala et al 2009, where they observed white roselle to be of better performance in terms of number of leaves, number of branches and calyx dry weight over the red variety. Bio-fertilizer treatment has been reported to promote growth characters (plant height; number of branches/plant and fresh and dry weight of shoots and roots of roselle plants) and increase yield component (number of calyx/plants and sepals dry weight and yield) of Roselle plants (Abo-baker et al 2011).

Of the different fertilizer rates, 7.5t ha^{-1} organic fertilizer was found to increase the number of leaves per plant, shoot dry weight, number of pods per plant and calyx dry weight in the two locations of production. 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 plants, thus delaying crop maturity. Tindall (1983) reported that only the soil which was supplied with organic material and essential nutrient from organic and inorganic fertilizer recorded the best economic yield of Roselle. Mahran et al (1978), Okosun (2000) and Babatunde (2001) observed increase in crop calyx yield production as a result of manure and nitrogen fertilizer. Abo-Baker and Mostafa (2011) showed that the inoculation of *Hibiscus sabdariffa* with the mixture of organic and inorganic fertilizer improved the growth characters. Similar results were observed on some plants such as *Nigella sativa*, *Ammi visnaga,* and *Salvia officinalis* (Yuonis et al 2004, Shaalan 2005).

Response of roselle varieties to fertilizer type

Table 4. Effect of variety, fertilizer type and rate on harvest index (%) of roselle in Abeokuta and Ibadan production locations

Treatment	Harvest Index %	
	Abeokuta	Ibadan
Varieties (V)		
white roselle	15.83	15.43
red roselle	18.51	17.89
LSD (p<0.05)	0.70	0.71
Fertilizer rate and type (F)		
2.5t ha^{-1} AOF	16.81a	14.94b
5.0t ha^{-1} AOF	14.03c	14.45b
7.5t ha^{-1} AOF	13.14c	13.38c
200kg ha^{-1} NPK	16.12a	15.16a
300kg ha^{-1} NPK	15.91b	16.21a
400kg ha^{-1} NPK	15.62b	14.95b
Control	28.57d	27.52d
SE ±	1.30	1.33
V x F	1.43	1.88

Means followed by the same letter within a column are not significantly different at the p<0.05% level according to DMRT.
AOF=Alesinloye Organic Fertilizer

Roselle plants grown with 7.5t ha^{-1} AOF rate produced higher dry calyx yield compared to those grown with other fertilizer treatments. This may be due to relatively high quantity of nutrient and organic matter contained in this fertilizer material. Similar results were obtained by Tindall (1983), Okosun (2000), Babatunde (2001) and Akanbi et al 2009) who reported that higher economic yield of roselle were obtained on soils which were well supplied with organic materials and essential nutrients as contained in optimum manure fertilization.

CONCLUSION

The results from the study revealed that the two Roselle varieties performed adequately well when fertilized with the different type and rates of fertilizers. However, for sustainable production of roselle in Southwest Agro-ecological zone of Nigeria, soil amendment with 7.5t ha^{-1} of organic fertilizer improved the performance of roselle plants in terms of higher number of leaves per plant, shoot dry weight, numbers of pods per plant, and calyx dry weight in both locations in this study. Alesinloye Organic fertilizer at 7.5t ha^{-1} or NPK fertilizer at 400kg ha^{-1} is therefore recommended for optimum performance of roselle in degraded soils of southwest Nigeria.

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