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Influence of Organic Manure, Variety and Intra Row Spacing On Dry Calyx Yield and Nutrients Uptake of Roselle In Yobe State, Nigeria

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Abstract:
Background: *Sustainable soil nutrient management and plant population are vital in improve productivity of any crop variety. In view of that this investigation was carried out to study the effect of organic manure rate (cow dung) and intra row spacing on dry calyx yield and nutrient uptake in three local varieties of roselle in two locations in Yobe State, Nigeria.*
Materials and Methods: *Three roselle varieties and three levels of intra row spacing were placed as main plot factor and organic manure (cow dung) levels as sub plot factor were laid out in a split plot designed replicated three times in each of the two experimental sites. Pre sowing soil samples, cow dung and roselle shoots were analyzed using standard laboratory procedures for physicochemical, nutrients and NPK content respectively.*
Results: *Results indicated the increased level of manure and closer intra row spacing produced higher dry calyx yield irrespective of the variety. NPK uptake in roselle shoot was positively improved by wider intra row spacing (75cm) and 6.0 to 9.0 ton ha^{-1} cow dung manure.*
Conclusion: *Intra row spacing of 25cm with 6.0 ton ha^{-1} cow dung manure was the best plant density and organic manure (cow dung) rate for improve calyx yield in Bursari and Jakusko Local Government areas of Yobe State, Nigeria.*
Key word: *Calyx, cow dung, roselle, Yobe.*

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I. Introduction

Roselle (Hibiscus sabdariffa L.) belongs to the Malvaceae family, and is an annual or biennial plant cultivated for its stems, fibres, edible calyces, leaves and seeds (Rao, 1996). It is a crop that is grown extensively as a tertiary crop in this part of the country. ICRA (2002) described roselle as an indigenous leafy vegetable that is considered as a minor crop in the production system and as a result little attention is paid to it in terms of labour and land allocation. In some cases, the crop is grown along cereal/legume mixtures not on any definite row arrangement and on soils that are limiting in most essential nutrient elements. Despite its importance, the crop is produced in traditional growing conditions by small-farmers, depending on rainfall and natural soil fertility without using chemical fertilizers or insecticides (El Naim et al., 2012). Drake (1985) reported that roselle has many uses in traditional medicine as digestive and purgative agent, healing of abscesses, cancer and hypertension management. The roselle leaves and calyces are high in ascorbic acid (Murdock, 1995). Atta et al. (2010) stated that the leaves of roselle have considerable economic importance because of their nutritional and medicinal uses. In Nigeria, the production of non-alcoholic beverage from dried red roselle calyces is very popular (Bolade et al., 2009). Despite all these and other related benefits, little has been reported on the agronomy of Roselle (Mera et al., 2009). The crop is usually grown as border crop or through traditional production practices to which optimum yield is not being realized. In order to fill these gaps of poor agronomic practices and considering the high cost of inorganic fertilizers in Nigeria coupled with their non- availability at the right time (Haruna et al., 2011) and the fact that there is increased awareness in the use of organic fertilizers, there is need to grow different cultivars of Roselle under different levels of organic manure at varying intra row spacing to evaluate the performance of the crop especially in this area with limited amount of rainfall.

II. Materials And Methods

Despite its importance, Roselle in the study area is mostly grown just to demarcate one farm from another. Considering its nutritional and health benefits, field experiment was conducted during 2016 rainy season.

Location: North East Arid Zone Development (NEAZDP) farm located in Garin Alkali (latitude 12.8364^o N and longitude 11.0659^o E) in Bursari Local Government Area and Rubber Research Institute of Nigeria (Gum Arabic station) farm located in Tajuwa (latitude 12.5623^o N and longitude 10.9258^o E) in Jakusko Local Government Area; both in Yobe State, Nigeria. The field in either location was harrowed and made into shallow basins based on the number of treatments. The treatments consist of three varieties of Roselle based on calyx colour and State being sourced (Table 1). Two (2) with dark red calyx seeds were sourced from Yobe and Gombe in the North East of Nigeria. The variety with red calyx seeds was sourced from Jigawa State in North Western Nigeria.

Table 1. Characteristics of the Varieties' Calyx

Source State	Variety	Calyx Color	Tag
Yobe	Gashua Local	Dark Red	Y
Gombe	Kwami Local	Dark Red	G
Jigawa	Gujungu Local	Red	J

Study Design: The treatments factors were three roselle varieties (Table 1), three (3) levels of intra row spacing (25cm, 50cm, 75cm) and four levels of cow dung (0, 3.0, 6.0 and 9.0 t ha-1 identified as F1, F2, F3 and F4 respectively). The plots were laid down in a split plot design with spacing and variety as the main plot (Table 2), whereas cow dung was placed as sub plot, a well decomposed cow dung was applied on to the plots 2 weeks before planting to plots to allow for further mineralization according to treatments rates. The experiment was replicated three (3) times; giving a total of thirty six (36) plots in each location.

Treatment combinations are:

Table 2. Main plot Treatments

Treatment No.	Intra Row Spacing (cm)	Variety	Combination Symbols
1	25	Y	M1
2	25	G	M2
3	25	J	M3
4	50	Y	M4
5	50	G	M5
6	50	J	M6
7	75	Y	M7
8	75	G	M8
9	75	J	M9

Y = Gashua Local, G = Kwami Local and J = Jigawa Local

Sampling and Cultural Practices: Composite soils samples were collected from both locations before the application of organic manure. Three to four seeds were sown at about 3cm - 4cm depth and later thinned to two (2) plants per hill according to the intra row spacing treatments while, an inter row spacing of 75cm was maintained for all plots. At full maturity calyces were harvested and dried at room temperature for dry calyx weight/plot and converted to tons ha-1 and shoots were also sampled for tissue analysis. Tissue analysis was carried out to determine N, P and K content of the plant shoot (without the calyx) in the laboratory using standard methods and their uptake estimated from the content using the expression:.

$$Uptake(kg/ha) = \left(\frac{nutrient(\%) \times yield(kg/ha)}{100}\right) \quad (1)$$

Statistical analysis

The collected data were subjected to analysis of variance (ANOVA) and significant difference between means were separated by LSD test (5%) using STAR software (STAR, 2013).

III. Results and Discussion

The results of analysis of the soils of the experimental sites (Table 3) as interpreted using Esu (1991) ratings showed that the soils belong to sandy loam textural class, moderately acidic (pH 5.8 and 6.0), low organic carbon (9.2 and 7.9 g kg-1) and total nitrogen (0.09 and 0.07 g kg^{-1}). Moderate value of available phosphorus was recorded at Garin Alkali (15.7 mg kg^{-1}) and low at Tajuwa (10.5 mg kg^{-1}). Calcium and Magnesium content were moderate in the soils of the both sites (2.58 and 0.83 cmol kg^{-1} and 2.42 and 0.67 cmol kg^{-1}) while, Potassium was moderate at Tajuwa (0.27 cmol kg^{-1}) and high at G/Alkali (0.76 cmol kg^{-1}) and sodium was very high at both sites (1.32 and 1.23 cmol kg^{-1}). The Effective Cation Exchange Capacity (ECEC) was generally low (5.17 and 5.41 cmol kg^{-1}).

Table 3. Physico-chemical properties of the soils from the experimental sites.

Physical properties (%)	**NEAZDP (G/Alkali)**	**RRIN (Tajuwa)**
Sand	55.36	66.36
Silt	29.28	19.28
Clay	15.36	13.36
Textural Class	Sandy loam	Sandy loam
Chemical properties		
pH (H_2O)	5.8	6.0
Organic carbon (g kg^{-1})	9.2	7.9
Total N (g kg^{-1})	0.09	0.07
Available P (mg kg^{-1})	15.7	10.5
Exchangeable Cations (cmol kg^{-1})		
Ca	2.42	2.58
Mg	0.67	0.83
K	0.76	0.27
Na	1.23	1.32
ECEC	5.41	5.17

The results of the main effect of variety, intra row spacing and organic manure levels on dry calyx yield, NPK content and uptake indicated significant interaction effect at both experimental sites (Table 4).

Table 4. Main Effect of the Treatments on Calyx Yield and NPK uptake in Roselle Shoots at both Sites

Treatment	Calyx yield (Kg ha^{-1})		N uptake (kg ha^{-1})		P uptake (kg ha^{-1})		K uptake (kg ha^{-1})	
Main Plot (M)	GA	TJ	GA	TJ	GA	TJ	GA	TJ
M1	317.20	294.40	3.86	29.36	0.0035	0.0042	0.0069	0.0067
M2	314.32	301.87	5.30	37.14	0.0052	0.0049	0.0102	0.0091
M3	286.17	321.27	13.38	31.06	0.0042	0.0046	0.0111	0.0084
M4	261.67	266.90	13.24	24.16	0.0042	0.0045	0.0086	0.0074
M5	224.98	199.14	10.85	22.76	0.0031	0.0029	0.0054	0.0052
M6	202.06	215.48	18.56	13.06	0.0036	0.0035	0.0058	0.0050
M7	223.90	236.79	20.97	17.55	0.0044	0.0046	0.0071	0.0057
M8	225.24	234.20	25.77	18.01	0.0043	0.0042	0.0070	0.0059
M9	168.46	199.38	16.58	16.03	0.0046	0.0048	0.0058	0.0052
S.E±								
Sub Plot (S)								
F1	220.73	204.47	15.55	24.06	0.0047	0.0046	0.0085	0.0070
F2	237.64	212.78	11.36	16.36	0.0033	0.0032	0.0062	0.0052
F3	257.98	248.15	14.60	22.93	0.0039	0.0032	0.0076	0.0065
F4	272.10	287.59	15.59	27.27	0.0044	0.0050	0.0079	0.0074
S.E±								
Interaction								
M*S	*	*	*	*	*	*	*	*

The interaction effect of dry calyx yield (Table 5) showed that M1F3 (376.69 kg ha-1) and M2F3 (387.55 kg ha-1) produced the maximum dry calyx yield and the least were obtained with M9F1 (139.24 kg ha-1) and M9F2 (126.65 kg ha-1) at Garin Alkali (GA) and Tajuwa (TJ) experimental sites respectively. This indicated that higher dry calyx yield were obtained under closed intra row spacing (25cm) and 6.0 t ha-1 organic manure rate, while the lower yield were found in wider intra row spacing (75cm) and 0 – 3.0 t ha-1 of manure. Higher plant population (due to closer spacing) and increased level of manure have positively influenced on the calyx yield. This was corroborated by Udom et al. (2007) and Oyewole and Mera (2010) who reported increased in calyx yield due manure application and that, organic manures supply nutrients to plants, improve soil structure, aeration and also encourages good root growth which may invariably result in increased growth and yield.

Table 5. Interaction Effect of Main and Subplot Factors on Calyx Yield (kg ha^{-1})

Sites	Treatments	F1	F2	F3	F4	Mean
GA	M1	218.44	320.66	376.69	353.01	317.20
	M2	257.96	300.48	340.00	358.85	314.32
	M3	216.37	276.81	316.32	335.16	286.17
	M4	215.44	244.45	283.97	302.82	261.67
	M5	294.64	228.95	178.75	197.59	224.98
	M6	152.74	252.12	192.26	211.10	202.06
	M7	269.97	175.92	215.44	234.28	223.90
	M8	221.78	193.76	233.28	252.12	225.24
	M9	139.24	145.57	185.09	203.93	168.46
	Mean	220.73	237.64	257.98	272.10	
	LSD (5%)			13.97		
TJ	M1	278.59	211.89	346.55	324.77	294.40

M2	261.42	188.24	329.81	387.55	301.87
M3	240.82	295.01	306.83	361.98	321.27
M4	212.67	198.21	275.45	327.04	266.90
M5	121.14	210.63	173.39	213.41	199.14
M6	132.89	231.95	186.49	227.99	215.48
M7	153.05	248.37	208.98	253.03	236.79
M8	168.57	204.03	226.28	272.29	234.20
M9	271.07	126.65	179.54	220.25	199.38
Mean	204.47	212.78	248.15	287.59	
LSD (5%)			13.97		

The Nitrogen uptake of the Roselle shoots was significantly affected by the interaction of variety, intra row spacing and organic manure levels (Table 6). The highest content was recorded with M7F3 (30.55 kg ha-1) and 43.84 kg ha-1 with M2F3 and lowest was found under M1F2 (1.94 kg ha-1) and M6F2 (7.40 kg ha-1) at GA and TJ respectively.

Table 6. Interaction Effect of Main and Subplot Factors on Nitrogen Uptake (Kg ha^{-1}) in Roselle Shoots

Sites	Treatments	F1	F2	F3	F4	Mean
GA	M1	2.35	1.94	7.44	3.71	3.86
	M2	6.10	4.86	4.43	5.80	5.30
	M3	7.48	6.96	21.03	18.06	13.38
	M4	12.75	12.74	12.77	14.69	13.24
	M5	10.92	11.26	9.87	11.36	10.85
	M6	14.16	17.01	22.19	20.86	18.56
	M7	11.37	20.51	30.55	21.46	20.97
	M8	20.19	27.66	29.88	25.36	25.77
	M9	15.96	15.95	15.35	19.05	16.58
	Mean	11.25	13.21	17.06	15.59	
	LSD (5%)			11.28		
TJ	M1	35.49	22.32	23.60	36.03	29.36
	M2	26.29	37.59	43.84	40.84	37.14
	M3	32.33	25.96	27.56	38.37	31.06
	M4	19.94	20.63	33.15	22.91	24.16
	M5	23.84	13.93	23.36	29.90	22.76
	M6	11.25	7.40	11.06	22.53	13.06
	M7	8.25	15.17	18.39	19.09	17.55
	M8	13.63	13.82	20.16	20.06	18.01
	M9	8.87	17.53	11.61	18.96	16.03
	Mean	19.99	19.37	23.64	27.63	
	LSD (5%)			11.28		

Phosphorus uptake in the roselle shoot tended to be significantly higher in M9F3 (0.0059 mg kg-1) in GA and M9F4 (0.0067 mg kg-1) in TJ, while minimum values were found in M3F1 (0.0026 mg kg-1) and M5F2 (0.0021 mg kg-1) for GA and TJ sites respectively (Table 7).

Table 7. Interaction Effect of Main and Subplot Factors on Phosphorus Uptake (Kg ha-^{1}) in Roselle Shoots

Sites	Treatments	F1	F2	F3	F4	Mean
GA	M1	0.0027	0.0032	0.0052	0.0029	0.0035
	M2	0.0049	0.0048	0.0056	0.0053	0.0052
	M3	0.0026	0.0042	0.0046	0.0054	0.0042
	M4	0.0034	0.0041	0.0046	0.0048	0.0042
	M5	0.0031	0.0024	0.0038	0.0030	0.0031
	M6	0.0031	0.0029	0.0045	0.0039	0.0036
	M7	0.0043	0.0028	0.0053	0.0051	0.0044
	M8	0.0044	0.0034	0.0046	0.0048	0.0043
	M9	0.0042	0.0038	0.0059	0.0043	0.0046
	Mean	0.0036	0.0035	0.0049	0.0044	
	LSD (5%)			0.0005		
TJ	M1	0.0041	0.0038	0.0044	0.0043	0.0042
	M2	0.0029	0.0046	0.0051	0.0068	0.0049
	M3	0.0039	0.0039	0.0047	0.0059	0.0046
	M4	0.0034	0.0035	0.0051	0.0058	0.0045
	M5	0.0031	0.0021	0.0028	0.0035	0.0029
	M6	0.0045	0.0025	0.0027	0.0044	0.0035
	M7	0.0048	0.0048	0.0037	0.0050	0.0046
	M8	0.0039	0.0034	0.0040	0.0054	0.0042
	M9	0.0044	0.0025	0.0054	0.0067	0.0048
	Mean	0.0039	0.0035	0.0042	0.0053	

LSD (5%)	0.0005

The combined effect of the treatment factors on K uptake was significantly higher with M3F4 (0.0122 mg kg-1) at GA and M4F4 (0.0108 mg kg-1) at GJ and lower with M5F1 (0.0041 mg kg-1 and 0.0034 mg kg-1) at both sites (Table 8). Generally the NPK uptake in the roselle shoot were higher in widely intra row spaced plants with higher rates of organic manure (Tables 6-8). This could be attributed to nutrient supply in a less competing environment, due less plant population. This finding was in agreement to Raja and Arivazhagan (2014) and Rajaraman and Pugalendhi (2013) who reported significant increase in N, P and K uptake in roselle due to combined effect of wider intra row spacing and higher level of fertilization.

Table 8. Interaction Effect of Main and Subplot Factors on Potassium Uptake (Kg ha^{-1}) in Roselle Shoots

Sites	Treatments	F1	F2	F3	F4	Mean
GA	M1	0.0089	0.0049	0.0064	0.0074	0.0069
	M2	0.0085	0.0111	0.0104	0.0106	0.0102
	M3	0.0099	0.0119	0.0104	0.0122	0.0111
	M4	0.0068	0.0085	0.0091	0.0098	0.0086
	M5	0.0041	0.0071	0.0049	0.0056	0.0054
	M6	0.0072	0.0048	0.0061	0.0052	0.0058
	M7	0.0081	0.0049	0.0076	0.0079	0.0071
	M8	0.0068	0.0059	0.0077	0.0076	0.0070
	M9	0.0053	0.0045	0.0054	0.0080	0.0058
	Mean	0.0073	0.0071	0.0076	0.0083	
	LSD (5%)			0.0010		
TJ	M1	0.0048	0.0095	0.0059	0.0067	0.0067
	M2	0.0096	0.0081	0.009	0.0096	0.0091
	M3	0.0067	0.0084	0.0089	0.0097	0.0084
	M4	0.0057	0.0059	0.0073	0.0108	0.0074
	M5	0.0034	0.0067	0.0042	0.0064	0.0052
	M6	0.0055	0.0033	0.0053	0.0058	0.0050
	M7	0.0056	0.0048	0.0056	0.0067	0.0057
	M8	0.0045	0.0055	0.0067	0.007	0.0059
	M9	0.0076	0.0026	0.0055	0.0052	0.0052
	Mean	0.0059	0.0061	0.0065	0.0075	
	LSD (5%)			0.0010		

IV. Conclusion

A positive increased in calyx yield was observed with increased level of organic manure and closer intra row spacing with all the varieties of roselle tested at both experimental sites. The nutrient uptake indicated different pattern with higher uptakes in wider intra row spaced crops with higher levels of organic manure. Although increased uptake were recorded in wider spaced crops, it may not be economically wise to forgo higher dry calyx yield found in closer spaced treatments because of the minor differences in nutrients' uptake. Therefore, an intra-row spacing of 25cm and 6.0 ton ha^{-1} of cow dung is recommended for any of the roselle variety tested in the study area.

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