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EFFECT OF SOLID AND LIQUID ORGANIC FERTILIZER ON GROWTH, YIELD AND YIELD COMPONENTS OF ROSSELLE (Hibiscus sabdariffa L.) IN THE NIGERIAN SAVANNAH

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ABSTRACT

The Study was conducted to evaluate the effect of solid and liquid organic fertilizer on growth and yield of rosselle in 2016 cropping season at Institute of Agricultural Reserve Zaria, Samaru (11011'N 07038E and 686m) and Institute of Horticultural Research Farm Bagauda (12000'N 8031"Em 488m) in Northern Guinea Savannah and Sudan Savannah Ecological Zones of above sea level Nigeria. Treatments consisted of four levels of solid poultry manure (0.0, 1.0, 2.0 and 3.0) tons/ha and five levels of liquid organic manure from Grand Total Organic Fertilizer Limited (0.0, 0.5, 1.0, 1.5 and 2.9) litres/ha, which were factorially combined in a randomized complete block design (RCBD) and replicated three times. Data on growth parameter were collected on plant height (cm), plant dry weight (g), leaf Area index crop growth rate (CGR) Relative Growth Rate (RGR) and Net assimilation rate (NAR) while data on yield parameters like number of calyx per pant, 100 seed weight (g) and calyx yield per hectare kg/ha were collected. Results showed that plant height, plant dry weight(g), 100 seed weight(g) and calyx dry yield kg/ha had a significant increase with application of 2.0litres/ha of liquid fertilizer than other rates. While application of solid poultry manure at 3.0ton/ha significantly increases plant height, net assimilation rate, leaf area index and calyx dry weight when compared with other rates. From the results obtained, the combination of 2.0 litres/ha liquid organic fertilizer and 3.0 ton/ha solid poultry manure produce the highest calyx yield at both location.

Keywords: Rosselle, solid, liquid, organic fertilizer growth, yield and Nigerian Savannah.

INTRODUCTION

Roselle or sorrel (*Hibiscus sabdariffa L.*) is an ornamental and medicinal tropical annual shrub that belongs to the family malvaceae, which produces fruit-like structures with often elaborate calyxes containing edible pigments (Hanan *et all*, 2019). Rosselle is cultivated in the tropical and sub-tropical regions for its leaves, edible calyces, seeds, fibre and pulp (Ibrahim *et al*, 2020).

Roselle is a native of India and Malaysia where it is commonly cultivated and must have been carried at an early date to Africa (Norhayati *et al*, 2019). Cultivation of the crop has been reported throughout the Indian subcontinent, parts of Asia, America, Australia and Africa. According to Abdel-kadar (2017), it is widely cultivated in the forest and savannah ecological zones of Nigeria.

Roselle leaves, fibre, calyces, seeds, pulp and roots have economic, nutritional and medicinal values. The succulent calyces and immature fruits are added to sauces as condiments (Hewidy *et al*.,2018), while calyces which are rich in vitamin C are used for the production of refreshing sorrel drink, popularly known as "Zoborodo or zobo" and also for the production of "roselle apple drink" (Ibrahim *et al* 2020).

Rosselle is a multi-product crop with diverse nutritional medicinal and economic benefits, its production in Nigeria is still at subsistence level. The challenge that threatens the crop's productivity is the reduced or lower inherent soil fertility of the savannah soils (Urok, 2015). Nitrogen (N) is the most limiting nutrient in the Nigeria Savannah Soil followed by phosphorus (p). chemical fertilizer are used in modern Agriculture to supplement nutrient deficiencies provide adequate levels of nutrition which aid plant to withstand nutrient stress condition, maintain optimum soil fertility condition and improve crop quality and quantity (Bekeko, 2014).

The use of mineral inorganic fertilizer is gradually becoming economically unsustainable. This situation has been aggravated by gradual reduction in subsidies on agricultural inputs as with on the likely hood of increased environmental pollution. The high cost of chemical fertilizers have limited its use by farmers and sometimes chemical fertilizer even if its available may be too expensive which farmers cannot afford, resulting to poor or non use by the farmers, thus poor crop growth, productivity resulting in low farm income thereby increasing poverty among subsistence farmers (Khadem *et al.*, 2010).

The use of Organic Manure can change both physical, chemical and biologicalcharacteristics of the soil. In many circumstances there changes improve soil physical structure and water holding capacity, resulting in better soil environment for root growth and development thus enhancing soil microflora and fauna activities all of which can affect available micronutrient level in the soil to the plant (Stevenson, 1991; 1994).Poultry manure as an organic fertilizer tend to contain more nutrients among the types of manure, since urine from birds is not lost apart from improving soil conditions that benefit the growing plant, poultry manure has a slow nutrient releasing capacity, this nutrient is somewhat available for a longer period to the plant (Taheri *et al.*, 2011).

Liquid organic fertilizers have been found to contain high Nitrogen (N) mainly in inorganic from which can provide nutrients instantly to the plants much like chemical fertilizers (Gross *et al.,* 2007). The use of liquid organic fertilizer directly to the leaves (foliar application) will also ease and reduce transportation cost as compared to bulky poultry manure, it is also environmentally friendly as less environmental pollution is experienced.

Poultry manure is relatively cheap and available, it 'use at subsistence level together or in conjunction with liquid organic fertilizer is to be looked into as the prices of other agricultural inputs are rising in the face of dwindling (shortage of) foreign exchange coupled with the near non-availability of the said inputs as sometimes they are not available and even when available, they may be too expensive to purchase. In view of the increased demand for rosselle products and in furtherance of research information on the use of manure (organic) requirement of the crop, this study was undertaken to investigate the effect of solid and liquid organic manure on growth and yield of rosselle in the Nigerian savannah.

MATERIALS AND METHODS

Field trials were conducted at Institute for Agricultural Research (IAR) Savannah Research Farm (Lat $11^{0}11$'N, $07^{0}3$'E, 686m above sea level) Samaru-Zaria and Institute for Nigerian Horticultural Research Farm ($12^{0}00$'N, $8^{0}31$'E, 488m above sea level) NIHORT, Bagauda-Kano during the 2016 cropping season. Soil sample collected at 0-15cm, 15-30cm, poultry manure and liquid organic fertilizer samples were collected for analysis at Analytical laboratory of Department of Agronomy, Ahmadu Bello University Zaria before planting, while the weather data for the two locations were monitored throughout the duration of the trials. The rosselle variety used was a local variety called Samaru-1882 obtained from Institute for Agricultural Research seed unit Samaru. Samaru-1882 is of medium high with profuse branching habit, dark calyces which matures at 4 months after sowing and has a potential seed yield of 900kha^{-1} (Hewidy et al, 2018)

The treatment consisted of a factorial combination of four levels solid organic fertilizer (poultry manure) at 0, 1, 2 and 3 tons/ha and five levels of liquid organic fertilizer at 0, 0.5, 1.0, 1.5 and 2.0 ltrs/ha laid out in a randomized complete block design (RCBD) with three replications. The gross and net plot sizes were 4m c 4.5m = 18m^2 and 4m x 1.5m=6m^2 made up of 6 rows (gross) and two inner rows for net plots. The land was ploughed, harrowed twice and their ridges made of 75m apart then plots and border areas were laid out which were separated by 1m and 0.5m paths respectively. Three seeds were manually sown 30cm apart along the ridges on 7 July and 21 July 2016 at Samaru and Bagauda respectively. Thinning was carried out at 2 WAS to 2 plants per stand.

The solid poultry manure (0, 1, 2 and 3 t/ha) were drilled along the side of the ridge three weeks before sowing while liquid organic fertilizer treatments (0, 0.5, 1.0, 1.5 and 2.0 litres ha^{-1} were applied in split doses on each plant stand (aerial spray on leaves) at 3 and 6 weeks after sowing (WAS). Weed control was conducted prior to land of litres/ha (1.4kg-1ha^{-1}) and this was followed by manual hoe weeding at 3 and 6 WAS. The ridges were molded up at 12 WAS. Karate (Lambdacyhalothrin) at the rate of 0.8 litre ha-^{1} along with Benlate (benomyl) at the rate of 11kga.i ha^{-1} were applied 3 times using CP-15 knapsack starting from 8WAS, 10 WAS and 12 WAS as a routine preventive measure against pest and disease incidence. The matured rosselle plants were harvested at full maturely (on 19 and 26 November, 2016 from the two sites respectively) when most leaves have turned brownish yellow and have shaded, the fruits (capsules) had splited open and seeds turned reddish brown and calyces were fully opened (expanded). The plants within the net plot were harvested by cutting the plants at the base with a sharp cutlass and placed in bags as par treatment. The calyces were then separated from Capsules by hand, oven dried and weighed using metler balance model P1200. After air drying, the capsules were shelled to obtain seeds which were then weighed again.

Data were collected at 8, 10 and 12 WAS on growth parameters like plant height (cm), plant dry weight (g), number of branches, leaf area index, crop growth rate, relative growth rates, net assimilation rates, data was also collected on yield parameters like number of calyces per plant, dry calyx yield (kg) per hectare, 100 seed weight (g) at harvest. The data collected were analyzed using analysis of variance (ANOVA) technique, the treatment means were separated using Duncan's Multiple Range Test (Gomez and Gomez, 1984).

RESULTS

Details of the soil physical and chemical properties of the experimental site is presented as table 1, likewise the details of the nutrient content of the poultry manure used as well as the liquid organic fertilizer used as presented as tables 2 and 3 respectively. The soil at Bagauda and Samaru was found to be of sandy loam textural class. The soil at Bagauda had a moderate N content, low level of available phosphorus (P), potassium (K) and Cathion exchange capacity (CEC). The Bagauda soil had a moderate level of Organic carbon, calcium, magnesium and sodium with a slightly acidic pH in water and moderately acidic in calcium chloride solution (Cacl2). The soil at Samaru has a moderate N and P content with moderate calcium, magnesium and sodium content, also low level of organic carbon, potassium and CEC were observed. Ph was slightly acidic in both water and Calcium Chloride solution.

The Organic fertilizer analysis for both solid and liquid used during this trial (Tables 2 and 3) indicated that liquid organic fertilizer contain high percentage of total organic matter, total nitrogen (N), Organic Nitrogen and water soluble K_20) were 25%, 3%, 1% and 4% respectively at both location showed that nitrogen available phosphorous and potassium contents were 2.28%, 0.90% and 0.82% respectively.

Table 1: Physical and Chemical Properties of the Soil at both Bagauda and Samaru during 2016 Wet Season

	Bagauda	Samaru
Physical Properties		
Clay	11.0	12.0
Silt	27.0	39.0
Sand	62.0	57.0
Textural Class	Sandy Loam	Sandy Loam
Chemical Properties		
PH (H_2O) 1:2,5	6.24	6.12
PH 0.01m $CaCl_2$	5.86	5.63
Total Nitrogen (gkg^{-1})	3.7	4.0
Available Pmg Kg^{-1}	1.65	5.24
Organic Carbon	1.67	1.01
Exchangeable Bases ($CmolKg^{-1}$)		
Calcium Meq/100g	2.59	2.12
Magnesium Meq/100g	0.71	0.80
Potassium Meq/100g	0.01	0.13
Sodium Meq/100g	0.17	0.61
CEC Meq/100g	3.48	3.64

Source: Analytical Lab of department of Agronomy, ABU Zaria

Table 2: Nutrient Content of Liquid Organic Fertilizer used at the Experimental Site during 2016 Wet Season

Nutrient Contents	Value (%)
Total Nitrogen	25
Available Phosphorus	3.0
Potassium	1.0
Water Soluble K_2O	4.0

Source: Analytical Lab of department of Agronomy, ABU Zaria

Table 3: Nutrient Content of Poultry Manure used at the Experimental Sites during 2016 Soluble K_2O

Nutrient Contents	Value (%)
Total Nitrogen	2.29
Available Phosphorus	0.90
Potassium	0.82

Source: Analytical Lab of department of Agronomy, ABU Zaria

Plate Height (cm)

Table 4 showed the effect of solid and liquid organic fertilizer on plant height (cm) at both experimental sites during 2016 wet season. Plant height was significantly affected (P<0.05) at Samaru but not at Bagauda. At Samaru significant difference in plant height (cm) was observed at 8, 10 and 12 WAS among the various rates of solid organic manure with 3 tons ha having tallest plants which was comparable to 2 and 1ton ha-1 in terms of plant height.

Plant height (cm) in terms of varying levels of liquid organic fertilizer was only statistically different at 12WAS at Samaru only where 2, 1.5, 1.0 and 0.5 litres/ha levels were statically similar at 12 WAS sampling pound.

Table 5 further showed the interaction effect between liquid and solid organic fertilizer at 12 WAS at Samaru only. Among all the levels of solid fertilizer levels increase in liquid fertilizer levels produce an increase in plant height up to 1.0 litre/ha and further increase will induce a reduction in plant height (cm) recorded at 12 WAS at Samaru.

Table 4: Effect of Solid and Liquid Organic Fertilizers on Rosselle Plant Height (cm) at both Bagauda and Samaru during 2016 Wet Season.

	Plant Height (cm)					
	Bagauda			Samaru		
	Weeks after Sowing (WAS)			Weeks after Sowing (WAS)		
Treatment	**8**	**10**	**12**	**8**	**10**	**12**
Solid Organic Fertilizer t/ha						
0.0	45.13	55.60	66.51	48.78[b]	56.60[b]	65.54[c]
1.0	48.20	56.47	67.24	49.18[b]	57.87[b]	69.9[bc]
2.0	48.33	60.20	71.02	54.84[a]	64.66[a]	89.53[ab]
3.0	51.56	62.37	73.51	55.58[a]	65.38[a]	4.69[a]
SE±	2.28	2.86	2.68	1.50	1.44	1.56
Significance	NS	NS	NS	*	*	*
Liquid Organic Fertilizer L/ha						
0.0	45.86	54.19	65.56	49.97	59.50	69.98[b]
0.5	46.61	58.62	69.59	51.20	60.00	70.70[ab]
1.0	49.47	58.20	69.61	51.47	60.60	73.97[ab]
1.5	49.61	59.78	70.22	52.58	67.44	74.53[a]
2.0	49.47	53.18	72.92	54.44	69.08	88.64[a]
SE±	2.55	3.18	2.99	1.68	1.62	1.75
Interaction						
L x S	NS	NS	NS	NS	NS	**

Means followed by the same letter(s) within a column of treatment b means are significant at 1% and 5% level of probability (DMRT). NS – Not Significant. * Significant at 5% level of probability, ** highly significant at 1% level of probability.

Table 5: Interaction effect between solid and liquid organic fertilizer rates on plant heights at 12 WAS at Samaru during 2016 Wet Season

	Plant Height (cm) 12 WAS				
	Liquid Organic Fertilizer L/ha				
Solid Organic Fertilizer t/ha	**0.0**	**0.5**	**1.0**	**1.5**	**2.0**
0.0	56.68[c]	61.56[bc]	71.67[ab]	66.78[a-c]	71.00[a-c]
1.0	67.89[a-c]	69.11[a-c]	71.78[ab]	67.78[a-c]	68.89[a-c]
2.0	77.33[a]	75.89[a]	85.00[a]	74.33[ab]	70.10[ab]
3.0	78.00[a]	76.22[a]	87.44[a]	86.22[a]	64.56[a-c]
SE			3.36		

Means followed by the same letter(s) within a column of treatments means are significant at 5% level of probability and 1% level of probability. NS: not significant.

Plant Dry Weight (g)

The effect of solid and liquid organic fertilizer on rossell plant dry weight (g) for both Bagauda and Samaru during the 2016 wet season is presented as table 6. Application of solid organic manure (fertilizer) did not significantly influenced plant dry weight throughout all sampling periods at both location. Application of liquid organic fertilizer influenced roselle plant dry weight at Samaru (8, 12 and 12 WAS) sampling periods. Increase in liquid organic fertilizer rate from 0.0 to 1.5L/ha-1 increase plant dry weight. Further increase to 2.0 Lha-1 led to significant increase in plant dry weight. Increasing liquid fertilizer at 10WAS at Samaru from 1.5 to 2.0L/ha result in statistically similar plant dry weight. There was no interaction effect between solid and liquid fertilizer on plant dry weight.

Table 6: Effect of Solid and Liquid Organic Fertilizer on Rossell Plant dry weight (g) during the 2016 wet season at Bagauda and Samaru

	Plant dry weight (g)					
	Bagauda			Samaru		
	Weeks after sowing			Weeks after sowing		
Treatment	**8**	**10**	**12**	**8**	**10**	**12**
Solid Organic Fertilizer t/ha						
0.0	15.86	18.56	21.48	34.54	36.94	40.09
1.0	15.90	19.53	22.31	38.98	41.50	44.04
2.0	17.06	19.53	22.73	46.37	48.79	51.49
3.0	18.15	21.31	23.65	49.74	52.25	53.27
SE±	2.04	4.31	0.75	5.45	0.07	0.13
Significance	NS	NS	NS	NS	NS	NS
Liquid Organic Fertilizer L/ha^{-1}						
0.0	14.15	17.65	20.38	33.41	36.38	39.02
0.5	14.83	17.94	21.04	38.39	41.02	43.63
1.0	15.82	20.37	21.83	39.02	41.30	44.01
1.5	16.58	19.37	22.44	44.30	46.39	48.88
2.0	22.34	24.17	27.02	56.88	59.18	61.75
SE±	2.28	4.57	0.87	6.11	0.08	0.14
Significance	NS	NS	NS	NS	NS	NS
Interaction						
L x S	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a column of treatment b means are significant at 1% and 5% level of probability (DMRT). NS – Not Significant. * Significant at 5% level of probability, ** highly significant at 1% level of probability.

Number of Branches per Plant

Number of branches of rosselle plant as influenced by solid and liquid organic fertilizer at various locations during 2016 wet season is presented as table 7. Solid and liquid organic fertilizer did not significantly influence number of branches of rosselle at both locations through the sampling periods. These was no interaction effect between solid and liquid organic fertilizer on a number of branches throughout the period of study.

Table 7: Effect of Solid and Liquid Organic Fertilizer on Number of Branches in Rosselle Plant at Bagauda and Samaru during 2016 Raining Season

	Number of Branches Plant^{-1}					
	Bagauda			Samaru		
	Weeks after sowing			Weeks after sowing		
Treatment	**8**	**10**	**12**	**8**	**10**	**12**
Solid Organic Fertilizer t/ha						
0.0	4.73	8.33	12.93	5.29	9.38	12.33
1.0	5.04	8.55	12.99	5.33	9.49	13.41
2.0	5.22	8.82	13.25	5.47	9.73	14.53
3.0	5.89	9.38	13.89	5.98	10.04	14.67
SE±	0.45	1.42	6.64	0.22	1.20	1.07
Significance	NS	NS	NS	NS	NS	NS
Liquid Organic Fertilizer L/ha^{-1}						
0.0	4.94	8.36	12.89	5.14	9.28	12.03
0.5	4.97	8.39	12.98	5.47	9.48	13.33
1.0	5.21	8.69	13.03	5.61	9.58	14.53
1.5	5.41	9.14	13.64	5.67	9.81	15.64
2.0	5.50	9.28	13.73	5.69	9.88	16.69
SE±	0.50	1.59	7.43	0.25	2.12	2.37
Significance	NS	NS	NS	NS	NS	NS
Interaction						
L x S	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a column of treatment b means are significant at 1% and 5% level of probability (DMRT). NS – Not Significant. * Significant at 5% level of probability, ** highly significant at 1% level of probability.

Leaf Area Index

Table 8 showed the leaf area index of rosselle as influenced by solid and liquid organic fertilizer during 2016 cropping season at Bagauda and Samaru solid and liquid organic fertilizer did not significantly influence the leaf area index throughout the sampling periods at both location. The interaction of solid organic manure and liquid organic fertilizer on leaf area index was not significant throughout the period of study.

Table 8: Effect of Solid and Liquid Organic Manure on Leaf Area Index of Rosselle at Bagauda and Samaru during 2016 Wet Season.

	Leaf Area Index					
	Bagauda			Samaru		
	Weeks after sowing			Weeks after sowing		
Treatment	**8**	**10**	**12**	**8**	**10**	**12**
Solid Organic Fertilizer t/ha						
0.0	0.89	1.38	1.56	0.94	1.90	1.99
1.0	0.94	1.40	1.59	0.98	1.31	2.01
2.0	0.97	1.51	1.69	1.00	1.12	2.32
3.0	1.00	1.42	1.74	1.31	1.62	2.41
SE±	1.62	1.41	1.54	1.08	2.33	2.19
Significance	NS	NS	NS	NS	NS	NS
Liquid Organic Fertilizer L/ha^{-1}						
0.0	0.85	1.18	1.49	0.39	1.03	1.84
0.5	0.92	1.21	1.43	0.68	1.26	1.95
1.0	0.98	1.33	1.56	0.44	1.33	2.08
1.5	0.96	1.34	1.59	0.03	1.39	2.28
2.0	1.05	1.49	1.98	0.26	1.54	2.41
SE±	1.82	2.01	2.11	1.21	1.60	2.45
Significance	NS	NS	NS	NS	NS	NS
Interaction						
L x S	NS	NS	NS	NS	NS	NS

Means followed by the same letter(s) within a column of treatment b means are significant at 1% and 5% level of probability (DMRT). NS – Not Significant. * Significant at 5% level of probability, ** highly significant at 1% level of probability.

Crop Growth Rate (CGR)

The effect of solid organic manure and liquid organic fertilizer on crop growth rate of rosselle at Bagauda and Samaru during 2016 wet season is presented as Table 9. Application of solid organic fertilizer on CGR was statistically significant only at 12WAS at Samaru. Increasing solid organic fertilizer from 0-1t/ha significantly influence Crop growth Rates which was statistically at par with other rates at the said sampling period. Further increase of solid manure to 2tha^{-1}, and 3tha^{-1} remained statistically insignificant but at par with 2 tonsha^{-1}. Application of liquid organic fertilizer did not influence crop growth rate at both locations throughout the sampling periods. There was no interaction effect between solid organic manure and liquid organic fertilizer on crop growth rate in this trial.

Table 9: Effect of Solid and Liquid Organic Fertilizer on Crop Growth Rate ($g^{-1}P^{-1}WK^{-1}$) of Rosselle at Bagauda and Samaru during 2016 Wet Season.

	Crop Growth Rate $g^{-1}P^{-1}wk^{-1}$			
	Bagauda		Samaru	
	Weeks after sowing		Weeks after sowing	
Treatment	**10**	**12**	**10**	**12**
Solid Organic Fertilizer t/ha				
0.0	1.17	1.33	1.20	1.51
1.0	1.19	1.44	1.21	1.67
2.0	1.46	1.58	1.26	1.69
3.0	1.60	1.84	1.26	1.77
SE±	0.25	0.52	0.15	0.21
Significance	NS	NS	NS	NS
Liquid Organic Fertilizer L/ha^{-1}				
0.0	1.20	0.91	1.28	1.39
0.5	1.20	1.21	1.30	1.52
1.0	1.36	1.23	1.31	1.59
1.5	1.43	1.70	1.35	1.69
2.0	1.55	1.98	1.25	1.89
SE±	0.32	0.57	0.17	0.28
Significance	NS	NS	NS	NS
Interaction				
L x S	NS	NS	NS	NS

Means followed by the same letter(s) within a column of treatment b means are significant at 1% and 5% level of probability (DMRT). NS – Not Significant. * Significant at 5% level of probability, ** highly significant at 1% level of probability.

Relative Growth Rate (RGR)

Relative growth rate of rosselle as influenced by solid organic fertilizer at Bagauda and Samaru during 2016 wet season is presented as table 10.

Significant response in terms of RGR by rosselle plant to solid organic fertilizer was observed at 10WAS at Samaru only. Increasing the solid organic fertilizer from 0.0tha-1 to 2tha-1 increased RGR further increase to 3tha-1 produced the highest RGR values which was statistically different from other rates. Application of liquid organic fertilizer influenced RGR at 10 WAS in Samaru and 12 WAS at Bagauda. At both Bagauda, increasing liquid organic fertilizer from 0.0Lha-1 to 0.5Lha-1 significantly increased RGR and further increase of the liquid fertilizer further increases RGR values upto 2.0. At Samaru however, increasing liquid fertilizer from 0.0 to 0.5Lha-1 produce an increase in RGR values which was statistically at par with further increase up to 2 L/ha. There was no significant interaction between solid and liquid organic fertilizer on RGR at both location.

Table 10: Relative Growth Rate (gg^{-1} wk^{-1}) of Rosselle as Influenced by Solid and Liquid Organic Fertilizer at Bagauda and Samaru during 2016 Wet Season.

	Relative Growth Rate ($gg^{-1}wk^{-1}$)			
	Bagauda		Samaru	
	Weeks after sowing		Weeks after sowing	
Treatment	**10**	**12**	**10**	**12**
Solid Organic Fertilizer t/ha				
0.0	0.02	0.10	0.02^{b}	0.12
1.0	0.03	0.12	0.06^{b}	0.14
2.0	0.05	0.15	0.08^{b}	0.16
3.0	0.06	0.16	0.09^{a}	0.16
SE±	0.01	0.06	0.02	0.08
Significance	NS	NS	*	NS
Liquid Organic Fertilizer L/ha^{-1}				
0.0	0.06	0.08^{b}	0.02^{bc}	0.03
0.5	0.07	0.11^{ab}	0.04^{bc}	0.03
1.0	0.08	0.12^{ab}	0.05^{abc}	0.04
1.5	0.06	0.17^{ab}	0.06^{a}	0.04
2.0	0.09	0.21^{a}	0.04^{a}	0.04
SE±	0.02	0.07	0.03	0.05
Significance	NS	*	*	NS
Interaction				
L x S	NS	NS	NS	NS

Means followed by the same letter(s) within a column of treatment b means are significant at 1% and 5% level of probability (DMRT). NS – Not Significant. * Significant at 5% level of probability, ** highly significant at 1% level of probability.

Number of Calyx Per Plant

The effect of solid and liquid organic fertilizer on number of calyx per plant of rosselle at Bagauda and Samaru during 2016 cropping season is presented as Table 11. Number of calyx was significantly influenced by solid organic fertilizer at Samaru only. Application of 1 ton ha^{-1} significantly increased number of calyx per plant as compared with 0.0 tons ha^{-1} increasing the solid organic manure up to 3tonsha^{-1} further increases number of calyx per plant which were all statistically similar. Liquid organic fertilizer application does not influence the number of calyx par plant. There was no significant interaction between the fertilizers on number of calyx per plant.

Table 11: The Effect of Solid and Liquid Organic Fertilizer on Number of Calyx per Plant of Rosselle at Bagauda and Samaru during 2016 Wet Season.

Treatment	Number of Calyx Per Plant	
	Bagauda	**Samaru**
Solid Organic Fertilizer (tha^{-1})		
0.0	65.56	85.83^{b}
1.0	65.83	98.93^{ab}
2.0	68.33	113.29^{ab}
3.0	74.73	129.62^{a}
SE±	9.90	15.67
Significant	NS	*
Liquid Organic Fertilizer L/ha^{-1}		
0.0	61.45	94.26
0.5	64.22	105.82
1.0	65.02	102.38
1.5	61.31	112.31
2.0	81.08	119.82
SE±	10.51	17.50
Significant	NS	NS
Interaction		
L x S	NS	NS

Means followed by the same letter(s) within a column of treatment b means are significant at 1% and 5% level of probability (DMRT). NS – Not Significant. * Significant at 5% level of probability, ** highly significant at 1% level of probability.

Calyx Dry Weight (g) Plant^{-1}

Calyx Dry Weight plant^{-1} as influenced by solid and liquid organic fertilizer at Bagauda and Samaru during 2016 wet season is presented as table 12. Calyx dry weight was significantly influenced by solid and liquid organic fertilizer at Bagauda only. Application of 3tons ha^{-1} produces heavier dry calyx than other rates which were statistically at par while liquid organic fertilizer did not significantly influence calyx dry weight. There was no interaction effect on calyx dry weight between solid and liquid organic fertilizer.

Table 12: Calyx Dry Weight (g) plant-1 of Rosselle as influenced by Solid and Liquid Organic fertilizer during 2016 Cropping Season at Bagauda and Samaru

Treatment	Calyx Dry Weight (g) Plant^{-1}	
	Bagauda	**Samaru**
Solid Organic Fertilizer (tha^{-1})		
0.0	9.72^{b}	13.95
1.0	10.55^{ab}	14.78
2.0	13.75^{ab}	15.21
3.0	13.18^{a}	16.44
SE±	1.53	2.33
Significance	*	NS
Liquid Organic Fertilizer L/ha^{-1}		
0.0	9.77	12.96
0.5	10.67	13.72
1.0	11.00	15.63
1.5	11.85	16.09
2.0	11.92	17.08
SE±	1.71	6.61
Significant	NS	NS
Interaction		
L x S	NS	NS

Means followed by the same letter(s) within a column of treatment b means are significant at 1% and 5% level of probability (DMRT). NS – Not Significant. * Significant at 5% level of probability, ** highly significant at 1% level of probability.

100 Seed Weight (g)

The effect of solid and liquid organic fertilizer on 100 seed weight (g) at Bagauda and Samaru during 2016 Wet Season is presented as Table 13. Solid organic manure did not signfiicanty influence 100 seed weight (g) of rosselle at both locations but liquid organic fertilizer does significantly influence rosselle 100 seed weight (g) at Samaru. Application of 2.0L/ha produces significantly heavier 100 seed weight than other rates on rosselle plant. There was no interaction effect between the treatment tested on the parameter.

Table 13: 100 Seed Weight (g) of Rosselle as Influenced by Solid and Liquid Organic Fertilizer during 2016 Wet Season at Bagauda and Samaru.

Treatment	100 Seed Weight (g)	
	Bagauda	**Samaru**
Solid Organic Fertilizer (tha^{-1})		
0.0	2.27	3.80bc
1.0	2.74	3.88ab
2.0	2.78	3.93ab
3.0	2.83	4.04a
SE±	0.11	0.12
Significant	NS	*
Liquid Organic Fertilizer L/ha^{-1}		
0.0	2.71	3.73
0.5	2.72	3.86
1.0	2.86	3.91
1.5	2.88	3.93
2.0	0.10	0.13
SE±	0.12	0.13
Significant	NS	NS
Interaction		
L x S		
	NS	NS

Means followed by the same letter(s) within a column of treatment b means are significant at 1% and 5% level of probability (DMRT). NS – Not Significant. * Significant at 5% level of probability, ** highly significant at 1% level of probability.

Calyx Dry Yield ($kgha^{-1}$)

Dry Calyx Yield kg/ha of rosselle as influenced by application of liquid and solid organic fertilizer in Bagauda and Samaru during 2016 wet season is presented as Table 14. Application of 3.0tha-1 solid organic fertilizer produced significantly higher dry calyx yield (kg/ha) of rossell than other rates at both locations which was statistically similar with application of 1.0 and 2.0 tons ha^{-1} and samara significantly influenced dry calyx yield (kg/ha) of rosselle at both olocations. Application of 2.0L/ha of liquid manure at both locations but at par with 1.5L/ha at Samaru. There was significant interaction effect on calyx dry yield (kg/ha) at Bagauda only. Application of 2.0 and 3.0tha^{-1} of solid organic fertilizer and 2.0 Lha^{-1} liquid organic fertilizer produced highest dry calyx yield (kg/ha) of rosselle.

Table 14: Dry Calyx Yield (kg/ha) of Rosselle as Influenced by Solid and Liquid Organic Fertilizer during 2016 Cropping Season at Bagauda and Samaru

	Dry Calyx Yield kg/ha at Harvest	
Treatment	**Bagauda**	**Samaru**
Solid Organic Fertilizer (tha^{-1})		
0.0	309.87^{d}	379.80^{b}
1.0	312.27^{c}	402.27^{a}
2.0	346.52^{b}	416.52^{a}
3.0	387.81^{a}	527.81^{a}
SE±	1.75	14.91
Significant	*	*
Liquid Organic Fertilizer L/ha^{-1}		
0.0	309.44^{e}	309.44^{c}
0.5	353.13^{d}	353.13^{c}
1.0	403.36^{c}	403.15^{ab}
1.5	434.24^{b}	454.15^{ab}
2.0	472.92^{a}	512.92^{a}
SE±	1.96	1.98
Significant	*	NS
Interaction		
L x S	**	NS

Means followed by the same letter(s) within a column of treatment b means are significant at 1% and 5% level of probability (DMRT). NS – Not Significant. * Significant at 5% level of probability, ** highly significant at 1% level of probability.

Table 15: Interaction Effect between Solid and Liquid Organic Fertilizer Levels on Dry Calyx Yield kgha-1 of Rosselle during 2016 Raining Season at Bagauda

	Dry Calyx Yield kgha^{-1}				
	Liquid Organic Fertilizer Lha^{-1}				
Solid Organic Fertilizer tha^{-1}	**0.0**	**0.5**	**1.0**	**1.5**	**2.0**
0.0	371.04^{m}	325.55^{ml}	381.55^{i}	431.37^{ef}	489.49^{c}
1.0	314.36^{m}	352.37^{k}	398.35^{h}	440.69^{e}	505.39^{b}
2.0	320.32^{m}	363.20^{jk}	411.20^{g}	463.89^{d}	524.00^{a}
3.0	331.84^{L}	371.41^{ij}	422.35^{fj}	480.64^{c}	532.80^{a}
SE±			3.92		

Means followed by the same letter(s) within a column of treatment b means are significant at 1% and 5% level of probability (DMRT). NS – Not Significant. * Significant at 5% level of probability, ** highly significant at 1% level of probability.

DISCUSSION

The soils of the experimental sites were texturally sandy loam Table 1. The soils were moderately low in nitrogen in both locations and were slightly acidic. Exchangeable bases were also moderately low in both locations. Total average rainfall for the experimental period May to December were 1457.9mm at Bagauda and 1822.8mm in 2016 wet season (Table 16). This means more moisture is made available for growth, development and yield of rossell at Samaru than at Bagauda. This is coupled with the fact that both locations had sandy loam soil for easy root growth and development. This can help explain why the performance of the crop is far better in terms of growth yield and yield component at Samaru than at Bagauda.

Table 16: Weather Data of the Bagauda and Samaru during 2016 Raining Season

Months	**Bagauda**					**Samaru**				
	Rainfall mm	**Temperature (^{0}C)**		**Relative Humidity (%) 0900Hrs**	**Sunshine (Hrs)**	**Rainfall mm**	**Temperature (^{0}C)**		**Relative Humidity (%) 0900Hrs**	**Sunshine (Hrs)**
		Max	**Min**				**Max**	**Min**		
May	233.7	30	23	42	4.8	347.7	31	21	40	
June	185.2	30	23	41	4.0	239.5	29	23	39	
July	344.2	30	23	47	3.1	236.4	28	22	39	
August	150.1	29	23	39	2.1	3.14	29	22	34	
Septemb	285.1	30	23	38	2.4	4.05	28	24	38	
er	295.2	30	23	37	2.3	2.34	29	21	33	
October	58.2	31	23	42	2.5	1.2	30	23	33	
Nov	0.0	33	21	41	2.1	9.6	31	21	31	
Dec										
Total	**1457.1**					**1822.9mm**				

Source: IAR Weather Station Samaru and NIHORT Weather Station Bagauda Kano

It was observed that application of solid organic fertilizer (poultry manure) significantly increased and enhance the growth, development and yield or rosselle in this trial. The general significant positive response of growth parameters like plant heights (cm), plant dry weight (g), leaf area index, crop growth rate, relative growth rate at Samaru could be attributed to relatively higher availability of moisture than at Bagauda. It could also be as a result of the role organic fertilizer play in releasing the nutrients like Nitrogen (N) slowly over a longer period of time thereby making it available to the growing plant when its needed. Organic matter also helps in maintaining and improving solid physical condition, soil fertility, soil structure, organic matter, soil productivity and aggregate stability. The increase in rossell growth (parameters) with higher fertilizer rates shows that organic manures apart from readily supplying necessary nutrients for growth and development but also improves the soil microbial and soil organic matter status, which in turn help in producing organic acids which enhances the promotive effect of auxious which has a direct effect on plant growth (Lawal, 2000). Tisdale and Nelso (1996) also reported that Nitrogen was linked with vigorous vegetative growth in crop plants. Salim *et al.* (1993) also reported significant response of plant height, Leaf area index, dry plant weight of rosselle to availability of Nitrogen.

The increase in number of calyx per plant, 100 seed weight calyx dry weight per plant and dry calyx yield with increase in solid organic fertilizer application could also be due to the beneficial effect of the organic fertilizer on the soil, plant growth and development and ultimately the yield and yield components of rosselle plant.

This results agrees with the report of El-Meleigys (1989) who also found that the number of rosselles fruit increased significantly when organic compost is incorporated into the soil as a source of fertilizer. Rosselle plant responded to liquid organic fertilizer at Samaru than at Bagauda, this could also be due to the higher moisture present at Samaru than at Bagauda, this then translate to the fact that liquid organic fertilizer contains high content of soluble nutrients (chiefly Nitrogen) that the plant utilize for growth and yield but also sustains the soil for plant growth and development. In addition, application of liquid organic fertilizer could improve the nutrient use efficiency and decrease the risk of nutrient loss (Criollo *et al.,* 2011). This result agrees with the work of Badvan (2004), who stated that liquid organic fertilizer contained a large amount of soluble nutrients which level to be more available quickly to the plants on application as compared with traditional manure (solid) incorporated fertilizer reduces the use of large quantity of fertilizer, avoid solid status problems and reduce ground water pollution in addition to the profound effect on growth and yield components (Hamayin *et al.,* 2011). Babatunde (2001) also reported that an increase in calyces yield and weight kg/ha was as a result of liquid manure application.

CONCLUSION

From the results obtained, rosselle plant responded positively to application of both solid and liquid organic manure. This response is more in terms of plant growth, yield and yield components at Samaru than at Bagauda. This could be due to the higher level of moisture at Samaru than that of Bagauda, thus the remarkable different in both growth and yield parameters.

Application of solid organic manure at the rate of 3 tons/ha produces highest yield and yield components when compared to other rates. So also is the application of 2litrs/ha of liquid organic manure also produces highest values among other rates in growth, yield and yield components at Samaru than at Bagauda. For better result combination of 2Ltrs/ha and 3tons/ha of both liquid and solid organic manure is to be tried in the Nigeria Savannah.

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