



## YIELD AND YIELD COMPONENTS OF ROSELLE (*Hibiscus sabdariffa* L.) AS INFLUENCED BY SOLID AND LIQUID ORGANIC FERTILIZER IN NIGERIAN SAVANNAH

\*Ladan, K.M, Abubakar, M.G. and Suleiman, J.

Department of Agronomy, Faculty of Agriculture and Agricultural Technology,  
Federal University Dutsinma, Katsina State.

\*Corresponding Author: [kladan727@gmail.com](mailto:kladan727@gmail.com)

### ABSTRACT

Assessment of yield and yield components of Roselle can enrich the current literature and help encourage farmers redouble effort in its cultivation in Nigeria. Therefore, two field trials were conducted to investigate the effect of solid and liquid organic Fertilizer on the yield and yield components of Roselle at Institute for Agricultural Research IAR, Research Farm (A.B.U, Zaria) and National Institute for Horticultural Research NIHORT-Farm Bagauda Kano State during 2016 wet season. Treatments, consisted of four levels of poultry manure (solid organic fertilizer) (0, 1, 2 and 3 t/ha) and five levels of liquid organic fertilizer (0, 0.5, 1.0, 1.5 and 2 L /ha) which were factorially combined and laid out in a Randomized Complete Block Design (RCBD) with three replications. Significant increment was observed at the rate of 2.0Lha<sup>-1</sup> of liquid organic fertilizer on plant height, plant dry weight, 100 seed weight and calyx dry weight (g) while application of solid poultry manure (pm) at the rate of 3.0tonnes/ha significantly increased plant height, leaf area index, calyx dry weight (g) and calyx yield (kg/ha) when compared with the control. From the result obtained, the combination of 2.0 L/ha of liquid organic fertilizer and 3.0t/ha of solid organic fertilizer (poultry manure)produced highest calyx yield (kg/ha) and yield components at both locations.

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

### INTRODUCTION

Among the members of malvaceae family is Roselle (*Hibiscus sabdariffa* L.) which is grown as an annual, ornamental and medicinal shrub in the tropical and subtropical areas of the world (Ibrahim *et al.*, 2020). Roselle plays a considerable economic role for food, feed and industrial use, even though it is largely underutilized and underappreciated. The importance of Roselle plant lies in its valued stem, fibres, leaves, seeds and edible calyces which is rich in Vitamin C and also exhibits therapeutic properties (Norhayati *et al.*, 2019). The part of flower used by customers and consumers is the dried and fleshy calyces which have large quantities of organic acids (that is Oxalic, Malic, Citric and Tartaric acids) for healthy human bodies (Hanan *et al.*, 2019). Roselle calyces are used in producing drinks and juices, jellies, chutneys, wines, sauces as well as preservatives. The calyces are also a source of natural food colourants (Delgado-Vargas and Percedes-lopez, 2003). In Nigeria, Roselle is mostly grown traditionally on a subsistence level with little or no chemical fertilizer. This sometimes is a vital source of concern as these chemical fertilizers are continually becoming expensive and sometimes unavailable due to politics in its availability and distribution to local farmers. This therefore makes the case for an alternative

source of fertilization in the form of organic manure (solid and liquid fertilization) as most rural farmers practice mixed (cultivating crops and rearing animals locally) farming. So poultry manure as a form of solid organic fertilizer is readily available which when applied to crops, releases nutrients slowly to the crops over a period of time, while reducing environmental pollution. Liquid organic fertilizer on the other hand, is fast in releasing nutrients to the crops after application with little or no wastage in terms of runoff or leaching into the soil and also have a high nutrient use efficiency than chemical (inorganic) fertilizers. Little information is available on the organic fertilizer requirement of Roselle in Nigeria, where fertilizer recommendation guidelines are lacking. The objective of this investigation therefore was to determine the effect of solid and liquid organic fertilization on yield and yield components of Roselle in Nigeria.

### MATERIALS AND METHODS

Field trials were carried out at the Research Farm of Institute for Agricultural Research (11°11'N, 07°38' and 686m above sea level) Samaru-Zaria, and National Institute for Horticultural Research (NIHORT) Farm (12°00'N, 8°31'E, 488m above sea

level) Bagauda – Kano State. Soil samples collected from the experimental sites at a depth of 0-15cm and 15-30cm prior to land preparation were analyzed for physico-chemical properties at the analytical laboratory of the Department of Agronomy, Ahmadu Bello University, Zaria in accordance with procedures as described by Black(1965). Samples of both the poultry manure and liquid organic fertilizer were also analyzed for their chemical properties at the same laboratory according to procedure as described by Billington,(1943). The treatments consisted of four levels of solid organic fertilizer (poultry manure) (0.0, 1.0, 2.0 and 3.0 tons/ha) and five levels of liquid organic fertilizer (GTO fertility solutions) from Ground total Organic fertilizer limited Abuja – Nigeria (0.0, 0.5, 1.0, 1.5 and 2.0) Litres/ha, the factorial combination were laid out in a Randomized Complete Block Design (RCBD) with three replications. The Roselle variety used for this trial was a local variety called ‘Samaru – 1882’ obtained from the seed unit of Institute for Agricultural Research (IAR) Samaru – Zaria. It is of medium height with profuse branching habit with dark red stem, petiole and midribs. It produces high quality calyces preferred by consumers and marketers alike, it matures within 3-4 months and has a potential yield of upto 900 kg ha<sup>-1</sup> (Kumar *et al.*, 1985).

#### EXPERIMENTAL SITE

The experimental site was cleared, harrowed twice and then ridges were made 75cm apart. The field was then marked out and layout established into values plots and border areas. The gross and net plot sizes (6 ridges) size was 6m<sup>2</sup> (4m x 1.5m), (2m x 1.5m) with 1m and 0.5m on distance/space between blocks and plots respectively. The growth parameters were taken from the net plot while destructive samples were taken from the gross plot.

#### CROP HUSBANDRY

Three seeds were sown 30cm apart on ridges at the two sites, on 7 July and 12 July respectively and later thinned to two plants per stand at two weeks after sowing (WAS). The solid organic fertilizer (poultry manure) 0, 1, 2 and 3 tons/ha were drilled along the middle of the ridge, two weeks before sowing as per treatment, while liquid organic fertilizer treatments (0, 0.5, 1.0, 1.5, and 2.0 litres ha<sup>-1</sup>) were foliar applied in split doses on each of the plant stand. The first half dose was applied at 3 (WAS) while the second half at 6 (WAS). Weed in the experimental site were controlled by spraying glyphosate (round-up) at the rate of 4 litres ha<sup>-1</sup> (1.4 kg a.i ha<sup>-1</sup>) prior to land preparation. This was followed by manual hoeing at 3 and 6 WAS. Earthing up (moulding) of ridges was carried out at 12 WAS. As a preventive

measure, karate (*lambda*cyclothrin) at the rate of 0.8 litres ha<sup>-1</sup> together with Benlate (*benomyl*) at the rate of 1 kg a.i ha<sup>-1</sup> were applied 3 times using cp-15 knapsack sprayer starting from 8 WAS, 10 WAS and 12 WAS. Harvesting of the matured Roselle plant was carried out when the plant have reached physiological maturity on 19<sup>th</sup> and 26<sup>th</sup> November, 2016 respectively. This was when most of the leaves have abscised (shed), the fruits (capsules) had begun to split open, seeds turned reddish brown and the calyces were fully expanded. The plants within the net plot were harvested by cutting their bases with a sharp cutlass and placed in bags as per treatments. The calyces were then separated from the capsules by hand, oven dried to a constant weight 70°C for 48 hrs and then weighed using a metler balance model P-1200. After air drying, the capsule were shelled to obtain the seeds which were then weighed on per net plot basis

#### GROWTH AND YIELD ATTRIBUTES: DATA COLLECTION

After the plant was established, five plants from the four inner ridges in each plot (treatment) were randomly selected and tagged to study the following growth parameters:

**Plant Height (cm):** This parameter was measured from the five tagged plants in each plot from the base immediately above the top soil to the tip of the flag leaf using a meter rule at 8, 10 and 12 WAS. The average of the five plants was recorded for each plot.

**Leaf Area Index:** This parameter was measured for the five tagged plant by measuring the length of the leaf blade from base to tip and multiplying it by the width of the leaf to get the leaf area.

The leaf area will then be multiplied by a factor 0.75 and divided by the area of ground subtended by the plant to get the leaf area index according to John and Leonard (1967).

$$LAI = A/P = \frac{\text{Leaf Area per plant (m}^2\text{)}}{\text{Area of ground subtended by plant (m}^2\text{)}}$$

**Number of Calyces Plant<sup>-1</sup>:** The number of calyces obtained from the five tagged plants at harvest from each net plot were counted and the average obtained were then recorded as mean number of calyces per plant.

**Calyx dry weight (g) per Plant:** The weight of calyces obtained from the five tagged plants at harvest from each net plot were recorded and the average obtained were then recorded as mean calyx dry weight per plant.

**100 Seed Weight (g)**

After shelling was carried out, 100 seeds were randomly selected from each net plot and their weight taken using meter balance.

**Calyx Yield per Hectare (kg/ha):** The calyx yield from the net plot was harvested, oven dried and weighed. The cumulative calyx yield harvested was computed for each plot, then yield for each plot was determined to obtain calyx yield per hectare and recorded.

**Statistical Analysis:** Data collected were analyzed using Analysis of Variance (ANOVA) according to Gomez and Gomez (1984). Treatment means were separated using Duncan Multiple Range Test (DMRT), (Duncan, 1955).

**RESULTS**

The result of soil physical and chemical properties of the experimental site was presented as Table 1, while

the results of the analysis of the solid organic fertilizer (poultry manure) and liquid organic fertilizer are also presented as Tables 2 and 3 respectively.

The soil at both Bagauda and Samaru was found to be sandy loam total. Nitrogen was moderately low at both locations while organic carbon was also low. The exchangeable bases (cmolkg<sup>-1</sup>) was also low for both locations. The pH of soil at both locations was found to be slightly acidic in water and moderately acidic in CaCl<sub>2</sub> solution. The organic fertilizer analysis for both solid and liquid organic fertilizer used for the trial indicated high content of total Nitrogen (N) and potassium oxide (k<sub>2</sub>O), Medium Organic material and low organic Nitrogen for liquid organic fertilizer. For solid organic fertilizer used, it contain high total organic material, high total Nitrogen (N), low organic Nitrogen and high water soluble potassium oxide.

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

Physical Properties	Bagauda	Samaru
Clay	11.0	12
Silt	27.0	31
Sand	62.0	57
Textural Class	Sandy Loam	Sandy Loam
<b>Chemical Properties</b>		
PH (H <sub>2</sub> O) 1:2,5	6.24	6.12
PH 0.01 Mcacl <sub>2</sub>	5.86	5.63
Total Nitrogen (gkg <sup>-1</sup> )	3.7	4.0
Available Pmgkg <sup>-1</sup>	1.65	5.24
Organic Carbon	1.67	1.01
<b>Exchangeable Bases (cmolkg<sup>-1</sup>)</b>		
Calcium Meg/100g	2.59	2.12
Magnesium Meg/100g	0.71	0.80
Pottasium Meg/100g	0.01	0.13
Sodium Meq/100g	0.17	0.61
CEC Meg/100g	3.48	3.64

**Source:** Analytical Laboratory, Department of Agronomy, Ahmadu Bello University, Zaria

**Table 2: Nutrient Content of Poultry Manure Used at the Trial Sales 2016 Wet Season**

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

**Source:** Analytical Laboratory, Department of Agronomy, Ahmadu Bello University, Zaria

**Table 3: Nutrient Content of Liquid Organic Manure Used at the Trial 2016 Wet Season**

Nutrient Content	Value (%)
Total Organic Material	25
Total Nitrogen	3.0
Organic Nitrogen	1.0
Water Soluble K <sub>2</sub> O	4.0

**Source:** Analytical Laboratory, Department of Agronomy, Ahmadu Bello University, Zaria

Appendix i showed the weather data for the experimental sites for the 2016 wet season. The amount of rainfall (moisture availability) recorded at Samaru is higher than that received at Bagauda. This means that more moisture will be readily available to the growing Roselle crop at Samaru than at Bagauda. This will then translate to better performance in terms of growth, yield and yield components of Roselle at Samaru than Bagauda.

#### Plant Height (cm)

Table 4 showed the effect of solid and liquid organic fertilizer rates on plant height of Roselle at Bagauda and Samaru during 2016 cropping season. Solid organic manure ( poultry manure) had a significant effect on Roselle plant height at 12 WAS at Samaru

only, where application of 3 tons/ha resulted in tallest plant compared to other treatments.

Likewise application of liquid organic fertilizer significantly affected the Roselle plant height at 12 WAS only also at Samaru. Application of 2litrs per ha also produce the tallest plant that were statistically similar than that 1.5 and 1ltr produced. There was interaction effect between sold and liquid organic fertilizer on Roselle plant at 12WAS at Samaru (table5). Where increase in liquid fertilizer rates across all levels of solid organic fertilizer, plant height increases up to 1 litre/ha. Then further increase in liquid organic fertilizer beyond 1.0ltr per ha resulting in decreasing plant height.

**Table 4: Effect of Solid and Liquid Organic Fertilizer Rates on Rosselle Plant Height (cm) during 2016 Raining Seaosn at Bagauda and Samaru.**

Treatment	Plant Height (cm)					
	Bagauda			Samaru		
	Weeks after Sowing (WAS)			Weeks after Sowing (WAS)		
	8	10	12	8	10	12
<b>Solid Organic Fertilizer t/ha</b>						
0.0	45.13	55.60	66.51	48.78 <sup>b</sup>	56.60 <sup>b</sup>	65.54 <sup>c</sup>
1.0	48.20	36.81	57.24	49.18 <sup>b</sup>	57.87 <sup>b</sup>	69.9 <sup>bc</sup>
2.0	48.48	60.20	71.02	54.84 <sup>a</sup>	64.66 <sup>a</sup>	74.53 <sup>ab</sup>
3.0	51.56	62.37	73.51	55.58 <sup>a</sup>	65.38 <sup>a</sup>	75.69 <sup>a</sup>
SE±	2.28	2.85	2.68	1.50	1.44	1.56
Significance	NS	NS	NS	*	*	*
<b>Liquid Organic Fertilizer L/ha</b>						
0.0	45.86	54.19	65.56	49.97	59.50	69.98 <sup>b</sup>
0.5	46.61	58.62	69.59	51.20	60.01	70.70 <sup>ab</sup>
1.0	49.51	59.28	69.81	51.84	60.70	73.97 <sup>ab</sup>
1.5	49.85	59.92	70.22	52.58	61.44	74.93 <sup>a</sup>
2.0	49.98	60.12	72.35	54.44	64.08	78.64 <sup>a</sup>
SE±	2.55	3.18	2.99	1.68	1.62	1.75
Significance	NS	NS	NS	NS	NS	*
<b>Interaction</b>						
L x S	NS	NS	NS	NS	NS	**

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

#### Leaf Area Index

Table 6 showed the leaf area index of Roselle as influenced by solid and liquid fertilizer rates during 2016 wet season at Bagauda and Samaru. Solid and liquid organic fertilizer rates did not significantly

influence the leaf area index of Roselle throughout the sampling periods at both locations. There was no interaction effect between solid and liquid organic manure on Roselle leaf area throughout the period of study.

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

Solid Organic Fertilizer t/ha	Plant Height (cm) 12 WAS				
	Liquid Organic Fertilizer L/ha				
	0.0	0.5	1.0	1.5	2.0
0.0	56.68 <sup>c</sup>	61.56 <sup>bc</sup>	71.67 <sup>ab</sup>	66.78 <sup>a-c</sup>	71.00 <sup>a-c</sup>
1.0	67.89 <sup>a-c</sup>	69.11 <sup>a-c</sup>	71.78 <sup>ab</sup>	67.78 <sup>a-c</sup>	68.89 <sup>a-c</sup>
2.0	77.33 <sup>a</sup>	75.89 <sup>a</sup>	75.00 <sup>a</sup>	74.33 <sup>ab</sup>	70.11 <sup>ab</sup>
3.0	78.00 <sup>a</sup>	76.22 <sup>a</sup>	77.44 <sup>a</sup>	77.01 <sup>a</sup>	64.56 <sup>a-c</sup>
SE			3.36		

Means followed by the same letter(s) within a column of treatment b means are significant at 1% and 5% level of probability (DMRT).

**Table6: Leaf Area Index of Roselle as Influenced by Solid and Liquid Organic Fertilizer Rates at Bagauda and Samaru during 2016 Wet Season**

Treatment	Leaf Area Index					
	Bagauda			Samaru		
	Weeks after sowing			Weeks after sowing		
	8	10	12	8	10	12
<b>Solid Organic Fertilizer t/ha</b>						
0.0	0.89	1.38	2.26	3.94	6.90	8.52
1.0	0.94	1.40	2.28	4.98	6.63	8.66
2.0	0.97	1.51	2.39	4.80	6.12	8.94
3.0	1.00	1.61	2.44	5.31	7.62	9.52
SE±	1.62	1.41	1.54	1.08	2.33	1.91
Significance	NS	NS	NS	NS	NS	NS
<b>Liquid Organic Fertilizer L/ha<sup>-1</sup></b>						
0.0	0.85	1.28	2.19	4.39	6.03	8.04
0.5	0.92	1.41	2.23	4.68	6.76	8.45
1.0	0.98	1.63	2.56	4.75	6.84	8.58
1.5	0.96	1.75	2.76	5.03	7.02	8.94
2.0	1.05	1.92	2.84	5.26	7.54	9.41
SE±	1.82	1.05	1.10	1.21	1.94	2.01
Significancce	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).

### Number of Calyx Per Plant

Number of calyx per plant Roselle as influenced by solid and liquid organic fertilizer levels at Bagauda and Samaru during 2016 wet season is presented as table7. Number of calyx per plant was significantly influenced at Samaru only. Application of solid fertilizer of 1tonha<sup>-1</sup>significantly increased number of calyx per plant when compared with the control i.e zero application or 0.0tonsha<sup>-1</sup>. Increasing the solid

organic fertilizer to 2.0 tonsha<sup>-1</sup>, the number of calyx was statistically similar to 1.0tonsha<sup>-1</sup>. Further increase from 2.0 to 3.0 tons ha<sup>-1</sup> significantly increased number of calyx per plant. Liquid organic fertilizer was found not to influence the number of calyx per plant at harvest. There was no significant interaction between the fertilizer on number of calyx per plant.

**Table 7: Number of Calyx Per Plant of Roselle as Influenced by Solid and Liquid Organic Fertilizer Rates at Bagauda and Samaru during 2016 Wet Season.**

Treatment	Number of Calyx Per Plant <sup>1</sup>	
	Bagauda	Samaru
<b>Solid Organic Fertilizer (tha<sup>-1</sup>)</b>		
0.0	65.56	85.83
1.0	65.83	98.93
2.0	68.33	113.29
3.0	74.73	129.62
SE±	9.90	15.67
Significant	NS	NS
<b>Liquid Organic Fertilizer L/ha<sup>-1</sup></b>		
0.0	61.45	94.26
0.5	64.22	105.82
1.0	65.02	107.38
1.5	71.31	112.31
2.0	81.08	119.82
SE±	10.51	17.5
Significance	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).

**Calyx Dry Weight (g) Per Plant**

Calyx Dry Weight per Roselle plant as influenced by solid and liquid organic fertilizer at Bagauda and Samaru during 2016 cropping season is presented as Table 8. Calyx dry weight (g) was significantly influenced by solid organic fertilizer at Bagauda

only. Application of 3 tonsha-1 produced heavier calyx dry weight than other rates. Liquid organic fertilizer did not significantly influenced calyx dry weight. There was no significant interaction effect on calyx dry weight between solid and liquid organic fertilizer.

**Table 8: Calyx Dry Weight (g) plant<sup>-1</sup> of Roselle as influenced by Solid and Liquid Organic fertilizer at Bagauda and Samaruduring 2016 Wet Season**

Treatment	Calyx Dry Weight (g) Plant <sup>-1</sup>	
	Bagauda	Samaru
<b>Solid Organic Fertilizer (tha<sup>-1</sup>)</b>		
0.0	9.72 <sup>b</sup>	13.95
1.0	10.55 <sup>ab</sup>	14.78
2.0	10.75 <sup>ab</sup>	15.21
3.0	13.18 <sup>a</sup>	16.44
SE±	1.53	1.95
Significant	*	NS
<b>Liquid Organic Fertilizer L/ha<sup>-1</sup></b>		
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	12.71	17.08
SE±	1.71	2.41
Significance	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).

### 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 9. Liquid organic fertilizer significantly influenced 100 seed weight (g) at Samaru only. Application of 2.0tons produced

significantly heavier 100 seed weight (g) than other rates tested. Solid organic fertilizer did not significantly influence the parameter. There was no significant interaction between the treatments tested on the parameter.

**Table 9: 100 Seed Weight (g) of Roselle as Influenced by Solid and Liquid Organic Fertilizer at Bagauda and Samaru during 2016 Wet Season.**

Treatment	100 Seed Weight (g)	
	Bagauda	Samaru
<b>Solid Organic Fertilizer (tha<sup>-1</sup>)</b>		
0.0	2.27	3.63 <sup>c</sup>
1.0	2.74	3.80 <sup>bc</sup>
2.0	2.83	3.88 <sup>ab</sup>
3.0	2.90	4.04 <sup>a</sup>
SE±	0.11	0.12
Significant	NS	*
<b>Liquid Organic Fertilizer L/ha<sup>-1</sup></b>		
0.0	2.71	3.61
0.5	2.75	3.73
1.0	2.86	3.86
1.5	2.88	3.91
2.0	2.95	3.93
SE±	0.10	0.13
Significance	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).

### Dry Calyx Yield (kg/ha)

Dry Calyx Yield kg/ha of Roselle as influenced by application of liquid and solid organic fertilizer in Bagauda and Samaru during 2016 wet season is presented as Table 10. Application of 3.0tha<sup>-1</sup> solid organic manure produced significantly higher dry calyx yield (kg/ha) of Roselle than other rates evaluated at Samaru and Bagauda. Application of 2.0 Litresha-1 of Liquid Manure significantly produced higher dry calyx yield of Roselle at both locations

than other rates. There was an interaction effect between solid and liquid organic manure on dry calyx yield at Bagauda. Across all the rates of solid organic fertilizer applied, increase in application of liquid organic fertilizer induces a progressive increase in dry calyx yield at Bagauda with the highest dry calyx yield observed on the combination of 3tons.ha of solid organic fertilizer and 2.0 litres per ha of liquid organic fertilizer.

**Table 10: Dry Calyx Yield (kg/ha<sup>-1</sup>) of Rosselle as Influenced by Solid and Liquid Organic Fertilizer at Bagauda and Samaruduring 2016 Farming Season**

Treatment	Dry Calyx Yield kg/ha <sup>-1</sup> at Harvest	
	Bagauda	Samaru
<b>Solid Organic Fertilizer (tha<sup>-1</sup>)</b>		
0.0	378.87 <sup>d</sup>	379.80 <sup>c</sup>
1.0	402.27 <sup>c</sup>	402.27 <sup>b</sup>
2.0	416.52 <sup>b</sup>	416.52 <sup>a</sup>
3.0	427.81 <sup>a</sup>	427.81 <sup>a</sup>
SE±	1.75	1.42
Significance	*	*
<b>Liquid Organic Fertilizer L/ha<sup>-1</sup></b>		
0.0	309.44 <sup>e</sup>	309.44 <sup>c</sup>
0.5	353.13 <sup>d</sup>	353.13 <sup>c</sup>
1.0	403.36 <sup>c</sup>	403.36 <sup>ab</sup>
1.5	454.24 <sup>b</sup>	454.15 <sup>ab</sup>
2.0	512.92 <sup>a</sup>	502.92 <sup>a</sup>
SE±	1.92	1.58
Significance	*	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).

**Table 11: Interaction Effect between Solid and Liquid Organic on Dry Calyx Yield (kg/ha<sup>-1</sup>) of Roselle at Bagauda during 2016 Wet Season**

Solid Organic Fertilizer tha <sup>-1</sup>	Dry Calyx Yield kg/ha <sup>-1</sup>				
	Liquid Organic Fertilizer L/ha <sup>-1</sup>				
	0.0	0.5	1.0	1.5	2.0
0.0	271.04 <sup>n</sup>	325.55 <sup>ml</sup>	381.55 <sup>l</sup>	431.37 <sup>ef</sup>	489.49 <sup>c</sup>
1.0	314.56 <sup>m</sup>	352.37 <sup>k</sup>	398.35 <sup>h</sup>	440.69 <sup>e</sup>	505.39 <sup>b</sup>
2.0	320.32 <sup>m</sup>	363.20 <sup>jk</sup>	411.20 <sup>g</sup>	463.89 <sup>d</sup>	524.00 <sup>a</sup>
3.0	331.84 <sup>L</sup>	371.41 <sup>ij</sup>	422.35 <sup>ij</sup>	480.64 <sup>c</sup>	532.80 <sup>a</sup>
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).

## DISCUSSION

The results of soil analysis and weather data for both location (Tables 1 and appendix I respectively) indicate that the soil textural class was sandy loam at both locations. Sandy loam soil is almost ideal for growth and yield of Roselle plant in the savannah agro ecology. This type of soil enhances better root growth and development while maintaining adequate soil aeration which encourage good soil microbial activities. It also allows for good water retention capacity of the soil while maintaining adequate drainage. Appendix I showed that among the weather parameters observed, rainfall appeared to have fallen more at Samaru (Average 1857.9mm) then at Bagauda (average 1622.6mm) of rainfall in the two location. This means more moisture is readily available to the growing Roselle plant for various physiological and enzymatic processes at Samaru

than at Bagauda. This probably explains why the performance of the Rosselle crop is better in terms of growth, yield and yield parameters at Samaru than those of Bagauda.

It was observed that the application of solid organic fertilizer significantly increased the growth and yield parameter of Rosselle in these trials. The positive response of some growth and yield components such as plant weight, leaf area index, number of calyx per plant, calyx dry weight (g), 100 seed weight (g) dry calyx yield kg/ha<sup>-1</sup> at Samaru could be attributed to the role organic fertilizer play in slowly releasing nutrients to the plants over a long period of time, also maintaining soil organic matter level, productivity and aggregate stability. This is in line with the report of Gendy *et al* (2012) who stated that more application of organic fertilizers, accumulated additional solutes in the soil, thus improves the

vegetative growth and dry matter yield. Norhayati *et al* (2019) affirmed that organic fertilizer increased the availability and uptake of nutrients, which enhanced the higher photosynthetic activity and in turn, increased growth and yield of Roselle plant. Norhayati *et al* (2019) further suggested that application of organic fertilizers led to the enhancement of soil physical criteria including better aeration, better water holding capacity, better nutrient availability and good balance between nutrients in the soil solution and improvement of nutrient exchange between the soil. The increased solid organic matter application probably resulted in an increase in number of calyx per plant, 100 seed weight, calyx dry weight and calyx dry yield. This result agrees with the report of Al-sayed *et al* (2019). who reported that increase application of organic compost in Roselle at planting, increases fresh and dry weight of calyx at harvest.

Roselle plant responded positively to liquid organic fertilizer application as indicated by some growth and yield parameters in this trial. Plant height, leaf area index, number of calyx per plant, calyx dry weight, 100 seed weight and dry calyx yield all responded to increase in level of liquid organic fertilizer application in both locations.

This might be due to the availability of high nitrogen content of liquid organic fertilizer applied at the two

trial sites. Liquid organic fertilizer generally contain soluble nutrients that maintain soil stability, plant health apart from supplying the required nutrients for growth, development and yield. In addition, the application of liquid organic fertilizer could improve the nutrient use efficiency and decrease the rate of nutrient loss. These results agree with the work of Badran, and Safwat, (2004) who stated that liquid organic fertilizer contains large amount of soluble nutrients and tend to more quickly and readily be available to plants compared to the traditional use of large quantity of solid incorporated fertilizer into the soil. Liquid fertilizer avoid soil problem like volatilization, see-page into the soil state, run off into lakes and rivers thus it reduces ground water pollution in addition to having profound effect on plant growth and yield components Majeed *et al* (2011).

**CONCLUSION**

Results from this study suggested that Rosselle plants responded positively to increase application of both solid and liquid organic fertilizer in the Nigerian savannah for higher yield and yield components. A combination of 2 Litres/ha and 3tons/ha of liquid and solid organic fertilizer is suggested to farmers in this agro ecology for higher Rosselle yield and yield components.

**Appendix i: Weather Data for the Experimental Sites during 2016 Wet Season**

Months	Bagauda					Samaru				
	Rainfall (mm)	Temperature °C		Relative Humidity % 0900hrs	Sunshine (hrs)	Rainfall (Min)	Temperature °C		Relative Humidity %	Sunshine (Hrs)
		Max	Min				Max	Min		
May	233.7	33	23	81	5.4	347.7	32	23	82	3.8
June	213.0	30	23	86	3.9	239.5	30	22	81	3.0
July	362.0	29	23	91	1.8	236.5	30	23	87	2.1
August	161.8	29	22	87	2.3	345.1	29	23	91	1.5
September	349.0	30	21	86	3.3	424.7	30	23	90	2.4
October	244.6	30	24	85	4.7	232.8	30	23	85	4.5
November	58.5	31	21	82	4.1	89.1	31	21	80	6.6
December	0.0	33	21	74	4.1	9.6	33	21	64	7.0
<b>Total</b>	<b>1622.6</b>					<b>1857.9</b>				

**Source:** Weather station of IAR-Samaru Zaria and NIHORT Weather Station Bagauda, Kano State

## REFERENCES:

- Al-sayed, H.M, S. A. Hegab, M.A Youssef and M. Y. Khalifallah (2019). Integrated Effect of Inorganic and Organic Nitrogen Sources on Growth and Yield of Roselle (*Hibiscus sabdariffa L.*). *Assiut Journal of Agricultural Science*. 50 (3) 2019 ISSN: 1110-0486.
- Badran, F.S. and Safwat, M.S. (2004). Response of Fennel Plants to Organic Manure and Biofertilizers in Replacement of Chemical Fertilization. *Egypt Journal of Agricultural Research*, 82(2):247-256.
- Billington, F. H (1943). *Compost for Garden Plot and Thousand Acre Farm Practical Guide to Modern Methods* (London:Russell Squire)
- Delgado-Vargas, F., and Percedes-Lopez, O. (2003). *Natural colorants for food and newtraceutical uses*. CRC press LCC Boca Raton. Florida USA.
- Duncan, D.B. (1955). Multiple Range and Multiple F-tests: *Biometrics*, 11:1-42.
- Gendy, A.S.H., Said-Al Ahl, H.A.H, & Mahmoud, A.A. 2012. Growth Productivity and Chemical Constituents of Roselle (*Hibiscus sabdariffa L.*) plants as influenced by Cattle manure and biofertilizers treatments. *Australian Journal of Basic and Applied Sciences*, 6(5): 1-12.
- Gomez, K.A. and Gomez, A.A. (1984). *Statistical Procedure for Agricultural Research*. 2<sup>nd</sup> Edition John Willey and Sons Limited, U.S.A PP. 98-108.
- Hanan M., Abu El-Fotoh, Lamyaa A., Abel El-Rahman and Samia M.S., El Kalawy (2019). Evaluate the Effect of Green Fertilizer and two Sources of Potassium on Growth, Yield and some Chemical Constituents of Roselle Plant (cv sabaheia 17) and the availability of micronutrients in the soil after harvest. *Journal of Soil Science and Agricultural Engineering*. Mansorra University 10(12):821-832.
- Ibrahim E.I.M, A.A Abdelbagi,E.H.A Ahamed (2020). Effect of Chemical and Organic fertilizers on Growth and Yield of two Roselle (*Hibiscus sabdariffa L.*) Cultives. IOP Conference series, Earth and Environmental Science (IC-FSSAT) DOI:10.1088/1755-1315/486/1/012109.
- John, H. M. and W. H. Leonard (1967). *Principles of Field Crop Production*. The Macmillan Company Colliev- Macmillan Limited, London. 650pp.
- Kumar, V., Idem, N.U.A. and Echemu, C.A. (1985). Yield Components of Five Rosselle (*Hibiscuss Sabdariffa L.*) Varieties in Northern Nigeria. *East Africa Agrioforestry Journal*, 51:108-112.
- Majeed, K. Abbas and Ali Sabah, Ali (2011). Effect of Foliar Application of NPK on Some Growth Characters of two Cutlivars of Rosselle (*Hibiscuss sabdariffa L.*). *American Journal ofPlant Physiology*, 6:220-227.
- Norhayati, Y., W.HNg and M.A. Adzemi (2019) Effects of Organic Fertilizers on growth and Yield of Roselle (*Hibiscus sabdariffa L.*) on Bris Soil. *Malaysian Journal of Applied Biological Science* 48(i):177-184.