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EFFECTS OF ORGANIC AMENDMENTS ON SOIL PROPERTIES AND GROWTH OF RED SCARLET ROSELLE (*Hibiscus sabdariffa L*) IN AN ALFISOLS OF WUKARI, NIGERIA

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ABSTRACT

A study was conducted at the Teaching and Research Farm of the Federal University Wukari, Taraba State, Nigeria to examine the effects of some organic amendments on selected physico-chemical properties of the soil and some agronomic characters of Red Scarlet Roselle under irrigation. The experiment was laid in a randomized complete block design with six treatments replicated thrice. The treatments are; T_1 (No amendment), T_2 (4 t/ha poultry manure), T_3 (4 t/ha rice husk), T_4 (60 kg/ha NPK 15:15:15 + 2 tons/ha PM), T_5 (60 kg/ha NPK15:15:15 + 2 tons Rice husk) and T_6 (120 kg/ha NPK15:15:15 fertilizer). Data was generated on plant height, leaf area, plant girth and number of leaves. The results of the pre-treatment soil analysis showed that the soil was sandy loam, slightly acidic with low organic matter content, low nitrogen and low calcium and magnesium while the potassium and sodium contents of the soil were high. The effect of the amendments on growth characteristic of Roselle showed that all the treatments performed better than the control. NPK 15:15:15 120 kg/ha and 4 t/ha poultry manure showed significant ($P < 0.05$) effect on the soil properties examined. The effect of the treatments on the soil properties shows acidic pH (4.5 and 4.4) in plot treated with 120kg/ha and 4t/ha poultry manure and are statistically different from all the other treatments. The organic carbon content (1.757 %) of the plot treated with 4t/ha rice husk was high and statistically different from the other treatments, the nitrogen content is low with the exception of plot treated with 2 t/ha PM + 60kgNPK15:15:15/ha and the ECEC is generally low in all the treatments. Application of 2 tons Poultry Manure + 60 kg NPK improved some of the soil physicochemical properties and growth performance of red scarlet Roselle plant.

Keywords: Soil amendments, Red scarlet Roselle, Soil properties, Agronomic characteristics, Alfisols.

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INTRODUCTION

Roselle *(Hibiscus sabdariffa L.)* is an annual, erect, bushy, herbaceous sub-shrub it belonged to the family malvaceae (Mahadevan *et al.*, 2009) and is commonly called Guinea sorrel or Bissap in Senegal, Karkadé in North Africa, Roselle or Sorrel in Asia and Flora of Jamaica in Central America (Lorenzo *et al*., 2000; Mc Clintock. and El Tahir, 2004; Nyarko *et al.,* 2006; Cisse *et al.,* 2009a; Cisse *et al*., 2009b). In Nigeria it is commonly called Isapa (Yoruba), Jan zobo or Bakinzobo (Hausa), Nwawhewanyo-nyo (Jukun), Ashwe (Tiv). It is thought to have originated from Asia (India to Malaysia) and tropical Africa. The plant is widely grown in the tropics including Caribbean,

Central America, India, Africa, Brazil, Australia, Hawaii, and Philippines, as a home garden crop (Mahadevan *et al.,* 2009). In Sudan, it is a major crop of export, especially, in the western part where it ranks after peal millet, and followed by *sesamum* (Gautam, 2004). Sudan is presently the major producer of Roselle; they call it 'karkade', however, farmers regard it as a famine food. When draught is expected, farmers prefer to cultivate Roselle rather than cereals because of its hardiness under adverse conditions (Mohammad, *et al.,* 2002).

Three common varieties of Roselle are widely cultivated in Nigeria as reported by Udom *et al* (2001). Two of these varieties have red calyces, which are common in the northern part while one has green calyces and is predominant in the southern parts of Nigeria. (Alegbejo, 2000). Roselle is used for many different purposes, the young leaves are eaten as cooked vegetables especially with soup (Fasoyiro *et, al.,* 2005). The seeds are pounded into meal, which is used as soup. The crop is used in making wine, juice, jam, jell, syrup, gelatin, pudding, cakes, ice cream, and also dried and brewed into tea as well as flavors and carbonated soft drinks, other acidic food, spices for butter, pies, sauces tarts and other desserts (Qi *et al*, 2005)..

Tropical soils are generally low in fertility, and it suffers degradation both in physical and chemical properties as a result of changing climate coupled with human activities which consequently result in low productivity (Van-Ranst, 1994). A lot of efforts have been made to amend the soil and restore its fertility. Aside from inorganic fertilizer, organic waste can also be used to ameliorate the fertility constraints, and improves the physical conditions of the soil (Ogunwole *et al.,* 2010). High cost of inorganic fertilizer and its timely availability led to the search for alternative fertilizer sources. Organic sources of fertilizer if properly harnessed could argument the costly and unavailable inorganic fertilizer and importantly also Rosselle is a resilient crop that strives in dry arid and semi arid environment. Therefore, the aim of the study is to investigate the effects of organic and inorganic amendments on some soil properties and growth of red scarlet *Roselle (Hibiscus sabdariffa*).

MATERIALS AND METHODS

The study was carried out at the Teaching and Research Farm of the Federal University, Wukari, Taraba state, Nigeria. The Study area is located between longitude 9º 8' and 10° 23'E east of the meridian and latitude 7°35' and 8°15' north of the equator. The average annual temperature in the study area is 26.8^0C, with average rainfall of 1205 mm per annum. Land preparation was manually done and the organic manure incorporated at land preparation while NPK was applied two weeks after sowing, three seeds were sown per hole at 50 cm×50 cm inter and intra row spacing, later thinned to two plants per stand. Watering and field maintenance were done throughout the period of the study

The experiment consist of six treatments [T_1 (No amendment), T_2 (4 t/ha poultry manure), T_3 (4 t/ha rice husk), T_4 (60 kg/ha NPK + 2tons/ha PM), T_5 (60 kg/ha NPK + 2 tons Rice husk) and T_6 (120 kg/ha NPK fertilizer)], arranged in a Randomized Complete Block Design (RCBD) replicated three times.

Physiological growth characteristics (Plant height, Number of leaves, plant girth and leave area) were collected at two weeks interval. Soil sample were collected at the depth of 0-25 cm before the experiment and from each plot at the end of the experiment. All soil samples collected were prepared and analyzed using standard laboratory procedures. Soil pH was determined at 1:1 soil to water ratio using glass electrode digital pH meter. Organic carbon was determined by chromic acid wet oxidation procedure as described by Jackson (1962). Available P

was extracted using Bray-1 solution (Bray and Kurtz, 1945) and the phosphate in the extract was analyzed calorimetrically by the molybdenum blue color method as described by Murphy and Riley (1962). Exchangeable bases were extracted using 1 N neutral ammonium acetate solution. Ca and Mg content of the solution were determined volumetrically by EDTA titration while K and Na were determined by flame photometry. The total Nitrogen of the soil was determined by Micro-Kjedhal procedure as described by Jackson (1962) and the exchangeable acidity was determined by the KCl extraction and titration method of Mclean (1965). All data generated were subjected to analysis of variance (ANOVA) using Genstat release 8.1 statistical package. All significant means were separated using LSD at 5% level of probability.

RESULTS AND DISCUSSION

The physical and chemical properties of the soil in the study area before treatment application are presented in Table 1. Results shows that the soil was loamy sand in texture, slightly acidic (pH 6.7), low in organic matter and nitrogen content, the potassium and sodium content were high while calcium and magnesium content was low, and the soil contains moderate level of exchangeable acidity (1.6 cmol kg^{-1}) as described by Usman, (2005).

Table 1: physical and chemical properties of soil before amendment

Parameter	Soil Test Value
pH in soil and water (1:2)	6.70
Organic carbon (gkg^{-1})	16.4
Total N (gkg^{-1})	1.90
Available P ($mgkg^{-1}$)	4.41
ECEC (cmol kg^{-1})	5.81
Exch. Acidity (cmol kg^{-1})	1.60
Silt (%)	7.0
Clay (%)	8.2
Sand (%)	84.8
Textural class	Loamy Sand
K^+ (cmol kg^{-1})	1.33
Na^+(cmol kg^{-1})	1.74
Ca^{2+}(cmol kg^{-1})	0.63
Mg^{2+}(cmol kg^{-1})	0.51

Table 2 depicts the properties of organic amendments (poultry manure and rice husk) used in the experiment. The elemental content of poultry manure and rice husk shows that rice husk was moderately acidic while the poultry manure is slightly acidic, very low P content in both materials (1.57 $mgkg^{-1}$ and 0.41 $mgkg^{-1}$ for PM and RH respectively), the nitrogen content of PM is high (3.68 gkg^{-1}) while RH (1.02 gkg^{-1}) contains low nitrogen, and the organic carbon content show medium in poultry manure ($10.29gkg^{-})^1$ and low in rice husk ($8.38gkg^{-1}$), this result is supported by the work of Usman (2005), application of poultry manure and rice husk is expected to improve soil fertility and growth of Roselle.

Table 2: Analysis of poultry manure and rice husk used in the experiment

Parameter	Poultry manure (PM)	Rice husk (RH)
pH	6.19	5.71
Nitrogen (gkg^{-1})	3.68	1.02
Phosphorus (mg kg^{-1})	1.57	0.41
Org. carbon gkg^{-1}	10.29	8.38
Potassium (cmol kg^{-1})	0.81	0.81
Calcium (cmol kg^{-1})	2.62	1.30
Sodium (cmol kg^{-1})	0.07	0.53
Magnesium (cmol kg^{-1})	0.48	2.32

Table 3 shows the effect of NPK 15:15:15 fertilizer and organic manure. There were no significant differences ($P < 0.05$) on plant height among all the

treatments. However, poultry manure applied 4t/ha at week 10 had the highest plant height (81.39cm) compared to other treatments, This may be as the result of the slow decomposition rate of some of the treatments like rice husk which has higher fiber content when compared to poultry manure and NPK fertilizer which releases nutrients in a short period and may have been leached out. This is supported by the work of Ahmed (2013), who reported that plant height of Roselle significantly ($p < 0.05$) defers when NPK and organic manure fertilizers are applied separately or in combination. .

Table 3: Effect of the treatments on plant height (cm)

Treatments	Weeks After Planting				
	2	4	6	8	10
Control	23.40	42.94	61.89	69.67	72.56
PM (4t/ha)	27.33	53.06	70.33	78.56	81.39
RH (4t/ha)	23.87	53.61	62.12	68.22	69.83
PM (2t/ha) + NPK (60kg/ha)	25.80	60.83	66.67	71.78	74.38
RH (2t/ha) + NPK (60kg/ha)	27.00	46.95	65.89	73.89	74.66
NPK (120kg/ha)	25.13	44.21	68.11	73.56	77.22

Means along the columns are not significantly different at 5% level of probability.
PM = Poultry manure, RH = Rice Husk.

Table 4 shows the treatment effects on leaf area. There was no significant difference ($P<0.05$) among the treatments on average leaf area. Treatment four (2 tons/ha poultry manure + 60 Kg/ha NPK) have the highest leave area (146.2 cm^2) compared to other treatments, All the treatments perform better than the control at 10 WAP with the mean value of 114.8cm^2, this is in line with the findings of Akanbi *et al.*, (2009) who mentioned that fertilized plants will perform better than the non fertilized ones. Number of branches of Roselle plants (Table 4) there is no significant difference among all the treatment, although the treatment with 4t/ha poultry manure perform better than the treatments at 10WAP. .

Table 4: Effects of the treatments on leaf area (cm^2)

Treatments	Weeks After Planting				
	2	4	6	8	10
Control	42.71	68.78	80.19	98.90	114.5
PM(4t/ha)	44.67	69.95	71.89	127.1	139.8
RH(4t/ha)	43.51	87.58	69.36	116.4	134.3
PM(2t/ha) + NPK (60kg/ha)	47.21	73.95	81.12	121.6	146.2
RH (2t/ha) + NPK (60kg/ha)	48.43	63.61	60.33	95.20	124.8
NPK (120kg/ha)	49.42	67.39	81.75	111.5	137.3

Means along the columns are not significantly different at 5% level of probability.
PM = Poultry manure, RH = Rice Husk.

Table 5 shows the effect of the treatments on plant girth. There was no significant difference ($P < 0.05$) among the treatments, however, plot treated with 120 kg/ha NPK fertilizer, 2 tons/ha poultry manure + 60 Kg/ha NPK and 4 t/ha rice husk had higher mean plant girth, compared to the other treatments; this may be attributed to the girth being a storage organ. These results were similar to those reported by Aliyu and Olarewaju. (1996) that the beneficial effects of nitrogen and

Phosphorous are associated with larger stem diameter. .

Table 5: Effect of treatment on plant girth (cm)

Treatment	Weeks After Planting				
	2	4	6	8	10
Control	0.2333	1.033	1.400	4.167ab	4.067
PM (4t/ha)	0.3333	1.267	2.033	4.267ab	4.233
RH (4t/ha)	0.2333	0.800	2.200	4.00b	4.133
PM (2t/ha) + NPK (60kg/ha)	0.3000	1.100	1.567	4.367a	4.233
RH (2t/ha) + NPK (60kg/ha)	0.3333	1.100	1.767	3.967c	4.167
NPK (120kg/ha)	0.3000	1.267	2.133	4.200ab	4.167

[a-b]Means along columns with different superscripts are significantly different at 5% level of probability. PM = Poultry manure; RH = Rice Husk.

Table 6 shows the effects of treatments on the leaf number. There was no significant difference observed among the number of leaves per plant ($P<0.05$) among the treatments (Table 6). Although the control had the lowest mean leaf number (12.43), whereas the plot treated with 2t/ha P.M +2t/ha NPK fertilizer produced a higher mean number of leaves per plant (13.77) when compared to other treatments, the combination of organic and inorganic fertilizer makes nutrient available to plant throughout the growth periods since organic manure decomposes slowly (Lekassi, 2003). .

Table 6: Effect of the treatments on number of leaves

Treatment	Weeks After Planting				
	2	4	6	8	10
Control	8.03	11.04	11.67	12.53	12.43
PM (4t/ha)	8.33	10.43	12.77	13.10	12.77
RH (4t/ha)	8.23	11.87	12.53	13.90	13.14
PM (2t/ha) + NPK (60kg/ha)	8.23	11.33	11.67	11.90	13.77
RH (2t/ha) + NPK (60kg/ha)	8.43	11.30	12.57	13.23	12.77
NPK (120kg/ha)	8.77	11.33	12.97	13.33	13.00

Means along the columns are not significantly different at 5% level of probability.
PM = Poultry manure; RH = Rice Husk.

Table 7 shows the effect of soil amendments on soil properties, the result reveals that there was no significant difference ($P<0.05$) in the chemical properties. However significant differences were observed in soil physical properties (percentage sand, silt and clay content of the soil), the highest % sand content was recorded in the plot without any amendment which serves as the control. The soil texture was sandy loam, moderately acidic in plots treated with 4t/ha poultry manure and acidic in plots treated with 120kg/ha NPK fertilizer, the plot treated with 4 t/ha poultry manure is high in Organic Carbon, available P, potassium, and sodium, moderate in total N, ECEC, Magnesium, and low calcium content. The initial soil pH before the application of the treatments was 6.7 while after the pH was 4.4, 4.5, 6.7, 6.8, 6.4 and 6.8 for 120kg/ha NPK fertilizer, 4t/ha poultry manure, 4t/ha rice husk, 2ton/ha poultry manure +60t/ha NPK fertilizer, 2t/ha rice husk + 2t/ha NPK fertilizer and the control respectively. The result showed more decrease in the pH on the plots treated with 120 kg/ha NPK fertilizer and

4 ton/ha poultry manure, the changes may be as a result of the treatment applied and leaching as a result of irrigation, Soil pH is an important indicator in assessing soil fertility and its environment (Sanchez *et al.* 2003). The normal pH range for optimal mineral elements availability for most crops is 6.0 - 7.5 (Sanchez *et al*., 2003).

Organic carbon content of the soil before application of the treatments was (16.4 gkg^{-1}) and increased to (17.57 gkg^{-1}) on the plot treated with 4t/ha rice husk with decrease in all the other treatments, this increase might be due to high OC contents of' rice husk, this results agrees with the work of Li *et al.* (2010) and Xueli *et al.* (2012) who reported that the application of OM in combination with inorganic fertilizers exerted greater influence and linearly increased soil OC levels, Adiku *et al.* (2009) also reported OC depletion caused by cultivation without OM application in Ghana. Kumwenda (1996) stated that fertilizer use efficiency is often low in tropical soils because of declining level of OM where the proportion of locally produced OM must be increased to maintain it and halt the downward spiral of soil fertility. Gitary and Fresen (2001) also reported that in central highlands of Kenya, long term trials have shown a decline in soil OC, and the decline had been greatest when no inputs were applied and minimized when a combination of inorganic fertilizer and manure were used.

Nitrogen is an important plant nutrient and is the most frequently deficient of all nutrients in tropical soils, this is because it is required by plants in large amount and its high mobility in the soil. Total N in soils of the study area was generally low which agree with the work Jones and wild (1975), the low N content may be as a result of the low organic matter content, at the end of the experiment there was generally decrease in the total N content of the soil, the highest mean N content was recorded in the plot treated with 2tons/ha PM + 60kg/ha NPK (1.8gkg^{-1}) which is significantly different ($P<0.05$) from the control and statistically similar to all the other treatments, this general decrease might be as a result of plant uptake for vegetative growth and leaching.

Available P content of the soil after the experiment revealed an increased in the plots treated with 120 kg/ha NPK (6.38 $mgkg^{-1}$) and 4 t/ha rice husk (5.20 $mgkg^{-1}$) this result agree with the work of María, *et al*. (2014) who said that soil OM had a positive effect on available P. In most cases higher P levels are associated with higher levels of organic matter and neutral to mildly alkaline pH (Gillman, 1985).

Exchangeable Potassium level in the soil before the application of the treatment was 1.33 Cmol kg^{-1} and increases to 2.03 cmol kg^{-1} in the plot treated with 2 tons/ha rice husk + 60 kg/ha NPK fertilizer and It is generally accepted that response to K fertilizers is medium when a soil has an exchangeable K value of < 0.2cmol kg^{-1} and high when it is above 0.4 cmol kg^{-1} (Anderson, 1973) This result generally suggests that K is not a limiting mineral element to crop productivity in the study area.

Exchangeable Na of the soil before the application of the treatment was 1.74 Cmol kg^{-1} and it increased to 3.480 Cmol kg^{-1}, 2.637 Cmol kg^{-1}, 2.607 Cmol kg^{-1}, in the plots treated with 120 kg NPK fertilizer, 4t/ha poultry manure, 4t/ha rice husk respectively while it decreased to 0.523 cmol kg^{-1}, 1.287 cmol kg^{-1} and 1.200 cmol kg^{1} in plots treated with 2 tons/ha PM + 60 kg/ha NPK fertilizer, 2 tons/ha RH + 60kg/ha NPK fertilizer and the control respectively. This may probably be related to high evaporation, poor management of irrigation water, lack of drainage systems and low Ca^{2+} due to high Na^{+} concentrations in the exchange complex.

Table 7: Physico-chemical properties of soil after application of soil amendments

Parameters	Control	4t/h PM	4t/ha RH	2t/hPM+ 60kg/hNPK	2t/hRH+ 60kg/hNPK	120kg/haNPK	LSD	CV
Sand %	86.79^{a}	78.93^{a}	85.337^{a}	83.47^{a}	85.21^{a}	83.93^{b}	1.975	1.518
Silt %	5.967^{c}	9.200^{b}	7.200^{b}	7.667^{b}	6.367^{c}	10.333^{b}	1.259	9.156
Clay %	7.243^{b}	11.867^{b}	7.423^{b}	8.867^{b}	8.423^{b}	12.733^{b}	1.108	6.226
Textural class	L/S	L/S	L/S	L/S	LS	L/S		
pH H_2O	6.483^{b}	6.783^{a}	6.717^{a}	6.750^{a}	4.403^{c}	4.510^{c}	0.126	1.161
O.C (gkg^{-1})	9.47^{d}	14.67^{ab}	17.57^{a}	13.73^{bc}	11.10^{cd}	15.6^{ab}	0.314	12.611
N (gkg^{-1})	0.867^{b}	1.300^{ab}	1.533^{ab}	1.800^{a}	1.167^{ab}	1.467^{ab}	0.077	31.143
Available P (mg kg^{-1})	3.995^{ab}	3.997^{ab}	5.204^{ab}	2.678^{b}	3.861^{ab}	6.379^{a}	2.998	37.875
K (cmol kg^{-1})	1.297^{abc}	1.253^{abc}	1.107^{bc}	0.673^{c}	2.027^{a}	1.823^{ab}	0.835	33.677
Na (cmol kg^{-1})	1.200^{bc}	2.637^{ab}	2.607^{ab}	0.523^{c}	1.287^{bc}	3.480^{a}	1.671	46.978
Ca (cmol kg^{-1})	0.403^{c}	0.770^{a}	0.747^{ab}	0.717^{b}	0.4200^{c}	0.773^{a}	0.042	3.616
Mg (cmol kg^{-1})	0.403^{c}	0.643^{a}	0.613^{a}	0.567^{b}	0.4200^{c}	0.647^{a}	0.36	3.608
E.A (cmol kg^{-1})	0.487^{b}	1.867^{a}	2.000^{a}	1.733^{a}	0.590^{b}	1.867^{a}	1.199	43.231
ECEC (cmol kg^{-1})	4.000^{c}	7.170^{ab}	7.073^{ab}	4.213^{bc}	5.300^{bc}	8.590^{a}	2.849	25.847

$^{a-d}$Means along the same row with different superscript are significantly ($p < 0.05$) different.

L/S=Loamy sand; LSD = Least significant difference; SE = Standard error; CV = Coefficient of variation; PM = Poultry manure; RH = Rice husk; EA = Exchangeable acidity; OC= Organic carbon; ECEC=Effective cation exchange capacity.

CONCLUSIONS

- The nutrient content of the soils of the study area is generally low and the use of organic and inorganic amendment sources for improving nutrients and increasing crop production on sustainable basis has become imperative, as the cost of inorganic fertilizers is high.
- Application of 2 tons Poultry Manure + 60 kg NPK improved some of the soil physicochemical properties and growth performance of red scarlet Roselle plant.
- Integrated soil fertility management involving the use of combined organic and inorganic fertilizers is a better approach to overcome soil fertility constraints.
- The need to efficiently use both organic and inorganic fertilizers to sustain soil fertility and crop production is recognized and advisable to the small-scale farmers due to the positive interactions between them.

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