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Effect of fertilizer sources on soil chemical properties, growth and yield of castor *(Ricinus communis*) at Badeggi

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A study was conducted in 2010 and 2011 cropping seasons to investigate the effect of poultry manure and urea on soil chemical properties, growth and yield of castor (*Ricinus communis)* at the Experimental Field of National Cereals Research Institute Badeggi in Southern Guinea Savanna zone of Nigeria. The treatments consisted of three levels each of urea and poultry manure at 0, 45 and 90kg N ha^{-1} and 0, 2 and 4 t ha^{-1} respectively. The treatments were laid in a randomized complete Block design (RCBD). Poultry manure was incorporated two weeks before sowing and urea was split applied at 3 and 6 weeks after sowing (WAS). Castor seeds used for the experiment was Lafia 4 accession. These were sowed on seed beds spaced at1.0 by 0.75m (inter and intra-row spacing). Soil samples were collected before and after cropping for determination of the chemical properties of the soil using standard laboratory procedures. Agronomic parameters were also collected and the data subjected to analysis of variance ANOVA using SAS (2003). Poultry manure used for the experiment was analyzed for its chemical composition. The results of the experiment revealed an increased in soil pH for all treatments except T^6 (4t ha^1 of poultry dropping + 45kg ha^1 of urea) However, organic carbon, total N, available P and cation exchange capacity values also increased. Application of these treatments therefore, positively affected the yield of castor particularly at 2 t ha^{-1} of poultry manure + 45 kg N ha^{-1} and 4 t ha^{-1} of poultry manure + 90 kg N ha^{-1} respectively.

Keywords: *Ricinus communis,* WAS, pH

Introduction

Castor bean *Ricinus communis L.,* family *Euphorbiaceae* is a plant of tropical origin which may have originated from Abyssinia (Weiss, 1970). Global castor seed production hovers around one million tons per year and the leading producing countries are India, China and Brazil. Together they account for over 90% of the acreage production of castor bean (FAOSTAT, 2000). The World production of Castor is said to increase yearly at 12.3 thousand tons

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/year between 2000 and 2009 (Severino, 2012), an indication that the cultivation of this crop is resuscitating amongst the comity of World important energy plants.

However, a major factor limiting crop yields is low soil fertility. The use of inorganic fertilizers to sustain crop yield on a long time basis has not been effective. It often leads to a decline in soil organic matter content, soil acidification and soil physical degradation which may lead to increased soil erosion. Soils in Savanna region of Nigeria are relatively low in plant nutrient and organic matter content, soil degradation becomes a serious problem and threatened agricultural production (Usman *et al.*, 2007). Beside these reasons, Heisy and Mwangi (1996) added that farmers appreciate the value of inorganic fertilizer but they are not able to apply them at recommended rates and appropriate time due to high cost, absence of agricultural credit facilities, delivery delay and low variable returns. Due to continued escalation of fertilizer prices, there is a great thrust either to supplement or replace mineral fertilizers with renewable and cheaper sources of nutrients like organic manures. In Nigeria, farmers use both urban and rural organic wastes wherever they are available. Organic materials were considered to be beneficial sources of plant nutrients in soil fertility management (Schoningh and Wichmann, 1990). Thus, incorporation of crop residues, farmyard manure, vermicompost, green manure is important in increasing soil nutrient.

The integrated nutrient management system is an alternative, and is characterized by Organic wastes containing varying amounts of water, mineral nutrients, organic matter (Brady and Weil, 1996).

There still exists a need to assess the potential impacts of poultry manure on soil chemical properties and crop yield and in particular evaluating the critical application levels. Moreover, the need and utilization of poultry manure has overtaken the use of other animal manure (e.g. pig manure, kraal manure) because of its high content of nitrogen, phosphorus and potassium (Warman, 1986; Schjegel, 1992). Reduced input of chemical fertilizers with organic materials such as animal's remains, crop residues, and green compost. Adeboye *et al.* (2006), therefore, suggested that researches on soil fertility should be focused on locally available and affordable internally sourced materials to increase production of crops. In conjunction with the above, Ipinmoroti *et al.* (2002) ascertained that a complementary use of organic and mineral fertilizers has been recommended for sustenance of long term cropping in the tropics. The objectives of the study were to: Evaluate changes in soil chemical properties as influenced by different treatments, Select the best treatment combinations for castor production, Evaluate the influence of different fertilizer rates on the yield performance and production of castor.

Materials and methods

The study was conducted at the Oil Seeds Research and Production Field of National Cereals Research Institute Badeggi, Niger State, which lies on Latitude 9^0 45¹N and Longitude 06º 07¹ E and 300m above sea level in Southern Guinea Savanna agro-ecological zone of Nigeria (FDALR, 1985).

The vegetation of the experimental site is characterized by woodland and tall grasses interspersed with tall grass of dense species (Imuesi, 2002) The area is underlined by the Nupe sandstone of cretaceous geological formation (Russ,1930) the soils are predominantly Umbric Acrisols, Dystric Cambisol, Eutric Cambisol and Gleyic Cambisol (Oyediran, 1987). The soils are low in organic matter content (0.01 -.2%), pH 5. 6 -6.5 and common in iron deficiency (Oikeh *et al.,* 1998).

The area has an average annual rainfall of 1124mm unevenly distributed. The mean annual temperature is between 23^0 and 33^0C (Gana, 2011). The mean annual potential evapotranspiration is 800 – 900mm (Derek and Oguntoyibo, 1987). The mean monthly relative humidity is about 40% (Ojanuga, 2006).

Treatments and Experimental Design

Treatments consisted of three levels of urea fertilizers (0, 45 and 90 kg N ha^{-1}) and three levels of poultry manure(0, 2 and 4 t ha^{-1}).Treatments were assigned randomly to the plots, laid out in randomized complete block design (RCBD) and replicated 3 times. The poultry manure used for experiment was analyzed for its chemical composition.

$T_1 = pd_o + Ur_2$	0 level of poultry manure+ 90 kg N ha^{-1}
$T_2 = pd_o + Ur_1$	0 level of poultry manure+ 45 kg N ha^{-1}
$T_3 = pd_2 + Ur_2$	2 t ha^{-1} of poultry manure+ 90 kg N ha^{-1}
$T_4 = pd_2 + Ur_1$	2 t ha^{-1} of poultry manure+ 45 kg N ha^{-1}
$T_5 = pd_4 + Ur_2$	4 t ha^{-1} of poultry manure+ 90 kg N ha^{-1}
$T_6 = pd_4 + Ur_1$	4 t ha^{-1} of poultry manure+ 45 kg N ha^{-1}
$T_7 = pd_o + Ur_o$	0 level of poultry manure+ 0 level of N (control)
$T_8 = pd_o + pd_2$	2 t ha^{-1} of poultry manure
$T_9 = pd_o + pd_4$	4 t ha^{-1} of poultry manure

Results and discussions

The results showed that the soils of the project sites were mainly acidic with soil reaction varying from moderately acidic to slightly acidic (pH 5.6-6.5) (Table 1). The organic carbon and total N values were generally low to medium. The available phosphorus values were also medium, cation exchange

capacity was found to be medium as suggested by Esu (1991). These parameters all indicated that the soils are low in fertility status prior to planting.

However, from the results of the soil analysis, it is imperative to mention that, judicious use of adequate amount of nutrient input will be important to improved fertility status and enhance productivity of the soil.

Table 1. Initial chemical properties during the cropping season (2010 and 2011)

Soil property	**2010**	**2011**
Chemical properties		
pH in (H_2O) soil -water ratio 1:1	5.6	6.5
Organic carbon (g kg^{-1})	8.68	10.1
Organic matter (g kg^{-1})	14.9	17.3
Total N (g kg^{-1})	0.75	1.50
Available P (mg kg^{-1})	16.1	13.3
Exchangeable Ca (cmol kg^{-1})	3.59	3.17
Cation Exchange Capacity (cmol kg^{-1})	7.33	6.58

Table 2. Effect of application of poultry manure and urea on soil pH, organic carbon, organic matter and total N at harvest in 2010 and 2011 cropping seasons

Treatments	**Organic carbon g kg^{-1}**		**Organic matter g kg^{-1}**		**Total N (g kg^{-1})**		
	2011	2010	2011	2010	2011	2010	2011
T_1	5.83^{b}	12.36^{c}	18.23^{f}	21.26^{c}	31.26^{e}	1.0^{ab}	1.06^{b}
T_2	6.06^{ab}	12.36^{c}	21.40^{d}	21.23^{c}	36.76^{c}	0.99^{ab}	0.90^{b}
T_3	6.33^{a}	14.20^{b}	21.76^{d}	24.50^{b}	37.36^{c}	1.3^{ab}	1.5^{ab}
T_4	5.10^{c}	15.76^{a}	27.03^{ab}	27.10^{a}	46.43^{a}	1.3^{ab}	1.6^{ab}
T_5	5.20^{c}	14.07^{b}	26.73^{b}	25.23^{ab}	45.90^{a}	1.5^{ab}	1.9^{a}
T_6	5.66^{b}	15.20^{a}	27.26^{a}	26.16^{ab}	46.65^{a}	1.4^{ab}	1.8^{a}
T_7	5.93^{b}	12.03^{d}	14.23^{g}	20.66^{c}	24.40^{f}	0.26^{b}	0.73^{c}
T_8	5.66^{b}	14.43^{ab}	20.13^{e}	24.80^{ab}	34.56^{c}	1.0^{ab}	1.5^{ab}
T_9	5.70^{b}	14.40^{ab}	23.10^{c}	24.36^{b}	39.70^{b}	1.2^{ab}	1.7^{ab}
Level of significance	*	*	*	*	*	*	*
SE	0.12	0.43	0.13	0.73	3.02	0.88	0.22

Means followed by the same letter (s) within the same column are not statistically different at 5% level of probability* Significant Ns= no significance

Table 3. Effect of application of poultry manure and urea on soil available P, Ca, Mg, K and CEC at harvest in 2010 and 2011 cropping seasons

Treatments	Available p (mg kg^{-1})		Exchangeable bases(cmol kg^{-1})						CEC Cmol kg^{-1}	
			Ca		Mg		K			
	2010	2011	2010	2011	2010	2011	2010	2011	2010	2011
T_1	10.21^{e}	12.31^{d}	2.52^{bc}	2.18^{f}	2.47^{b}	2.32^{f}	0.24^{b}	0.15^{e}	5.10^{b}	5.07^{e}
T_2	10.36^{f}	11.41^{e}	2.83^{bc}	2.51^{e}	1.43^{c}	2.40^{d}	0.19^{b}	0.19^{d}	4.77^{b}	5.65^{d}
T_3	16.12^{c}	16.82^{b}	3.14^{ab}	4.11^{a}	3.30^{a}	3.73^{b}	0.22^{b}	0.31^{b}	7.09^{a}	8.69^{a}
T_4	16.50^{b}	16.82^{b}	3.86^{a}	3.70^{bc}	3.28^{a}	3.40^{c}	0.21^{b}	0.26^{c}	7.84^{a}	7.94^{c}
T_5	17.51^{a}	18.10^{a}	3.86^{a}	3.67^{bc}	3.22^{a}	3.33^{c}	0.25^{b}	0.27^{c}	8.20^{a}	3.05^{bc}
T_6	15.00^{d}	15.50^{c}	3.08^{ab}	3.51^{c}	3.22^{a}	3.68^{b}	0.24^{b}	0.31^{b}	7.05^{a}	8.09^{b}
T_7	10.00^{g}	11.00^{g}	2.11^{c}	1.97^{g}	1.25^{c}	2.32^{f}	0.16^{b}	0.20^{d}	4.84^{b}	4.92^{e}
T_8	16.35^{b}	17.00^{b}	2. 90^{bc}	3.23^{d}	3.52^{a}		0.24^{b}	0.39^{a}	7.18^{a}	7.70^{c}
T_9	16..32^{b}	16.99^{b}	2.90^{bc}	3.75^{b}	3.44^{a}	3.94^{a}	0.73^{a}	0.38^{a}	7.36^{a}	8.61^{a}
Level of significance	*	*	*	*	*	*	*	*	*	*
SE	1.15	0.234	0.26	0.07	0.13	0.05	0.09	0.09	0.36	0.08

Means followed by the same letter(s) within the same column are not statistically different at 5% level of probability

* Significant Ns = Not significant

Table 4. Effect of application of poultry manure and urea on growth and yield parameters of castor plant in 2010 and 2011 cropping seasons

Treatments	Plant height (cm)		Leaf area (cm^2)		Number of seeds per pod		Total yield (kg ha^{-1})	
	2010	2011	2010	2011	2010	2011	2010	2011
T_1	74.33^{a}	74.33^{a}	6.00	7.33^{abcd}	13.66^{a}	15.33	85.3	141.3
T_2	74.66^{a}	74.66^{a}	4.00	6.00^{cd}	10.66^{ab}	15.66	121.3	143
T_3	74.66^{a}	76.66^{a}	4.00	8.00^{abc}	9.33^{ab}	16.33	138.6	139
T_4	76.66^{a}	76.66^{a}	5.33	7.33^{abcd}	8.33^{ab}	16.33	148.8	139
T_5	49.66^{bc}	49.66^{bc}	5.00	9.33^{a}	8.33^{ab}	17.66	133.7	151.4
T_6	52.56^{c}	52.66^{b}	3.33	8.66^{ab}	11.00^{ab}	16.66	136.8	142.1
T_8	54.66^{c}	44.50^{c}	4.33	6.00^{cd}	12.00^{ab}	11.66	132.4	133.3
T_9	45.33^{c}	45.33^{bc}	4.66	7.33^{abcd}	11.00^{ab}	18.33	135.4	142.1
T_7	44.66^{c}	44.66^{c}	3.66	5.33^{d}	4.66^{b}	16.00	130.1	116.1
Level of significance	*	*	NS	*	*	NS	NS	NS
SE $\pm$	2.20	2.26	0.87	0.72	1.93	4.36	5.41	

Means followed by the same letter(s) within the same column are not statistically different5% level of probability

* Significant, Ns- not significance

Addition of poultry manure improved most of the soil chemical properties. Soil pH, organic matter, total nitrogen, available phosphorus, exchangeable caution and percent base saturation were improved this therefore,

implies that poultry manure could be used as soil management strategy for sustainable production of Castor. In line with this, Ano and Agwu (2006) had found that animal manure increased soil pH and macronutrients of soil in southern Nigeria. Also, Salako (2008) reported that poultry manure improved surface P and other major nutrients and yield of maize. These findings confirmed earlier report by Lombin *et.al* (1991). That animal manure improved soil productivity in two ways; through improvement of the physical conditions of the soil and through the Nutrient it supplies to the soil. The reduction in Exchangeable acidity in plots amended with poultry Manure suggests the ability of poultry manure in lowering soil Al^{3+} and Fe^{2+} concentrations.

The higher pH of poultry manure amended plots compared to plots without poultry manure application might partially be due to the calcium supplied to the soil by poultry manure (Cooper and Warman, 1986). In support of these findings, recent studies had shown that poultry manure increased soil organic matter, nitrogen, pH, phosphorus, CEC (Adeniyan and Ojeniyi, 2003; Mbah and Mbagwu, 2006; Ayeni *et al.,* 2008).

The mineralization of poultry manure probably resulted in the release of organic bound nutrients as reflected in increased N, P, K and organic matter in the soil. The increase in soil pH observed from the treated plots confirmed the liming effect of poultry manure as reported by Duruigbo *et al.* (2006). However, a general decrease in pH observed in 2011 may be due decomposition of organic material that leads to the production of organic acid and or accumulation of nitric acid due to mineral fertilizer application as observed by Lynch, (1983). Poultry manure and Urea amended plot had greatest effect on available P at 4t ha^1 of poultry manure. The available P increased in these amended plots over the control by a range of 62.1 - 91.9% in 2010 whereas a steady increase was observed in 2011. Nalatwadmath *et al.* (2003) reported a buildup of available K only in organic manure treatment which was maximum (33%) as compared to control. Consequently, the nutrient content of the residue is translated in terms of growth and yield of castor plant which were significantly affected as reported by Sree and Reddy (2003) that the use of organic and inorganic manure significantly affected the plant height, leaf area and seed yield. Lombin *et.al.*(1991) observed that, complimentary use of organic and inorganic manure as proved to be a sound soil fertility management strategy in many countries of the world.

Conclusion

This experiment has demonstrated the effectiveness of combining organic and inorganic fertilizer in improving the chemical properties of the soil which

are key indicators of soil fertility status. This follows that 2t ha^{1} poultry manure +45kg $ha^{1\ N}$

And 4t ha^{1} poultry manure +90kg $ha^{1\ N}$ were observed to be the best combinations recommended for a better Castor production in Southern Guinea savanna of Nigeria.

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