



## EFFECTS OF NUTRIENT SOURCES AND AGRO-ECOLOGY ON PHYSICAL AND CHEMICAL PROPERTIES OF SOIL IN BAUCHI STATE, NIGERIA

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### ABSTRACT

The study was conducted at both Abubakar Tafawa Balewa University teaching and research farm, Bauchi located in the Northern Guinea Savannah and also at Bulkachuwa village of Katagum LGA located in Sudan Savannah both in Bauchi state, during the wet seasons of 2016, 2017 and 2018 to investigate the effects of nutrient sources and agro-ecology on physico-chemical properties of soil. The treatments consisted of a factorial combination of five nutrient sources (poultry manure, cow dung, chicken feather, municipal waste, mineral fertilizer) and a control and two varieties of castor (Ex-India 1 and 2), these gave 12 treatment combinations and laid out in a randomized complete block design (RCBD) with three replications. The results of the experiment revealed a significant ( $P \leq 0.05$ ) difference among the treatments used throughout the study period. The results of the soil analysis before the conduct of the experiment revealed that, the soil in both locations is sandy loam in texture. It also indicated that, the soils are slightly acidic, low in organic carbon, available P (mg/kg) and total N (g/kg) while the exchangeable cations (cmol/kg) are medium, following the ESU rating. The result after treatment application showed that, soil texture remained the same (sandy loam) in both locations. The soil pH was neutral to slightly acidic while organic carbon ranged from medium to high with highest value in poultry manure and chicken feather in Bauchi but generally low to medium in Bulkachuwa location. Available P and total N were medium to high in Bauchi but low to medium in Bulkachuwa location. However, the exchangeable cations were rated to be high in both locations following ESU rating. Based on the results of this study, Application of poultry manure or chicken feather at the rate of 2 tons/ha should be adopted by farmers in the study area for good soil fertility restoration.

**Keywords:** Poultry manure, Chicken feather, Cowdung, Municipal waste.

### INTRODUCTION

The use of inorganic fertilizer for crop production has not been helpful under intensive agriculture because, it is often associated with reduced crop yield, soil acidity, nutrient imbalance and very expensive (Mullens *et al.*, 2002). The quantity of soil organic matter in the soil has been found to depend on the quantity of organic material which can be introduced in to the soil either by natural return through roots, stubble, root nodules and roots exudate or by artificial application in form of organic manure. Organic waste contains varying amount of water, mineral, nutrient, organic matter (Weber *et al.*, 2014). While the use of organic waste as manure has been in practice for centuries worldwide and in the recent times (Lopez *et al.*, 2008). Cow dung treatment gave taller plant height, number of leaves per plant and increasing the yield of dry matter. Wang *et al.* (2015) reported that, potential use of poultry manure as



fertilizer and soil amendment increase crop yield significantly. On the other hand, Mullens *et al.* (2002) reported that poultry litter contain considerable amount of organic matter, thereby impacting soil pH and liming due to the varying amount of calcium carbonate in poultry feed. Lopez *et al.*, (2008) reported physical and chemical properties of soil improvement due to organic matter decomposition. The source of nitrogen in cow manure results in taller plant because nitrogen was found to increase node and inter-nodes length and consequently plant height. Higher rate of cow manure significantly increases the number of growth attribute of sorghum cultivar (Weber *et al.*, 2014).

Mullens *et al.* (2002) found that, manure alone or mixed with N.P.K result in an increase growth and yield of sorghum cultivar. Mullens *et al.* (2002) also reported that crop yield was statistically the same under NPK alone and control in both locations. Agbede *et al.* (2008) affirmed that, application of cow manure alone or in combination with urea N significantly increased the yield characters of sorghum. The grain and straw yield increased significantly with different treatments and highest yield was obtained with application of 2tonCD + 45kgNPK. The NPK uptake was positively influenced by different treatments (Meena *et al.*, 2016). Farmyard manure if heterogeneously composted, composed of a mixture of dung, crop residues, and/or household sweepings at varying stages of decomposition. It is an important organic resource for sustainable agricultural production in many countries (Meena *et al.*, 2016). It promotes sustainability in agriculture by different ways and long-term positive effects on soil properties; recycling plant nutrients within a farm; possible substitution of readily available organic inputs for chemical fertilizers and improvement in crop yield (Navaro *et al.*, 2002). This research is therefore conducted to study the influence of different nutrient sources, agro-ecology and castor varieties on physical and chemical properties of soil.

## **MATERIALS AND METHODS**

The experiment was conducted at teaching and research farm of the Faculty of Agriculture and Agricultural Technology, Abubakar Tafawa Balewa University Bauchi, (10° 22'N and 9° 47'E) in the northern Guinea savanna ecological zone and also at Bulkachuwa Village (11°38'N and 10°31'E) of Katagum LGA in the Sudan savanna ecological zone during the wet seasons of 2016, 2017 and 2018 both located in Bauchi state of Nigeria. The treatments consisted of five nutrient sources (poultry manure, cow dung, chicken feather, municipal waste, NPK fertilizer and a control) and two cultivars of castor (Ex-India 1 and 2). The five nutrient sources with their control and the two cultivars were factorially combined to give 12 treatment combinations and laid out in a randomized complete block design (RCBD) replicated three times. The poultry manure used was poultry litter and it was obtained directly after sweeping the pen and allowed to dry for 5 days before application. The Municipal waste used was applied immediately after its collection in each year of the study. Mineral fertilizer used, was NPK 15:15:15 and Urea (46% N) and the feathers used were obtained at the chicken dressing unit, sundried for 5 days before they were applied to the experimental plots in each year of the study. The Cow manure used for the experiment was packed from the cow pen and allowed to dry for 5 days before application in each year of the study.

The field was ploughed once and harrowed twice to a fine tilth during the first year using tractor drawn implement. However, manual tillage, using hand hoe was carried out in the subsequent years so as to maintain plots and their treatments. The organic fertilizers (poultry manure, chicken feather, municipal waste and cowdung) were applied at the rate of 2 tons/ha after land preparation and worked into the soil at two weeks before sowing in both locations and in each year of the study. Inorganic fertilizer however was applied at the rate of 100 kg N,



50 kg  $P_2O_5$  and 50 kg  $K_2O$  in two split doses. The complete dose of P and K with half dose of N (50:50:50) was applied at one week after emergence as basal application. The remaining half dose of N (50 kg) in the form of urea (46%N) however, was applied as top dress beside the plant and then covered with soil at 6 weeks after sowing (WAS). A composite soil sample of the experimental site was collected at a depth of 0 – 30cm. The ‘Z’ samples were taken at 10 different spots in a ‘Z’ pattern following the procedure of IFDC (2003) before the onset of the experiment. In the subsequent years, the sample was collected based on treatments from each plot and the composite obtained was analyzed for physical and chemical properties using standard procedure as described by Whingwiri *et al.* (1987).

## RESULTS AND DISCUSSION

The results of the soil physical and chemical properties before the conduct of the experiment are presented in Table 1. The results revealed that, the soil in both locations is sandy loam in texture. It also indicated that, the soils are slightly acidic, low in organic carbon, available P (mg/kg) and total N (g/kg) while the exchangeable cations (cmol/kg) are medium, following the ESU rating.

**Table 1:** Physical and chemical properties of soils of the experimental sites before the commencement of the research in 2016

Properties	Bauchi	Bulkachuwa
<b>Physical analysis</b>		
Sand(%)	60.64	73.64
Silt(%)	22.28	12.26
Clay(%)	17.08	14.10
Texture	<b>Sandy Loam</b>	<b>Sandy Loam</b>
Soil pH(water)	6.06	6.73
Organic Carbon(g/kg)	6.82	1.17
Available P(mg/kg)	5.34	7.23
Total N(g/kg)	0.56	0.21
<b>Exchangeable cations(cmol/kg)</b>		
Ca	2.56	2.16
Mg	0.79	0.65
K	0.25	0.22
Na	0.10	0.11

Table 2 shows the individual treatment soil analysis after the conduct of 2016 experiment. The table showed that, the soil texture remained the same (sandy loam) in both locations. It further revealed a slight increase in soil pH with the application of treatments, indicating a slight decrease in the acidic nature of the soil in both locations. There was also marked increase in soil organic carbon, available P and total N with poultry manure and chicken feather application in both locations. Organic carbon and available P were rated to be medium in Bauchi but low in Bulkachuwa location with the exception of soils treated with poultry manure and chicken feather. The exchangeable cations were also rated medium to high in both locations.

The soil analysis after the conduct of 2017 experiment is presented in Table 3. The result obtained revealed that, the soil texture remained the same (sandy loam) in both locations. Soil pH was slightly acidic while organic carbon ranged from medium to high with poultry



manure and chicken feather taking the lead in Bauchi but generally low to medium in Bulkachuwa location. Available P and total N observed, was medium to high in Bauchi but low to medium in Bulkachuwa location. Exchangeable cations however, were rated to be high in both locations.

After the conduct of 2018 experiment, the results of the soil analysis (Table 4) indicated that, the soil texture was the same (sandy loam) in both locations. The soil pH was neutral to slightly acidic while organic carbon ranged from medium to high with highest value in poultry manure and chicken feather in Bauchi but generally low to medium in Bulkachuwa location. Available P and total N were medium to high in Bauchi but low to medium in Bulkachuwa location. However, the exchangeable cations were rated to be high in both locations, following ESU rating.

With respect to variety however, no much variation was observed in terms of their influence to physical and chemical properties of the soil tested. Based on the result obtained, texture, pH, organic carbon, available P, total N and exchangeable cations are the same under the two varieties throughout the study period.

The soils at the two experimental sites were low in essential nutrients such as N, P, K and exchangeable cations. The organic carbon was generally low in both locations, probably due to sparse vegetation and intensive cultivation. The result obtained indicated that the soils of the experimental site was low in fertility and can therefore, respond well to fertilizer application. The present finding is in line with the report of Lasekan *et al.* (2013) who stated that, savannah soils are inherently low in fertility due to sparse vegetation and continues cultivation. The increase in essential nutrients observed as a result of the application of the different nutrient sources in the present investigation indicates their importance to soil fertility improvement. Increase in organic carbon, total N and available P observed under poultry manure and chicken feather could be due to their low carbon to nitrogen ratio. It can therefore, be inferred from this result that, poultry product improves physical and chemical properties of soils. This is in conformity with the earlier report of Meena *et al.* (2016) who stated that, poultry manure decreases bulk density and increase total porosity, infiltration and water holding capacity. The result also lend support from the findings of Mullens *et al.* (2002) that, poultry litter contains considerable amounts of organic matter due to the manure, feathers and bedding materials which can have an impact on soil pH and liming due to varying amounts of calcium carbonate in the poultry feed.

The slight increase in soil fertility noticed with the application of cowdung and municipal waste also revealed their role in soil fertility improvement, availability of nutrients and also in crop growth. Similarly, the increase in soil organic carbon, total N and available P observed with the application of cowdung could be due to its significance in improving soils physical and biological properties. This is in line with the earlier report of Wang *et al.* (2015) that, manure from cattle can improve soil physical and biological properties due to its contents of humus and organic constituents. Essential nutrients were also observed to increase with increase application of municipal waste. Moreover, municipal waste application might tend to improve soil structure by reducing compaction and increase in aeration. The findings of Mbarki *et al.* (2008) concurs with the present study that, long term application of municipal waste develops a good soil structure, improves water holding capacity and increase aggregate stability through the formation of ionic bridges.

**Table 2:** Physical and chemical properties of soils of the experimental sites under each treatment after the first year study of 2016 rainy season

2016												
Ex-India 1						Ex-India 2						
Control	PM	MW	CF	CD	MF	Control	PM	MW	CF	CD	MF	
<b>Bauchi</b>												
Sand(%)		63.64	60.64	62.14	61.62	59.64	62.44	64.24	60.04	62.53	61.26	61.45
61.90												
Silt(%)		19.28	21.28	20.28	21.18	23.28	21.28	19.28	19.08	21.11	20.13	20.82
21.82												
Clay(%)		17.08	18.08	17.58	17.20	18.08	16.28	16.48	20.88	16.36	18.61	17.73
16.28												
<b>Texture</b>												
<b>Loam</b>												
Soil pH(water)		5.78	6.48	6.20	6.93	6.53	6.03	6.09	6.67	6.21	6.87	6.65
6.54												
Organic Carbon(g/kg)		8.60	14.00	13.20	14.08	13.50	12.90	8.10	14.70	13.22	14.10	13.52
12.93												
Available P(mg/kg)		10.63	14.95	13.63	14.54	13.86	14.25	10.26	14.86	13.68	14.65	13.92
14.36												
Total N(g/kg)		0.95	1.20	1.05	1.24	1.11	1.30	0.97	1.92	1.10	1.96	1.16
1.45												
<b>Exchangeable cations(cmol/kg)</b>												
Ca		2.58	3.75	2.93	3.86	3.63	3.29	2.15	3.86	2.94	3.89	3.72
3.31												
Mg		0.78	0.81	0.79	0.80	0.82	0.76	0.72	0.94	0.80	0.82	0.84
0.81												
K		0.29	0.37	0.35	0.34	0.35	0.38	0.30	0.38	0.36	0.36	0.35
0.39												
Na		0.21	0.28	0.29	0.28	0.22	0.30	0.20	0.29	0.30	0.31	0.24
0.32												
<b>Bulkachuwa</b>												
Sand(%)		72.60	70.14	72.24	71.04	69.68	71.64	74.64	71.64	72.42	71.56	72.20
72.32												
Silt(%)		13.28	13.18	13.16	12.20	14.38	13.28	11.28	10.81	12.83	11.04	13.50
12.82												
Clay(%)		14.12	16.68	14.60	16.76	15.94	15.08	12.08	17.55	14.74	17.40	14.30
14.86												
<b>Texture</b>												
<b>Loam</b>												
Soil pH(water)		6.08	6.48	6.20	6.23	6.13	5.93	6.19	6.87	6.36	6.78	6.28
6.08												
Organic Carbon(g/kg)		2.60	10.00	8.20	9.80	8.50	9.60	3.10	10.70	9.11	10.81	9.05
9.82												
Available P(mg/kg)		8.63	10.95	9.63	10.94	9.86	10.25	7.26	10.86	9.64	10.96	9.89
10.92												
Total N(g/kg)		0.70	1.10	1.05	1.14	1.01	1.23	0.85	1.12	1.08	1.24	1.09
1.35												
<b>Exchangeable cations(cmol/kg)</b>												
Ca		2.28	3.75	2.93	3.86	2.63	3.29	2.15	3.86	2.94	3.89	2.86
3.34												
Mg		0.75	0.81	0.78	0.80	0.82	0.76	0.82	0.84	0.82	0.86	0.84
0.86												
K		0.29	0.37	0.31	0.34	0.32	0.38	0.30	0.38	0.32	0.35	0.33
0.39												
Na		0.24	0.28	0.27	0.28	0.22	0.20	0.25	0.29	0.28	0.30	0.25
0.31												

PM = Poultry Manure, CF = Chicken Feather, CD = Cowdung, MW = Municipal Waste, MF = Mineral Fertilizer





**Table 3:** Physical and chemical properties of soils of the experimental sites under each treatment after the second-year experiment of 2017 rainy season

2017												
Ex-India 1							Ex-India 2					
Control	PM	MW	CF	CD	MF		Control	PM	MW	CF	CD	MF
<b>Bauchi</b>												
Sand(%)		63.10	60.60	62.18	61.64	59.54	61.44	63.28	60.06	62.51	60.26	62.45
62.92												
Silt(%)		19.26	21.28	20.34	21.15	22.35	22.28	20.24	19.08	21.14	21.13	19.82
20.82												
Clay(%)		17.64	18.12	17.48	17.21	18.11	16.28	16.48	20.86	16.35	18.61	17.73
16.26												
<b>Texture</b>		<b>Sandy Loam</b>			<b>Sandy Loam</b>			<b>Sandy Loam</b>			<b>Sandy</b>	
<b>Loam</b>												
Soil pH(water)		6.08	6.68	6.42	6.96	6.65	6.13	6.10	6.79	6.32	6.94	6.75
6.32												
Organic Carbon(g/kg)		10.67	15.02	13.56	15.04	13.98	13.60	10.70	15.70	13.76	15.21	14.02
13.63												
Available P(mg/kg)		11.76	15.05	14.03	14.84	14.06	14.55	11.82	15.86	14.15	15.04	14.08
15.54												
Total N(g/kg)		1.02	1.55	1.15	1.54	1.24	1.56	1.05	2.02	1.35	2.03	1.32
2.07												
<b>Exchangeable cations(cmol/kg)</b>												
Ca		2.66	3.86	2.95	3.98	3.73	4.09	2.51	4.06	3.01	4.01	3.81
4.02												
Mg		0.85	0.92	0.85	0.91	0.86	0.96	0.82	0.99	0.94	0.93	0.89
0.95												
K		0.31	0.47	0.37	0.46	0.38	0.48	0.33	0.48	0.39	0.48	0.37
0.45												
Na		0.24	0.31	0.32	0.34	0.31	0.32	0.26	0.35	0.33	0.36	0.32
0.34												
<b>Bulkachuwa</b>												
Sand(%)		71.62	70.16	72.22	71.07	70.68	71.64	73.66	71.62	72.43	71.50	72.21
71.33												
Silt(%)		14.28	13.20	13.16	12.23	13.36	13.26	12.26	10.85	12.82	11.10	13.46
13.84												
Clay(%)		14.10	16.64	14.62	16.70	15.96	15.10	12.08	17.53	14.75	17.40	14.33
14.83												
<b>Texture</b>		<b>Sandy Loam</b>			<b>Sandy Loam</b>			<b>Sandy Loam</b>			<b>Sandy</b>	
<b>Loam</b>												
Soil pH(water)		6.08	6.78	6.21	6.93	6.53	6.23	6.29	6.67	6.23	6.94	6.51
6.32												
Organic Carbon(g/kg)		4.62	12.07	10.20	11.80	10.50	10.60	5.10	12.70	10.32	12.03	11.03
11.12												
Available P(mg/kg)		7.63	11.95	10.63	11.54	10.16	11.25	7.86	12.06	10.76	11.46	10.61
10.92												
Total N(g/kg)		1.02	1.51	1.35	1.54	1.31	1.50	1.05	1.62	1.43	1.51	1.45
1.49												
<b>Exchangeable cations(cmol/kg)</b>												
Ca		2.78	3.97	3.13	3.93	3.53	3.49	2.85	4.06	3.23	4.11	3.83
3.50												
Mg		0.80	0.83	0.85	0.90	0.87	0.86	0.82	0.94	0.91	0.92	0.91
0.87												
K		0.30	0.36	0.35	0.34	0.35	0.39	0.32	0.35	0.36	0.36	0.38
0.37												
Na		0.28	0.35	0.30	0.38	0.29	0.32	0.26	0.39	0.39	0.37	0.34
0.33												

PM = Poultry Manure, CF = Chicken Feather, CD = Cowdung, MW = Municipal Waste, MF = Mineral Fertilizer

**Table 4:** Physical and chemical properties of soils of the experimental sites under each treatment after the third-year study of 2018 rainy season

2018												
Ex-India 1						Ex-India 2						
Control	PM	MW	CF	CD	MF	Control	PM	MW	CF	CD	MF	
<b>Bauchi</b>												
Sand(%)	63.64	60.66	62.16	61.64	59.66	61.42	63.26	60.04	62.50	61.24	61.43	
61.81												
Silt(%)	19.26	21.24	20.27	21.14	23.24	22.28	20.36	19.28	21.14	20.15	20.80	
21.82												
Clay(%)	17.10	18.10	17.57	17.22	18.10	16.30	16.38	20.68	16.36	18.61	17.77	
16.37												
<b>Texture</b>												
<b>Loam</b>												
Soil pH(water)	6.28	7.08	6.56	7.03	6.53	6.48	6.19	6.97	6.82	7.03	6.68	
6.37												
Organic Carbon(g/kg)	10.70	15.62	13.67	15.80	14.50	13.64	10.81	15.74	13.74	15.89	14.45	
13.94												
Available P(mg/kg)	11.83	15.45	14.33	15.54	14.32	15.25	11.96	15.91	14.32	15.67	14.29	
15.21												
Total N(g/kg)	1.20	2.10	1.95	2.04	1.87	2.02	1.25	2.12	1.93	2.13	1.98	
2.13												
<b>Exchangeable cations(cmol/kg)</b>												
Ca	2.78	4.15	3.93	4.06	3.86	3.99	2.55	4.16	3.84	4.21	3.90	
4.25												
Mg	0.82	0.95	0.79	0.90	0.89	0.97	0.83	0.94	0.81	0.93	0.87	
0.93												
K	0.29	0.53	0.51	0.49	0.35	0.58	0.30	0.45	0.53	0.51	0.42	
0.56												
Na	0.26	0.42	0.30	0.42	0.37	0.40	0.24	0.39	0.29	0.39	0.38	
0.37												
<b>Bulkachuwa</b>												
Sand(%)	72.62	70.14	72.24	71.10	69.58	71.62	74.64	71.63	72.43	71.50	72.30	
71.52												
Silt(%)	13.24	13.28	13.13	12.20	14.56	13.26	11.26	10.83	12.83	11.10	13.40	
13.63												
Clay(%)	14.14	16.48	14.63	16.70	15.86	15.12	12.10	17.54	14.74	17.40	14.30	
14.85												
<b>Texture</b>												
<b>Loam</b>												
Soil pH(water)	6.28	6.78	6.30	6.96	6.66	6.63	6.19	7.07	6.45	6.97	6.56	
6.49												
Organic Carbon(g/kg)	6.60	13.05	9.98	12.80	11.52	10.69	5.70	13.32	10.08	13.09	11.87	
11.08												
Available P(mg/kg)	8.13	12.95	11.13	12.54	10.86	13.35	8.26	13.86	10.72	12.89	11.09	
12.87												
Total N(g/kg)	1.15	1.67	1.45	1.94	1.53	1.86	1.25	1.92	1.51	1.86	1.58	
1.91												
<b>Exchangeable cations(cmol/kg)</b>												
Ca	2.88	3.95	3.23	3.96	3.63	3.79	2.91	4.16	3.35	3.99	3.84	
3.92												
Mg	0.85	0.86	0.85	0.93	0.85	0.97	0.82	0.94	0.90	0.94	0.90	
0.98												
K	0.28	0.37	0.35	0.36	0.35	0.41	0.31	0.37	0.38	0.39	0.39	
0.40												
Na	0.29	0.41	0.32	0.40	0.32	0.34	0.27	0.42	0.41	0.43	0.36	
0.44												

PM = Poultry Manure, CF = Chicken Feather, CD = Cowdung, MW = Municipal Waste, MF = Mineral Fertilizer



## CONCLUSSION AND RECOMMENDATIONS

In conclusion however, application of the organic nutrient sources had an influence on the physical and chemical properties of the soil. Even though, these organic sources had similar influence on the soil, the potentials of poultry products as an organic source may not be overemphasized. Regarding location, Bauchi being located in the Northern guinea Savannah with higher rainfall and soil organic matter, recorded better than Bulkachuwa which is located in the Sudan Savannah with less rainfall and soil organic matter throughout the study period. Based on the results of this study, Application of poultry manure and chicken feather at the rate of 2 tons/ha should be adopted by farmers in the study area for good soil fertility restoration.

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