Effect of Types of Manure on Growth and Yield of Cassava (*Manihot esculenta*, Crantz)

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Abstract: Two field experiments were conducted in Akure, South Western Nigeria to compare the effect of types of livestock manure on growth, yield and plant nutrient contents of cassava. Four types of manure (Poultry, Goat, Pig and Cattle at 10 t/ha) a control treatment (0 t/ha) and 30:30:30 kg/ha NPK were compared in a randomized block design with three replications. The test soils were low in organic matter (OM), N, and available P. Analysis of manures showed that Poultry manure (PM) was highest in N, K, Ca and Na. Pig manure (PG) was highest in P, Cattle manure (CM) was highest in Mg, while Goat manure (GM) had least Na, Ca, Mg and P. Plants fertilized with different manure types and fertilizer showed similar growth pattern. The PG, GM, CM, PM and NPK increased tuber yield by 32, 22, 44, 24 and 40% respectively. Highest fresh root weight (t/ha) given by PM was 13.07 t/ha and 27.7 t/ha at 9 and 12 MAP respectively. Manures and NPK significantly increased leaf N, Zn and Fe; GM and NPK increased stem N; CM, PM and NPK increased leaf K; PG, CM, and NPK increased Ca in plant and PM increased leaf Mg. Livestock manure enhanced availability of nutrients for increased yield in cassava production.
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Introduction

In Africa as in some other ACP (Africa, Caribbean and Pacific) regions, rising population are putting growing pressure on the land. One of the main casualties is soil fertility, since time-honored mechanisms for resting and regenerating the land are increasingly being abandoned in an effort to feed more mouths. Unless new ways are found to re-fertilize the soil, the battle to feed those extra mouths will in any case be lost, as yields sink lower and lower. Organic fertilizer represents the cheapest and most sustainable option for ACP producers and animal manure offers an affordable and readily available solution to many soil fertility problems (Spore, 2006). The growth environment of cassava crops in most fields in Africa receive little additional soil nutrient from applied manures or fertilizers. Consequently, yields usually depend on the native fertility of soils. Cassava can grow and yield reasonably well on soil of low fertility where production of most other crops would be uneconomical (Carter, *et al.,* 1992). Although cassava can grow in a wide variety of soil conditions, to obtain optimal growth and good yields the crop requires friable light texture and well-drained soils, which contain sufficient moisture and a balanced amount of plant nutrients. Under favourable soil and climatic conditions, fresh tuber yields of 40-60 t/ha can be obtained (IITA, 2005).

Animal manures may contribute to improving the soil's physical conditions and are important source of Ca, Mg, S, and micronutrients; they contain only low and highly variable amounts of N, P, and K. Livestock play a significant role in maintaining soil fertility. Livestock can replenish a substantial share of soil nutrients, and therefore reduce the need for inorganic fertilizer with corresponding savings for farmers in terms of cash outlay, for the country in foreign exchange, and for the world in non-renewable resources. This study was planned to compare different farm manures and NPK fertilizer effects on nutrient contents, growth and yield of cassava and maintenance of soil fertility.

Materials and Methods

The experiments were carried out in Akure, Ondo State, Nigeria. Akure lies between latitude 7^0 30'N and longitude 3^0 52' E in the tropical rainforest belt. There are two rainy seasons, one from April to July (early season) and from mid-August to November (late season). Average annual rainfall ranges between 1100 mm and 1200 mm. Annual average minimum and maximum temperatures are 24.80^0C and 28.10^0C. The experiment was carried out in March in the early planting season of 2005 involving six treatments, namely 0 t/ha, 10 t/ha poultry, 10 t/ha goat, 10 t/ha pig, 10 t/ha cattle manures and 200 kg/ha NPK 15:15:15. The six treatments were laid out in randomized complete block design with three replications. Nine core samples were randomly taken using 5mm soil auger at 0 -30 cm depth before planting. They were bulked, air-dried and sieved with 2 mm mesh sieve for analysis. The particle size analysis was done by pipette method (Gee and Bauders, 1986); soil pH in water was determined using soil: water ratio of 1:2 by a pH meter with a glass electrode. Organic matter was determined using the Walkey & Black method (Nelson and Sommers, 1996). Total N in the soil was determined by Kjedahl digestion and N determined colourimetrically (Bremner, 1996). Exchangeable bases in the samples were extracted in 1M NH_4OAC at pH 7.0. Ca and Mg in the extract were read by atomic absorption spectrophotometer (AAS). Na and K were analyzed by using flame photometry. Exchangeable acidity was determined by extracting with 1N KCl and determined by NaOH titration (Sims, 1990). Available phosphorous was determined by Bray-1 extraction and determined colourimetrically by the molybdenum blue procedure (Bray and Kurtz, 1945). The farm manures were cured by air drying and later pounded in a mortar with pestle to increase their surface area for easy application and mineralization. The stem cuttings of cassava variety TMS 30572 were cut to a 25 cm length and planted at a spacing of 1m x 1m. Treatments were applied by ring method at 2 months after planting (MAP). Three hoe weeding were carried out at 3 weeks after planting (WAP), 8 and 12 WAP. Data collection commenced one month after treatment application and subsequently on a monthly basis for six months. The plot size was 5 m x 5 m each. Five plants were randomly selected per plot for data collection at one month interval from one month after treatment application. Plant height was estimated with a tape measure at harvest, number of branches per plant and number of leaves/plant and numbers of nodes/25cm cuttings were counted physically. Stem girth (cm), plantable stake (cm) and number of 1m cutting/stand were estimated with a tape measure. Leaf area (cm^2): LA = 0.407la + 11.38 where la = product of length x breath of median leaflet x number of leaflets and 11.38 = a constant was estimated using Spencer (1962). Leaf area index (LA1 = leaf area x number of leaves x number of stands/ land area) was calculated as described by Wahua (1983). For yield parameters tuber girth (cm), length of tuber (cm), single root weight/plant (kg), weight of tuber (t/ha), biomass production (t/ha): tuber yield x ca 1.6 by Boardman (1980) and number of tubers per plant were all estimated. The harvest index was used as selection criteria for high yield. Leaf, stem (phelloderm) and root were collected at 4 months for analysis. The samples were collected per plot, oven dried at 80^0C for 72 hours and milled for chemical analyses. Total N was determined by micro–kjeldahl method (Jackson, 1962). For P, K, Ca and Mg, samples (0.5g) were ashed, dissolved in 10% HCl and diluted to 50ml. P was determined using Vanado molybdate colourimetry. Ca and Mg were determined by EDTA titration, Na and K by flame photometry. The mean values of leaf, stem and root contents, growth and yield components of cassava were compared. The Duncan multiple range test (P=0.05) was used for mean separation.

Results and Discussion

Initial soil fertility analysis

Table 1 shows the physico-chemical properties of the soil before planting. The textural class of the soil is sandy loam with pH 5.80.The soil is low in organic matter, nitrogen, available P, cation exchange capacity (CEC) and exchangeable Ca (Akinrinde and Obigbesan, 2000). The application of the different sources of livestock manure as fertilizer is expected to benefit the crop and soil.

Table 1: Soil analysis before planting

Na	K	Ca	Mg	pH	H^+	CEC	Av. P	Zn	C	OM	N	Silt	Clay	Sand	Textural Class
←Exchangeable cation (cmol/kg) →				(H_2O)	← cmol/kg →		← mg/kg →		← % →						
0.98	0.28	1.09	0.69	5.80	0.12	3.16	6.28	7.09	0.90	1.55	0.09	13.07	8.90	78.03	Sandy loam

The soil on which the experiments were conducted was found to be low in organic matter (OM), N and available P. This is in agreement with earlier observations that soils in south-west Nigeria which are mostly weathered alfisols were deficient in nutrients (Ojeniyi and Akanni, 2008; Agbede *et al.,* 2008) especially OM, total N, available P, exchange K and Ca.

Chemical Composition of Different Animal Manures.

The chemical composition (%) of different animal manures is shown on Table 2. Poultry manure had the highest values in % Na, K, Ca, Mg and N. The highest % P was observed for Pig manure while Cattle manure recorded the highest value in Zn (mg/kg). Goat manure had the lowest values in % Na, Ca, Mg and P. The manures of poultry (PM), pig (PG), cattle (CM) and goat (GM) were composed of macro-nutrients, with PM having highest N, K, Ca, PG with highest P, CM with highest Mg concentration and GM with least P, Ca and Mg. Therefore the animal wastes are expected to improve the availability of these nutrients in soil which was deficient in macronutrients. The contents of base elements (K, Ca and Mg) will serve to reduce soil acidity. The PM had highest values of most nutrients.

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Table 2: Chemical Composition (%) of different animal manures

Manures	Na	K	Ca	Mg	P	N	Zn(mg/kg)
Poultry	0.28	0.68	2.09	1.92	1.28	1.38	138
Pig	0.10	0.28	1.80	1.88	2.16	1.30	189
Goat	0.08	0.30	1.00	0.48	0.84	1.37	286
Cattle	0.16	0.38	1.06	0.52	0.88	1.22	298

Relative Effect of Different Source of Manures on Growth of Cassava.

The effect of different source of manures and NPK fertilizer treatment on growth of cassava is shown in Table 3. There were no significant differences in plant height (cm), plantable stake (cm), number of 1m cutting/stand, number of nodes/25cm cutting, stem girth (cm) and length of Internodes (cm). Though not significantly different, poultry manure recorded the highest values in plant height (290. 73) and plantable stake (187.73) while the lowest values were observed in cattle manure and pig manure for plant height and plantable stake respectively. Significant differences were observed in number of leaves/plant and number of branches/plant. Highest values were observed in NPK fertilizer treatment for number of leaves/plant and control treatment for number of branches/plant while the lowest values were recorded by pig and cattle manures for number of leaves/plant and number of branches/plant respectively. Trials carried out on different crops on alfisols of southwest and southeast Nigeria confirmed that manures such as duck, poultry, turkey, cattle, swine and goats increased significantly soil and crop macronutrient content and yield of crops such as coffee, amaranthus, okra, pepper, sorghum and maize (Adeniyan and Ojeniyi, 2003 and 2005; Ayeni *et al*., 2008; Ayeni *et al.*, 2009; Mbah, 2006; Mbah and Mbagwu, 2006; Olomilua *et al.*, 2007; Awodun and Alafusi, 2007; Ojeniyi and Adejobi, 2002; Adekiya and Agbede, 2009; Moyin Jesu, 2007 and Moyin Jesu, 2008).

Table 3: Effect of different sources of manure on growth of cassava

Treatments (t/ha)	Plant height (cm) at harvest	Plantable stake (cm)	Number of cutting/stand	Number of nodes /25cm cutting	Stem girth (cm)	Length of internodes (cm)	Number of leaves/plant	Number of branches/plant
Control	270.67	162.13	1.67	15.47	7.50	2.50	91.73b	2.60a
Poultry	290.73	183.73	1.80	17.27	9.16	2.51	82.83b	1.80ab
Pig	272.93	148.00	1.67	16.47	8.83	2.38	81.17b	1.82ab
Goat	267.87	186.20	1.53	15.93	8.00	2.15	87.37b	1.93ab
Cattle	257.93	170.27	1.67	15.53	8.33	2.28	102.63ab	1.55b
NPK	281.40	177.27	1.93	15.53	8.33	2.32	122.53a	1.62b
Ns	Ns	Ns	Ns	Ns	Ns			
S.E±	27.61	16.73	0.28	1.54	0.82	0.16	12.15	0.38

Values are means of triplicate readings

Means followed by different lowercase letters in the same column are significantly different (P < 0.05)

Ns- Not significant

Relative Effect of Different Source of Manures on Yield of Cassava.

Data on yield and yield components of cassava as produced by different source of manures and NPK fertilizer treatment in 9 and 12 months are shown in Table 4. At 9 and 12 months, 10 t/ha poultry manure was the most efficient and it gave optimal fresh tuber yield of 13.07 t/ha and 27.73 t/ha respectively. However, the findings indicated that there was no significant difference in tuber weight (t/ha) at 9 months, while significant difference was observed in tuber weight (t/ha) at 12 months. The lowest values were recorded by goat manure in 9 and 12 months. Significant difference was observed in number of tubers/plant, tuber length and tuber girth in 9 months. However, no significant difference was observed in single root weight/plant and biomass production in 9 months. The 10 t/ha poultry manure also recorded the highest values in tuber girth and was significantly different from 10 t/ha goat manure and the control treatment. Significant differences were observed in tuber girth, single root weight/plant and biomass production in 12 months. 10 t/ha poultry manure recorded the highest value in tuber girth, though this was not significantly different from 10 t/ha pig, goat, cattle manures and NPK fertilizer treatment. This was also the trend in single root weight/plant at 12 months. The mean biomass production for the different source of manures and NPK fertilizer treatment are in order: poultry > pig > NPK > control > goat > cattle.

Table 4a: Effect of different sources of manure on yield of cassava (9 months)

Treatments (t/ha)	Number of tubers/ stand	Tuber length (cm)	Tuber girth (cm)	Single root weight /plant (kg)	Biomass Prod.(t/ha)	Tuber weight (t/ha)	Harvest index
0	9.00a	23.66b	12.23c	0.46	14.51	9.07	0.63
Poultry	7.00ab	32.16a	19.07a	0.45	20.91	13.07	0.63
Pig	8.66ab	31.33a	17.67ab	0.37	16.85	10.53	0.63
Goat	4.33b	32.00a	14.47bc	0.36	12.37	7.73	0.63
Cattle	6.66ab	26.33ab	17.33ab	0.42	12.80	8.00	0.63
NPK	9.00a	31.33a	17.27ab	0.37	16.43	10.27	0.63
				Ns	Ns	Ns	
S. E ±	1.85	3.12	1.86	0.05	3.85	2.41	

Values are means of triplicate readings

Means followed by different letters in the same column are significantly different (P < 0.05).

Ns – Not significant

Table 4b: Effect of different sources of manure on yield of cassava (12 months)

Treatments (t/ha)	Number of tubers/ stand	Tuber girth (cm)	Single root weight /plant (kg)	Biomass Prod.(t/ha)	Tuber weight (t/ha)	Harvest index
0	8.27	17.47b	0.56b	30.51ab	19.20b	0.63
Poultry	9.93	24.13a	1.41ab	44.80a	27.73a	0.62
Pig	10.33	23.30a	0.96ab	34.85ab	19.33b	0.56
Goat	9.00	20.20ab	1.75a	25.17b	15.73b	0.63
Cattle	8.27	22.83a	0.84ab	26.88b	16.80b	0.63
NPK	8.73	22.27ab	1.03ab	34.24ab	21.48ab	0.63
	Ns					
S. E ±	0.91	2.12	0.38	7.28	3.15	

Values are means of triplicate readings

Means followed by different letters in the same column are significantly different (P < 0.05).

Ns – Not significant

The poultry, goat and cattle manures at 10 t/ha and 200 kg/ha NPK fertilizer significantly increased cassava biomass, tuber girth and weight (yield). The increases in tuber yield relative to the control were 32, 22, 44, 24 and 40% for poultry, pig, goat, cattle and NPK respectively. Poultry manure gave the highest yield, and was superior to NPK fertilizer. Increase in growth and yield of cassava is attributable to release of nutrients such as N, P, K, Zn, Fe, Ca and Mg which are contained in the organic manures. These nutrients were available for crop uptake.

Relative Effect of Different Source of Manures on Leaf, Stem and Tuber Nutrient Contents.

Table 5 contains data on response of leaf, stem and tuber nutrient contents of cassava in relation to the different source of manures and NPK fertilizer treatment. Nutrient contents in the leaf, stem and tuber of cassava did not follow any consistent pattern (Table 5). Except in leaf P, significant differences were observed in all leaf nutrient contents. Highest leaf N was observed in 10 t/ha goat manure (0.76), though this was not significantly different from NPK fertilizer treatment (0.73). The lowest value was recorded in the control treatment (0.51). For leaf P though not significantly different, the control treatment recorded the highest value while the least was observed in 10 t/ha poultry manure.

NPK fertilizer treatment recorded the highest value (1.21) for leaf K while the lowest was in the pig manure. The values were significantly different relative to the control treatment. Leaf Fe were reduced in poultry manure and NPK fertilizer compared to other treatments, while leaf Zn increased with addition of cattle, pig manures and NPK fertilizer treatment compared to control. Cattle manure recorded the highest value in leaf Zn and this was significantly different from other manure sources and NPK fertilizer treatment. Leaf Ca was significantly different and cattle manure recorded the highest value (0.94) while the lowest was observed in NPK fertilizer treatment.

The 10 t/ha goat manure and NPK fertilizer treatments increased stem N compared to control and these were significantly different from other manurial sources. The lowest value was observed in 10 t/ha poultry manure. Stem P increased with the addition of 10 t/ha cattle manure though this was not significantly different from the control treatment. The 10 t/ha poultry manure recorded the lowest value (0.20%) but was not significantly different from 10 t/ha pig manure and NPK fertilizer treatment with 0.25% respectively. It is shown that stem K increased with the addition of 10 t/ha poultry manure and NPK fertilizer compared to the control treatment. The pig manure recorded the lowest value (1.01), though, this was not significantly different from 10 t/ha goat and cattle manures with values of 1.08 and 1.09 respectively. The 10 t/ha cattle manure significantly increased stem Ca compared to control treatment and other sources of manure. Source of manures and NPK fertilizer treatment reduced stem Mg compared to control treatment. The control treatment gave the highest value (0.71); though this was not significantly different from value recorded for 10 t/ha cattle manure (0.66). The lowest value was observed in 10 t/ha goat manure (0.53) but this was not significantly different from value for NPK fertilizer treatment. The 10 t/ha poultry manure increased stem Na which was significantly different from the value for control, NPK fertilizer treatment and other source of manures. The control had the lowest value (0.35) which was significantly different from values for 10 t/ha pig, goat, cattle manures and 200 kg/ha NPK fertilizer treatment. The 10 t/ha cattle manure increased stem Zn compared to sources of manures, control and NPK fertilizer treatment and its value was significantly different from other treatments. The control treatment gave the least value in stem Zn which was significantly different from the values for four sources of manures and NPK fertilizer treatment. Relative to other sources of manures and NPK fertilizer treatment, the control treatment gave the highest value for stem Fe and which was significantly higher than values for other treatments. The lowest value for stem Fe was observed in 200 kg/ha NPK fertilizer treatment.

Significant differences were observed in tuber Na, K, Ca, Mg, P, N, Zn and Fe. The 10 t/ha poultry manure gave the highest value (0.61) in tuber Na but was not significantly different from values for 10 t/ha goat and cattle manures. The 200 kg/ha NPK fertilizer treatment had the highest value in tuber K and was significantly different from the value for control and other sources of manures. The lowest value was observed in 10 t/ha cattle manure, except for control, poultry and goat manure treatments. Tuber Ca increased with addition of other sources of manure and NPK fertilizer treatment. The highest value was observed in 10 t/ha pig manure. Tuber Mg reduced with the addition of manures and NPK fertilizer treatment. The control treatment had the highest value in tuber Mg; however, this was not significantly different from values for 10 t/ha goat and cattle manures. The 10 t/ha pig manure had the lowest. Tuber P increased with addition of manures and NPK fertilizer treatment relative to control treatment. The 10 t/ha pig manure gave the highest value however; this was not significantly different from values for other manure sources and NPK fertilizer treatment. Except for goat manure treatment, there was no significant difference in tuber N contents of other manorial treatments and control. The control treatment gave the highest value, while the 10 t/ha goat manure had the lowest value. The 10 t/ha cattle manure had the highest value in tuber Zn and was significantly different from other manure sources, the control and NPK fertilizer treatment. The lowest value was observed in 10 t/ha goat manure. Tuber Fe increased with the addition of manure sources and NPK fertilizer treatment compared to the control. The highest value was observed in 10 t/ha cattle manure and this was significantly different from values for other manure sources, the control and NPK fertilizer treatment. The control gave the lowest value (87.67). Moreover, positive influence of these treatments might be due to slow and steady availability of nutrient throughout the crop period from organic manures. These treatments increased cassava root yield by about 31% compared to the control in 9 and 12 months respectively. The increase of cassava root yields in both harvests could also be attributed to the increase in the number of tubers per stand and single root weight per stand (Kogram *et al.,* 2002 and Evangeline *et al.*, 2002). The manures also increased biomass production by 31 and 32% in 9 and 12 months respectively compared to the control. Adequate biomass production, better nutrient uptake and improvement in yield parameters might have resulted in higher tuber yields consequent to application of manures. The harvest index (HI) in both months was not affected by the addition of manures probably due to the fact that the variety used is one of high yielding (Ikeorgu, 2000).

The amount of nutrient in the tuber, stem and leaf were quiet variable. Tuber N, P and K were low in 10 t/ha poultry manure compared to the control and other manures. The tuber generally accumulated more K than N, follow by Ca, Na, and P. Similar results were reported by Puttacharoen *et al.,* (1998) and Howeler (2002). Higher amount of

Zn was accumulated in the stem compared to the tuber while this was the opposite in the case of Fe. The amount of nutrients absorbed by the plant or that removed in the tuber harvest is highly dependent on growth rate and yield, which in turn depend on climate, soil fertility conditions and variety.

Table 5: Effect of manure on percent leaf, stem and tuber nutrient contents

Treatments (t/ha)	Na	K	Ca	Mg	P	N	Zn	Fe
Leaf								
0	0.26c	0.96c	0.85b	0.49b	0.36	0.51d	55.67d	96.33a
Poultry	0.43a	1.07b	0.76c	0.59a	0.32	0.68bc	59.67cd	87.33b
Pig	0.18d	0.89c	0.87b	0.49b	0.35	0.66c	65.00b	94.00a
Goat	0.28bc	0.98bc	0.66d	0.45bc	0.33	0.76a	57.00cd	95.00a
Cattle	0.27c	1.07b	0.94a	0.50b	0.34	0.63c	76.00a	95.00a
NPK	0.33b	1.21a	0.76c	0.40c	0.35 Ns	0.73ab	60.67c	67.67c
S.E $\pm$	0.02	0.4	0.03	0.03	0.03	0.02	1.84	2.15
Stem								
0	0.35b	1.13b	0.97b	0.71a	0.29ab	0.45b	65.67c	103.67a
Poultry	0.53a	1.34a	0.94b	0.46d	0.20c	0.42b	76.00b	96.33b
Pig	0.32b	1.01c	0.95b	0.64b	0.25bc	0.47b	74.33b	77.00c
Goat	0.39b	1.08bc	0.87c	0.53c	0.27b	0.56a	73.67b	71.00d
Cattle	0.37b	1.09bc	1.07a	0.66ab	0.32a	0.45b	84.67b	75.67cd
NPK	0.38b	1.31a	0.93c	0.56c	0.25bc	0.53a	74.33b	47.67e
S.E $\pm$	0.04	0.04	0.02	0.02	0.02	0.02	2.30	2.07
Tuber								
0	0.37c	1.36b	1.13c	0.48a	0.42b	0.39a	34.00bc	87.67e
Poultry	0.61a	1.39b	1.24b	0.38bc	0.44ab	0.32ab	32.33c	105.33c
Pig	0.47b	1.14d	1.42a	0.34c	0.48a	0.34ab	38.00b	105.67c
Goat	0.58a	1.42b	1.15c	0.42ab	0.43ab	0.28c	26.00d	115.33b
Cattle	0.55a	1.26c	1.38a	0.42ab	0.44ab	0.38ab	45.67a	124.67a
NPK	0.40bc	1.50a	1.36a	0.38bc	0.46ab	0.35ab	36.33bc	94.67d
S.E $\pm$	0.03	0.03	0.03	0.03	0.03	0.03	2.05	2.54

Means followed by different letters in the same column are significantly different ($P<0.05$)
Ns – Not significant

Chemical Analysis after Harvest

The effect of different source of manures and NPK fertilizer treatment on soil chemical analysis after harvest of cassava is shown in Table 6. Soil Na after harvest reduced in manures and NPK fertilizer treatments compared to the control. The control had the highest value though this was not significantly different from values for 10 t/ha poultry manure. 10 t/ha pig manure had the lowest value and was significantly different from values for other manure sources, NPK fertilizer and the control. Soil K increased with addition of pig, poultry and goat manures than the other treatments. The pig manure gave the highest value and was significantly different from other manure sources. The lowest value was observed in the control and 10 t/ha cattle manure. Manures and NPK fertilizer increased soil Ca after harvest except in 10 t/ha cattle manure. Among the different manures and NPK fertilizer, 200 kg/ha NPK fertilizer gave the optimal soil Mg which was similar to the values for 10 t/ha pig and goat manures. The lowest value was observed in 10 t/ha cattle manured soil. No significant difference was observed among the soil CEC (cmol/kg) and pH (H_20) after harvest. The 10 t/ha goat manure increased soil Av. P after harvest compared to control, however, this increase was not significantly different from that of 10 t/ha poultry manure and the control. The cattle, pig manures and NPK fertilizer gave similar values of soil Av. P after harvest. There was no significant difference in soil N after harvest. The same value (0.08) was observed in all manurial treatments, NPK fertilizer and the control. The pig manure recorded the lowest value in soil Zn after harvest and was significantly different from value for the control, other manurial treatments and NPK fertilizer treatment. The cattle manure had the highest values in soil C and organic matter respectively. Significant differences were observed in both soil C and organic matter, with values for 10 t/ha goat manure and the control significantly different from value for 10 t/ha cattle manure. The lowest values were observed in NPK fertilizer treatment and 10 t/ha pig manure with 0.79 for soil C and 1.37 for organic matter respectively. These were significantly different from values for poultry.

Table 6: Soil chemical analysis after harvest

Treatments	Na	K	Ca	Mg	H^+	CEC	pH	Av. P	Zn	C	N	OM
t/ha	←exchangeable cations (cmol/kg)→					← cmol/kg	→	(H_20)	mg/kg		← %	→
0	0.68a	0.28c	0.89bc	0.69c	0.12ab	2.67.	5.92	6.50ab	6.00a	0.82c	0.08a	1.41c
Poultry	0.66ab	0.33b	0.96ab	0.73bc	0.11b	2. 80	6.12	6.98a	6.01a	0.80d	0.08a	1.38d
Pig	0.48d	0.36a	0.98a	0.78ab	0.12ab	2.73	5.82	6.02b	5.02b	0.79e	0.08a	1.37e
Goat	0.56c	0.31b	0.99a	0.79ab	0.13a	2.79	5.62	7.00a	5.97a	0.83b	0.08a	1.43b
Cattle	0.63b	0.28c	0.86c	0.68c	0.12ab	2.58	5.92	6.01b	5.92a	0.88a	0.09a	1.52a
NPK	0.49d	0.29c	0.92abc	0.82a	0.11b	2.64	6.02	6.10b	5.95a	0.79e	0.08a	1.37e
							Ns	Ns				Ns
S.E ±	0.004	0.003	0.004	0.002	0.002	0.004	0.008	0.018	0.015	0.019	0.003	0.003

Values are means of triplicate readings
Means followed by different lowercase letters in the same column are significantly different ($P < 0.05$)
Ns - Not significant.

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