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Effects of Poultry Manure on Some Soil Chemical Properties and Nutrient Bioavailability to Soybean

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Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

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ABSTRACT

Organic manures are known to be rich sources of both macro and micro nutrients of the crop. They also help in improving the physical status of the soil. Pot experiments were carried out to determine the effects of poultry manure on some soil chemical properties pH, organic C, available P, exchangeable Ca, Mg, K, Na, and Effective Cation Exchange Capacity i.e. ECEC) and dry matter yields, plant heights, concentrations of N, P and K in plant tissues of soybean plants. Five soil samples collected from research farms in Federal University of Agriculture, Abeokuta (FUNAAB), Odeda, Ayetoro, Ibadan, Ikenne in South Western Nigeria, were used for the screen house pot experiment. Treatments consisted of five rates of poultry manure (0, 2.5, 5.0, 7.5 and 10 t ha^{-1}) and 100 kg ha^{-1} of NPK 20:10:10 fertilizer as basal application. The pot experiments were conducted at the Research Farm of FUNAAB. Experimental design was Completely Randomised Design (CRD) with three replicate. Soybean (TGx 1448-2E) was grown for three consecutive cycles of seven weeks per cycle and both soil and plant samples were collected and analysed. Application of

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poultry manure significantly increased organic carbon, exchangeable bases and effective cation exchange capacity in the soils, concentrations of N, P and K in plant tissue. The study concluded that application of poultry manure increased available nutrients, increased nutrient uptake and improved dry matter yield in soybean.

Keywords: Poultry manure; soil nutrients; soybean; tissue nutrient concentrations.

1. INTRODUCTION

The suitability of organic manures in improving crop production has been well reported [1,2,3]. Continuous use of only the inorganic fertilizers for increasing soil nutrients is usually accompanied on the long term by reduction in soil organic matter, increase in soil acidity, leaching losses, erosion, and degradation of soil physical properties [4,5]. Amendment by the use organic manures is considered less likely to have detrimental effect on soil physico-chemical properties compared with mineral fertilizers [6]. Therefore, organic amendment is appropriate for soil, crop growth, environment, and economic improvements.

Studies have shown that the application of manure has positive effects on the physical and chemical properties of soil mainly due to increase in organic matter [7,8,9]. The important roles of organic matter include being a rich source of essential plant nutrients [10], helps in improving moisture holding capacity of the soil, improves soil structure, soil aeration, water permeability, acts as pH buffer, contains metal-organic matter complexes that help in making available micro nutrients to crop [11,12,13]. Nutrient availability to crop is affected by soil physical, chemical and biological properties and these are also influenced by the environmental factors. These properties include soil pH, organic matter content, soil texture, soil water content, nutrient interactions, temperature, and microbial activities [14,15]. Many series of reactions and activities, including decomposition, mineralisation, humification, adsorption, desorption, precipitation, immobilization, ligand exchange, leaching, dissolution, diffusion and fixation, could be triggered within the soil environment by addition of organic manure such as poultry manure [16,17]. These inevitably lead to changes in soil physical and chemical properties and resultant effects on the growth of crops.

Soya bean is among the major industrial and food crops grown on every continent. Soybean cultivation in Nigeria has expanded as a result of its nutritive and economic importance and diverse domestic usage. Soybean has an average protein content of 40% and is more protein-rich than any of the common vegetable or animal food sources found in Nigeria. Soybean seeds also contain about 20% oil on a dry matter basis, and this is 85% unsaturated and cholesterol-free [18].

The objective of this work is to study the effects of organic amendment on soil chemical properties, nutrient availability and growth of soybean.

2. MATERIALS AND METHODS

The study involved laboratory and screen house pot experiments.

2.1 Laboratory Experiments

The laboratory experiments consisted of soil physical and chemical analyses and incubation experiment. Surface soil samples (0-20 cm depth) were collected from five different locations: Abeokuta, Odeda, Ayetoro, Ibadan and Ikenne. The soil samples from each of these locations were bulked, air dried, and sieved using a 2 mm sieve. Each of these soils was used for laboratory physical and chemical analysis and incubation studies

2.1.1 Soil physical and chemical analysis

Particle size distribution was determined by the hydrometer method [19]. Soil pH was determined in 1:1 (soil-water ratio) using electrode pH meter [20]. Nitrogen was determined by Kjeldahl method [20]. Organic matter was determined by the wet digestion method by Walkley and Black [21]. Exchangeable sodium, potassium, calcium and magnesium in the soils were extracted with neutral ammonium acetate (1M NH_4OAC). Extracted K and Na were determined by flame photometry while Ca and Mg were determined by atomic absorption spectrophotometry [22]. Available phosphorus was determined by Bray 1 P extraction method and analysed colorimetrically by molybdenum blue procedure [23]. Soil exchangeable acidity (EA) was determined by titration of normal KCl extracted acidity against 0.05 N sodium hydroxide solution [24]. Effective cation exchange capacity was determined by summation of exchangeable cations and exchangeable acidity.

2.1.2 Locations of soils used

The five soils are Alfisols collected from different locations. The soils locations in longitude and latitude included Abeokuta (N 7° 14.30ˡ, E 3° 26.21 ˡ); Odeda (N 7° 14.17ˡ, E 3° 31.79ˡ); Ayetoro (N 7° 15.00ˡ, E 3° 30.00ˡ); Ibadan (N 7° 30.17ˡ, E 3° 54.50ˡ) and Ikenne (N 6° 50.95ˡ, E 3° 42.57ˡ)

2.2 Pot Experiments

The pot experiments were carried out at research farm of Federal University of Agriculture, Abeokuta. Soil samples from five locations were used for the experiment. These included soil samples taken from experimental farms in Abeokuta, Odeda, Ayetoro, Ibadan and Ikenne. Five kilogrammes of soil samples already air-dried and sieved through 2 mm sieve was weighed into each pot. Each pot was taken as an experimental unit. The treatments consisted of five rates of poultry manure at 0, 2.5, 5, 7.5 and 10 t ha^{-1} in three replicates and 100 kg ha^{-1} of NPK 20:10:10 fertilizer as basal application for all treatments. This is equivalent of 0, 5.7, 11.4, 17.1, and 22.8 g of PM per pot and 0.23 g of NPK 20:10:10 fertilizer per pot. The experimental design was completely randomised block design. The poultry manure was incorporated into the soil two weeks before sowing of soya bean seeds. The NPK 20:10:10 was applied 1 week after germination of soya beans. The variety of soya beans used was TGx 1448-2E. Three seeds of soya beans were planted per pot, but were thinned to 2 seedlings two weeks after germination. The soya bean plants were grown for 3 cycles at 7 weeks per cycle. Plant height and dry matter yield were determined in each cycle.

Soil samples were taken, air-dried and analysed for soil pH, available P, exchangeable bases, effective cation exchange capacity and organic C. The soil analysis was done after 7 weeks (after first cycle), at another 7 weeks (after second cycle), and at the end of the third cycle.

Plant samples were taken and analysed at the end of each cycle to determine the plant nutrients concentrations. Plant shoots were oven dried at 65℃ for 48 hours to constant weight and dry matter yield was determined. Plant samples were ground with electric grinder with stainless steel grinding chamber. Total nitrogen in the sample was determined colorimetrically after Kjeldahl digestion. For P and K determination, the plant samples were ashed in a muffle furnace at a temperature of 450℃. The nutrients in the ash were extracted by washing with 0.1 N HCl. Phosphorus was determined colorimetrically by the vanadomolybdate method [25]. Potassium was determined by flame photometry.

2.3 Poultry Manure Analysis

Total analysis was done by wet digestion. This involved addition of 10 ml of HNO_3 /$HClO_4$ (2:1) to 0.5 g of poultry manure and digested at 150℃. After heating for 90 minutes the temperature was increased to 230℃ and 2 ml of HCl/H_2O (1:1) was added. The digestion was allowed to continue for 30 minutes [26].The results are shown in Table 1.

2.3.1 Chemical composition of poultry manure

The chemical composition of poultry manure used is shown in Table 1.

The data collected were subjected to analysis of variance (ANOVA) using GENSTAT. Means were separated by Least Significant Difference.

Table 1. Some chemical properties of the poultry manure used

Parameter	Value	Parameter	Value
Nitrogen	23.6 g kg^{-1}	Iron	7.0 g kg^{-1}
Phosphorus	14.9 g kg^{-1}	Sulphur	5.7 g kg^{-1}
Potassium	14.2 g kg^{-1}	Zinc	53.50 mg kg^{-1}
Calcium	4.3 g kg^{-1}	Organic carbon	128.4 g kg^{-1}
Magnesium	1.8 g kg^{-1}	C : N	5.44

3. RESULTS AND DISCUSSION

3.1 Some Initial Physico-chemical Properties of Soils Used

The initial physico-chemical properties of soils used before application of manure treatment are shown in Table 2. Five of the soils were loamy sand, four soils were sandy and one was sandy loam. The values of pH ranged from 6.1 to 6.3.

Organic carbon ranged from 8.8 to 48.0 g kg^{-1}. Available P was highest in Ayetoro soil (26.99 mg kg^{-1}) and least in Odeda soil (9.85 mg kg^{-1}). Generally, the cations order of abundance was: Ca > Mg > K > Na, except in Odeda where it was in order of Mg > Ca > K > Na. The values of ECEC ranged from 2.42 cmol kg^{-1} (in Odeda soil sample) to 5.40 cmol kg^{-1} (in Ayetoro soil sample).

3.2 Results of Pot Experiments

3.2.1 Effects of poultry manure on soil pH, available phosphorus and soil organic carbon

Table 3 shows the effects of poultry manure application on soil pH, available P and organic C. All the soils in the pot experiments resulted in significant increase in pH except for second cycle of Ibadan soil. In the Abeokuta soil, there was relative increase in pH of treated soils in second cycle compared to the first cycle. However, there was decline in pH in third cycle compared to the second cycle. The highest pH in the third cycle was 7.17, obtained at treatment rate of 10 t ha^{-1}. There was significant increase in pH in the treated soils of Ikenne compared to the control in the three cycles. Highest pH values in the first and third cycles were 6.92 and 6.88 respectively. Increase in pH was a result of release of cations by the organic matter due to mineralization. Soybean can be grown in soils with a wide range of pH from 4.5 to 8.5 [18]. Nitrogen fixing bacteria do not function effectively under very low pH condition. Organic manure is known to have liming effect on the soil [27]. Decrease in exchangeable Al in soil following poultry manure addition has been observed [28]. The reduction in soil pH in second and third cycles could be attributed to uptake of exchangeable cations by soybean plants, leaching, and decomposition of organic matter and increase in Al ions [29].

Poultry manure application significantly increased available P in all the soils except in first cycle in Ayetoro soil experiment. There were relative increases in available P from the first cycle to the third cycle. In Ayetoro soil, poultry manure at 10 t ha^{-1} gave the highest value of 63.01 mg kg^{-1} of Bray 1 P in the third cycle while in Odeda soil pot experiment, highest values of available P were obtained at 10 t ha^{-1} of the three cycles. Increase in availability of P was attributed to the mineralization of organic P in poultry manure.

Values of organic C were significantly different in the three cycles of the Abeokuta soil pot experiments. There was slight increase in organic C in the second cycle in both the control and treated soils. Slight decrease was observed in the third cycle compared to the second cycle. For Odeda soil, there was significant increase in the organic C in treated soils compared to the control in the three cycles. In the third cycle highest value of 9.4 g kg^{-1} was obtained at 10 t ha^{-1}. However in Ayetoro soil, organic C values were also significantly different in the three cycles. In the first cycle, the highest organic C of 20.5 g kg^{-1} was observed at treatment rate of 10 t ha^{-1}. In the third cycle, highest organic C of 18.2 g kg^{-1} was observed at treatment of 2.5 t ha^{-1}.

Organic carbon increased in pot experiments following organic manure application since the organic manure is a rich source of organic carbon. However, decrease in soil organic carbon in the second and third cycles could be due to its use during microbial activities [30, 31].

3.3 Effects of Poultry Manure on Exchangeable Calcium, Magnesium and Potassium

Table 4 shows the effect of poultry manure on exchangeable Ca, Mg and K. There was significant increase in the amount of exchangeable Ca in the soils following the application of manure. In Abeokuta soil pot experiment, the highest value of 3.90 cmol kg^{-1} was obtained at 10 t ha^{-1} of the first cycle while the control had the least in the three cycles.

In the first cycle, poultry manure increased the concentrations of Ca, Mg and K in all the treated soils compared to the control. Treatment did not have significant effects on exchangeable Mg in the second cycles of Odeda, Ayetoro, and Ikenne soil pot experiments, and third cycle of Ibadan pot experiment. Also, values of K in third cycle of Ikenne soil were not significantly different. Generally, there was a relative decrease in the exchangeable Mg in the third cycle compared to the first cycle in all the soils. Treated pots had higher exchangeable K than control in all the soils in the first, second and third cycles except in Ikenne pot experiment in the third cycle where it was not significant. Poultry manure is a rich source of exchangeable cations. Their reduction could be attributed to their uptake by the crop.

Table 2. Some initial physico-chemical properties of the soils used in this study

Soil location	Sand g kg^{-1}	Silt g kg^{-1}	Clay g kg^{-1}	Textural Class	pH ($H_2$0)	Organic C (g kg^{-1})	Available P (mg kg^{-1})	N g kg^{-1}	Ca	Mg	K	Na	E A	ECEC
									cmol kg^{-1}					
Abeokuta	772.0	88.0	140.0	LS	6.3	29.0	12.7	1.7	1.88	1.25	0.34	0.29	0.10	3.86
Odeda	912.0	28.0	60.0	S	6.1	24.0	9.8	1.6	0.80	1.21	0.17	0.13	0.11	2.42
Ayetoro	872.0	48.0	80.0	S	6.2	40.8	27.0	3.3	3.25	1.32	0.43	0.30	0.10	5.40
Ibadan	852.0	68.0	80.0	LS	6.3	8.8	17.5	1.0	1.13	1.19	0.28	0.17	0.09	2.86
Ikenne	772.0	88.0	14.00	LS	6.2	26.4	10.6	2.3	1.25	1.20	0.28	0.16	0.10	2.99

LS - Loamy sand
S - Sandy

Table 3. Effects of poultry manure on soil pH, available P and organic C in different soils of pot experiments

	Manure rate	Soil pH					Available P (mg kg-^{1})					Organic C (g kg^{-1})				
	(t ha^{-1})	Abeokuta	Odeda	Ayetoro	Ibadan	Ikenne	Abeokuta	Odeda	Ayetoro	Ibadan	Ikenne	Abeokuta	Odeda	Ayetoro	Ibadan	Ikenne
	0	6.50 b	6.18 c	6.39 c	6.81 e	6.39 c	14.87 b	12.55 d	19.07 a	34.36 b	13.42 b	6.5 d	6.0 c	14.5 c	4.3 c	5.4 d
First cycle	2.5	6.82 ab	6.36 c	6.96 a	6.93 d	6.74 b	19.28 ab	19.90 c	20.36 a	38.02 b	20.36 b	7.9 c	7.1 bc	16.7 b	4.9 bc	6.0 d
	5	7.06 a	6.61 b	6.78 b	7.02 c	6.88 a	21.73 a	26.80 b	19.28 a	36.65 b	36.65 a	10.2 b	8.7 ab	19.3 a	5.9 a	7.5 b
	7.5	7.01 a	6.76 ab	6.94 a	7.31 a	6.87 a	23.27 a	31.59 b	19.74 a	42.17 ab	42.55 a	10.5 b	7.5 bc	14.9 a	4.5 c	6.8 c
	10	6.92 ab	6.91 a	6.69 b	7.13 b	6.92 a	23.31 a	42.12 a	26.18 a	48.03 a	39.68 a	13.5 a	9.5 a	20.5 a	5.3 ab	9.6 a
	0	6.55 d	6.21 c	6.30 c	6.88 a	6.41 c	20.44 b	25.28 b	28.53 c	45.07 c	30.82 c	6.9 c	5.4 b	14.9 c	3.9 a	5.2 c
Second cycle	2.5	7.04 c	6.93 ab	6.45 bc	6.86 a	6.64 b	50.71 a	54.13 a	38.26 bc	86.39 a	65.23 b	11.2 ab	8.0 a	26.8 a	4.3 b	6.2 bc
	5	7.17 b	6.87 b	6.55 abc	6.92 a	6.74 ab	55.32 a	57.97 a	32.07 bc	72.32 b	73.08 ab	10.6 ab	8.5 a	25.1 b	6.1 a	6.8 b
	7.5	7.05 c	6.99 b	6.67 ab	6.97 a	6.88 a	54.46 a	56.82 a	46.85 ab	76.61 ab	82.23 a	11.4 a	9.2 a	26.9 a	6.5 a	9.2 a
	10	7.44 a	7.02 a	6.76 a	7.05 a	6.81 a	58.12 a	59.17 a	55.26 a	89.42 a	85.63 a	9.9 b	8.6 a	23.7 b	5.6 a	6.9 b
	0	6.48 e	6.15 d	6.26 d	6.80 bc	6.32 d	25.56 b	23.16 b	35.81 b	50.24 d	24.75 b	5.9 c	6.3 c	13.9 b	4.1 a	3.7 b
Third cycle	2.5	6.80 d	6.37 cd	6.36 cd	6.80 bc	6.50 c	53.82 a	48.73 a	35.04 b	63.59 c	58.20 a	9.1 a	7.1 bc	18.2 a	4.3 a	4.5 b
	5	6.90 c	6.57 bc	6.46 bc	6.75 c	6.88 a	60.76 a	61.15 a	37.71 b	82.10 ab	56.42 a	9.2 a	7.2 bc	17.8 a	2.9 a	4.0 b
	7.5	6.98 b	6.82 ab	6.57 ab	6.82 b	6.77 b	63.83 a	54.94 a	44.35 ab	85.05 a	58.43 a	7.4 b	8.1 b	17.5 a	4.0 a	7.2 a
	10	7.17 a	7.02 a	6.71 a	7.03 a	6.87 a	58.13 a	64.14 a	63.01 a	75.26 b	51.64 a	9.3 a	9.4 a	17.6 a	3.0 a	7.8 a

Means in a column followed by the same letters are not significantly different at 5 % probability level according to LSD

Table 4. Effects of poultry manure on soil exchangeable Ca, Mg and K in different soils of pot experiments

Cycle	Manure rate	Exchangeable Ca (cmol kg^{-1})					Exchangeable Mg (cmol kg^{-1})					Exchangeable K (cmol kg^{-1})				
	(t ha^{-1})	Abeokuta	Odeda	Ayetoro	Ibadan	Ikenne	Abeokuta	Odeda	Ayetoro	Ibadan	Ikenne	Abeokuta	Odeda	Ayetoro	Ibadan	Ikenne
	0	1.80 d	0.75 d	3.20 e	1.13 d	1.15 b	1.05 c	1.14 c	1.26 c	1.17 b	1.10 d	0.28 c	0.10 c	0.38 d	0.25 d	0.22 d
First	2.5	3.32 c	1.20 c	4.01 d	2.25 b	2.13 a	1.98 b	1.42 bc	2.49 b	1.46 ab	1.25 c	0.39 c	0.25 b	0.54 c	0.33 cd	0.32 c
cycle	5	3.58 b	2.03 b	4.37 c	2.40 ab	2.17 a	2.03 ab	1.55 ab	2.84 b	1.53 a	1.32 c	0.61 b	0.47 a	0.72 b	0.37 c	0.28 cd
	7.5	3.87 a	2.36 a	4.70 b	1.80 c	2.15 a	2.23 a	1.69 ab	3.67 a	1.48 ab	1.68 a	0.81 a	0.42 a	0.94 a	0.55 b	0.63 a
	10	3.90 a	2.44 a	4.99 a	2.54 a	2.19 a	2.22 ab	1.77 a	3.82 a	1.55 a	1.49 b	0.76 a	0.47 a	0.82 b	0.71 a	0.54 b
	0	1.27 c	0.77 d	2.12 b	1.06 b	1.23 c	1.12 ab	0.81 a	1.25 a	0.67 b	0.64 a	0.28 d	0.11 d	0.30 c	0.23 b	0.20 c
Second	2.5	3.16 a	1.73 c	3.14 a	1.31 a	1.77 ab	1.01 b	0.74 a	1.31 a	0.78 ab	0.61 a	0.30 cd	0.19 b	0.45 b	0.22 b	0.21 c
cycle	5	3.02 a	2.97 a	2.87 a	1.32 a	1.44 bc	1.16 ab	0.76 a	1.33 a	0.51 c	0.66 a	0.35 bc	0.22 a	0.47 b	0.21 b	0.23 bc
	7.5	3.07 a	2.44 b	2.85 a	1.35 a	2.01 a	1.21 a	0.72 a	1.28 a	0.85 a	0.68 a	0.37 b	0.20 ab	0.51 ab	0.24 b	0.25 b
	10	2.45 b	2.49 b	2.72 a	1.42 a	1.78 ab	0.92 c	0.69 a	1.21 a	0.66 bc	0.67 a	0.45 a	0.16 c	0.56 a	0.30 a	0.31 a
	0	1.19 d	0.70 d	1.82 c	0.95 b	1.19 b	0.77 b	0.55 b	1.15 b	0.42 a	0.46 c	0.23 b	0.08 c	0.28 c	0.14 b	0.14 a
Third	2.5	1.91 c	1.63 bc	3.28 a	1.22 a	1.27 ab	0.81 b	0.48 bc	1.29 ab	0.47 a	0.56 bc	0.25 b	0.16 ab	0.35 abc	0.14 b	0.13 a
cycle	5	3.21 a	2.05 ab	2.79 b	1.17 a	1.30 ab	0.79 b	0.39 cd	1.46 a	0.48 a	0.52 c	0.21 b	0.15 b	0.36 ab	0.17 b	0.19 a
	7.5	2.54 b	1.35 c	2.72 b	1.31 a	1.35 ab	0.76 b	0.33 d	1.18 b	0.51 a	0.74 a	0.30 a	0.18 a	0.33 bc	0.16 b	0.14 a
	10	3.43 a	2.48 a	3.32 a	1.27 a	1.38 a	0.94 a	0.75 a	1.16 b	0.41 a	0.69 ab	0.23 b	0.15 ab	0.40 a	0.23 a	0.19 a

Means in a column followed by the same letters are not significantly different at 5 % probability level according to LSD

Table 5. Effects of poultry manure on soil exchangeable Na, EA, and ECEC in different soils of pot experiments

Cycle	Manure rate	Exchangeable Na (cmol kg^{-1})					EA (cmol kg^{-1})					ECEC (cmol kg^{-1})				
	(t ha^{-1})	Abeokuta	Odeda	Ayetoro	Ibadan	Ikenne	Abeokuta	Odeda	Ayetoro	Ibadan	Ikenne	Abeokuta	Odeda	Ayetoro	Ibadan	Ikenne
	0	0.21 c	0.11 d	0.25 c	0.15 b	0.15 c	0.03 ab	0.05 a	0.02 b	0.03 ab	0.03 a	3.37 d	2.15 e	5.11 d	2.73 c	2.65 c
First	2.5	0.30 bc	0.23 b	0.31 bc	0.26 ab	0.28 b	0.03 ab	0.03 bc	0.02 b	0.04 a	0.02 b	6.02 c	3.13 d	7.37 c	4.34 b	4.00 b
cycle	5	0.35 b	0.18 c	0.28 bc	0.24 ab	0.26 b	0.02 b	0.04 ab	0.02 b	0.02 bc	0.01 c	6.59 b	4.27 c	8.23 b	4.56 ab	4.04 b
	7.5	0.57 a	0.21 bc	0.39 ab	0.27 ab	0.31 b	0.03 ab	0.02 c	0.02 b	0.01 bc	0.01 c	7.51 a	4.70 b	9.72 a	4.11 b	4.78 a
	10	0.33 b	0.27 a	0.46 a	0.32 a	0.41 a	0.03 ab	0.03 bc	0.03 a	0.02 bc	0.01 c	7.24 a	4.98 a	10.12 a	5.14 a	4.64 a
	0	0.19 c	0.12 a	0.22 ab	0.10 b	0.13 b	0.09 b	0.10 a	0.09 a	0.08 a	0.07 b	2.95 d	1.91 d	3.98 b	2.14 b	2.27 d
Second	2.5	0.22 bc	0.14 a	0.22 ab	0.16 a	0.16 ab	0.08 b	0.07 bc	0.07 a	0.10 a	0.09 ab	4.77 b	2.87 c	5.19 a	2.57 a	2.84 bc
cycle	5	0.26 ab	0.13 a	0.18 b	0.14 ab	0.20 ab	0.12 a	0.06 c	0.11 a	0.10 a	0.11 ab	4.91 ab	4.14 a	4.96 a	2.28 a	2.64 c
	7.5	0.25 ab	0.16 a	0.23 ab	0.15 a	0.22 a	0.11 a	0.08 b	0.06 a	0.09 a	0.10 ab	5.01 a	3.60 b	4.93 a	2.68 a	3.26 a
	10	0.29 a	0.15 a	0.29 a	0.17 a	0.23 a	0.09 b	0.08 b	0.08 a	0.07 a	0.13 a	4.20 c	3.57 b	4.86 a	2.62 a	3.12 ab
	0	0.17 b	0.11 a	0.19 b	0.10 a	0.11 b	0.11 a	0.13 a	0.09 b	0.10 a	0.10 bc	2.47 e	1.57 d	3.53 c	1.71 b	2.00 b
Third	2.5	0.20 ab	0.14 a	0.20 ab	0.11 a	0.10 b	0.07 c	0.10 c	0.10 ab	0.11 a	0.09 c	3.24 d	2.51 bc	5.22 a	2.05 a	2.15 b
cycle	5	0.15 b	0.14 a	0.21 ab	0.14 a	0.16 a	0.10 ab	0.13 a	0.13 a	0.09 a	0.13 ab	4.46 b	2.86 b	4.95 a	2.06 a	2.30 ab
	7.5	0.18 b	0.13 a	0.20 ab	0.12 a	0.11 b	0.09 abc	0.10 bc	0.09 b	0.08 a	0.12 abc	3.87 c	2.09 c	4.52 b	2.18 a	2.46 a
	10	0.25 a	0.12 a	0.25 a	0.12 a	0.15 a	0.08 bc	0.12 ab	0.08 b	0.12 a	0.13 a	4.93 a	3.62 a	5.21 a	2.14 a	2.54 a

Means in a column followed by the same letters are not significantly different at 5 % probability level according to LSD

Table 6. Effects of poultry manure on dry matter yield and plant height in different soils of pot experiments

Cycle	Manure rate (t ha^{-1})	Dry matter yield (g plant^{-1})					Plant height (cm)				
		Abeokuta	Odeda	Ayetoro	Ibadan	Ikenne	Abeokuta	Odeda	Ayetoro	Ibadan	Ikenne
First cycle	0	2.08 a	1.74 a	2.45 b	2.52 a	1.96 a	31.00 b	37.67 b	37.33 b	39.33 ab	34.33 a
	2.5	2.17 a	1.81 a	4.42 ab	2.27 a	1.98 a	32.17 b	37.17 b	43.17 b	37.83 b	37.67 a
	5	2.37 a	1.53 a	6.17 a	3.24 a	2.05 a	40.67 a	38.67 ab	53.00 a	38.50 b	34.67 a
	7.5	2.79 a	2.05 a	4.98 ab	2.65 a	2.87 a	41.67 a	37.67 b	42.50 b	40.67 b	35.00 a
	10	2.87 a	2.45 a	5.16 a	3.00 a	2.77 a	44.83 a	39.83 a	46.00 ab	44.83 a	35.67 a
Second cycle	0	5.75 a	2.60 b	10.16 a	5.78 a	3.11 c	46.67 a	40.00 b	43.67 a	45.87 ab	36.33 a
	2.5	7.29 a	4.34 ab	10.70 a	5.85 a	4.47 bc	47.20 a	46.00 ab	43.13 a	45.00 ab	33.00 a
	5	6.61 a	3.80 ab	11.71 a	4.43 a	5.75 b	47.60 a	45.13 ab	46.60 a	39.67 b	39.33 a
	7.5	6.48 a	4.64 ab	12.97 a	8.30 a	5.23 bc	43.67 a	48.90 a	46.57 a	53.00 a	45.67 a
	10	8.26 a	5.11 a	12.23 a	8.06 a	8.32 a	44.33 a	42.17 b	46.90 a	53.10 a	44.43 a
Third cycle	0	6.12 c	3.87 c	8.69 b	5.90 b	6.93 a	55.67 b	46.83 b	51.67 c	56.27 a	44.93 c
	2.5	9.20 bc	6.32 b	9.22 b	7.13 ab	6.21 a	62.17 ab	54.47 ab	60.30 bc	52.60 a	50.67 b
	5	8.88 bc	6.99 b	11.32 ab	7.78 ab	7.06 a	56.83 b	59.07 a	66.83 ab	55.90 a	57.33 a
	7.5	9.64 ab	9.45 a	13.71 a	8.40 a	9.02 a	66.40 a	60.73 a	71.83 a	56.83 a	60.33 a
	10	12.78 a	9.60 a	14.21 a	8.34 a	8.85 a	57.83 ab	60.80 a	68.70 ab	60.27 a	56.90 a

Means in a column followed by the same letters are not significantly different at 5 % probability level according to LSD

Table 7. Effects of poultry manure on concentrations of N and P in plant tissues in different soils of pot experiments

Cycle	Manure rate (t ha^{-1})	Tissue concentration of N (%)					Tissue concentration of P (%)					Tissue concentration of K (%)				
		Abeokuta	Odeda	Ayetoro	Ibadan	Ikenne	Abeokuta	Odeda	Ayetoro	Ibadan	Ikenne	Abeokuta	Odeda	Ayetoro	Ibadan	Ikenne
First cycle	0	0.17 c	0.25 e	0.47 c	0.86 c	0.62 c	0.12 ab	0.07 cd	0.06 d	0.06 b	0.06 b	0.12 ab	0.07 cd	0.06 d	0.06 b	0.06 b
	2.5	0.21 c	0.83 d	0.67 c	1.17 b	0.79 bc	0.10 b	0.03 d	0.11 cd	0.10 ab	0.06 b	0.10 b	0.03 d	0.11 cd	0.10 ab	0.06 b
	5	1.83 b	1.26 c	3.08 a	1.09 b	0.87 ab	0.12 ab	0.10 bc	0.19 bc	0.07 ab	0.09 a	0.12 ab	0.10 bc	0.19 bc	0.07 ab	0.09 a
	7.5	1.79 b	1.74 a	2.80 a	1.15 b	1.02 a	0.18 a	0.14 b	0.27 a	0.11 a	0.10 a	0.18 a	0.14 b	0.27 a	0.11 a	0.10 a
	10	2.90 a	1.48 b	1.39 b	3.03 a	0.92 ab	0.16 ab	0.37 a	0.23 ab	0.09 ab	0.07 b	0.16 ab	0.37 a	0.23 ab	0.09 ab	0.07 b
Second cycle	0	0.20 e	0.34 d	0.77 b	0.92 c	0.94 d	0.09 d	0.05 c	0.07 d	0.09 a	0.07 d	0.09 d	0.05 c	0.07 d	0.09 a	0.07 d
	2.5	1.22 d	0.95 c	0.81 b	1.25 b	1.08 cd	0.08 d	0.11 bc	0.16 c	0.08 b	0.10 cd	0.08 d	0.11 bc	0.16 c	0.08 b	0.10 cd
	5	1.82 c	1.56 b	0.87 b	1.27 b	1.19 bc	0.18 c	0.08 c	0.30 b	0.07 b	0.12 bc	0.18 c	0.08 c	0.30 b	0.07 b	0.12 bc
	7.5	2.46 b	1.48 b	1.51 a	1.31 b	1.33 ab	0.31 a	0.19 b	0.41 a	0.12 ab	0.16 a	0.31 a	0.19 b	0.41 a	0.12 ab	0.16 a
	10	2.96 a	1.97 a	1.43 a	2.03 a	1.38 a	0.25 b	0.46 a	0.38 a	0.15 a	0.14 ab	0.25 b	0.46 a	0.38 a	0.15 a	0.14 ab
Third cycle	0	0.46 e	0.55 e	1.05 c	0.79 e	0.78 c	0.14 c	0.03 c	0.11 d	0.05 d	0.05 d	0.14 c	0.03 c	0.11 d	0.05 d	0.05 d
	2.5	1.65 d	0.87 d	0.93 c	1.15 d	0.86 c	0.17 bc	0.12 b	0.14 d	0.19 bc	0.12 c	0.17 bc	0.12 b	0.14 d	0.19 bc	0.12 c
	5	2.39 c	1.59 c	2.70 b	1.45 c	1.23 b	0.27 b	0.13 b	0.26 c	0.16 c	0.13 c	0.27 b	0.13 b	0.26 c	0.16 c	0.13 c
	7.5	2.62 b	2.56 a	3.30 a	1.96 b	2.16 a	0.24 bc	0.16 b	0.36 b	0.24 b	0.23 b	0.24 bc	0.16 b	0.36 b	0.24 b	0.23 b
	10	3.46 a	1.80 a	3.39 a	2.19 a	2.28 a	0.39 a	0.23 a	0.45 a	0.34 a	0.36 a	0.39 a	0.23 a	0.45 a	0.34 a	0.36 a

Means in a column followed by the same letters are not significantly different at 5 % probability level according to LSD

3.4 Effects of Poultry Manure on Soil Exchangeable Sodium, Exchangeable Acidity and Effective Cation Exchange Capacity

Table 5 shows the effects of poultry manure on exchangeable Na, EA and ECEC. In most of the soils there was relative decline in values of Na and ECEC from first to third cycle. Application of poultry manure had significant effect on soil Na in all the pots except in Odeda soil in second and third cycles; and Ibadan soil in the third cycle. Treatment had significant effects on values of EA in all the pots except in second cycle of Ayetoro, Ibadan pot experiments and third cycle of Ibadan soil. Poultry application had significant effects on ECEC in all the pots of all the cycles. Most of the soil had the highest values of Na and ECEC at 7.5 and 10 t ha^{-1} and lowest values at 0 t ha^{-1}. In Ibadan soil highest ECEC in first, second and third cycles were 5.14, 2.62, and 2.14cmol kg^{-1} respectively. Highest value of ECEC (10.12 cmol kg^{-1}) was observed in the first cycle of Ayetoro pot experiment Increase in the exchangeable cations (Ca, Mg, Na and K) and ECEC in the first cycle of pot experiment is attributed to their release from the organic manure rich in these nutrients. Organic matter is known to have negatively charged sites for these positively charged cations to be adsorbed. These negative charges attract positively charged cations by electrostatic forces [32].

3.5 Effects of Poultry Manure on Dry Matter and Plant Height

Table 6 shows changes in dry matter and plant height. There were relative and progressive increases in the dry matter yields and plant heights from the first cycle to the third cycle in all the five soils used. In the first cycle, treatment had significant effect only in the Ayetoro soil pot experiment. In the second cycle, treatment had significant effect only in Odeda and Ikenne soil experiments. However, in the third cycle, treatment had significant effects on all soils except dry matter yields in Ikenne soil.

Increases in heights of plants in pot experiments from first cycle to the third cycle could be attributed to increase in nitrogen uptake indicated by its concentration in plant tissues. This increase could be attributed to symbiotic fixation of N by rhizobia bacteria in the root nodules of soybeans. These increases in heights of plants could also be attributed to increase in available phosphorus observed in the soils. Increases plant heights and dry matter yield with the application of organic manure had been observed [33,34]. Other essential nutrients must have increased in the soils because organic manure is known to be reservoir of macro and micro nutrients. Similar increases in dry matter yields and concentrations of N, P and K in plant tissue could be associated with more essential nutrients available for the crop following decomposition and mineralisation of organic manure applied to the soils. Same trend with application of poultry manure had been observed [35]. Time was needed for these processes of mineralisation to take place. That is why third cycle had highest dry matter yields. This also showed the residual effect of organic manure. Earlier work supported this [36]. Studies have indicated that application of poultry manure helps soil improve the growth and yield of crops [37,38,39].

3.6 Effects of Poultry Manure on Concentrations of Nitrogen, Phosphorous and Potassium in Plant Tissues

Tables 7 shows effects of poultry manure on concentrations of N, P and K in plant tissues. Highest concentrations of N, P and K in plant tissues were mostly obtained at 7.5 and 10 t ha^{-1} of poultry manure of the three cycles. Also lowest concentrations were mostly obtained at 0 and 2.5 t ha^{-1} of poultry manure. There were significant differences in tissue concentrations following the poultry manure application except in third cycle of Odeda soil pot experiment and second cycle of Ikenne soil experiment. Generally there was relative increase in tissue concentrations from first cycle to the third cycle. In the Ikenne soil experiment, concentrations of N in plant tissue ranged from 0.78 to 2.28%, concentrations of P in plant tissue ranged from 0.05 to 0.36% and concentrations of K in plant tissue ranged from 0.75 to 1.74%.

4. CONCLUSION

Poultry manure significantly improved soil nutrient status as shown in increases in organic C, available P, exchangeable cations, and ECEC. However, some of these properties slightly decreased in the second and third cycles. Furthermore, it brought about increases in plant tissue concentrations of N, P and K, plant height, and dry matter yields. Values of plant height and dry matter yield in third cycle was higher than the previous cycles. This showed the residual effects of poultry manure in these soils. Highest dry matter yields and plant heights were observed at 10 t ha^{-1} of poultry manure application.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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