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SOIL SCIENCE

Influence of Animal Manure Mixture on Soil Nitrogen Indices and Maize Growth[1]

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Abstract—A study was conducted to evaluate the effects of animal manure mixtures on soil nitrogen availability indices in incubation study and maize growth in screen house and field experiments. Surface soil samples (0–20 cm) from four locations and cured animal manures (goat, cattle and poultry) were collected, dried and analyzed. Treatments included control, cattle-goat, cattle- poultry, poultry-goat mixtures and NPK 15:15:15 at 90 kg P ha^{-1} were applied to soils; samples were taken fortnightly and analyzed for NH_4^+–N and NO_3^-–N. Results indicated that poultry manure had higher N, Ca and Mg. An increase in soil NH_4^+–N and NO_3^-–N was observed in amended soils from 2nd to 4th week after incorporation in incubation experiment. The highest value of 207.20 mg N kg^{-1} (NH_4^+–N) and 69.52 mg N kg^{-1} (NO_3^-–N) was recorded with the application of cattle—goat manure while poultry-goat manure was observed to significantly increase NH_4^+–N and NO_3^-–N in screen house experiment. Under field trial, the highest value of NH_4^+–N and NO_3^-–N was recorded with application of cattle-poultry manure as 171.48 mg N kg^{-1} and 96.88 mg N kg^{-1}, respectively. The application of cattle-poultry manure treatment significantly increased plant height, stem girth compared to other amendments and control. The inclusion of poultry manure is therefore recommended for use in manure mixture.

Keywords: animal manure mixture, agronomic performance, mineral nitrogen, inorganic fertilizer

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INTRODUCTION

The use of organic fertilizers is required for sustainable agriculture to supply nutrients, improve soil organic matter, soil physical, chemical properties, and soil productivity [1] since soil organic matter is the key to soil fertility and productivity. However, using organic manure such as farmyard manure, animal manure (cattle manure, poultry manure) serves a better option in substitute for chemical fertilizer. Animal manure is an important source of nitrogen (N) that provides nutritional needs of growing crops [2]. Nutrients contained in organic manures are released slowly and stored for a longer time in the soil, thereby ensuring a long residual effect [3]. Nitrogen (N) is typically the nutrient of most concern because it has a strong influence on cereal crop yields [4]. Mineralization and N recycling begin as soon as the manure is incorporated into the soil. The rate of mineralization however, varies with N sources, but the highest rate is at application and the rate decreases with time [4]. However, an understanding of N mineralization from organic manure is required to predict both the short and long-term release of N, and to avoid high levels of soil N accumulation that may be subjected to nitrate leaching and denitrification losses.

Maize (*Zea mays* L.) is the most important cereal worldwide. It occupied the third place among cereal crops in Nigeria [5], right after sorghum and millet. Appropriate nitrogen fertilization serves as the principal factor of nutrient management in high-yielding maize production systems [6]. It is also the nutrient element applied for most annual crops, which usually has significant effect on growth, development and yield of maize [7]. The performance of Nigeria agricultural sector in maize production has become abated over the decade due to some factors that militate against sufficient crop yields and fertilizer use [8]. In Nigeria, soil nutrient leaching and low level of soil organic matter have made nitrogen a limited nutrient to maize production [9, 10]. [11] reported that applica-

[1] The article is published in the original.

tion of higher dose of N fertilizer enhance days to emergence, delayed days to tasseling and maturity, improved vegetative growth and grain yield of maize.

The disposal of large volumes of animal manure waste can be an expensive and environmentally threatening operation as this contributes to environmental problems such as greenhouse gas release and contamination of streams and ground water. However, creating innovative processes and pathways would allow this resource to be properly utilized and simultaneously reduce environmental impacts. The potential contamination of applying fresh animal manure waste cannot be overlooked thus making drying of animal manure waste an important process before usage. Dried livestock manures can be applied directly to crop fields either spread directly as this reduce field application costs by increasing bulk density, reducing volume and weed seeds content.

Several researches have been carried out on the application of sole animal manure neglecting other manure that cause environmental nuisance in our society. There is still lack of information on effects of animal manure mixture on dynamics of nitrogen forms hence the need for this study. The objectives of the study were to determine the (1) effect of animal manure mixture on ammonium nitrogen, nitrate nitrogen (2) synergistic effect of animal manure mixture on growth and yield of maize.

MATERIALS AND METHODS

Location of the Experiment, Soil Sample and Manure Collection

This study was conducted at the Federal University of Agriculture, Abeokuta, Ogun State, Nigeria situated between latitude 7°12′ N and longitude 3°20′ E. Soil samples (0–20 cm) were collected from four locations in Ogun state: Two locations from basement complex (Alabata and Osiele) and the other two from sedimentary parent materials (Itori and Papalanto). Soil samples from each location were bulked, air-dried and sieved with 2 mm mesh sieve. Three animal manures: poultry, goat and cattle manures were collected from the University farm, the Federal University of Agriculture Abeokuta. The manures were air-dried to constant weight after which they were grinded using porcelain mortar and pestle to reduce the particle size.

Soil and Manure Analysis

Sub samples from the soils were collected and analyzed as follow: Soil pH was determined in a soil water ratio of 1:2 using glass electrode attached to a pH meter [12]. Particle size analysis was determined using the hydrometer method [13]. Organic carbon content was determined using the wet-oxidation method [14]. Total nitrogen (N) was determined by Kjeldahl method after material digestion [15]. Exchangeable bases were extracted with 1 N ammonium acetate buffered at pH 7. Potassium and sodium in the extract were determined using flame photometer. Calcium and magnesium were determined using Atomic Absorption Spectrophotometer (AAS). Dried animal manures were digested with acids and analysed for organic carbon, total nitrogen and exchangeable bases, the pH and electrical conductivity (EC) of the dried manures were determined using distilled water according to standard procedures [16].

Nitrogen Forms Analysis

Ammonium nitrogen (NH_4^+–N) and Nitrate nitrogen (NO_3^-–N) were determined by extracting from 10 g soil using 20 ml of 1M potassium sulphate. The extracts were analyzed for NH_4^+–N and NO_3^-–N according to method described by [17].

Experimental Design

The experiment consisted of incubation study, screen house and field experiments. Incubation study and screen house experiment were laid out in complete randomised design while field experiment was laid out in randomized complete block design with five treatments and three replications. The treatments were control, cattle-goat manure mixture, cattle-poultry manure mixture, poultry-goat manure mixture and NPK 15:15:15 at 90 kg P ha^{-1}. The combined manure mixtures at 90 kg P ha^{-1} were halved into two at an application rate of 45 kg P ha^{-1} for each manure (cattle, goat and poultry manure). However, the manure was mix at ratio 1 : 1.

Incubation

Four soils were used for this experiment; two soil each from basement complex (Alabata and Osiele) and sedimentary parent materials (Itori and Papalanto). One hundred grams of air-dried soil were dispensed into 200 g capacity plastics and treatments were applied. The incubation plastics used were labelled and each treated soil was thoroughly mixed and moistened with water to field capacity. Soil and manure mixture were incubated in dark cupboard for eight weeks at an ambient temperature of 27.5°C. Soil samples were taken at 0, 2, 4, 6 and 8 weeks of incubation and analysed for ammonium nitrogen (NH_4^+–N) and nitrate nitrogen (NO_3^-–N) according to the method as mentioned earlier.

Table 1. Physical and Chemical properties of soils

Soil Properties	Units	Incubation and Screen House				Field
		Alabata	Osiele	Itori	Papalanto	FUNAAB
pH		7.16	6.75	7.63	6.84	6.54
Organic Carbon	g kg^{-1}	52.5	55.9	43.7	51.3	51.8
Total N	g kg^{-1}	2.1	1.9	2.3	1.8	1.7
Ca	cmol kg^{-1}	5.13	4.06	6.71	2.56	6.85
Mg	cmol kg^{-1}	1.05	2.25	1.34	1.71	1.35
K	cmol kg^{-1}	0.27	0.25	0.34	0.18	0.49
Na	cmol kg^{-1}	0.47	0.47	0.60	0.31	0.68
Texture		Loamy sand	Loamy sand	Loamy sand	Sandy	Loamy sand

Screen House Experiment

Based on the result of the incubation experiment, two soils were used for this study; one soil each from basement complex (Alabata) and Sedimentary parent material (Papalanto). Five kilogrammes of soil sample were dispensed into perforated 7 kg capacity containers with saucers placed under to avoid nutrient leaching. Dried manure mixtures were applied 2 weeks before planting while NPK fertilizers were applied 2 weeks after planting. Maize seeds (BR-9928-DMR-S-Y) were sown at 3 seeds per pot and thinned to one plant per pot at two weeks after planting. Soil samples were taken at 0, 2, 4, 6 and 7 weeks from containers and analysed for NH_4^+–N and NO_3^-–N, maize agronomic parameter (plant height, stem girth) were measured at 2, 4, 6 and 7 weeks after planting. Similar procedure was carried out for another 6 weeks for the second cycle of maize growth though soil samples and agronomic data were only collected at 4 and 6 weeks after planting.

Field Experiment

One soil of the two soils from screen house experiment was used for the field experiment. Soil from Alabata which belonged to basement complex parent material was chosen for the field experiment, although the field location (FUNAAB) was used since it was analyzed as a separate soil based on the fact that soils characteristics usually vary with distance. The field experiment was carried out at the Directorate of teaching and research farm, the Federal University of Agriculture, Abeokuta. The field was cleared mechanically with tractor, ploughed and harrowed. Dried manure mixtures were applied 2 weeks before planting by spreading on the field manually while NPK fertilizers were applied 2 weeks after planting. Maize seeds (BR-9928-DMR-SR-Y) were sown at a spacing of 0.25 by 0.75 m. Maize plants that were representative of each plot were tagged within the net plot, plant height and stem girth of tagged plant were measured with meter ruler and venier calliper at 2, 4, 6, 8 and 10 weeks after planting, respectively. At 2, 4, 6, 8 and 10 weeks, soil samples were also taken and analysed for nitrogen forms. At 12 weeks after planting, maize shoot (above ground portion) from net plot was harvested, dried in an oven at 65°C to constant weight. Data on dry shoot weight were recorded.

Statistical Analysis

Experimental data for all parameters of treatment effects were analyzed using a one-way ANOVA implemented in PROC ANOVA in SAS [18] followed by mean comparisons using Duncan multiple range test at 5% level of probability.

RESULTS

Pre-Cropping Analysis of the Soil Samples

Some of the properties of soils used for the study are presented in Table 1. All the soils except soil from Papalanto were loamy sand. The pH of the soils varied from neutral to alkaline. The organic carbon and magnesium content of the soils was the lowest and highest in soils form Itori and Osiele, respectively. The highest total N was obtained in soil from Itori while the least value was found in soil from FUNAAB. There was variation in exchangeable cation. It was observed that soil from Papalanto had the least of Ca, K and Na while the highest value was recorded in FUNAAB.

Characterization of Animal Manure Amendments

The pH of the manures ranged from 8.20 in poultry manure to 9.60 in goat manure (Table 2). The total nitrogen content of the manures ranged from 3.20 g kg^{-1} to 3.60 g kg^{-1}. The order of organic carbon was goat manure > poultry manure > cattle manure while the carbon:nitrogen ratio was in the order of cattle manure > goat manure > poultry manure. Poultry manure was significantly higher in calcium when compared to

Table 2. Characterization of animal manure

Chemical properties	Units	Poultry manure	Goat manure	Cattle manure
pH		8.20c	9.60a	8.70b
Total N	g kg^{-1}	3.60a	3.40ab	3.20ab
Organic C	g kg^{-1}	51.80b	53.20a	51.30b
C/N		14.39ab	15.65ab	16.03a
Ca	g kg^{-1}	44.10a	17.80c	30.10b
Mg	g kg^{-1}	30.70a	20.00b	15.80b
Na	g kg^{-1}	15.20b	38.40a	10.40c
K	g kg^{-1}	15.30b	38.70a	10.20c

Means with the same letter in each row were not significantly different at $p < 0.05$.

other manures. The magnesium content was significantly higher in poultry manure, followed by goat manure and cattle manure. The order of sodium and potassium content of the manures were goat manure > poultry manure > cattle manure.

Soil NH_4^+–N and NO_3^-–N Content of Unamended and Amended Soils in Incubation Experiment

Significant difference ($P \leq 0.05$) was observed in the mineral N (NH_4^+–N and NO_3^-–N) with different treatment applied across the weeks (Table 3). A significant increase in NH_4^+–N and NO_3^-–N was observed in soil from Alabata. NH_4^+–N and NO_3^-–N increased from 2nd to 4th WAI (weeks after incubation) and decrease from 6th WAI to 8th WAI. Co-application of cattle-goat manure mixtures gave the highest value at 4th week for both NH_4^+–N and NO_3^-–N (207.20 mg N kg^{-1} and 69.52 mg N kg^{-1}), respectively and the least value of NH_4^+–N and NO_3^-–N was observed with the application of NPK at 8th WAI. Similar trend was observed in soil from Osiele with NH_4^+–N and NO_3^-–N increasing from 2nd to 4th WAI and decreasing from 6th to 8th WAI. The application of poultry-goat manure mixture resulted in the highest value of NH_4^+–N (212.15 mg N kg^{-1}) at 6th WAI and NO_3^-–N (98.23 mg N kg^{-1}) at 4th WAI. The NH_4^+–N and NO_3^-–N in soil from Itori with the application of amendment significantly differed when compared with control at the 0th WAI of incorporation. NH_4^+–N decreased at 2nd WAI, increased at 4th WAI, decreased at 6th WAI and finally increased at 8th WAI while NO_3^-–N increased from 2nd to 6th WAI and later decreased at 8th WAI. Cattle-goat manure mixture gave the highest value in NH_4^+–N (188.51 mg N kg^{-1}) at 4th WAI and NO_3^-–N (67.83 mg N kg^{-1}) at 6th WAI. The least value in NH_4^+–N (100.38 mg N kg^{-1}) and NO_3^-–N (10.74 mg N kg^{-1}) was observed at 8th week with the application of NPK. Similar trend was observed in soil from Papalanto.

Table 4 shows that application of manure mixture produced higher amount of NH_4^+–N and NO_3^-–N in soil compared to NPK fertilizer and control in cycle 1 and 2. NH_4^+–N in soil from Alabata decreased significantly at 4th and 7th WAP (weeks after planting) in the first cycle while significant increase in NH_4^+–N was observed in second cycle at 4th and 6th WAP. The least amount of NH_4^+–N was observed in NPK treatment for both cycles. The application of amendment also had significant effect on NO_3^-–N of soil from Alabata in both cycles. NO_3^-–N increased at 4th WAP and decreased at 7th WAP in cycle1, similar trend was also observed in cycle 2. The highest value of NO_3^-–N was recorded as 165.39 mg N kg^{-1} and 64.13 mg N kg^{-1} with application of cattle-poultry manure mixture in cycle 1 and cycle 2 respectively while the least value was observed in NPK amended soil. Treatment application had a significant effect on soil from Papalanto. NH_4^+–N in cycle 1 decreased at 4th WAP and increased at 7th WAP. The highest NH_4^+–N was observed with poultry-goat manure mixture (250.62 mg N kg^{-1}) at 6th week after planting. Similar trend was observed in cycle 2. A significant increase in NO_3^-–N was observed at 4th WAP while a decrease was recorded at 7th WAP. Poultry—goat manure amended soil had the highest NO_3^-–N value at 4WAP while the least value of NO_3^-–N was recorded in NPK amended soil at 7 WAP. Similar trend was observed for NO_3^-–N in cycle 2. Comparing both cycle in the screen house experiment based on the treatment

Table 3. Effect of animal manure mixture on soil NH_4^+–N and NO_3^-–N in incubation study

Treatment	NH_4^+–N, mg kg^{-1}					NO_3^-–N, mg kg^{-1}				
	0WAI	2 WAI	4 WAI	6 WAI	8 WAI	0WAI	2 WAI	4 WAI	6 WAI	8WAI
Alabata soil										
Control	88.49d	107.70b	167.00c	114.10b	106.30c	23.50d	57.84c	63.81c	442.13d	41.29b
Cattle-goat manure	111.60c	116.50ab	207.20a	118.20bc	113.70b	29.15c	60.18b	69.52a	559.85a	34.93c
Cattle-poultry manure	122.60a	157.20ab	186.9b	140.10a	132.50b	30.84b	66.41b	63.94c	554.33c	30.71d
Poultry-goat manure	116.00c	117.60ab	182.5b	173.70a	144.00a	34.80a	57.84c	68.09ab	554.07c	46.74a
NPK(15-15-15)	145.70b	131.40a	188.5b	183.00a	114.00a	30.51b	68.74a	65.82bc	557.44bc	40.85b
Osiele soil										
Control	89.59d	118.71c	169.28d	114.32c	107.72b	22.79d	58.07d	60.03c	27.19a	10.11bc
Cattle-goat manure	126.61a	128.41b	190.71a	115.97c	107.17b	31.49b	60.11d	60.44c	26.63a	11.62d
Cattle-poultry manure	114.36b	120.32c	188.51a	183.57b	142.89a	29.73c	51.36b	75.61b	25.68a	22.65c
Poultry-goat manure	102.49c	138.78a	179.72bc	212.15a	137.95a	28.89c	54.59a	98.23a	29.69a	24.67a
NPK(15-15-15)	123.15b	140.66a	179.17c	142.16b	102.35c	34.15a	49.48a	77.19b	29.07a	23.08abc
Itori soil										
Control	104.42d	106.07bc	171.48c	104.42b	100.91d	21.49b	44.08c	58.10c	66.51ab	11.30b
Cattle-goat manure	109.37d	117.07a	188.51a	107.17b	125.86d	31.09ab	55.05b	58.29c	67.83ab	12.53b
Cattle-poultry manure	121.46c	108.27bc	179.17b	138.50a	176.97b	29.28ab	56.15b	55.24c	67.45ab	21.17a
Poultry-goat manure	139.60b	104.79c	185.22ab	137.95a	185.22a	39.02a	59.02b	66.15b	67.45ab	21.49a
NPK(15-15-15)	170.93a	112.67ab	184.12ab	142.35a	120.38c	31.62ab	66.73a	71.60a	67.86b	12.74a
Papalanto soil										
Control	102.23c	111.57c	171.48c	100.42b	103.33e	22.46e	67.78a	58.62d	62.19c	20.91b
Cattle-goat manure	105.52c	128.06a	191.26a	104.58b	133.55d	30.45d	80.95a	66.73b	74.07ba	13.89c
Cattle-poultry manure	104.97c	114.32c	184.67ab	136.85a	174.77c	48.04a	74.26a	62.51c	78.22a	20.26b
Poultry-goat manure	172.01a	92.33d	181.92b	140.15a	185.22b	31.98c	69.52a	59.27d	64.00c	20.84b
NPK(15-15-15)	136.30b	122.01b	178.07bc	137.40a	203.90a	33.24b	77.18a	69.78a	70.11b	20.05a

Means with the same letter in each column are not significantly different at $P \le 0.05$ for each soil type.
WAI—Weeks after incorporation.

applied, Soil from Alabata had significantly higher amount of NH_4^+–N and NO_3^-–N than soil from Papalanto. It was observed that poultry-goat manure and cattle-goat manure had positive effect at increasing the NH_4^+–N and NO_3^-–N. The values observed were higher with poultry-goat manure mixtures in comparison with other manure mixtures in both cycles.

Application of animal manure mixture had significant effect on NH_4^+–N and NO_3^-–N in the field experiment (Table 5). An increase in the value of NH_4^+–N from 2nd WAP till 6th WAP, decrease at 8th WAP and final increase at 10th WAP was observed with the addition of manure amendment and NPK fertilizer. The highest concentration of NH_4^+–N was recorded with the application of cattle-poultry manure mixture (171.48 mg N kg^{-1}) at 8th week and the least value was obtained in NPK amended soil as 95.63 mg N kg^{-1}. NO_3^-–N significantly increased at 4th WAP, decreased at 6th WAP and later increased from 8th to 10th WAP. The highest value of NO_3^-–N was recorded with cattle-poultry manure mixture (96.98 mg N kg^{-1}) at 4th WAP and the least value was obtained for NPK (20.05 mg N kg^{-1}) at 6th WAP.

Effect of Animal Manure Mixture on Plant Height and Stem Girth of Maize

Table 6 shows that a significant increase was recorded at 7th week when compared with 4th week for plant height. At 4th week, plant height gave the highest value with the application of poultry-goat manure followed by cattle-poultry manure and cattle-goat manure. Manure amendments increased increase the plant height than in NPK and control. Similar trend was observed at 7th week except that the highest

Table 4. Effects of animal manures mixture on NH_4^+–N and NO_3^-–N of soils in screen house experiment for two cycles

Treatment	Cycle 1						Cycle 2					
	NH_4^+–N, mg kg^{-1}			NO_3^-–N, mg kg^{-1}			NH_4^+–N, mg kg^{-1}			NO_3^-–N, mg kg^{-1}		
	0 WAP	4 WAP	7 WAP	0 WAP	4 WAP	7 WAP	0 WAP	4 WAP	7 WAP	0 WAP	4 WAP	7 WAP
	Alabata soil											
Control	217.64c	120.91c	96.23bc	33.82d	86.46d	30.90b	85.74e	120.91d	187.96b	32.85b	49.14c	24.67d
Cattle-goat manure	243.47a	138.49b	105.52b	36.68b	164.29a	48.82a	105.52c	153.89b	194.56ab	48.82a	61.93a	37.85b
Cattle-poultry manure	231.38b	136.30b	117.07a	35.32bc	165.39a	34.73ab	117.07b	153.89b	197.86ab	34.73b	64.13a	25.46cd
Poultry-goat manure	239.08ab	152.79a	122.01a	40.57a	111.71c	34.21ab	130.81a	135.75c	210.50a	34.02b	56.67b	43.75a
NPK(15-15-15)	239.08ab	139.05b	102.73b	35.06cd	119.37b	34.67ab	96.73d	217.09a	193.46ab	34.67b	63.88a	27.20c
	Papalanto soil											
Control	130.26b	98.93b	219.39c	24.41d	82.76c	23.24e	102.4ab	106.62e	168.18c	26.42c	57.51c	19.74b
Cattle-goat manure	135.20ab	139.05b	240.73b	136.05a	129.50b	31.94b	183.0ab	137.40c	191.81ab	31.1bc	61.0bc	24.93b
Cattle-poultry manure	137.40ab	109.92b	236.88b	30.77d	133.84b	35.06a	123.11b	126.41d	192.91ab	41.55a	54.53c	26.55b
Poultry-goat manure	137.95ab	237.98a	250.62a	109.50b	171.30a	24.67d	237.98a	155.54b	200.60a	36.35b	88.34a	46.48a
NPK(15-15-15)	140.69a	109.37b	220.39c	34.15c	96.20c	26.10c	109.37b	234.13a	189.06b	36.10b	68.88b	28.24b

Means with the same letter in each column are not significantly different at $P \leq 0.05$ for each soil type.
WAP—Weeks after planting.

Table 5. Effects of animal manures mixture on soil NH_4^+–N and NO_3^-–N in field experiment for ten weeks

Treatments	NH_4^+–N, mg kg^{-1}						NO_3^-–N, mg kg^{-1}					
	0WAI	2WAI	4WAI	6WAI	8WAI	10WAI	0WAI	2WAI	4WAI	6WAI	8WAI	10WAI
Control	85.74c	102.78b	130.20bc	139.59a	123.66c	155.93b	20.31b	31.03a	39.59e	28.57a	20.57a	23.63c
Cattle-goat manure	90.68c	106.62b	147.45ab	143.99a	142.35b	159.54ab	24.54b	43.75a	58.29d	33.11a	37.19b	66.41a
Cattle-poultry manure	109.92b	105.52b	134.10c	138.75a	135.49b	171.48ab	35.06a	33.46a	106.06a	30.06a	51.28a	67.64a
Poultry-goat manure	124.76a	141.84a	136.85bc	143.45a	137.40b	170.93ab	23.83b	33.53a	96.98b	42.59a	28.72d	66.86a
NPK(15-15-15)	124.21a	95.63b	133.84a	157.19a	139.05a	170.87a	22.58b	32.99a	65.49c	20.05a	23.37d	59.85b

Means with the same letter in each column are not significantly different at $P \le 0.05$.
WAP—Weeks after planting

Table 6. Effects of animal manures mixture on plant height of maize in screen house experiment for two cycles of two soils

Treatment	Alabata soil				Papalanto soil			
	Cycle 1		Cycle 2		Cycle 1		Cycle 2	
	4WAP	7WAP	4WAP	4WAP	4W4P	7WAP	4WAP	6WAP
Plant height, cm								
Control	48.67a	103.67a	30.33b	59.33b	47.33b	89.00b	33.33a	58.00c
Cattle-goat manure	52.00a	113.30a	52.67a	88.00a	52.00a	126.33a	50.00a	77.67a
Cattle-poultry manure	52.67a	113.33a	43.00ab	62.33b	48.00ab	123.33a	52.00a	64.67abc
Poultry-goat manure	54.33a	108.33a	42.00ab	71.33ab	48.67ab	119.33a	48.00a	74.00ab
NPK(15-15-15)	51.00a	90.67a	33.33ab	68.67ab	42.33b	104.00ab	41.33ab	62.67bc
Stem girth, cm								
Control	0.53a	0.53a	0.57a	0.33b	0.57ab	0.63b	0.10b	0.30b
Cattle-goat manure	0.57a	0.73a	0.27a	0.63a	0.70a	0.90a	0.22ab	0.53a
Cattle-poultry manure	0.67a	0.57a	0.22a	0.60a	0.60ab	0.87a	0.25a	0.47ab
Poultry-goat manure	0.63a	0.67a	0.20a	0.47ab	0.63ab	0.67b	0.17ab	0.47ab
NPK(15-15-15)	0.60a	0.53a	0.13a	0.33b	0.50b	0.63b	0.25a	0.37ab

Means with the same letters in each column are not significantly different at $P \le 0.05$ for each soil type.
WAP—Weeks after planting

value was observed in cattle-goat manure and cattle-poultry manure (113.33 cm). Significant increased was observed in the second cycle of the experiment for soil from Alabata. At 4th week, plant height increased significantly across the manure mixture applied. However, in the first and second cycles in soil from Papalanto, significant difference was observed across the weeks and within the treatment. At 4th week, plant height gave the highest value with manure amendments in comparison with the control and NPK. Similar trend was observed at 7th week, the order of increase was cattle-goat manure > poultry-goat manure > cattle-poultry manure > NPK > control. The highest value of plant height was recorded in soil amended with cattle-goat manure at 4th week and 7th week (52.00 cm) and (126.33 cm) respectively with the least value observed in NPK.

Effect of treatment application on stem girth in soil from Alabata was not significant throughout the planting week in first cycle (Table 6). In the second cycle, stem girth was significantly different across the weeks and within the treatment applied at 6th week. Effect of treatment application in soil from Papalanto led to significant increase in stem girth in first cycle. At 4th week, increase was observed across the treatment used, with cattle-goat manure resulting in highest value (0.70 cm). At 7th week, increase was observed in different treatment used over control with the highest value obtained with co-application of cattle and goat manure (0.90 cm). For the second cycle, stem girth

Table 7. Effects of animal manures mixture on plant height and stem girth of maize in field experiment for ten weeks

Treatment	Plant height, cm					Stem girth, cm				
	2WAP	4WAP	6WAP	8WAP	10WAP	2WAP	4WAP	6WAP	8WAP	10WAP
Control	17.50a	36.00a	114.00a	171.50a	201.92a	1.73a	2.83a	4.38a	6.79a	7.00ab
Cattle-goat manure	20.00a	39.00a	125.17a	182.67a	191.83a	1.80a	2.89a	4.46a	6.96a	7.25b
Cattle-poultry manure	27.92a	50.92a	143.58a	201.08a	215.17a	2.73a	4.13a	4.71a	7.00a	7.75a
Poultry-goat manure	27.50a	50.50a	140.00a	197.50a	206.50a	3.35a	4.75a	5.08a	7.58a	7.42ab
NPK(15-15-15)	17.08a	34.75a	124.08a	181.58a	210.17a	1.97a	2.95a	4.83a	7.33a	6.50ab

Means with the same letter in each column are not significantly different at $P < 0.05$.
WAP—Weeks after planting

Table 8. Effect of animal manures mixture on shoot dry weight of maize in screen house and field experiments

Treatment	Screen house experiment, gpot^{-1}				Field experiment, kg ha^{-1}
	Alabata		Papalanto		
	Cycle 1	Cycle 2	Cycle 1	Cycle 2	
Control	7.4a	4.7ab	7.3b	2.3b	4.37a
Cattle-goat manure	10.1a	7.5a	12.9a	4.9a	4.97a
Cattle-poultry manure	9.1a	4.8ab	11.1ab	4.7ab	5.94a
Poultry-goat manure	10.0a	4.1b	12.4a	4.8a	4.78a
NPK(15-15-15)	8.3a	3.5b	9.7ab	4.2ab	2.39a

Means with the same letter in each column are not significantly different at $P \leq 0.05$.

was significantly different across the weeks and within the treatment applied. Increase was observed in the treatments applied at 4th week with the highest value obtained with cattle-poultry manure mixture (0.25 cm).

The result showed the effect of animal manure mixture application and NPK fertilizer on plant height and stem girth of maize in field experiment on Table 7. There was no significant difference in plant height during the experiment. At 2nd week, the plant height obtained with cattle poultry manure was higher than poultry-goat manure followed by cattle-goat manure. Increase in plant height was observed at the 4th weeks in comparison to the 2nd week. There was continuing increase in plant height from 6th week to the 10th week. The stem girth of maize did not differ within treatment from 2nd week to 8th week. At 2nd week, the stem girth obtained with poultry-goat manure was higher than cattle-poultry manure followed by cattle-goat manure, NPK and control. At the 10th week, application of cattle-poultry manure significantly increased the stem girth than other manure amendments, NPK and control. Shoot dry weight of maize grown in screen house experiment on soil from Alabata did not differ in the first cycle (Table 8). Shoot dry weight of maize across the treatment in the second cycle was greater with cattle-goat manure while the least was recorded with NPK. Significant difference ($P \leq 0.05$) in shoot dry weight was observed in both cycle of screen house study for papalanto soil. Significant increase in shoot dry weight across the treatment applied in first cycle and second cycle was recorded. Cattle-goat manure gave the highest value in shoot dry weight for both cycles though the value did was similar to those recorded with the application of cattle-poultry manure and poultry-goat manure. Comparing the two cycles, shoot dry weight was heavier in the first cycle than the second cycle.

There was no significant difference ($P \leq 0.05$) observed in shoot dry weight across the treatment applied in field experiment. Cattle-poultry manure had the highest value, while the control had the least according to the treatment applied. The trend of increase for shoot dry weight for the amendments were cattle-poultry manure > cattle-goat manure > poultry-goat manure > NPK > control.

DISCUSSION

Result of pre cropping soil analysis showed that the soils varied in physicochemical properties. The soils have low natural fertility due to nutrient depletion resulting from continuous cultivation of the soil. Major constraint in crop production in south western Nigeria and indeed the tropics have been identified as having problems relating to nutrient deficiencies and imbalances as reported by [19]. The soils were loamy sand to sandy. They were generally low in nutrient content and hence would respond to nutrient application making them suitable for the study. The low nutrient status of most of these soils were similar to observations of [20] who reported that low nutrient status of most tropical soils necessitates the use of fertilizers for intensive cultivation, since they are not able to support sustainable crop production over a long time.

The pH of the pure poultry manure was considered moderately alkaline, while that of pure cattle and goat manure was strongly alkaline [21]. The alkaline pH in the three manures indicates the presence of basic cations at the expense of acidic ones. This would allow for nutrients availability in the soil after mineralization. The variation in manure nutrient content is an indication that manure quality varies in relation to animal type, age, diet and management system as reported by [22]. Goat manure is richer in organic carbon, sodium and potassium while poultry manure is richer in calcium and magnesium. The high content of calcium and magnesium in poultry manure could be as result of calcium and magnesium salts which are specifically added to poultry diets for body osmotic balance, building of bones and egg production (for layers). This is in agreement with the findings of [16] who observed that Ca and Mg content of poultry litter was seen to be significantly higher than other manures. The high sodium content of goat manure shows that application of this manure to soils should be done with caution, in order to avoid the problem of soil salinity; the salt content of application rates of goat manure should be considered especially when it is to be applied to non-tolerant crops. The C/N ratios of the manures are potential indicators of faster mineralization and high nutrient availability. Similar results were observed from previous research by some authors [22, 23] that poultry manure is expected to mineralize faster compare to goat manure and cattle manure. [16] also reported that immobilization of applied nutrients is likely to occur in cattle and goat manure when compared to poultry manure because of their higher C:N ratios.

The changes in nutrient release patterns during the first few weeks after applying organic amendments are important since it has implications on crop growth. The type of amendment added differently affected the nutrient releasing pattern from amended soils in the study. This rapid rise of NH_4^+–N content is attributable to the decomposition of the easily decomposable nitrogenous substances present in the organic materials. The application of cattle-goat manure mixture (CGM) produced the highest amount of mineral N in soil from Alabata and Papalanto, in which increase was observed in the NH_4^+–N across the incubation weeks with the application of poultry goat manure. The manure treatments significantly increased NH_4^+–N over the control treatment. The differences in N mineralization among the manures studied were larger as expected from their initial characterization. Manure amendment added a sharp decline in soil N mineralization after 8th weeks of field experiment. Subsequently, there was a gradual increase in N mineralization as it reaches the end of the field experiment. Adding manure amendment to soil is sometimes followed by an extended period where N immobilization limits N availability [24]. Other workers have found that laboratory incubations of manure soil lasting for weeks may result in negative N mineralization values [25], while longer incubations resulted in positive values [26]. Comparing the incubation weeks, NO_3^-–N increased at 2nd week and later decreased at 4th week while increase was also observed at 6th week, decreased at 8th week. The result indicated that application of treatment significantly increased and later decreased NO_3^-–N mineralization content at different weeks of incubation. Increase in the concentration of NO_3^-–N was observed with the treatments after incubation as a result of the activity of nitrifying bacteria which converts NH_4^+–N into NO_3^-–N. It was observed from the study that the amount of NH_4^+–N and NO_3^-–N mineralized significantly differed among the treatments. On average, the effect of cattle-goat manure was seen to cause the increase in NO_3^-–N in incubation study, poultry-goat manure in screen house and cattle-poultry manure in field experiment study. [27] reported that the mineralization of N is influenced by incubation period, moisture regime, type of soil and the rate of organic materials applied.

Considering plant height, it was observed that cattle poultry manure treatment increased plant height, compared to other manure amendment and control. These responses may be attributed to its high content of nitrogen, phosphorus and potassium [28]. Another explanation might be due to the effect of poultry manure on soil fertility (poultry manure restored soil fertility). On the other hand, [29] reported that poultry litter contains, a considerable amount of organic matter, hence have an impact on soil pH and liming due to varying amount of calcium carbonate in poultry feed. The source of nitrogen from poultry manure resulted in taller plants because nitrogen was found to increase plant height. This is agreement with [30] who reported that chicken manure fertilizer significantly increased plant height. The increase in vegetative growth parameters such as plant height, stem girth and others resulted from improved soil nutrient, as a result of animal manure mixture (cattle poultry manure). [31] reported that nitrogen and phosphorus uptake, as a function of chicken manure application rate, increased progressively with increasing manure rates.

Stem girth of maize was highest with the application of cattle poultry manure in the field experiment even though no manure amendment differed from each other. This could be attributed to losses of plant available nitrogen making all the manure amendment to behave the same way. The experiment studied showed that manure mixture ratio 1:1 gave good maize growth and performance. This was an indication of higher availability of nutrients from poultry manure, relative to other manure and NPK. All manures and NPK used in the study showed that six weeks is the optimum for peak of growth. By eight weeks, growth was marginal. This means that nutrients from applied manure amendment must be available for plant growth by the sixth week.

CONCLUSIONS

The findings in this study showed that manure amendment increased chemical properties of the soil and agronomic performance of maize. An increase in NH_4^+–N and NO_3^-–N was observed from the 2nd week to the 4th week after incorporation in incubation experiment. Application of poultry-goat manure and cattle-poultry manure had significant effect on increasing soil nitrate nitrogen and ammonium nitrogen in screen house and field experiments, respectively. Cattle-poultry manure mixture had interacting effect on agronomic performance of maize. Therefore, the inclusion of poultry manure is recommended for use in manure mixture.

COMPLIANCE WITH ETHICAL STANDARDS

The authors declare that they have no conflict of interest. This article does not contain any studies involving animals or human participants performed by any of the authors.

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