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INFLUENCE OF GOAT DUNG ON SOIL PROPERTIES, GROWTH AND YIELD OF MAIZE IN GWAGWALADA, FCT, NIGERIA

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ABSTRACT
Farmers in the Guinea Savannah region of Nigeria rely on inorganic fertilizer to mitigate yield reduction caused by low soil fertility. Unfortunately, high purchasing cost and harmful residual effect of chemical fertilizers render them unsustainable. However, goat dung, which is an animal waste, can be harnessed as organic amendment. Therefore, a field experiment was conducted at the Teaching and Research Farm, Faculty of Agriculture, University of Abuja, Nigeria to evaluate growth and yield response of maize to goat dung amended soils. Three levels of goat dung (0 kg, 1.8 kg, and 2.7 kg of goat dung) were incorporated into the soil during land preparation. A Randomized Complete Block Design (RCBD) was used for arranging the treatments, which were replicated three times. Vegetative components: plant height, leaf area, number of leaves, as well as yield parameters: cob length, cob diameter, cob weight, number of seeds/cob, 1000 seed weight and seed yield were evaluated and subjected to Analysis of Variance (ANOVA) using GenStat statistical software (17th Edition). Significantly different means were separated using Duncan New Multiple Range Test (DNMRT) at 5% level of significance. Result showed that application of goat dung increased soil properties (pH, organic matter content, total N, available P, CEC, exchangeable K, Na, Ca, Mg) and improved growth and yield of maize; however, increments were not significant. Thus, further trials are recommended using higher quantities of goat dung.

Keywords: Goat dung, Growth, Maize, Soil amendment, Yield

INTRODUCTION
Maize (*Zea mays*) is an economically important crop cultivated worldwide. Maize, a staple cereal crop, has nutritional, medicinal, and industrial benefits (Adiaha, 2018). Maize serves as a vital source of food, feed, and industrial raw materials (Amanjyoti *et al*., 2024). In fact, it is a major raw material in feed production, especially poultry. Nigeria ranks 13th in the world and 2nd in Africa in term of maize production, with a production value of 12.9 million tons annually (FAOSTAT, 2022). Despite this competitive production figure and position, maize yield in Nigeria (2232.6 kg/ha) is extremely low compared to other producers like Saint Vincent and the Grenadines (31620.7 kg/ha) and United Arab Emirates (23625.3 kg/ha) (FAOSTAT, 2022). This could be attributed to low soil fertility caused by shortened fallow period, especially in Guinea savannah of Nigeria (Eifediyi *et al.*, 2021).

Although, farmers have resorted to using inorganic fertilizers to boost yield, the high purchasing cost and environmental pollutant effect of chemical fertilizer render it unsustainable. According to Makama *et al.* (2022), high cost of fertilizer accounts for 24.2% and ranks third among the constraints to maize production in Nigeria. Alternatively, organic fertilizers such as goat dung occur as animal waste products that could be harnessed as soil amendment.

Goat dung, a by-product of goat farming, serves as a valuable organic fertilizer that can enhance nutrient availability and support plant growth (Ahmad et al., 2019). It contains essential macronutrients like nitrogen (N), phosphorus (P), and potassium (K), as well as a range of micronutrients that are critical for optimal plant development (Rana & Roy, 2024). In addition to providing these nutrients, goat dung plays a key role in improving soil fertility by increasing organic matter content, enhancing soil structure, and boosting the soil's ability to retain nutrients (Srinivasarao *et al*., 2021). Due to its slow-release characteristics, goat dung ensures a steady supply of nutrients to plants over time, helping to reduce nutrient leaching and improve overall nutrient use efficiency (Sogbedji *et al*., 2019). If properly used, goat dung could contribute to soil health and crop productivity (Batubara *et al*., 2021). Nutrient-wise, the most prominent ones in the composition of goat dung are the ones the soil would most wish for-nitrogen, phosphorus, and potassium. On top of this, these organic materials will contain micronutrients: calcium, magnesium, and sulfur, fundamental elements necessary for overall soil fertility (Gbenou *et al.*, 2017). The action is that in which such nutrient elements could gradually be released from the composition for an enduring nourishing of the plants. Various studies have documented the positive influence of goat dung on the growth and yield of maize. For instance, Alade *et al*. (2019) noted that goat dung application increased plant height, stem diameter, grain yield, and nutrient uptake of maize. Uwah and Eyo (2014) reported significant increases in growth and yield parameters of sweet maize due to goat manure. Results showed that the application rate of 15 t/ha of goat manure significantly increased the growth attributes of sweet maize, grain yield, and also hastened days to 50% tasseling (Uwah *et al*., 2014). Obute *et al*. (2019) compared organic and inorganic manure effects on the growth of maize at Makurdi, Nigeria, and recorded that organic fertilizers including goat dung gave significantly higher yields of than inorganic fertilizer. Hence, this study evaluated the effect of goat dung levels on selected soil properties, growth and yield of maize during the 2023 cropping season in Gwagwalada, FCT, Nigeria.

MATERIALS AND METHODS

Experimental Site:
The experiment was conducted at the Teaching and Research Farm, University of Abuja, situated in the Guinea savannah zone of Nigeria, during the 2023 cropping season. The area is characterized by bimodal pattern of rainfall and lies on Latitude 8^0 45' and Longitude 6^0 45'. The soil of the area is well drained sandy loam and classified as Feric Acrisol, the mean annual rainfall of the experimental site is about 1500 mm (FAO, 2017).

Experimental Materials
The planting materials used in this experiment include goat dung and maize seeds (Obasuper-60), sourced from Premium Seeds.

Soil Sampling and Analysis
Before the site was prepared for seed sowing, soil samples were collected using an auger at a depth of 0 to 30 cm. The samples were then bulked in a polythene bag to create a composite soil sample. Following that, the samples were taken to the lab for physicochemical analysis in using standard procedures.

Treatments, Experimental Design and Field Layout
The experiment consisted of three treatments (0 kg (control), 1.8 kg and 2.7 kg of goat dung). Each treatment was replicated three times to give a total of nine experimental plots, arranged in a Randomized Complete Block Design (RCBD). Plots measured 0.5 m apart while blocks were 1 m apart.

Crop Husbandry:
The study site was cleared, and debris removed. It was manually ploughed and harrowed into fine raised seedbeds. Each plot measured 3 m by 3 m with inter-row and intra-row spacing of 75 cm 25 cm, respectively. Two weeks after land preparation and incorporation of goat dung, seeds were sown at 2-3 seeds per hole, which were later thinned to 1 plant per stand after emergence. Each plot consisted of 5 rows with 13 plants per row to give a total of 65 plants per plot (72,222 plants per hectare). All appropriate agronomic practices such as harvesting, disease and pest control and weeding etc. were carried out as at when due.

Data Collection
Growth and yield data were obtained from five randomly selected plants per plot, with the average values for each plot recorded.

Growth Parameters
The following growth parameters were measured at 4, 8, and 12 weeks after sowing (WAS): plant height, leaf area, and number of leaves.
Plant Height: The height of the plants, defined as the vertical distance from the base to the highest point of the main stem, was measured using a measuring tape.
Leaf Area: The length and width of representative leaves was measured, then extrapolated to give the leaf area using the equation: Leaf Area $= L \times W \times 0.75$.
Where "L" and "W" are the average length and width of leaves.
Number of Leaves: The total number of leaves present on each plant, considering both fully expanded and emerging leaves was counted and properly recorded.

Yield and Yield Components
Data were gathered on various yield parameters, including cob length, cob diameter, number of seeds per cob, 1000-seed weight, and total seed yield.
The seed weight obtained per plot was extrapolated on a hectare basis using the equation below:

$$yield = \frac{seed\ weight\ \times 10{,}000}{area\ harvested}$$

Data Analysis
Data collected were subjected to Analysis of variance (ANOVA) using GenStat statistical package *(17th Edition)*; significantly different means were separated by Duncan New Multiple Range Test (DNMRT).

RESULTS AND DISCUSSION

Physicochemical Properties of Soil before Cropping
The results of the laboratory analysis of the soil in the experimental sites prior to planting are presented in Table 4.1. Analysis showed that the soil pH (5.4) was strongly acidic; organic carbon (0.55%) and organic matter (0.95%) were low; total nitrogen (0.04 gkg^{-1}) content and CEC (2.6 $cmolkg^{-1}$) of the soil were very low; Phosphorus (6.20 $cmolkg^{-1}$) and calcium (2.37 $cmolkg^{-1}$) were low; K (0.45 $cmolkg^{-1}$) and Mg (2.15 $cmolkg^{-1}$) were moderately available; and Na (0.14 $cmolkg^{-1}$) was low. The soil of the experimental site has a sandy loam texture.

Table 1: Physical and Chemical Properties of Soil before Cropping

	Properties													
	(%)			Textural class	pH (H_2O)	(%)			($cmolkg^{-1}$)					
	Sand	Silt	Clay			C	OM	N	CEC	P	Ca	K	Mg	Na
Values	67.5	12.5	20	Sandy loam	5.40	0.55	0.95	0.04	2.60	6.20	1.37	0.45	2.15	0.14

Chemical Compositions of Goat Dung
The chemical composition of goat dung used in the experiment is presented in Table 4.2. Results showed that the goat dung was slightly alkaline (7.7), high in organic carbon (1.5%); organic matter (2.58%); Ca (12.61 $cmolkg^{-1}$) and Mg (4.52 $cmolkg^{-1}$). However, total nitrogen (0.36%); K (1.35 $cmolkg^{-1}$); and Na (3.13 $cmolkg^{-1}$) were very high, while phosphorous (10.25 $mgkg^{-1}$) was moderately available.

Table 2: Chemical Compositions of Goat Dung

	Properties								
	pH (H_2O)	(%)			($cmolkg^{-1}$)				
		C	OM	N	P	Ca	K	Mg	Na
Values	7.7	1.5	2.58	0.36	10.25	12.61	1.35	4.52	3.13

Effect of Goat Dung on Soil Physicochemical Properties after Cropping

The data on soil properties after cropping is presented in Table 2. The result showed that soil properties (pH, organic carbon and organic matter, nitrogen, Cation Exchange Capacity, Phosphorus, calcium, potassium, magnesium and sodium) increased after application of goat dung to plots. After the application of 1.8 kg and 2.7 kg goat dung, soil pH changed from strongly acidic to slightly acidic, organic carbon increased from low to moderate, organic matter changed from very low to low, nitrogen increased from very low to moderately high, CEC increased from very low to moderate, Phosphorus increased from low to moderate, potassium remained moderate, magnesium increased from moderate to high, and sodium increased from low to moderate. On the other hand, application of 1.8 kg goat dung increased calcium from low to moderate, while the application of 2.7 kg goat dung increased calcium from low to high.

Table 3: Physical and Chemical Properties of Soil after Cropping

Treatment	Properties													
	(%)			Textural class	pH (H_2O)	(%)			($cmolkg^{-1}$)					
	Sand	Silt	Clay			C	OM	N	CEC	P	Ca	K	Mg	Na
Control	67.5	12.5	20	Sandy loam	5.40	0.55	0.95	0.04	2.60	6.20	1.37	0.45	2.15	0.14
1.8 kg	66.9	15.6	17.5	Sandy loam	6.2	1.12	1.93	0.22	9.35	12.30	5.33	0.52	3.18	0.35
2.7 kg	65.8	17.9	16.3	Sandy loam	6.5	1.26	2.17	0.24	9.81	15.45	11.13	0.59	4.11	0.70

Effect of Goat Manure on the Plant Height of Maize at 4, 8 and 12 Weeks after Sowing

Table 4.3 shows the influence of goat manure at the rates of 1.8kg and 2.7kg on plant height of maize. Results showed that application of goat manure had no significant effect ($p \leq 0.05$) on the plant height of maize across all sampling periods. However, at 4 WAS, the highest plant (11.55 cm) was obtained from plots where no goat dung was applied. At 8 and 12 WAS, the highest plant (92.78 cm) was found on plots where 1.8 kg of goat manure was applied.

Table 4: Effect of Goat Manure on Plant Height of Maize at 4, 8 and 12 Weeks after Sowing

Treatments	Plant Height (cm)		
	4 WAS	8 WAS	12 WAS
0	11.55^a	77.67^a	171.9^a
1.8	9.78^a	92.78^a	177.8^a
2.7	9.73^a	85.44^a	177.2^a
LSD ($p \leq 0.05$)	NS	NS	NS

Means in the same column followed by the same superscript letter are statistically similar ($p \leq 0.05$), WAS: Weeks After Sowing

Effect of Goat Manure on Leaf Area of Maize at 4, 8 and 12 Weeks after Sowing

The effect of goat manure on leaf area of maize is shown in table 4.4. The result obtained indicates that application of 2.7 kg of goat dung produced maize plants with the highest leaf area at 4, 8 and 12 WAS; although, differences were only significant ($p \leq 0.05$) at 4 WAS.

Table 5: Effect of Goat Manure on Leaf Area of Maize at 4, 8 and 12 Weeks after Sowing

Treatment	Leaf Area (cm^2)		
	4 WAS	8 WAS	12 WAS
0	64.31^b	134.2^a	579.0^a
1.8	93.31^a	194.5^a	691.7^a
2.7	99.6^a	258.1^a	725.0^a
LSD ($p \leq 0.05$)	9.82	140.5	184.8

Means in the same column followed by the same superscript letter are statistically similar ($p \leq 0.05$), WAS-Week as after sowing

Effects of Goat Manure on the Number of Leaves of Maize

The effects of goat manure on leaves number of maize is presented in table 4.5. The results indicate that goat manure did not significantly affect ($p \leq 0.05$) the number of leaves on maize plants. However, the application of 2.7 kg of goat manure resulted in the highest leaf count (8.07 leaves) at 4 weeks after sowing (WAS), followed by 1.8 kg of goat manure, which produced 7.5 leaves. At 8 WAS, the application of 2.7 kg of goat manure led to the lowest leaf count (10.29), while 1.8 kg of goat manure produced the highest number of leaves (11.56). By 12 WAS, 2.7 kg of goat manure again resulted in the highest number of leaves (12.44), while the control plot had the fewest leaves (11.67).

Table 6: Effect of Goat Manure on Number of Leaves of Maize at 4, 8 and 12 Weeks after Sowing

Treatments	Number of Leaves		
	4 WAS	8 WAS	12 WAS
0	6.7[a]	11.11[a]	11.67[a]
1.8	7.5[a]	11.56[a]	12.44[a]
2.7	8.07[a]	10.29[a]	12.06[a]
LSD ($p \leq 0.05$)	1.50	1.53	1.940

Means in the same column followed by the same superscript letter are statistically similar ($p \leq 0.05$), WAS-Week as after sowing

Effect of Goat Manure on Yield and Yield Components of Maize

The effect of goat manure on yield and yield components of maize is shown in table 4.6. The results indicate that goat manure had no significant effect ($p \leq 0.05$) on cob length, cob diameter, number of seeds per cob, 1000-seed weight, or seed yield. However, the application of 2.7 kg of goat manure showed the most favorable impact on all observed yield components.

Table 7: Effects of Goat Manure on Yield and Yield Components of Maize

Treatment	Cob Length (cm)	Cob Diameter (cm)	Number of seeds/cob	1000 seed weight (g)	Seed Yield (kg/ha)
0	17.50[a]	15.18[a]	463.3[a]	360[a]	390[a]
1.8	18.53[a]	14.92[a]	398.8[a]	350[a]	390[a]
2.7	19.38[a]	15.38[a]	498.3[a]	370[a]	410[a]
LSD ($p \leq 0.05$)	2.78	1.63	130.8	0.04	0.04

Means in the same column followed by the same superscript letter are statistically similar ($p \leq 0.05$), WAS-Week as after sowing

Discussion

Soil from the experimental site was low in most of the nutrients evaluated prior to the experiment, as suggested by soil interpretation (Landon, 2014). This may be due to poor agricultural practices of shortened fallow period or continuous cropping without appropriate application of fertilizer (Eifediyi *et al*., 2021). In contrast, the soil parameters after crop cultivation (pH, organic carbon and organic matter, nitrogen, CEC, phosphorus, calcium, potassium, magnesium, and sodium) increased in response to goat dung application to plots. This can be linked to the role of goat dung in soil nutrient enrichment. Rana and Roy, 2024 had earlier reported that goat dung is rich in essential nutrients, such as nitrogen (N), phosphorus (P), potassium (K), and micronutrients. This agrees with the findings of Uwah and Eyo (2014) where the application of goat manure significantly enhanced the soil pH, organic matter, total nitrogen, available Phosphorus, exchangeable K, Na, Ca, Mg, and the cation exchange capacity of the soil. The additions of the goat dung favored growth of maize; the higher plant height recorded at 12 WAS in the 18 kg rate can thus be attributed to the addition of nitrogen from the manure source. Although the highest plant height was recorded at 4 WAS in the control experiment, this might be due to the slow release of the nutrients in the organic fertilizer that might have caused the ineffectiveness of the manure rate at an early growth stage. This agrees with Talip *et al*. (2017), where there was recorded increase in plant height of sweet corn with the addition of goat manure over bio-fertilizer. The leaf area varied among the treatments; the recorded significant difference was only at 4 WAS in the treatment with the application of goat dung of the rate of 2.7 kg. The same treatments also recorded the highest in plant height throughout the experiment, and this could be due to the high response of the plant to nitrogen, which is supplied by the goat's dung. Nitrogen is said to aid the development of green plants and leaf functions. This is also in agreement with the result of Haridi *et al*. (2016) where there is an increasing trend in leaf area due to the effect of adding one-third goat manure to two-thirds of soil in the maize variety grown in the pot experiment and the experiment conducted by Haridi *et al*. (2016) also agreed with the findings in this experiment that the treatments with rates of goat dung recorded the highest number of leaves at 4 WAS and 12 WAS compared with the control treatments. Other yield components of the crop-like cob length, cob diameter, number of seeds per cob, 1000 seed weight, and seed yield also increased in the treatments with different application rates of goat dung. However, the obtained result shows that there is no significance among the treatments for all the yield components. However, the performance of the treatments supplied with 2.7 kg goat dung was better; the higher performance was observed in yield components. This was in agreement with Adiwibowo *et al*. (2024), in an investigation of the effect of using goat manure in addition to rice husk, which increases the cob weight and number of cobs per plant in the maize crop. These findings, therefore, suggest that nutrients, that were more readily available with the supply by goat dung, resulted in improved root growth and were largely the cause of the observed reaction. Meanwhile, such superior growth parameters of maize acquired with high rates of goat manure in the course of this study commemorate with the findings of Odedina *et al*. (2011) and Gitari *et al*. (2015).

CONCLUSION

This study was undertaken to assess the effect of goat dung as organic manure on soil physicochemical properties, growth and yield of maize. Results revealed that application of goat dung increased soil properties (pH, organic matter content, total N, available P, exchangeable K, Na, Ca, Mg, and CEC; and improved growth and yield of maize. Incorporating 1.8 kg of goat dung to into the soil increased plant height and number of leaf at 8 and 12 WAS. Applying 2.7 kg of goat dung increased leaf area across all sampling periods with significant difference at 4 WAS; it also increased number of leaf at 4 WAS; and increased yield components (cob length, cob diameter, number of seeds per cob, 1000 seed weight and seed yield) of maize. Application of goat dung as soil amendment increased soil properties. It also enhanced growth and yield of maize; however, increments were not significant. This suggests that goat dung could be a sustainable alternative to expensive chemical fertilizers in Gwagwalada, FCT, Nigeria. Thus, further trials are recommended using higher quantities of goat dung.

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