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RESEARCH ARTICLE

POULTRY MANURE-INDUCED INFLUENCE ON SOIL PROPERTIES OF COARSE-TEXTURED TROPICAL SOIL

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ABSTRACT

Organic manures are known to be rich sources of both macro and micro nutrients for crop, and also improve the physical attributes of the soil. A pot experiment was conducted to determine the influence of poultry manure on the physicochemical properties of coarse-textured soil. Four different rates of poultry manure were applied: 0, 5, 10 and 15 t/ha, designated as PM_0, PM_5, PM_{10} and PM_{15}, respectively. The experiment was laid out in completely randomized design (CRD) with five replications. Disturbed and undisturbed soil samples were collected at 4, 8 and 12 weeks after incorporating treatments for selected physical and chemical determinations using standard methods. Application of poultry manure significantly influenced SOM, available P, bulk density and total porosity of the soil across sampling period, and at least one of the three sampling periods in total N, TEB, and ECEC. The relationships between chemical properties reveal that SOM and TEB play a crucial role in sustaining the fertility status of the soil. The study demonstrates the potential of poultry manure to improve the physicochemical properties of coarse-textured soil. It is suggested that a test crop be considered for further study.

KEYWORDS

Organic manure, Soil properties, Coarse-textured soil, Disturbed soil, Undisturbed soil

1. INTRODUCTION

Poultry manure has proven to be an effective, ecologically acceptable, and cost-effective approach for improving the physical and chemical condition of degraded soil (Adeyemo et al., 2019). Poultry manure is an excellent source of organic fertilizer because it contains a high percentage of nitrogen, phosphorus, potassium, and other important nutrients readily available for plant uptake when compared to other organic sources (Pangaribuan et al., 2020; Schmidt and Knoblauch, 2020; Ismael et al., 2021). Organic amendments, such as poultry manure, improve soil properties by increasing organic matter content, which stimulates soil structure and aggregate stability, thus improving aeration, buffering of soil reaction, water holding capacity, cation exchange capacity, and microbial activities (Ojeniyi et al., 2013; Prasai et al., 2018).

Intensive poultry production systems generate large volumes of manure which is deposited on the soil and causes enormous pollution concerns, due to the substances they produce, contaminating the soil, water, and air. Furthermore, the development of potentially harmful microbes, antibiotic pollution, the formation of antibiotic resistance genes, groundwater contamination, and greenhouse gas emissions all pose a risk to human and animal health (Choudhury et al., 2020; Owamah et al., 2020). It is anticipated that the global poultry manure generation would reach 457 million tons in 2030 (Zhang et al., 2021). Undoubtedly, one of the most serious issues is the unpleasant odour of these poultry wastes (Mullo, 2012; Gohil et al., 2020). Poultry manure is regarded an organic fertilizer since it contains all the nutrients required for crop production (Kobierski et al., 2017; Casas and Guerra, 2020). Factors that influence its composition include the type of bird, litter material, feed nutritional content, and other management factors. Organic manure, such as pig, cattle, and poultry manure, is regarded an essential source of plant nutrition and soil conditioners (Hossain et al., 2017; Soremi et al., 2017; Joseph et al., 2017; Ojomah et al., 2020).

The importance of continual improvement of the physicochemical quality of coarse-textured tropical soils cannot be overemphasized, giving their susceptibility to various degradation agents. The potentials of sole application of poultry manure as both soil fertilizer and conditioner has been poorly researched in tropical soils of the derived savanna of Nigeria, particularly in Anyigba, Kogi State. This research aimed to explored the influence of poultry manure on some soil physical characteristics and fertility indicators in a tropical coarse-textured soil.

2. MATERIALS AND METHODOLOGY

2.1 Study Area

This study was conducted from April to July 2024 at the Faculty of Agriculture, Prince Abubakar Audu University (PAAU), Anyigba, Kogi State, Nigeria (Latitude 7° 06'N and Longitude 6° 43'E). This region is located in Nigeria's Northcentral Guinea savannah (Kowal and Knabe, 1972). With distinct dry and wet seasons and a bimodal rainfall pattern that peaks in July and September, the location experiences a warm, humid climate. Annual rainfall varies between 1560 to 1808 mm (Amhakhian et al., 2010). The average monthly temperature ranges from 17^{0}C to 36.2^{0}C, with variation occurring throughout the year. At 65% and 85% annually, relative humidity is still moderately high (Amhakhian et al., 2010). The geology is part of Nigeria's cretaceous to recent sediments and is located within the Anambra Basin (Amhakhian and Osemwota, 2012). It is mostly made up of the Ajali formation. The soils in the area are formed from the sandstone mineralogy.

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2.2 Sample collections, Treatments and Experimental Design

Using a spade, soil sample was collected from a continuous cultivated farmland at a depth of 0 – 20 cm located at the Faculty of Agriculture, PAAU. The soil was air dry until constant weight was achieved, sieved using a 2-mm mesh sieve to remove extraneous materials. Sub-sample was taken for routine analysis. The poultry manure used for this study was collected from the Animal Production Farm, PAAU, cured by air-drying for 2 weeks, crushed using mortar and pestle and sieved through a 2-mm mesh sieve. Composite sample of the poultry manure was analyzed at the Department of Soil and Environmental Management laboratory, Faculty of Agriculture, PAAU, Anyigba to determine some selected chemical composition. The treatment include 4 levels of poultry manure (0, 5, 10 and 15 t/ha) and replicated 5 times to give a total of 20 experimental units. Five kilograms of soil was weighed into each of the 20 pots. The fraction of the poultry manure that was < 2 mm was measured appropriately, added and thoroughly mixed with the required soil sample. The experiment was laid out in a completely randomized design (CRD).

2.3 Soil Sampling and Analysis

At 4, 8 and 12 weeks after incorporating amendments into the soil, undisturbed soil samples were collected from each experimental unit using core samplers with a volume of 123.2 cm^3 for hydraulic properties determination; the core samples were prepared by trimming the adhering soils and oven-drying at 105°C for 24 hrs. The adjoining disturbed soil was collected at a depth of 0 – 15 cm for analysis of chemical properties.

2.4 Soil Physical, chemical and hydraulic properties determination

The soil physicochemical and hydraulic characteristics determined include: particle size distribution determined using the hydrometer method as reported (Gee and Or, 2002). Soil pH was conducted by potentiometric determination using a pH meter, with a soil – liquid ratio of 1:2.5 suspensions of soil in distilled water, following (McLean, 1982). Soil organic carbon was determined using the Walkley - Black wet oxidation procedure (Nelson and Sommers, 1996). Organic matter percentage was computed by multiplying percent organic carbon with the Van Bemmelen factor of 1.724. Total nitrogen was determined by the salicylic acid-thiophosphate digestion method, followed by distillation using a modified macro-kjeldhal apparatus, as described (Juo, 1979). Available phosphorus was extracted by the Bray No.2 and Bray No. 1 methods (Murphy and Riley, 1962). Exchangeable potassium (K^+) and sodium (Na^+) was extracted with HCl solution and their levels determined by flame, and exchangeable magnesium (Mg^{2+}) and calcium (Ca^{2+}) by atomic absorption spectrophotometer (Senjobi and Ogunkunle, 2010). Exchangeable acidity was extracted in 1 N KCl using the titrimetric method (McLean, 1982). Effective cation exchange capacity (ECEC) was calculated by summation of exchangeable bases (Ca^{2+}, Mg^{2+}, K^+, Na^+) and exchangeable acidity. The soil bulk density was calculated according (Grossman and Reinsch, 2002). Total porosity was calculated according (Wu et al., 1990). Water holding capacity was calculated according to (Piper, 1966).

2.5 Data Analysis

Data from all observations were subjected to Analysis of Variance (ANOVA) by using Genstat software (18th edition, VSN International Ltd., Rothamsted, UK). Treatment means were compared using the least significant difference (LSD) test. Correlation analysis was performed to investigate the relationship between poultry manure rates and each physicochemical property at each sampling time using IBM SPSS Statistical software (version 27).

3. Results And Discussions

3.1 Physicochemical Properties of the Studied Soil and Poultry Manure

Table 1 shows the physicochemical properties of the soil before the study. From the particle size distribution, the soil belongs to the textural class Loamy Sand. The pre-amendment physicochemical properties of the soil show that it is an acid soil with low contents of macro-nutrients (particularly total N and available P). The PM showed low values for organic carbon and total nitrogen but high values for pH, phosphorus, sodium, potassium, magnesium and calcium compared to those used in the studies (Joseph et al., 2017).

Table 1: Some physicochemical properties of the soil and poultry manure used for the study

Parameter	Pre-soil analysis	Poultry manure analysis
Sand (g/kg)	850.80	-
Silt (g/kg)	43.0	-
Clay(g/kg)	106.20	-
Textural class	Loamy Sand	-
Soil pH in H_2O	6.60	7.00
% Soil organic carbon, SOC	1.39	3.76
% Soil organic matter	2.40	6.48
% Total nitrogen, N	0.09	0.25
Available phosphorus, P (mg/kg)	1.07	23.80
Exchangeable sodium, Na^+ (cmol/kg)	0.27	0.62
Exchangeable magnesium, Mg^{2+} (cmol/kg)	2.39	3.69
Exchangeable potassium, K^+ (cmol/kg)	1.89	3.42
Exchangeable calcium, Ca^{2+} (cmol/kg)	4.01	6.52

3.2 Effects of Poultry Manure on Soil pH, SOM, total N and available P

Table 2 shows the effect of poultry manure on some selected chemical properties of the soil. The pH of the soil was not affected by the treatment, but there were steady increase across the sampling periods. This indicates that as poultry manure decomposes, it releases basic cations like Ca, Mg and K, which can increase soil pH (Piash et al., 2022). The soil pH was observed to be highest at 8 weeks after incorporation (WAI) across all treatments (6.4, 6.5, 6.5 and 6.5 at PM_0, PM_5, PM_{10} and PM_{15}, respectively), but thereafter, there was a decline. This suggests that the soil's buffering capacity, which initially neutralized the alkaline effect of the manure, has been overcome, allowing the soil pH to decline (Butterly et al., 2022).

There was significant increase in the amount of SOM in the soils following the application of manure. This indicates that the decomposition of poultry manure leads to the addition of organic carbon to the soil, which is being stored as SOM. The highest value of SOM (5.26%) was observed in PM_{10} at 8 WAI while the control (PM_0, 0.95%) at 12 WAI had the least in the sampling periods. At all sampling periods, poultry manure increased the concentrations of SOM in all the treated soils compared to the control. It was observed that there was increase in the amount of SOM at 8 WAI when compared to its values at 4WAI. A decline was however notice at 12 WAI. This suggests that the added carbon from the manure has been mineralized by chemical reaction or microbial actions, leading to a decline in SOM (Soremi et al., 2017).

Treatment did not affect soil total N at 4 and 12 WAI, but it affected soil total N at 8 WAI. The treatment may have stimulated soil biota activity, leading to increased N release at 8 WAI, but this effect was not sustained. Lower contents of N was however observed at 8 WAI compared to the other sampling periods. The poultry manure released N initially (at 4 WAI). Between 4 and 8 WAI, microorganism immobilized some of the N, reducing it availability. By 12 WAI, the immobilized N was mineralized, making it available again. This pattern indicates dynamic N cycling processes, with fluctuations in N availability. This report was in agreement with the findings of who reported that the increase in N content was not sustained throughout the sampling periods (Soremi et al., 2017).

Treatment was observed to affect available P across the sampling period. A decline in available P content was evident across the sampling period. The added poultry manure may have triggered phosphorus fixation, making it less available over time. The observed significantly higher value of available P in PM_0 (2.40 mg/kg) suggest that the control soil may have released phosphorus from its native sources, resulting in higher available P values. This pattern suggests that poultry manure may not have provided sufficient P for plant growth, or the P was not in a readily available form.

Table 2: Effect of poultry manure on soil chemical properties at 4, 8 and 12 weeks after incorporation

Treatment	pH-H_2O	%SOC	%SOM	%Total N	Avail P (mg/kg)	Na	Mg	K	Ca	EA	ECEC	TEB
						cmol/kg						
4 weeks after incorporation												
PM_0	5.4	0.65b	1.13b	0.10	4.70b	0.27	2.41	1.94	4.07	1.60	10.29	8.69b
PM_5	5.7	1.75ab	3.05a	0.12	6.70a	0.56	2.67	2.38	4.70	1.40	11.48	10.08a
PM_{10}	5.8	2.20a	3.83a	0.15	7.08a	0.32	2.59	2.34	4.56	1.46	11.27	9.81a
PM_{15}	5.8	1.58ab	2.67a	0.16	6.69a	0.30	2.72	2.23	4.45	1.42	11.05	9.63ab
Sig. level	ns	*	*	ns	*	ns	ns	ns	ns	ns	ns	*
8 weeks after incorporation												
PM_0	6.4	0.56	1.03c	0.06d	3.90ab	0.34	2.48	2.11	4.39	1.57	10.89	9.32
PM_5	6.5	1.62	5.74a	0.11a	3.43b	0.39	2.71	2.39	4.63	1.34	11.46	10.12
PM_{10}	6.5	1.50	5.26ab	0.10b	4.66a	0.43	2.66	2.42	4.59	1.39	11.49	10.07
PM_{15}	6.5	1.14	4.63b	0.07c	3.43b	0.35	2.58	2.70	4.44	1.48	11.22	9.74
Sig. level	ns	ns	*	*	*	ns	ns	ns	ns	ns	ns	ns
12 weeks after incorporation												
PM_0	6.3	1.91	0.95c	0.13	2.40a	0.29b	2.79	2.20	4.20	1.52	11.00b	9.48b
PM_5	6.5	3.30	3.23a	0.22	1.27b	0.44a	2.66	2.15	4.20	1.52	10.97b	9.45b
PM_{10}	6.4	3.02	2.98ab	0.20	1.20b	0.37ab	2.96	2.74	4.86	1.31	12.24ab	10.93a
PM_{15}	6.4	2.66	2.93ab	0.18	1.93ab	0.31b	2.37	2.80	4.95	1.17	12.60a	11.43a
Sig. level	ns	ns	*	ns	*	*	ns	ns	ns	ns	*	*

PM – poultry manure; SOC – soil organic carbon; SOM – soil organic matter; Na – sodium; K – potassium; Mg – magnesium; Ca – calcium; EA – exchangeable acidity; TEB – total exchangeable bases; ECEC – effective cation exchange capacity; * – significant difference at p ≤ 0.05; ns – not significant

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

From Table 2, treatment did not affect exchangeable Ca, Mg, K and acidity across sampling period, but affected exchangeable Na only at 12 WAI with PM_5 having a significant higher value of 0.44 cmol/kg. This could be a result of slow release of Na from the poultry manure which made it more available at 12 WAI. The overall lack of significance observed in this study may be related to the quality of the poultry manure used in this study. The poultry manure's composition, including nutrient content and carbon-nitrogen ration, might not have been suitable for impacting soil CEC (Toluwase et al., 2020). However, the treatment performed better across sampling period.

3.4 Effects of Poultry Manure on Effective Cation Exchange Capacity and Total Exchangeable Bases

From table 3 also, treatment affected both ECEC and TEB at 12 WAI, and affected TEB alone at 4 WAI with PM_5 having the highest value of 10.08 cmol/kg. The significance observed at 12 WAI, with PM_{15} having the highest value of 12.60 cmol/kg, indicate that the decomposing manure must have released organic acids, which can chelate metal ions and increase ECEC (Cai et al., 2021). The effect observed at 4 and 12 WAI on TEB could be tied to initial manure decomposition and release at 4 WAI, temporary stabilization in soil nutrient dynamics at 8 WAI and delayed secondary release of nutrients from the manure due to further decomposition of organic matter or increased microbial activity and/or a change in pH at 12 WAI.

3.5 Effects of Poultry Manure on Soil Bulk Density, Total Porosity and Water Holding Capacity

From table 3, treatment affected bulk density and total porosity across all sampling period. The control (PM_0) had higher significant values of bulk density across sampling period (1.44, 1.42 and 1.43 g/cm³ at 4, 8 and 12 WAI respectively). The lower values of bulk density observed in the treatment indicate that the added organic matter from poultry manure has reduced soil bulk density, making it less compact. This is also evident in the results of total porosity, where treatment gave significant and higher total porosity, allowing better water infiltration, aeration and root growth. It was also observed that bulk density reduces across treatment at 8 WAI compared to 4 WAI, thereafter an increase, which suggest that as manure decomposes, its volume decreases, potentially increasing bulk density. Some researchers also reported similar trend of increment in bulk density after a period of organic manure application (McGrath and Henry, 2016). Overall, PM_{15} impacted the soil bulk density and total porosity the most even though there was no statistical difference among amendment. Treatment did not affect soil WHC across sampling period, which could be related to the amount of poultry manure added to the soil that might not be sufficient enough to significantly impact WHC.

Table 3: Effect of poultry manure on soil physical properties at 4, 8 and 12 weeks after incorporation

Treatment	Bulk density (g/cm³)	Total Porosity (%)	WHC (%)
4 weeks after incorporation			
PM_0	1.44a	43.72b	13.73
PM_5	1.37b	45.93a	14.48
PM_{10}	1.37b	45.99a	14.94
PM_{15}	1.36b	46.53a	15.64
Sig. level	*	*	ns
8 weeks after incorporation			

Table 3 (Cons): Effect of poultry manure on soil physical properties at 4, 8 and 12 weeks after incorporation

PM_0	1.42a	46.75b	15.70
PM_5	1.32b	49.50a	18.68
PM_{10}	1.32b	48.99a	17.84
PM_{15}	1.30b	49.96a	18.24
Sig. level	*	*	ns
12 weeks after incorporation			
PM_0	1.43a	46.17b	12.70
PM_5	1.33b	48.96a	13.68
PM_{10}	1.34b	48.89a	13.84
PM_{15}	1.34b	49.52a	14.24
Sig. level	*	*	ns

PM – goat manure; Ksat – saturated hydraulic conductivity; WHC – water holding capacity; abcd – significant difference at $p \leq 0.05$

3.6 Relationship between treatment-induced variations in soil chemical properties at 12 weeks after incubation

Table 4 shows the relationships between treatment-induced variations in soil chemical properties of the study. Soil organic matter had moderate positive significant correlation with total N (r = .557, p<.05), and strong positive significant correlation with Na (r = .813, p<.01). This implies that SOM directly influence total N and Na levels, acting as a reservoir for N and Na. Total N had strong positive significant correlation with Mg (r = .891, p<.01), which suggest that soil mineralization that releases nutrients like N and Mg, is happening together. Total N also had moderate negative significant correlation with Ca (r = -.661, p<.05), which suggests the occurrence of soil acidification, which can increase total N availability, is also reducing Ca availability. Total exchangeable bases had a strong positive significant correlation with K (r = .871, p<.01) and ECEC (r = .710, p<.01), this implies that there is a balance in soil fertility status.

Table 4: Coefficient of the correlations between treatment-induced variations in soil physicochemical properties at 12 weeks after incubation (n = 20)

Soil properties	pH-H_20	SOC	SOM	TN	AP	Na	K	Mg	Ca	TEB	EA
SOC	0.050										
SOM	0.068	0.395									
TN	0.046	0.424	.577*								
AP	-0.106	0.020	-0.429	-0.286							
Na	0.127	0.124	.813**	0.397	-0.546						
K	-0.006	-0.226	-0.306	0.400	-0.085	-0.142					
Mg	-0.017	0.221	0.300	.891**	-0.106	0.072	.660*				
Ca	0.000	0.120	-0.266	-.661*	0.293	-0.105	-0.178	-.588*			
TEB	-0.002	-0.389	-0.528	-0.056	-0.106	-0.218	.871**	0.234	0.216		
EA	-0.485	0.086	-0.086	-0.297	-0.302	-0.234	-0.499	-0.397	-0.091	-0.369	
ECEC	-0.002	-0.328	-0.264	-0.323	0.179	0.067	0.460	-0.111	.673*	.710**	-0.570

SOC – soil organic carbon; SOM – soil organic matter; TN – total nitrogen; AP – available phosphorus; Na – sodium; K – potassium; Mg – magnesium; Ca – calcium; EA – exchangeable acidity; TEB – total exchangeable bases; ECEC – effective cation exchange capacity; ** – Correlation is significant at the 0.01 level; * – Correlation is significant at the 0.05 level.

4. Conclusion

Poultry manure application significantly improved soil chemical and physical properties, as evident from increased levels SOM, total N, available P, TEB, and ECEC; and reduced soil bulk density, accompanied by enhanced total porosity. However, some of these properties exhibited a slight decline during the second sampling period due to temporary stabilization in soil nutrient dynamics. Overall, PM_5 demonstrated the most notable improvement in soil properties. The relationships among chemical properties reveal that SOM and TEB play a crucial role in sustaining the fertility status of the soil. The findings of this study highlight the benefits of using poultry manure to enhance the physicochemical properties of coarse-textured soil. Future research should consider incorporating a test crop to further explore the practical applications of these results.

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Conflict Of Interest

The authors declare no conflict of interest

Author Contributions

Paul Omaye Joseph: Conceptualization; methodology; validation; formal analysis; data curation; writing – original draft. **Frank Ojochegbe Ojomah:** Project supervision; investigation; resources; writing – review. **John Babatunde Abioye:** Project administration; resources.

References

Adeyemo, A., Akingbola, O., and Ojeniyi, O., 2019. Effects of poultry manure on soil infiltration, organic matter contents and maize performance on two contrasting degraded alfisols in southwestern Nigeria. International Journal of Recycling of Organic Waste in Agriculture, 8 (1), Pp. 73–80. https://doi.org/10.1007/s40093-019-0273-7.

Amhakhian, S.O., and Osemwota, I.O., 2012. Physical and chemical properties of soil in Kogi State, Guinea Savanna of Nigeria. Nigeria Journal of Soil Science, 22 (1), Pp. 44 – 52.

Amhakhian, S.O., Oyewole, C.I., and Isitekhale, H.H., 2010. Effect of different levels of phosphorus on the growth and yield of maize (Zea mays l.) in ofere (Basement Complex) Soils Kogi State, North Central Ecological Zone, Nigeria Continental Journal Agricultural Science, 4, Pp. 20-28

Butterly, C.R., Amado, T.J.C., and Tang, C., 2022. Soil acidity and acidification. In Subsoil Constraints for Crop Production (pp. 53-81). Cham: Springer International Publishing.

Cai, Z., Wang, B., Zhang, L., Wen, S., Xu, M., Misselbrook, T.H., and Gao, S., 2021. Striking a balance between N sources: Mitigating soil acidification and accumulation of phosphorous and heavy metals from manure. Science of the Total Environment, 754, Pp. 142189.

Casas, S., and Guerra, L., 2020. Poultry Manure, Effect on the Environment and Reuse Possibilities, Revista Producción Animal, 32 (3), Pp. 1–15.

Choudhury, A., Felton, G., Moyle, J., and Lansing, S., 2020. Fluidized bed combustion of poultry litter at farm-scale: environmental impacts using a life cycle approach. Journal of Cleaner Production, 276, Pp. 124231. https://doi.org/10.1016/j.jclepro.2020.124231

Gee, G.W., and Bauder, D., 1986. Particle size analysis. In Methods of Soil Analysis. Part 1 Physical and Minerological Methods., Klute A. Ed. Chapter 15. American Society of Agronomy. Soil Science Society of America, Pp. 383-411.

Gohil, A., Budholiya, S., Mohan, C.G., and Prakash, R., 2020. Utilization of poultry waste as a source of biogas production. Materialtoday: Proceedings, 45, Pp. 783–787. htpps://doi:10.1016/j.matpr.2020.02.807.

Grossman, R.B., and Reinsch, T.G., 2002. Bulk Density and Linear Extensibility: Core Method. In: Dane, J.H. and Topp, G.C., Eds., Methods of Soil Analysis. Part 4, Physical Methods, SSSA, Incorporated, Pp. 208-228

Hossain, M.Z., von Fragstein, P., von Niemsdorff, P., and Heß, J., 2017. Effect of different organic wastes on soil properties and plant growth and yield: a review. Scientia Agriculturae Bohemica, 48 (4), Pp. 224–237. https://doi.org/10.1515/sab-2017-0030.

Ismael, F., Ndayiragije, A., and Fangueiro, D., 2021. New fertilizer strategies combining manure and urea for improved rice growth in Mozambique. Agronomy, 11 (4), Pp. 783. https://doi.org/10.3390/agronomy11040783

Joseph, P.O., Ojomah, F.O., and Eguma, A.A., 2017. Effect of poultry manure and NPK fertilizer on growth and yield of Eggplant. Journal of Agriculture and Rural Research, 1 (2), Pp. 112-117.

Juo, A.S.R., 1979. Selected methods for soil and plant analysis. International Institute for Tropical Agriculture (IITA), Ibadan, Nigeria.

Kobierski, M., Bartkowiak, A., Lemanowicz, J., and Piekarczyk, M., 2017. Impact of poultry manure fertilization on chemical and biochemical properties of soils. Plant, Soil and Environment, 63 (12), Pp. 558–563. htpps://doi.org/10.17221/668/2017-PSE.

Kowal, J.M., and Knabe, D.T., 1972. An Agro – Climatologically Atlas of Northern States of Nigeria. A.B.U Press.

McGrath, D., and Henry, J., 2016. Organic amendments decrease bulk density and improve tree establishment and growth in roadside plantings. Urban Forestry and Urban Greening, 20, Pp. 120-127. https://doi.org/10.1016/j.ufug.2016.08.015

McLean, E.O., 1982. Soil pH and lime requirement. In: Page A.L., Miller R.H. & Kenny D.R. (eds.), Methods of Soil Analyses, Part 2. (pp. 199-224). Agronomy Monograph No. 9. Madison WI: American Society of Agronomy & Soil Science Society of America Inc.

Mullo, I., 2012. Handling and processing of poultry manure: Escuela Superior Politécnica de Chimborazo. http://dspace.espoch.edu.ec/bitstream/123456789/2114/1/17T1106.

Murphy, J., and Rilley, J.P., 1962. A modified simple solution for the determination of phosphorus in natural water. Analytica Chimica Acta, 27, Pp. 31-36. https://doi.org/10.1016/S0003-2670(00)88444-5.

Nelson, D.W., and Sommers, L.E., 1996. Total carbon, organic carbon, and organic matter. In: Sparks DL, Page AL, Helmke PA, Loeppert RH, Soltanpour PN, Tabatabai MA, Johnston CT, Sumner ME, editors. Methods of Soil Analysis, Part 3, Chemical and Microbiological Properties. Madison, Wisconsin, USA: American Society of Agronomy and Soil Science Society of America (pp. 961–1010).

Ojeniyi, S.O., Amusan, O.A., and Adekiya, A.O., 2013. Effect of poultry manure on soil physical properties, nutrient uptake and yield of cocoyam (*Xanthosoma saggitifolium*) in southwest Nigeria. American-Eurasian Journal of Agriculture and Environmental Sciences, 13 (1), Pp. 121–125. Htpps://doi.org/10.5829/idosi.aejaes.2013.13.01.1861.

Ojomah, F.O., Joseph, P.O., and Amhakhian, S.O., 2020. Influence of Combined Application of Cattle Dung and NPK Fertilizer on Soil Physico-Chemical Properties, Growth, Nutrient Uptake and Yield of Fluted Pumpkin (Telfairia occidentalis) in Anyigba, Kogi State, Nigeria. South Asian Research Journal of Agriculture and Fisheries, 2 (1), Pp. 1 – 14. https://doi.org/10.36346/sarjaf.

Owamah, H.I., Alfa, M.I., and Onokwai, A.O., 2020. Preliminary evaluation of the effect of chicken feather with no major pre-treatment on biogas production from horse dung. ENMM. 14, Pp. 100347. htpps://doi.org/10.1016/j.enmm.2020.100347

Pangaribuan, D.H., Sarno Liliana, Y., Bahriana, S., and Bahriana, S., 2020. Effects of chicken compost and KCl fertilizer on growth, yield post-harvest quality of sweet corn and soil health. Agrivita Journal of Agricultural Science, 42 (1), Pp. 131–142. htpps://doi.org/10.17503/agrivita.v42i1.1805.

Piash, M.I., Iwabuchi, K., and Itoh, T., 2022. Synthesizing biochar-based fertilizer with sustained phosphorus and potassium release: Co-pyrolysis of nutrient-rich chicken manure and Ca-bentonite. Science of the Total Environment, 822, Pp. 153509.

Piper, C.S., 1966. Soil and Plant Analysis, Inter Science Publishers, Inc., New York. Pp. 368.

Prasai, T.P., Walsh, K.B., Midmore, D.J., Jones, B.E., and Bhattarai, S.P., 2018. Manure from biochar, bentonite and zeolite feed supplemented poultry: moisture retention and granulation properties. Journal of Environmental Management, 216: 82–88. htpps://doi.org/10.1016/j.jenvman.

Schmidt, F., and Knoblauch, R., 2020. Extended use of poultry manure as a nutrient source for flood irrigated rice crop. Pesquisa Agropecuária Brasileira, 55, Pp. 1–10. https://doi.org/10.1590/S1678-3921.pab2020.v55.00708

Soremi, A.O., Adetunji, M.T., Adejuyigbe, C.O., Bodunde, J.G., and Azeez, J.O., 2017. Effects of poultry manure on some soil chemical properties and nutrient bioavailability to soybean. Journal of Agriculture and Ecology

Research International, 11 (3), Pp. 1–10. https://doi.org/10.9734/JAERI/2017/32419

Toluwase, O.A., Tolulope, Y.A., Joseph, U.E., Chengsen, Z., and Hongyan, W., 2020. Effect of biochar and poultry litter application on chemical properties and nutrient availability of an acidic soil. Communications in soil science and plant analysis, 51 (12), Pp. 1670-1679.

Wu, L., Vomocil, J.A., and Childs, S.W., 1990. Particle size,aggregate size, pore size, and water retention. Soil Science Society of American Journal, 54, Pp. 952-956. https://doi.org/10.2136/SSSAJ1990.03615995005400040002X

Zhang, B., Yin, R., Tan, Y., Fan, B., Li, H., Peng, Y., Yang, R., and Li, G., 2021. Evaluation of maturity and greenhouse gas emission in co-composting of chicken manure with tobacco powder and vinasse/mushroom bran. Processes, 9 (12), Pp. 2105. https://doi.org/10.3390/pr9122105

Senjobi, B.A., and Ogunkunle, O.A., 2010. Effect of Land Use on Soil Degradation and Soil Prodcutivity Decline on Alfisols and Ultisols in Ogun State in Southern Western Nigeria. Agriculturae Conspectus Scientificus, 75 (1), Pp. 9-19