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Effects of Animal Manure on the Performance of Soybean *Glycine max (L.*) Merri Grown on Ultisols, Akwa Ibom State, Nigeria

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Abstract

Soil fertility attributes are relevant to improved crop yield and can be enhanced by organic manure from animal sources. The effect of animal manure on soil properties and performance (yield) of soybean Glycine max (L.) merri was evaluated. A pot experiment was conducted at the Screen house, of the Akwa Ibom State University Teaching and Research farm, Obio Akpa in 2020. The experiment was laid out in a Completely Randomized Design in a 3 x 4 split plot arrangement replicated 3 times. The three manure sources served as the main plot (pig manure, goat manure, and poultry manure) and the four rates of manure (0, 10, 20, 40g/plant) as subplots. Before planting the soil sample was analyzed for its physical and chemical properties as well as the manure for its chemical composition. Results showed that the addition of manure did not change the soil's textural class which was sandy. Animal manure contained essential plant nutrients (N.P.K, OM, Ca, Mg). The chemical properties showed a slight change upon application of animal manures when compared with the control. The trend of pH values were: pig manure (5.6) > poultry manure (5.2) > goat manure (5.0) >control (4.4). The trend of organic matter values were poultry (4.82%) > pig manure (4.65%)>goat manure (3.8%). The trend of available phosphorus were; pig manure (24.9 mg kg^{-1}) > poultry (24.6 mg kg^{-1})> goat manure (17.0 mg kg^{-1}) > control (13.7 mg kg^{-1}). There were no significant interactions between manure rate and type on soybean yield parameters but there was a single effect of manure rate on yield parameters. Animal manure at 40 grams/plant produced the highest pod no/plant (10.89), no of seeds/pod (30.44) and grain yield. The trend of animal manure on grain yield at 40 grams/plant were poultry manure (0.98 tonnes ha^{-1})> pig manure (0.94 tonnes ha^{-1})> goat manure (0.85tonnes ha^{-1}). Therefore, poultry manure at 40 grams/plant was recommended for the cultivation of soybean in the study area.

Keywords: Goat manure, Pig manure, Poultry manure, Soil properties and Soybean plant

1.0 Introduction

Soil nutrient depletion is among the major cause of decline in crop yield and per-capita food production (Udom et al., 2019). Poor cultivation practices such as continuous cropping could result in low soil fertility through a reduction in soil organic matter (SOM), and an increase in soil acidity (Aihou et al., 2008). In recent times, due to the high cost of inorganic fertilizers, and the inherent low nutrient fertility (Iren et al., 2016), attention has moved to organic manure as a superior option to improve crop yield. Umoh et al. (2022b) revealed that goat, pig and poultry manures added to soil increased organic matter, N, P, K and Ca levels which significantly increased the growth and yield of maize. Udoh et al. (2021) reported a significant yield response of cocoyam to animal manure and K application on coastal plain sand, while Umoh et al. (2022a) observed lower yield of groundnut with a single K application.

It has also been observed that a high percentage of sand (93.5 to 95.5%) in sandy soils encourages high nutrient leaching leading to low nutrient level; particularly maize yield of sandy soils in south-eastern Nigeria have declined owing to high leaching potentials (Umoh et al., 2020; Umoh et al., 2021). Furthermore, a short lasting effect of K added to coastal plain sand has been linked to the sandy nature of this soil type and this in turn adversely affects crop yield (Umoh et al., 2018). Umoh et al. (2021) reported that low residual values of fertilizer K obtained in these soils may not give a full development of maize. They suggested that organic manure should be incorporated in soil to maintain its fertility for crop production.

Beneficial effects of organic soil amendments have been reported to include a decrease in soil bulk density, an increase in water holding capacity, aggregate stability, saturated hydraulic conductivity, water infiltration rate and biochemical activities (Udom et al., 2019; Umoh et al., 2020). Organic material contributes directly to the building block of soil organic matter, which performs diverse functions in improving the soil's physical, chemical and biological properties Umoh et al. (2018). The maintenance and management of soil organic matter in a cropped field are central to sustaining soil fertility (Woomer & Swift, 1994). Organic manures are essential constituents of soil; they are present in a variety of forms, ranging from plants and livestock materials. Organic manure comprises waste and residues from crops and livestock but are however not capable of returning more than 50% of the nitrogen, phosphorous and potassium to the soil (Asadu & Unagwu, 2012; Iren et al., 2016).

Most farmers in Nigeria use chemical fertilizers because it gives a quick response and the nutrients are readily available to the crops. However, due to the high cost and scarcity of chemical fertilizers, most farmers cannot afford the use as it is often associated with soil acidity and nutrient imbalance among other factors under intensive cultivation (Ojeniyi, 2000). Organic fertilizer is relatively cheap, readily available, and environmentally friendly and can be used as an alternative to chemical fertilizer to maintain sustainable crop yield and soil fertility. Its application has been shown to sustain crop yield, improve nutrient recycling and enhance crop productivity (Belay et al., 2001; Efretuei et al., 2023; Ekwere & Efretuei, 2021).

Soybean is one of the most economic and nutritious crops in the world with high protein content, an excellent source of both oil and protein supplements (Maerere et al., 2001). In Nigeria, soybean is mostly used as poultry and fish feed. Its demand is increasing with the increase in poultry and fish industries. In Nigeria, the area coverage of soybean is 60,893 ha and the annual production is 112,024 tons with an average yield of 1.83 t ha^{-1} which is very low to meet the increasing demand (Osodeke & Ojeniyi, 2003). Therefore, a huge quantity of

soybean is imported every year at the cost of a substantial amount of hard currency. The use of animal manures as fertilizer on the performance of soybean is limited. The present study was undertaken to investigate the effects of different rates of animal manure sources (pig manure, poultry, and goat manures) on the growth of soybeans.

2.0 Materials and Methods

2.1 Experimental Site

The study was conducted at the Soil Science Screen House, Faculty of Agriculture, Akwa Ibom State University, which lies between Latitudes $4^0 32^{!}$N and $5^0 33^{!}$N and Longitudes $7^0 25^{!}$E and $8^0 25^{!}$E, with a mean annual rainfall of over 300 mm and temperature between 26 and 28^0C.

2.2 Soil Sampling and Analysis

A composite soil sample on coastal plain sand at 0-15cm depth was collected for analysis and Pot experiments. The samples were air-dried and sieved through a 2mm mesh; and the physical and chemical properties of the soil were determined using standard methods as described by Udoh et al. (2009). Particle size analysis was done by the hydrometer method, pH was determined in a 1:25 soil to water ratio using a glass electrode pH meter, soil organic carbon was determined by wet oxidation method and multiplied by 1.72 to obtain organic matter, and the total nitrogen in the soil was determined by the macro kjeldahl method, available P in the soils were extracted by the Bray No. 1 method. Exchangeable acidity was measured by the 1M KCL extraction procedure. The exchangeable cations in the soils were extracted using 1M NH_4OHC, K and Na in the extracts determined by atomic absorption spectrophotometry. Effective cation exchange capacity (ECEC) was taken as the sum of exchangeable cations. The organic manures (goat, poultry and pig manure) were cured under a shade for four weeks then crushed, sieved and analyzed for chemical composition .The chemical composition of animal manure is shown in Table 3.2.

2.3 Pot Experiment

The pot experiment was sited at the Screen house of the Akwa Ibom State University. The treatments were arranged in a split plot experiment in a completely randomized design (CRD) with three replications. The manure types (goat, pig & poultry manures) occupied the main plot while the manure rates (0, 10, 20 and 40g) were assigned to the subplots. Soybean (*Glycine max*) was used as the test crop in the experiment. Ten kilograms of the sieved soil samples were weighed into a 12-litre plastic pot mixed with different rates of animal manures sources and moistened to fixed capacity and allowed to equilibrate for two weeks before planting. Soybean at the seed rate of 3 seeds per pot were sown and later thinned to one seedling per pot at 2 weeks after germination. The pots were irrigated at three days intervals. Plant height from the base of the crop to the tip of the inflorescence, leaf number, and seed per pod were assessed by counting, stem girth was measured with a vernier caliper. Pod weights per plant and grain yield per plant were determined with a sensitive electronic balance Udoh et al. (2009).

2.4 Statistical Analysis

Data collected for growth and yield parameters were subjected to analysis of variance (ANOVA) to determine the effect of manure type, manure rate as well as their interaction effect on the growth and yield of soybean. If there were significant differences between

treatment means the means were separated using the Fisher's Least Significant Difference (LSD) at a 5% probability level.

3.0 Results and Discussion

3.1 Physical and Chemical Properties of the Soil Before and after the Experiment

The effect of animal manures on soil physical and chemical properties before and after the experiment is presented in Table 3.1. The result of the physical properties showed that the application of manures did not change the texture of the amended soils which is sand, but a slight change in clay and silt occurred in pots amended with poultry and pig manures. The slight change in the particle size distribution of the soil in terms of clay and silt fraction could be due to the addition of animal manure to this sandy soil. This observation agreed with the research of Adaikwu et al. (2012), who reported that good soil management practices may slightly raise the clay fraction of the soil and improve soil productivity but cannot change the textural class.

The result of the chemical properties of the soil showed that manure types added to the soil increased soil pH when compared to unamended pots. The values ranged from 5.6 (Pig manure) > 5.2 (Poultry manure) > 5.0 (Goat manure) > 4.4 (unamended pot). The increase in soil pH by the addition of manure could be due to the inherent content of the manure types as shown in Table 3.2. Application of the manure types slightly increased the salt level in the treated soil (Table 3.1) but the increase was quite low to affect the soybean growth. The different changes that occurred could be attributed to the feedstocks given to the animals. Organic matter contents were higher in the soil of the amended pots than in the unamended. The values ranged from 4.82g/kg (poultry manure) > 4.65g/kg (pig manure) > 3.80g/kg (Goat manure) > 3.76g/kg (u-amended pot). This could be attributed to an increase in moisture retention which creates a favourable environment for microbial activity, and for decomposition and mineralization to take place. This observation agreed with the findings of Akanbi et al. (2002) who observed that the application of organic wastes improved soil organic matter. An increase in soil total nitrogen, and available phosphorus was observed with the addition of the manure as shown in Table 3.1. This could be due to the fast rate of decomposition and mineralization. The cation exchange capacity of the soils was slightly higher than the unamended pot. The order of abundance were Calcium>potassium>magnesium>sodium. The increase observed could be due to the addition of manure as shown in Table 3.2 indicating that animal manure contains essential plant nutrients. This is in agreement with the findings of Onwudike et al. (2015) who reported a positive effect of organic manure on soil properties. Table 3.2 showed the nutrient composition of manure which indicated that animal manure contains essential plant nutrients.

3.2 Effect of Manure Types on the Growth of Soybean

Results for the effects of manures on the growth of soybeans are presented in Table 3.3. Results showed that pots amended with animal manures significantly ($P < 0.05$) increased the plant height; and the number of branches were significantly ($P<0.05$) different among the manure types. The plant height values followed the trend of goat manure (66.11cm) > poultry manure (45.70cm) > pig manure (34.33cm). While the number of branches were goat manure (12.59) > pig manure (15.44)> poultry manure (8.55). The number of leaves, stem girth and leaf area were not significantly ($P <0.05$) different among the manure types. This change could be attributed to the inherent high nutrient content (Table 3.2) associated with animal manure. A similar result was observed by Sifolo et al. (2019) who reported an increase in maize growth with the application of animal manures.

Table 3.1: Physical and chemical properties of the soil before and after the experiment

	Before Experiment (Untreated soil)	After Experiment		
		Poultry Manure	Goat Manure	Pig Manure
Particle Size Distribution				
Sand %	88.2	87.1	86.0	86.1
Silt %	3.8	5.0	6.0	3.9
Clay %	9.0	8.0	8.0	10.0
Textural class	**Sand**	**Sand**	**Sand**	**Sand**
Chemical Properties				
pH	4.4	5.2	5.0	5.6
EC (dSm-1)	0.08	0.14	0.1	0.12
OM (%)	3.76	4.82	3.8	4.65
	Exchangeable bases			
Total N (%)	0.14	1.21	1.1	1.16
AVP ($mgkg^{-1}$)	13.7	24.6	17.0	24.9
K ($cmolkg^{-1}$)	0.68	1.46	1.56	1.4
Ca ($cmolkg^{-1}$)	8.8	8.9	9.3	12
Mg ($cmolkg^{-1}$)	0.2	0.27	0.22	6.24
Na ($cmolkg^{-1}$)	0.08	0.08	0.09	0.1

EC- electrical conductivity; OM – Organic matter, AV.P-available phosphorous

3.3 Effect of Manure Rates on the Growth of Soybean

The effects of manure rates on the growth of soybean are presented in Table 3.4. The result showed significant differences ($P<0.05$) among the treatment levels on growth parameters. Manure at 40grams recorded the tallest plant with a value of (57.05cm), a higher number of branches (14.36), the highest number of leaves (236.4) and leaf area ($27.66cm^2$) while the control pot showed the lowest values.

3.4 Effect of Interaction between Manure Types and Rate on the Growth of Soybean

Table 3.5 shows the relationship between manure types and rates of application. Result revealed that there was no significant difference ($P<0.05$) between the manure types and rates of application suggesting that all the manure types contributed to the growth of soybean and their effect was independent of manure rates. Among the manure types, goat manure at 40 grams produced the tallest plant (74.73cm), poultry manure at 40 grams produced (59.72cm) and pig manure produced (36.69cm) while the control had the shortest plant across the manure types. The shortest plants recorded at the control could be attributed to poor nutrient uptake from the soil. A similar trend was observed in other growth parameters. The highest increase could be attributed to their nutritional qualities that increased the rate of photosynthesis which led to an increase in plant height. This also indicated that animal

Table 3.2: Chemical composition of manure

Parameter		Poultry	Pig	Goat
pH		7.58	6.92	6.50
Organic matter gkg^{-1}		26.30	25.42	21.00
Total nitrogen gkg^{-1}		3.08	1.82	1.42
Available phosphorous ($mgkg^{-1}$)		15.10	12.89	0.74
Ca	$cmolkg^{-1}$	5.12	4.46	3.92
Mg		1.34	0.83	0.48
K		0.26	0.30	0.28
Na		0.21	0.18	0.09

manure supplied balanced nutrients to plant roots which stimulate growth. Similar findings were reported by Sifolo et al. (2019).

3.5 Effect of Manure Type on the Yield of Soybean

Results of the effect of manure types on the yield of soybeans are presented in Table 3.6. Result revealed that manure types significantly ($P<0.05$) increased the yield parameters of soybean. Among the manure types, pig manure produced the highest grain yield (0.84 tonnes ha^{-1}) while goat manure produced the least (0.73 tonnes ha^{-1}). The trend was in this order; pig manure 0.84> poultry manure 0.75> goat manure 0.73 (tonnes ha^{-1}).

3.6 Effect of Manure Rate on the Yield of Soybean

Results of the effect of manure rate on the yield of soybean are shown in Table 3.7. The results reveal significant ($P<0.05$) differences with the manure rates contributing significantly to the yield of soybean when compared with the control. Animal manure rate at 40grams gave the highest number of pods per plant (10.89), the number of seeds per pod (30.44) and grain yield (0.92 tonnes ha^{-1}). The yield increased with increasing rates of manure application. This could be due to the manure application to the soil while lower yield obtained in control could be attributed to low nutrients in the soil. This agreed with the research carried out by Asadu and Unagwu (2012) which stated that organic materials such as poultry droppings, cowdung, goat dung, pig dung and farm yard manure as soil amendments were suitable for increasing plant yield.

3.7 Effect of Interaction between Manure Types and Rate on the Yield of Soybean

The effect of manure types and rate relationship is presented in Table 3.8. Results showed that there were no significant interaction ($P<0.05$) between the manure types and rates. This indicated that manure application contributed significantly ($p<0.05$) to the yield and yield parameters of soybeans and the effect of manure type was independent of manure rates. Among the manure types, poultry manure at 40 grams produced the highest numerical yield (0.98 tonnes ha^{-1}) and goat manure produced the least (0.85 tonnes ha^{-1}). This observation agrees with the work of Umoh et al. (2022b) who observed that poultry manure increased the levels of nitrogen and phosphorus compared with other animal manures, and this increased crop yield.

Table 3.3: Effect of manure types on the growth of soybean

Treatment	Plant Height (cm)	NOB	NOL	Stem Girth (cm)	Leaf Area $(cm)^2$
Goat manure	66.11	12.59	176.6	1.70	25.85
Pig manure	34.33	15.44	259.4	1.70	24.02
Poultry manure	45.70	8.55	192.7	1.70	23.50
$LSD_{(0.05)}$	8.26	1.50	189.9	0.00	1.52
Sig.	**	**	NS	NS	NS

** - highly significant, ns - not significant, NOB - number of branches, NOL - Number of leaves,

Table 3.4: Effect of manure rate on the growth of soybean

Treatment (g/plant)	Plant Height (cm)	NOB	NOL	Stem Girth (cm)	Leaf Area $(cm)^2$
0	40.05	10.13	182.5	1.70	20.29
10	44.92	11.76	198.8	1.70	24.46
20	52.83	12.52	213.3	1.70	25.43
40	57.05	14.36	236.4	1.70	27.66
$LSD_{(0.05)}$	9.53	1.73	219.4	0.00	1.76
Sig.	NS	**	NS	NS	**

** - highly significant, ns - not significant, NOB - number of branches, NOL - Number of leaves,

Table 3.5: Effect of interaction between manure types and rate on soybean growth

Treatment (g/plant)	Plant Height (cm)	NOB	NOL	Stem Girth (cm)	Leaf Area $(cm)^2$
GoatM-0	56.84	10.73	151.7	1.70	23.41
GoatM-10	58.83	12.17	169.7	1.70	25.33
GoatM-20	74.02	12.80	182.7	1.70	26.50
GoatM-40	74.73	14.67	656.6	1.70	28.17
PigM-0	30.66	12.40	226.1	1.70	20.47
PigM-10	34.12	15.00	244.7	1.70	23.17
PigM-20	35.83	16.07	258.0	1.70	24.35
PigM-40	36.69	18.29	308.7	1.70	28.10
PoultryM-0	32.63	7.27	169.7	1.70	16.98
PoultryM-10	41.80	8.12	182.0	1.70	24.89
PoultryM-20	48.63	8.69	199.3	1.70	25.43
PoultryM-40	59.72	10.14	219.7	1.70	26.70
$LSD_{(0.05)}$	16.51	2.99	379.6	0.00	3.05
Sig.	NS	NS	NS	NS	NS

NS - not significant, NOB - number of branches, NOL - Number of leaves, GoatM-0-0 grams of goat manure/plant

Table 3.6: Effect of manure types on the yield of soybean

Treatment	No of pods per plant	No of seeds per pod	Grain yield per plant(g)	Grain yield (kg ha^{-1})	Grain yield (tonnes ha^{-1})
Goat manure	7.28	19.25	3.63	726.00	0.73
Pig manure	10.88	27.83	4.20	840.50	0.84
Poultry manure	8.19	22.75	3.77	754.33	0.75
$LSD_{(0.05)}$	0.87	1.99	0.18	38.07	0.04
Sig.	**	**	**	**	**

** - highly significant

Table 3.7: Effect of manure rate on the yield of soybean

Treatment (g/plant)	No of pods per plant	No of seeds per pod	Grain yield per pot	Grain yield (kg ha^{-1})	Grain yield (tones ha^{-1})
0	6.36	15.11	2.92	566.89	0.57
10	8.15	22.00	3.58	716.89	0.72
20	9.73	25.56	4.34	868.89	0.87
40	10.89	30.44	4.61	921.78	0.92
$LSD_{(0.05)}$	1.00	2.29	0.21	43.96	0.04
Sig.	**	**	**	**	**

** - highly significant at P<0.05 by LSD

Table 3.8: Effect of the interaction between manure type and rate on the yield of soybean

Treatment (g/plant)	No of pods per plant	No of seeds per pod	Grain yield per plant(g)	Grain yield (kg ha^{-1})	Grain yield (tones ha^{-1})
GoatM-0	4.37	10.00	2.74	494.00	0.49
GoatM-10	6.60	19.00	3.49	697.33	0.70
GoatM-20	8.67	22.67	4.05	810.67	0.81
GoatM-40	9.47	25.33	4.23	846.00	0.85
PigM-0	8.63	20.67	3.15	630.00	0.63
PigM-10	10.67	26.33	4.08	816.00	0.82
PigM-20	11.77	30.67	4.87	974.00	0.97
PigM-40	12.47	33.67	4.69	938.00	0.94
PoultryM-0	6.08	14.67	2.88	576.67	0.58
PoultryM-10	7.17	20.67	3.19	637.33	0.64
PoultryM-20	8.77	23.33	4.11	822.00	0.82
PoultryM-40	10.73	32.33	4.91	981.33	0.98
$LSD_{(0.05)}$	1.73	3.97	0.36	76.14	0.08
Sig.	NS	NS	NS	NS	NS

* - highly significant at P<0.05 by LSD, NS – not significant, GoatM-0-0grams of goat manure

4.0 Conclusion and Recommendation

The results of this study confirm that animal manure contains essential nutrients (N.P.K, OM, Ca and Mg), and its application to soil affects the clay and silt fraction but may not change the textural class. Also, the application of animal manure can improve the chemical properties of the soil and cause a slight change to the pH level. Furthermore, this study has shown that manure application is beneficial to the growth of soybean. Particularly the application of poultry manure at 40 grams/plant will increase grain yield and yield parameters-such as no of seeds/pod and no of pods/plant. This rate is recommended to be used on coastal plain sand for soybean production.

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