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An evaluation of three contrasting rates of animal wastes on degraded sandy soil and their immediate and residual effect on dry matter yield of maize

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Abstract
In this study, the comparative effectiveness of three animal wastes (poultry manure, pig manure and cow dung) in improving the productivity of a degraded sandy soil was simultaneously investigated in a greenhouse study. The study was a factorial experiment with four treatment of 0, 5, 10 and 20 tha^{-1} each of poultry manure (PM), pig manure (PG), cow dung (CD) and control soil. Each treatment was replicated three times. Following the characterization of the plant nutrients, PM relatively had higher concentration of nutrients in all the rates studied compared with PG and CD. All the rates of the wastes studied improved the physico-chemical properties of the degraded soil and adequately supported maize growth and yield relative to the control soil. The wastes improved soil physical properties significantly through increased aggregate stability, total available water (TAW) and water retention. The exchange properties of the soil improved, the organic carbon, total N, available P and pH increased, these accounted for the increased maize growth and yield observed in the study. Amendment with highest dry matter yield during the 1st cropping had the worst residual effect.

Keywords:*Animal waste, available water, organic carbon, pH, residual effect, sandy soil,*

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I. Introduction

Animal wastes differ in their characteristics and properties. Hence, a suitable animal waste should have the capacity to increase crop yields and improve soil fertility without at least any harmful effect either to the soil or crop. Each animal waste has unique properties that could be thoroughly investigated. Some of them are known to be easily mineralised and release their available nutrients rapidly as a result of microbial attack. In some cases, this is desirable particularly on soils that are already degraded like sandy soil. Also, marginal erodible, slopping and generally less productive soils will benefit at least initially from application of animal waste having a higher degree of microbial stability. Such materials will release their available nutrients very slowly. Some materials such as composted animal manures, green manures and activated sewage sludge are subject to rapid microbial decomposition in soils and tend to release their plant available nutrients rapidly. However, some materials such as cereal straws, wood bark, uncomposted animal wastes, saw dust, rice husks, crop wastes like cassava and yam peels, sewage sludge etc will be resistant to microbial attack and release their nutrients at a relatively slower rate. The higher level of organic stability will provide a distinct advantage in the initial reclamation of already degraded and marginal soils because it imparts a beneficial and long-term residual improvement of soil physical properties. Unless the physical nature of these marginal soils is improved first, the plant use efficiency of nutrients with any organic amendments or chemical fertilizer as reported by Parr et al. (1986) will be unacceptably low. Soil application of organic wastes activates enzymatic activities in the soil because according to Garcia et al. (1993), the added organic fractions contain intra and extra-cellular enzymes that Saviozzi et al. (1997) and Bhattacharyya et al. (2001) noted to stimulate microbial activity in the soil. The driving force behind the organic matter decomposition, mineralisation and immobilization of chemical nutrients is the microbial biomass (Nweke, 2018). Its improvement in soils changes totally the productivity and fertility scenario of the soil. The improvement of soil structure and water retention capacity may be all that is needed to ensure a better soil environment for root development and nutrient uptake while on soils with good structure improved physical properties are secondary to the enhanced fertility status associated with animal waste application. The agronomic potentials of animal waste could also be assessed through the physical observation of crop response and performance on soils due to the amendment material. Crop yield response to additions of animal waste is highly variable and is dependent upon soil type, the crop, climatic condition, management systems and type and rates of animal waste used. Therefore, yield response according to Parr et al. (1986) is a determining factor in knowing whether a particular waste material is suitable as a soil amendment relative to another waste material used. Positive results have been reported by various authors using animal wastes as soil amendment. Nweke and Nsoanya (2015), noted that cow dung improved the productivity of soils more than inorganic fertilizers due to its slow release of nutrients. While Ipinmoroti and Akanbi (2012) observed that poultry manure and cow dung performed better than NPK fertilizer in cashew growth and soil N and P content. The use of cow dung, pig and poultry manure in soil fertility improvement in the performance of many tropical crops have been documented. In view of this, a study was conducted to evaluate 3 contrasting rates of animal wastes on degraded sandy soil and dry matter and residual yield of maize.

II. Materials and methods

Sample collection

The study is greenhouse study, 0-20cm top soil of an ultisol belonging to Nkpologwu series and located on the University of Nigeria Nsukka, Teaching and Research Farm was collected using soil auger. The soil sample was air dried at room temperature about 26^oC and sieved through a 2mm sieve. The animal wastes (Cow dung, Pig manure and Poultry manure) were collected from the cow, piggery and poultry sections of the Department of Animal Science farm of the University of Nigeria Nsukka. Each waste material was dried at room temperature and crushed to fine particles (< 2mm). Maize (Western yellow var. NSI) used as a test crop for the study was purchased locally.

Green house study

This was carried out in the department of Soil Science green house complex of the University. Before planting maize 4kg of soil was weighed out and mixed thoroughly and separately with the following rates of cow dung, poultry manure and pig manure 0, 0.25, 0.50 and 1.00% an equivalent of 0, 5, 10 and $20tha^{-1}$. They were transferred into clay pots with drainage holes at the base. To avoid excessively loss of water by drainage the holes were plugged with cotton wool. The soil and the amendment mixtures were incubated for one week before planting maize. This was to give time for transformation and possible detoxification of harmful materials that might be produced during the decomposition of the wastes. Five seeds of maize NS1 variety were planted per pot and later thinned down to three stand per pot after germination. The plant height was measured and after 42 days of growth, the shoots were cut and oven dried at 60% for seven days for dry matter yield determination. The same procedure above was repeated without further addition of wastes to test the residual effect of the animal wastes on maize growth and yield. The experiment was arranged as a factorial experiment in a randomized complete block design with each treatment replicated three times. A control was also included.

Laboratory analysis

Before and at end of the greenhouse study the following chemical properties of the soil, organic wastes, soil/organic wastes mixtures were determined

pH determination: The pH was determined in duplicates both in distilled water and in 0.1N KCl solution using soil/liquid ratio of 1:2.5. After stirring for 30 minutes the pH values were read by using a Beckman and Zeromatic pH meter (Peech 1965).

Organic carbon: This was determined by the Walkley and Black (1934) method as modified by Allison (1965). The percentage organic matter was calculated by multiplying the figure for organic carbon by the conventional Van Bemmeler factor of 1.724 which is based on the assumption that soil organic matter contains 58% C (Allison 1965)

Total Nitrogen: Total nitrogen was determined by Kjeldahl method (Bremner, 1965) using $CuSO_4/Na_2SO_4$ catalyst mixture. The ammonia (NH_3) from digestion was distilled with 45% NaOH into 2.5% Boric acid and determined by titrating with 0.05 NHCl.

Exchangeable basis: The complexiometric titration method describe by Chapman (1965) was used for the determination of calcium and magnesium. Sodium and potassium were determined from IN ammonium acetate (NH_4OAC) using the flame photometer.

Exchangeable acidity: This was determined by titrimetric method using INKCl extract (Mclean, 1965).

Available phosphorous: This was determined by Bray II method (Bray and Kurtz, 1945). The available P was read off from the standard curve after obtaining the optical density from a colorimeter.

Cation exchange capacity: The apparent cation exchange capacity of the soil was obtained by the ammonium acetate (NH_4OAC) method (Jackson, 1958).

Base saturation: Base saturation (BS) was calculated by multiplying total exchangeable bases (TEB) by 100 and dividing by the corresponding cation exchange capacity value.

$$\text{Base saturation (BS)} = \frac{\text{TEB x 100}}{\text{CEC}}$$

Physical properties: Particle size distribution was determined by hydrometer method (Bouyoucos 1951). Moisture retention at -10 and -1500kPa potentials using the saturation water percentage based estimation models of Mbah (1998) and total available water capacity (TAWC) computed as difference between moisture retained at -10kPa (field capacity) and -1500kPa potentials (wilting point). The models are:

$\Theta .1$ (FC) = - 6.22+0.79 (SP)
$\Theta 1.0$ = - 10.95+0.67 (SP)
PWP ($\Theta 15$) = - 8.65+0.51 (SP)
Where FC and PWP are the field capacity and permanent wilting point respectively and SP is the saturation water percentage

Determination of saturated water percentage

For the determination of saturated percentage ceramic crucible with perforated bottom were used. Duplicate determinations were made per sample. Portions of the air dry soil/amendment mixtures were transformed into the crucible a little at a time with intermittent gentle tapping on the work bench to consolidate the mixture. The process was continued until the crucible was about four-fifth full. The crucible was then transferred into a basin and water was added into the basin up to a depth of about two third of height of the crucible. It was then allowed to stand in the basin for the soil to absorb water by capillarity through the porous base of the crucible. Water absorption continued until the exposed soil surface glistened as it reflected light, indicating that saturation point had been reached. This point was reached after 24hrs of contact with water. The crucible were then removed from the basin and the outside wiped dry. After obtaining the mass of the crucible and saturated soil /amendment mixture, it was dried in the oven for 24hours at 105^{o}C. Therefore, the mass of the crucible plus dry soil was recorded. Saturation water percentage was then calculated as follows

$$SP = \frac{K-J}{J-C} \times \frac{100}{1}$$

Where K = weight of crucible +wet sample
J = weight of crucible + dry sample
C = weight of crucible only

Water stability of aggregates

This involved placing 20 grams of the soil/amendment mixture on a 0.25mm sieve and pre-soaking in distilled water for 30 minutes. After this the sieve plus soil was oscillated 20 times in water along a 4cm stroke at the rate of one oscillation per second. Care was taken to ensure that the soil was always below the water surface during each oscillation. At the end of this wet sieving the resistant material on the sieve was transferred into a beaker and dried in the oven at 105^{o}C for 24hrs. The mass of the sand particles contained in these resistant material was also obtained and used to make the necessary corrections to ensure that only the true aggregates were determined. These true aggregates were expressed as percentage water stable aggregates (WSA) thus:

WAS = (Ma+s – Ms/Mt – Ms) x 100
Where Ma+s = mass of the resistant aggregation plus the sand fraction (g)
Ms = Mass of the sand fraction alone (g)
Mt = Total mass of the sieved soil (g)

Dry matter yield

Percentage dry matter yield increase over control was calculated thus:

$$P1 = \frac{Yt - Yc}{Yc} \times 100$$

Where Yt = maize dry matter yield in the treated soil
Yc = maize dry matter yield in the control within each phase of study
P1 = percentage yield increase
Percentage maize yield reduction with time was computed thus;

$$\frac{Y1 - Y2}{Y1} \times \frac{100}{1}$$

Where Y1 = maize dry matter yield in the first phase planting
Y2 = maize dry matter yield in the second phase planting for corresponding treatments.
An estimate of the residual effect of the study was made thus

$$\frac{Y2}{Y1} \times \frac{100}{1}$$

Where Y1 and Y2 are as defined above

Data analysis

Measured data were analysed according to the procedures for a factorial in a randomized complete block design by Little and Hills (1978) least significant difference (LSD) was used to detect differences between treatment means

III. Results and Discussion

The result in Table 1 showed the nutrient content of the studied soil, cow dung, pig and poultry manure. The result indicated the soil to be acidic and deficient in plant nutrients, while the animal wastes showed to be rich in mineral nutrients. The concentration was highest in poultry manure, followed by pig manure and the least in cow dung. It is then expected that the animal wastes will impart positive changes in both physical and chemical properties of the degraded soil and the test crop maize. Increased pH is associated with nutrient availability on the exchange site.

Table 1 Properties of soil and Animal wastes before the commencement of the experiment

Parameters	Soil	CD	PM	PG
Silt%	2	-	-	-
Clay %	12	-	-	-
Fine sand%	36	-	-	-
Coarse sand%	60	-	-	-
Textural class	Sandy	-	-	-
OC %	0.56	7.86	13.50	6.84
OM%	0.96	13.55	23.29	11.79
TN%	0.067	1.85	2.86	2.00
Na meq/100g soil	0.11	0.43	0.72	0.44
K meq/100g soil	0.15	0.48	1.50	0.65
Cameq/100g soil	0.8	1.50	8.10	2.30
Mg meq/100g soil	0.6	1.29	6.89	1.09
Avail. P ppm	3.2	0.23	2.05	0.82
CEC meq/100g soil	7.0	-	-	-
pH H_2O	4.80	6.69	7.11	6.38

Effect of animal wastes on the physical properties of degraded sandy soil

The result of the physical properties of the studied soil is shown in Table 2a, b. The recorded values of the parameters tested showed higher values in the amended soils relative to the control soil in both 1st and 2nd year planting. This indicates that the amended soils retained appreciably higher water at these potentials than in the control. Also, the recorded value showed that the wastes as soil amendment significantly increased aggregate stability over the control. This probably may be due to OM supplied to the soil by these amendments which help in building the soil particles together. Nweke (2015) noted that OM is a very important factor in the stability of soil aggregates especially binding smaller aggregates to larger ones of which will limit the erodibility of the soil and provision of optimum tilth. Poultry manure contributed more to aggregate stability relative to the other two wastes probably due to its higher content in OM (Table 1). On the average, the relative improvement in water stable aggregates (WSA) of the soil was in the order PM > PG > CD > CO for the two yeas planting observation. The recorded values of the parameters in both 1st year and 2nd planting showed increase in value as dosage application of wastes increased, though in some parameters, their effect is fairly constant. The total and readily available water result in 1st year planting and 2nd year planting, saturation indicated that the animal wastes did not significantly affect the values recorded for the parameters. This probably may be due to the rates of wastes used for the study. The result showed an increase in soil moisture content in all the amended soils relative to control at 15bars (Permanent wilting point). Mbagwu et al. (1994) reported that dehydrated swine waste as organic residue increased moisture retention capacity of similar soils at all metric potentials including -1500KPa. At the rates of 5, 10, 20 tha^{-1}, animal waste increased TAWC by 4% in all the treatments relative to their recorded values in control. The RAWC was slightly affected by the wastes as their increases were merely 1% for cow dung and 2% for poultry and pig manure respectively. The result scenario probable results from the type and rates of animal waste used. The more the readily available water in a soil, the less the moisture stress the crop will have in the soil. The recorded values of the parameters decreased as the planting year increased, probably because of the non-application of the animal waste in the 2nd year planting, leading to more acceleration of OM mineralization as well as low content of OM in the studied soil (Table 1).

Table 2a Effect of the Animal waste on physical properties of the sandy soil (1st year planting)

Treatments	Saturation	0.1 bar	1.0 bar	15 bar	TAWC	RAWC	WSA
Control (CO)	33.70	20.4	11.6	8.50	11.9	8.8	64
CD_5	35.40	21.70	12.80	9.40	12.30	8.90	67
CD_{10}	36.00	22.20	13.20	9.70	12.50	9.00	68
CD_{20}	35.10	21.50	12.60	9.30	12.10	8.90	69
Mean	35.50	21.80	12.87	9.47	12.30	8.93	68
PM_5	35.30	21.60	12.60	9.30	12.30	9.00	72
PM_{10}	35.90	22.10	13.10	9.70	12.40	9.00	73
PM_{20}	35.90	22.10	13.10	9.70	12.30	9.00	74
Mean	35.70	21.93	12.93	9.57	12.33	9.00	73

PG_5	35.60	21.90	12.90	9.50	12.50	9.00	71
PG_{10}	35.70	22.00	13.00	9.60	12.40	9.00	72
PG_{20}	35.50	21.80	12.80	9.50	12.30	9.00	73
Mean	35.60	21.90	12.90	9.53	12.40	9.00	72
$LSD_{0.05}$	NS	0.95	0.53	0.07	NS	NS	1.05

Table 2b Effect of the Animal waste on physical properties of the degraded sandy soil (2nd year planting)

Treatments	Saturation	0.1 bar	1.0 bar	15 bar	TAWC	RAWC	WSA
Control (CO)	33.60	20.21	11.47	8.49	11.65	8.65	63
CD_5	35.01	20.70	12.56	8.79	11.96	8.80	66
CD_{10}	35.15	21.15	13.18	9.58	12.40	9.00	67
CD_{20}	35.00	20.49	12.50	9.27	12.20	8.85	68
Mean	35.05	20.78	12.75	9.21	12.19	8.88	67
PM_5	34.75	21.60	12.55	9.00	12.20	8.75	71
PM_{10}	34.98	22.05	13.05	9.45	12.37	9.00	72
PM_{20}	35.58	22.08	13.08	9.40	12.19	8.76	73
Mean	35.10	21.91	12.89	9.28	12.25	8.84	72
PG_5	35.40	21.50	12.60	9.38	12.50	9.01	70
PG_{10}	35.65	21.80	12.95	9.56	12.47	8.58	71
PG_{20}	35.37	21.65	12.76	9.50	12.25	8.67	72
Mean	35.47	21.65	12.77	9.48	12.41	8.75	71
$LSD_{0.05}$	NS	NS	0.53	0.65	NS	NS	0.96

Effect of animal waste on the chemical properties of the degraded sandy soil

The result presented in Table 3a, b showed significant difference ($P<0.05$) in the chemical properties of the soil assessed in this study for 1st and 2nd year planting, except for pH (1st and 2nd year), C/N (1st and 2nd year), and OC (1st year) and Al^{3+} + H^+ (2nd year) results respectively. The amended soils showed increased value relative to the control soil in all the parameters tested in both 1st year planting and 2nd year planting. In both studies (1st and 2nd year), their values increased with attendance increase in the rates of animal waste used, while in some parameters, the recorded values were fairly constant. The 1st year result of K and Al^{3+}+ H^+ for the rates of PM and PG respectively were constant. That is PM rates and PG rates recorded the same value. Higher values of the parameters in most cases were more observed in 1st year planting relative to the 2nd year planting. Increase in pH observed may be due to release of Ca and Mg into the soil from the waste degradation and removal of Al^{3+} from the exchange site of the soil. On the average, CD recorded the least value in OC content indicating that CD had the least contribution to the OC content of the soil. At 20tha^{-1}, improvement in OC over the control were 13.3%, 30%, and 26.67% (1st planting) and 22.45%, 106.12%, 67.35% (2nd year) respectively for CD, PM and PG.The relative increase in OC and N observed in both 1st and 2nd year planting may be due to higher content of the nutrients in the waste relative to the soil (Table 1). The observed percentage increase in the OC content of the 2nd year may suggest low productivity and increased decomposition of the wastes or can be explained in the light of the residual effect of the 1st year planting. The result of P obtained indicated that the animal waste imparted much on the availability of the nutrient via its content on the initial (Table 1). This probably may result from the OM content, its mineralization and solubilization properties that might have affected the fixed P to dissolve and come into solution and come to the exchange site of the soil. Thus increasing the value of P relative to the control soil and initial (Table 1). On the average, the C/N ratio of PM and PG values were similar but of higher value than CD and CO for 1st year planting, while the 2nd year planting result showed an order PG > PM > CD > CO. Available P deficient in CO relative to the amended soils may be due to removal of maize plant without external addition. The increase in exchangeable bases may be due to OM mineralization from the wastes applied with consequent release of nutrients. In all the treatments, increase in exchangeable bases were in most cases not reflected in increasing rate of application. However, the highest increments in the exchangeable bases were obtained in soil amended with poultry manure. The CEC content increase observed in the study could be attributed to the OM increase from the waste applied. This should be expected as Mbagwu etal. (1994) reported that OM more than inorganic clay colloid contribute more to CEC in soils that are low in clay, and this studied soil is very low in clay content (Table 1). On the average, the CEC value recorded in PM and PG are similar (1st year) but was highest in PM (2nd year) compared to its value obtained from the other treatments. The decreased exchangeable acidity observed from this study with respect to the control soil perhaps may suggest the removal of Al^{3+} from soil exchange site resulting from OM decomposition and mineralization. It can also be attributed to neutralization of Al^{3+} by Ca^{2+} and Mg^{2+} released from decomposing animal wastes or absence of the possibility of Al toxicity. Generally, the low CEC values observed in the study may suggest the influence of low OM in the soil (Table 1). The low exchangeable base values recorded may be linked to the low OC content of the soil and weathering intensity as the soil is degraded.

Soils with low OC lack the capacity to hold cations in the exchange site. The low base status may likely be associated with low clay usually found in acid sands like the studied soil.

Table 3a Effect of animal waste on the chemical properties of sandy soil (1st year planting)

Treatment	$pH_{(H2O)}$	OC%	TN%	P ppm	C/N	Na	K	Mg	Ca	CEC	$Al^{3+} + H^{+}$
						←meq/100g soil			→		
Control (CO)	4.7	0.60	0.058	16.8	10.3	0.10	0.12	1.0	1.0	5.0	1.8
CD_5	5.1	0.60	0.058	12.8	10.3	0.13	0.14	1.4	1.4	5.5	1.2
CD_{10}	5.2	0.64	0.060	16.8	10.7	0.13	0.15	1.4	1.5	5.5	1.10
CD_{20}	5.3	0.68	0.061	21.0	11.1	0.14	0.15	1.5	1.0	6.0	1.0
Mean	5.2	0.64	0.06	16.87	10.70	0.13	0.15	1.43	1.30	5.67	1.10
PM_5	5.4	0.65	0.062	25.2	11.0	0.14	0.16	1.5	1.3	5.5	1.10
PM_{10}	5.5	0.72	0.059	31.5	10.8	0.15	0.16	1.6	1.9	6.0	1.10
PM_{20}	5.8	0.78	0.069	58.8	10.4	0.15	0.16	1.6	1.9	6.5	1.0
Mean	5.57	0.72	0.063	38.5	10.73	0.15	0.16	1.57	1.70	6.0	1.07
PG_5	5.1	0.64	0.061	18.9	11.1	0.12	0.13	1.6	1.4	5.0	1.2
PG_{10}	5.2	0.64	0.063	31.5	10.2	0.13	0.13	1.6	1.4	6.0	1.2
PG_{20}	5.3	0.76	0.070	48.3	10.9	0.14	0.15	1.8	1.3	7.0	1.2
Mean	5.2	0.68	0.065	32.9	10.73	0.13	0.14	1.67	1.37	6.0	1.2
LSD0.05	NS	NS	0.003	2.05	NS	0.02	0.01	0.15	0.14	0.23	0.17

Table 3b Effect of animal waste on the chemical properties of the degraded sandy soil (2nd year planting)

Treatment	pH H_2O	OC%	TN%	P ppm	C/N	Na	K	Mg	Ca	CEC	$Al^{3+} + H^{+}$
						← meq/100g soil →					
Control (CO)	5.0	0.49	0.011	14.82	9.98	0.08	0.11	0.90	0.99	5.0	1.90
CD_5	5.2	0.50	0.014	11.79	10.09	0.12	0.12	1.09	1.30	5.21	1.11
CD_{10}	5.3	0.59	0.018	14.68	10.15	0.11	0.13	1.28	1.46	5.42	1.09
CD_{20}	5.4	0.60	0.020	19.09	11.50	0.15	0.14	1.34	1.34	6.35	1.12
Mean	5.23	0.56	0.017	15.19	10.50	0.13	0.13	1.24	1.37	5.66	1.11
PM_5	5.29	0.60	0.015	25.01	10.25	0.12	0.14	1.4	1.28	5.45	1.08
PM_{10}	5.41	0.89	0.017	30.16	9.89	0.13	0.15	1.5	2.0	6.02	1.13
PM_{20}	5.49	1.01	0.030	54.35	11.0	0.13	0.16	1.6	1.98	6.37	0.9
Mean	5.40	0.83	0.021	36.51	10.35	0.13	0.15	1.50	1.75	6.95	1.04
PG_5	5.3	0.50	0.013	17.19	11.01	0.09	0.11	1.49	1.34	5.0	1.09
PG_{10}	5.1	0.61	0.020	31.05	10.09	0.12	0.12	1.59	1.37	6.06	1.16
PG_{20}	5.4	0.82	0.016	47.23	10.01	0.13	0.14	2.0	1.18	7.05	1.18
Mean	5.23	0.64	0.016	31.82	10.70	0.11	0.12	1.69	1.30	6.04	1.14
$LSD_{0.05}$	NS	0.04	0.003	2.35	NS	0.02	0.01	0.16	0.13	0.25	NS

Effect of animal waste on the growth and dry matter yield of maize

The general trend of growth rate monitored in terms of increases in plant height and dry matter as influenced by the treatments in the 1st and 2nd year planting season are shown in Table 4. The two parameters showed significant ($P<0.05$) increase in value in the 1st year planting and significant ($P<0.05$) decrease in value in 2nd year planting relative to the 1st year planting. The yield values of plant height and dry matter of maize increased in all the amended soils relative to the control. The tallest maize plant and dry matter yield of 124.8cm and 13.35gkg^{-1} (1st year) and 95.2cm and 2.03gkg^{-1} (2nd year) respectively was obtained from soil amended with 20tha^{-1} of poultry manure among the other treatments. While the shortest of the plant height and least dry matter yield was recorded in the control. On the average, the order of height and dry matter increase were PM > PG > CD > CO for 1st and 2nd year as well as 1st year dry matter respectively, and PM > CD > PG > CO for 2nd year dry matter result. Obi and Ebo (1995) and Nweke (2019) observed that poultry manure application significantly improved average maize grain yield. The dry matter unlike the height yield increases did not depend on the rates of application. The yield improvements observed with the animal wastes were likely be as a result of enhanced nutrient status of the soil due to soil amendments.

Table 4 Effect of three contrasting rates of animal waste on plant height (cm) and dry matter yield (gkg-1) of maize at harvest

Treatment	Plant height (cm)		Dry matter yield (gkg^{-1})	
	1st year	2nd year	1st year	2nd year
Control	54.9	48.7	2.78	1.31
CD_5	72.6	53.3	4.63	1.57
CD_{10}	83.7	59.7	4.61	1.37
CD_{20}	69.7	61.8	3.02	1.97
Mean	75.33	58.27	4.09	1.64
PM_5	107.0	58.8	7.95	1.71
PM_{10}	110.9	62.4	9.31	1.49
PM_{20}	124.8	95.2	13.35	2.03
Mean	114.23	72.13	10.20	1.74
PG_5	105.0	64.5	7.01	1.75
PG_{10}	112.8	57.5	8.39	1.37
PG_{20}	123.4	64.9	11.13	1.68
Mean	113.73	62.30	8.85	1.60
$LSD_{0.05}$	14.67	3.64	2.50	1.0

Also, in Table 5 the percentage yield increase over the control result depicted poultry manure to have given the highest value in both 1st and 2nd year planting. The order of increase is PM >PG > CD, and PM > CD > PG respectively for 1st and 2nd year planting. On the average, the yield increase order is PM > PG > CD. Soil treated with $20tha^{-1}$ PM rate among all the rates of animal wastes used gave the highest yield increase of 380.2% and 55% for 1st and 2nd year planting respectively (Table 5).

Table 5: Percentage yield increase over the control

Treatment	Yield increase		
	1st year	2nd year	Average
CD_5	66.5	19.8	42.9
CD_{10}	65.8	4.6	35.2
CD_{20}	8.6	50.4	29.5
Mean	46.97	24.93	35.86
PM_5	186.0	35.0	110.5
PM_{10}	234.9	13.7	124.3
PM_{20}	380.2	55.0	217.6
Mean	267.03	34.57	150.80
PG_5	152.2	33.6	92.9
PG_{10}	201.8	4.6	103.2
PG_{20}	300.0	28.2	164.1
Mean	218	22.13	120.07

Effect of animal wastes on yield reduction and residual effect of maize

From the result presented in Table 6, poultry manure gave the highest yield reduction followed by PG, CD and control. This could be attributed to fast degradation of PM and PG suggesting that most of their nutrients may have been released during the crop 1st growing season. This probably may be associated to the N content C/N ratio of the wastes. The CD showed the lowest yield reduction and high residual effect. This probably may be that decomposition rate is low, hence slow release of nutrients therein. Generally, it was observed that amendment that gave highest dry matter yield during the 1st planting season had the worst residual effect.

Table 6 Yield reduction with time and residual effect of maize as influenced by animal waste

Treatment	Yield reduction	Residual effect %
Control	52.9	47.1
CD_5	66.0	14.0
CD_{10}	70.0	30.0
CD_{20}	34.8	65.2
Mean	56.93	36.4
PM_5	77.7	22.3
PM_{10}	84.0	16.0

PM_{20}	84.8	15.2
Mean	82.17	17.83
PG_5	75.0	25.0
PG_{10}	83.7	16.3
PG_{20}	84.9	15.1
Mean	81.20	18.80

IV. Conclusion

The potentials of any animal waste used as soil amendment to ameliorate the physico-chemical properties of degraded soils and improve crop yield is dependent on the nutrient content of the waste and its ability to decompose quickly and make them available for crop growth and development. Thus, the result findings have shown that PM, PG and CD have good promises as soil amendment materials for improving soil productivity. These accounted for the improved aggregate stability, water retention capacity of the soil, pH, OC, N, P, exchangeable bases and CEC. These may have accounted for the improvements recorded in maize performance and yield. Poultry manure had the highest contribution of nutrients compared with pig manure and cow dung. The agronomic ranking of the studied wastes is PM > PG > CD > CO. The organic and greenhouse farmers are advised to make use of these wastes and rates as it has shown to influence soil nutrients, crop development and yield.

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