Journal of Food Processing & Technology
Sasanya and Ogedengbe, J Food Process Technol 2019, 10:2
DOI: 10.4172/2157-7110.1000780

Research Article Open Access

Investigating the Effects of Bioslurries on Some Agronomic Properties of Common Vegetables

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Abstract

The increasing costs, dwindling supply, and the environmental effects associated with the uses of petroleum products call for attention. It is, therefore, appropriate to look out for environmentally sustainable alternatives to inorganic fertilizers which have direct links to agricultural production and sustainable food supply. The aim of this study is to investigate the potency of digested organic manure (bioslurry) for the production of common vegetables. Six growth parameters of two vegetable types- *Amanranthus hybridus* and *Corchorus olitorius* were investigated on five soil treatments in three replicates. The wastes and soil samples were also analyzed before and after the experiments. At 95% level of confidence, the soil amendments had no significant difference in the plant's heights, root lengths, Leaf Area Index, an Average number of leaves and fresh plant weight since 6.39>F=1.50,1.00,0.59,0.69 and 0.36 respectively, 14 days after planting. The same trend was noticed for 21 and 28 days measurements since 6.39>F=1.02,2.59,0.51,0.55 and 0.83 respectively for 21 days measurements. However, there are significant differences between the two plant types for the parameters measured. Duncan Multiple Range Test (DMRT) more often than not revealed better performances of poultry bio-slurry. Bio-slurry can thus serve as good replacements for inorganic fertilizers for the production of common Nigerian Vegetables.

Keywords: Bio slurries; Plants; *Corchorous olitorius; Amanranthus hybridus*

Introduction

As part of efforts to conserve the environment coupled with the likely menace arising from animal wastes, alternative uses, such as their use as energy and nutrient sources had been emphasized. The use of solid wastes from animals in the production of alternative fuels such as biogas was a great landmark but has its setback in the challenges faced in the ultimate disposal of the less toxic leftover slurry (with lesser polluting power) which had been acted upon by microorganism and methanogenic bacteria [1].

Bio slurries which are produced from the decomposition of organic materials in the absence of oxygen in an airtight container are good organic fertilizer of great quality [1]. Almost 30% of organic matter in wastes is converted to biogas in the course of anaerobic digestion, while the remaining can be useful for plant growth as manure [2].

Bio-slurry is obtained from anaerobic digestion of organic material when released as residual-product from the digester after the production of inflammable biogas which mainly contains 65%-80% methane and (20%-35%) CO_2 [1]. Bio-slurry is the anaerobic digested organic manure obtained from the production of biogas which is an inflammable methane gas for cooking lighting, and running machinery [3]. Bio-slurries are semi-solid organic remains from bioreactor or biodigesters obtained after the biological treatment of wastes [1]. The handling and ultimate disposal of bio-slurry pose lots of problems and difficulties. Bio-slurries are capable to supply micronutrients and macronutrient for the improvement of soil structure, the increment of microbial population and the maintenance crop produce quality [2].

Vegetables are of great importance in the human diet as a source of vitamins, minerals, and plant proteins and their cultivation is one of the more efficient and major branches of agriculture, as this can be traced to their economic as well as nutritional value [4]. Yield and growth behaviors of vegetables to bio-slurry have been reported for several crops [5]. *Corchorous olitorius and Amanranthus hybridus* are vegetables of great importance which serve as diet in the western part of Africa. *Corchorous olitorius* draws after cooking. It is usually consumed as a substitute for okra in most parts of Africa. *Amanranthus hybridus*, on the other hand, is a leafy vegetable which serves as leaf supplements in soups in the western part of Africa especially in the southwestern part of Nigeria.

The need to research into the potency of poultry and piggery solid wastes which was digested under anaerobic condition, to support the growth and yield of vegetables in comparison with their growth and yield when inorganic fertilizers are used sterns from the larger need to ensure a sustained and conserved environment as industrial and agricultural activities are being carried out. The interest to have an elaborate quantitative research on the bio-slurries produced from these wastes (piggery and poultry wastes) sterns from the need to abate environmental menaces such as odour, degradation of the aesthetic value of the farm environment and bottlenecks in the management of these wastes which arises from the exposure and outdoor dumping of the waste on the farm environment without putting them into further uses. However, several types of research had been carried out on the use of these wastes for biogas production, yet the production of biogas leaves behind digested slurries; there is, therefore, the need to research into the possible ways of putting these digestives (bio-slurries) into further environmentally friendly uses.

Nutrients from bio-slurries had been reported to be much more available to plants than nutrients from undigested farm animal wastes; however there is the need to have an elaborate comparison of the effects of inorganic fertilizer, bio-slurry from piggery wastes, bio-slurry from

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Received October 30, 2018; **Accepted** January 03, 2019; **Published** January 08, 2019

Citation: Sasanya BF, Ogedengbe K (2019) Investigating the Effects of Bioslurries on Some Agronomic Properties of Common Vegetables. J Food Process Technol 10: 780. doi: 10.4172/2157-7110.1000780

poultry wastes and the equal mixture of bio-slurry from piggery and poultry wastes on the growth of plants. There is a dearth of information on the comparison of the effect of inorganic fertilizer and bio-slurry produced from poultry and piggery solid wastes for the growth of green leafy vegetables. This study is therefore aimed at investigating the potential use of decomposed bio-slurry from poultry and piggery wastes to enhance vegetable yield and quality in comparison with its growth using inorganic fertilizers.

Materials and Methods

Waste collection

Freshly voided poultry and piggery solid wastes (in pasty or slurry states) which had undergone little or no deterioration was collected from the University of Ibadan teaching and research farm. The wastes were thereafter loaded into the bio-digesters for anaerobic digestion.

Experimental design

The randomized block experimental design was done in three (3) replicates. The obtained data were subjected to 2-way analysis of Variance (ANOVA) at 0.05 level of significance. Further significant differences between the treatments were tested using the Duncan Multiple Range Test (DMRT). Five (5) treatments or soil amendment types were considered and two plant types arranged into blocks are *Amaranthus hybridus* (A) and *Corchorus olitorius* (C). The experimental design layout for this study is shown in Table 1.

Laboratory analysis of soil samples, undigested wastes, and bio-slurries

The soil samples collected randomly from Ninety (90) points on the field (3 points from each plot) within the depth of 0 cm-15 cm below the soil using a soil collection auger after the seedbeds had been made. This was done in order to have a truly representative sample from the plant growth region (topsoil) of the soil. The collected soil samples were thereafter mixed thoroughly and air dried before sending it to the laboratory for analysis. The soil samples were analyzed in the laboratory prior to and after planting to determine the micro and macronutrients using the samples using standard laboratory analysis procedures according to IITA [6] and APHA, AWWA and WPCF [7]. The slurries were also analyzed before and after digestion according to standards.

Land preparation

The bushy land area of 33 $m^2 \times 10$ m^2 was ploughed on the 3rd day of July 2015. The topsoil was overturned and the weeds were buried below the topsoil. Thirty (30) sets of seedbeds were made with six (6) and five (5) seedbeds along the rows and columns respectively using a handheld hoe on the 17th day of July 2015. The height of the seedbeds was up to 20 cm and they have an equal area of 2.1 m^2.

Application of digested slurry and inorganic fertilizer

Digested slurries from piggery and poultry wastes were applied at agronomic rates of 2.5 kg/m^2 which is equivalent to 4 litres of bio-slurry according to recommendations which were specified in the planting guide for *Amaranthus spp.* by Andreas et al., [8] to the soil surface, mixed thoroughly into the soil and evenly spread afterward using a handheld rake. The inorganic fertilizer was however applied once at the rate of (40 gram /m^2) recommended by Andreas et al., [8].

Planting and cultivation of vegetables

Each plot (seedbed) for the experimental set up has an area of 2.1 m^2. The seeds of two vegetables; *Corchorous olitorius* and *Amaranthus hybridus* were planted on the plots for each of the treatments and this was replicated thrice in order to average out possible errors during data collections. The vegetable seeds were broadcasted at a rate of 1gram per square meter on each plot as recommended by Andreas et al. [8].

All other conditions such as temperature, water supply (irrigation), atmospheric conditions, and soil conditions which are needed for plant growth were kept equal for all the treatments so as to cater for all extraneous variables.

In the absence of rainfall events or three (3) days after each rainfall events, the plots were irrigated using seven (7) liters of water per plot with the aid of watering can. For this experiment, there was no rainfall event until 10 days after which the plantings had been done. The plantations were irrigated twice thereafter and henceforth, there were consecutive rainfall events up to the time of harvest; twenty-eight (28) days after planting. The average daily temperature for the planting period was 30°C.

The weeds which sprang up at sides and on the seedbeds were controlled by physical measures such as uprooting and cutting. The weeds were well taken care of and were not allowed to outgrow the planted vegetables at any instance so as to give room for full and undisturbed development of the vegetables. The experimental site is shown in Figures 1-3.

Data collection

The growth of the planted vegetables (*Corchorous olitorius* and *Amaranthus hybridus)* was monitored from 21 days after planting (3 weeks) for 3 consecutive weeks up to 28 days after planting. The planting was done on the 29th of July 2015 and growth parameters

Treatments/Block	Replicate E		Replicate F		Replicate G	
	1	2	3	4	5	6
Piggery Bio-slurry (V)	V1A	V2C	V3C	V4A	V5C	V6A
Poultry Bio -slurry (W)	W1C	W2A	W3A	W4C	W5A	W6C
50% Piggery Bio-slurry	X1C	X2A	X3A	X4C	X5A	X6C
50% Poultry Bio-slurry(X)						
Control (Y)	Y1A	Y2C	Y3C	Y4A	Y5C	Y6A
Inorganic Fertilizer (N.P.K 15: 15: 15) (Z)	Z1C	Z2A	Z3A	Z4C	Z5A	Z6C
V1A to Z6C represents each of the plots 1 to 6 represents each of the blocks which made up the replicates A means *Amaranthus hybridus* while C represents *Corchorus olitorius*						

Table 1: Experimental design to measure the effects of bio-slurries on plant growth.

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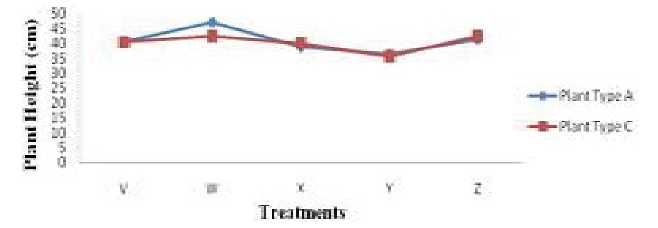

Figure 1: Average plant height (cm) 28 days after planting.

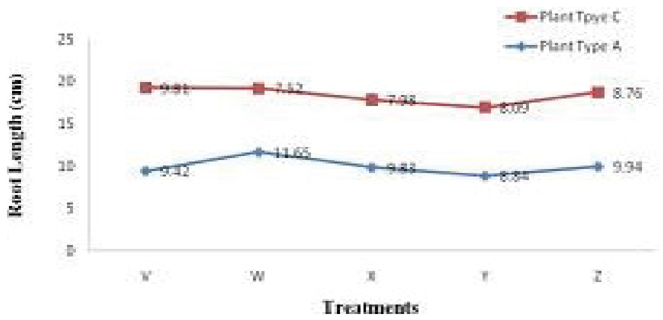

Figure 2: Average root length 28 days after planting.

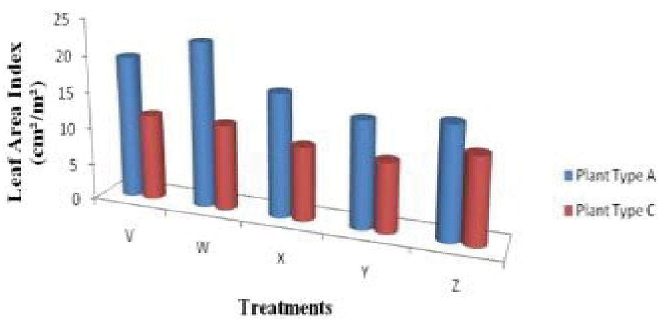

Figure 3: Average leaf area indices of plant samples 28 days after planting.

were measured on the12th of August, 19th of August and 26th of August, 2015 which are the 14th, 21st and 28th days after planting respectively. The plant growth parameters were measured for each week after the samples had been randomly uprooted. Three (3) plant stands were uprooted randomly from each of the six (6) plots; which made up each of the treatments. The roots of the harvested plants stands were cleaned up, by shaking off the attached soil in order to avoid additional weight on the plant stand. The following growth parameters were used to assess the plant growth for each treatment on each of the plots:

The plant height which was determined on the freshly harvested three (3) plant sample from the part of the plant on the soil surface to the point of leaf convergence using a scale rule and the average height was found

The root length was measured on the freshly harvested three (3) plant samples from the tip of the plant part below the soil surface to the part on the soil surface using a scale rule and the average length was found

The number of each true well developed leaf on each of the three (3) harvested plant stands samples were counted physically and the average number was found

The fresh plant weight of the three (3) randomly harvested plant stand was measured using an Ohaus Adventurer Pro top loading weighing balance and the average weight was found for each fresh plant stand

The dry weight of the plant: the randomly selected fresh plant stands were oven dried at 80°C for 24 hours to constant weight. The weight was measured using an Ohaus Adventurer Pro top loading weighing balance and the average weight was found for each dry plant stand

The crop growth rate=dW/dt/GA (1)

Where dW=Change in dry weight=Fresh plant weight-Dry plant weight

dt=change in time,

GA=Ground Area harvested [9,10]

The leaf area index=Leaf Area/ Ground Area (2)

The leaf area=Length of a leaf × Width of the leaf × 0.74 (3)

(Which is the leaf area factor measured from a planimeter) [9,10].

Results and Discussions

Chemical analysis of digested wastes, undigested wastes, and soil

The Tables shows the statistical comparison of the laboratory analysis of the digested and undigested wastes. The chemical analysis of the undigested and digested poultry and piggery wastes showed different contents of the wastes and this, therefore, suggests some high-level anaerobic digestion. The biochemical oxygen demand (BOD) (mg/l) of the poultry and piggery wastes dropped by 37.00% and 36.08% respectively.

The pH of both wastes moved downward toward the acidic range. The carbon: nitrogen ratio of both the piggery and the poultry wastes increased by 42.9% and 22.84% respectively after the anaerobic digestion process. The carbon-nitrogen ratio, however, ranged from 9:1 to 10:1; but this ratio may not actually support optimum bio-gas production which requires a carbon-nitrogen ratio of between 20:1 and 30:1. This suggests that pure animal wastes mixed with other organic waste such as plant materials with less organic matter contents are best materials for anaerobic digestion for optimum gas production.

The phosphorus content of the wastes increased by gave 71.43% and 38.60% for piggery and poultry wastes respectively. This is in line with the result of the research carried out by APRBRTC (1983) cited by Gurung [11] where the phosphorus content of biogas sludge was given to range between 0.4% and 0.6%.

The Nitrogen content of the piggery wastes increased after digestion by 16.09% while the nitrogen content of the poultry waste dropped by 26.98% after digestion. The drop in the nitrogen content of poultry waste is in line with the result obtained by Adelekan and Bamgboye [12]. The range of the nitrogen content of the bio-slurry from piggery waste (0.87%) is however within the range reported by APRBRTC (1983) cited by Gurung [11] as 0.8% to 1.5% for biogas sludge.

The potassium contents of the bio-slurries were obtained as 0.77% and 0.93% respectively for the poultry bio-slurries and piggery bio-slurries and these values are in line with the range of 0.8% to 1.0% given for the potash content of digested slurry cited in Gurung [11]. The increase in this nitrogen, phosphorus and potassium content of the wastes suggests they were mineralized in the course the digestion and these invariably made them much more available for plant utilization than when manures are used directly to enhance plant growth prior to anaerobic digestion. The organic matter content of the bio-slurries also increased by 21.85% and 35.14% over their initial values of 11.8% and 12.0% in the undigested poultry and piggery wastes respectively.

Plant growth parameters

Tables 2-18 show the statistical details of the growth parameters as discussed in the research. Figures 4-9 shows the growth parameters at maturity.

Plant height (cm)

The statistical analysis shows no significant difference on the plant heights after two weeks of planting for the soil amendments; since F=1.5<6.39 (Table 2).

The same trend was shown after 21 and 28 days of planting since F=1.02 (Table 3) and F=0.67 (Table 4) are respectively less than 6.39. The plant type, however, showed the significant difference after the respective 14 and 21 days, since F=69.29 and 28.57 are greater than 7.71. A deviation in this trend was observed for both plant types after one month since F=1.09 is less than 7.71 as shown in Table 4 and Figure 10.

The Duncan Multiple Range Test (DMRT) after 14 days showed the heights of plants on the piggery bio-slurry amended soil (V) are significantly greater than the height of plants on the soil without amendments (Y) and the soil amended with the mixture of both bio-slurries (X) while the heights of plants on the poultry bio-slurry amended soil (W) and soil amended with inorganic fertilizers (Z) is significantly greater than the height of plants on the soil without amendments (Y). After 21 days of planting, soil amendments W, Z and X recorded superiority over Y based on DMRT. The differences in the plant height were only significant between W and X after 28 days (at maturity).

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Soil Amendments	4	3.85	0.96	1.5
Plant Type	1	44.35	44.35	69.29
Error	4	2.56	0.64	
Total	9	50.78		

Table 2: Plant height after 14 days.

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Soil Amendments	4	24.36	6.09	1.02
Plant Type	1	172.73	172.73	28.57
Error	4	24.07	6.02	
Total	9	221.16		

Table 3: Plant height after 21 days.

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Soil Amendments	4	37.35	9.34	0.67
Plant Type	1	15.35	15.35	1.09
Error	4	56.09	14.02	
Total	9	108.79		

Table 4: Plant height after 28 days.

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Soil Amendments	4	0.48	0.12	1
Plant Type	1	0.41	0.41	3.42
Error	4	0.47	0.12	
Total	9	1.36		

Table 5: Root length after 14 days.

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square
Soil Amendments	4	2.78	0.7
Plant Type	1	3.5	3.5
Error	4	1.09	0.27
Total	9		

Table 6: Root length after 21 days.

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Soil Amendments	4	39.8	9.95	0.33
Plant Type	1	5.4	5.4	0.18
Error	4	121.29	30.3	
Total	9	166.49		

Table 7: Root length after 28 days.

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Soil Amendments	4	1.9	0.47	0.59
Plant Type	1	1.4	1.4	1.77
Error	4	3.17	0.79	
Total	9	6.47		

Table 8: Leaf area indices (LAI) after 14 days.

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Soil Amendments	4	9.9	2.48	0.51
Plant Type	1	93.02	93.02	19.14
Error	4	19.45	4.86	
Total	9	122.37		

Table 9: Leaf area indices (LAI) after 21 days.

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Soil Amendments	4	34.55	8.64	2.24
Plant Type	1	114.51	114.51	29.67
Error	4	15.44	3.68	
Total	9	164.5		

Table 10: Leaf area indices (LAI) after 28 days.

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Soil Amendments	4	1.04	0.29	0.69
Plant Type	1	17.58	17.58	41.86
Error	4	1.68	0.42	
Total	9	20.3		

Table 11: Number of leaves after 14 days.

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Soil Amendments	4	0.66	0.17	0.55
Plant Type	1	20.24	20.24	68.02
Error	4	1.19	0.3	
Total	9	22.09		

Table 12: Number of leaves after 21 days.

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Soil Amendments	4	2.14	0.54	2.35
Plant Type	1	18.69	18.69	81.26
Error	4	0.93	0.23	
Total	9	22..06		

Table 13: Number of leaves after 28 days.

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Soil Amendments	4	0.14	0.04	0.36
Plant Type	1	0.1	0.1	0.9
Error	4	0.44	0.11	
Total	9	0.68		

Table 14: Fresh plant weight after 14 days.

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Soil Amendments	4	8	2	0.83
Plant Type	1	64.01	64.01	26.07
Error	4	9.63	2.4	
Total	9	81.04		

Table 15: Fresh plant weight after 21 days.

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Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Soil Amendments	4	66.37	16.59	1.92
Plant Type	1	367.26	367.26	42.46
Error	4	34.59	8.65	
Total	9	468.22		

Table 16: Fresh plant weight after 28 days.

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Soil Amendments	4	0.0018	0.000045	0.003
Plant Type	1	0.02	0.02	14.08
Error	4	0.0057	0.001425	
Total	9	0.0275		

Table 17: Crop growth rate (CGR) after 21 days.

Source of Variation	Degree of Freedom	Sum of Squares	Mean Square	F
Soil Amendments	4	0.017	0.00425	5.67
Plant Type	1	0.0081	0.0081	108
Error	4	0.003	0.00075	
Total	9	0.101		

Table 18: Crop growth rate (CGR) after 28 days.

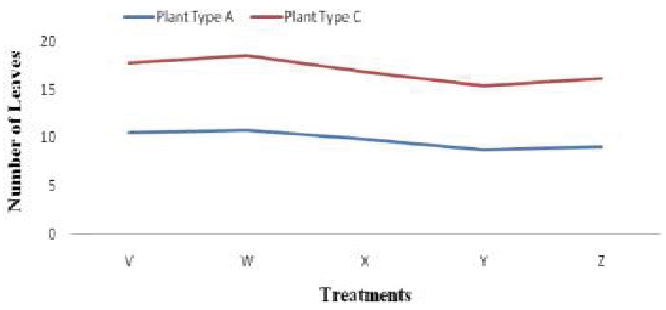

Figure 4: Average number of leaves 28 days after planting.

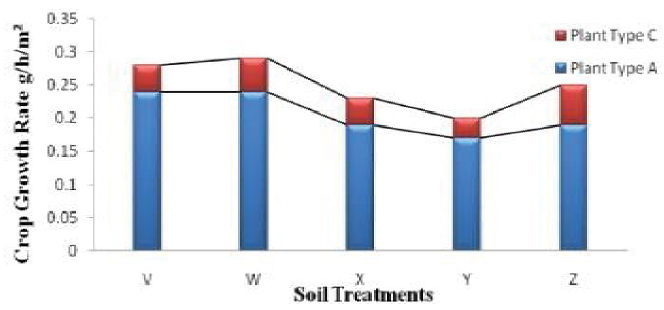

Figure 6: Land area 14 days after planting.

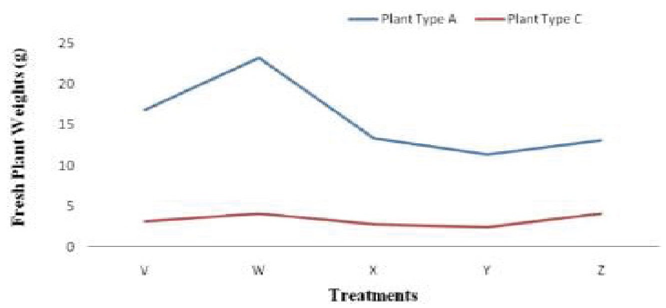

Figure 5: Average fresh plant weight 28 days after planting.

Figure 7: Average crop growth rate 28 days after planting.

Root length (cm)

The root length has no significant difference for the soil amendments and plant type throughout the experiment. The F values=1.00, 2.59 and 0.33 are less than 6.39 (Tables 5-7) for the soil amendments after 14, 21 and 28 days respectively. The F values less than 7.71 for the plant types are 3.42,3.21 and 0.18 respectively as shown on the Tables 5-7. DMRT showed a significant difference between soil amendments Y and Z as well as Y and W after 14 days. This might be due to the need for the plants to absorb unavailable nutrients on the soil surface from the depth. Three weeks after planting, the roots of the plant's samples on V were significantly longer than those on Z and W. The roots of the plant's types on Y and X are also significantly longer than the roots of plants on Z. That is; V produced longer root than Z and W while Y and X had significantly longer roots than Z. The root lengths had no significant difference at maturity.

Leaf area index (LAI) (cm²/m²)

The leaf area indices for the soil amendments indicated no significant difference since the F=0.59,0.51 and 2.24 are respectively less than 6.39 after 14,21 and 28 days of planting (Tables 8-10). There are however significant differences in the leaf area indices of the plant types after 21 and 28 days the planting had been done. This is specifically due

Figure 8: Cultivated land area 21 days after planting.

Figure 9: Cultivated land area 28 days after planting.

to the different growth characteristic of the two plant species. The F values 19.14 and 29.67 are greater than 7.71 as shown in Tables 9 and 10 respectively. The LAI after 14 days, however, showed no significant difference for the plant types since F=1.77<7.71 (Table 8). DMRT showed no significant difference for the soil amendments after 14 days as expected based on the analysis of variance. A significant difference, however, existed between W and Y after 21 days. W, however, showed better comparative leaf area index than Y, X, and Z after 28 days. There was also a significant difference between V and Y at maturity.

Number of leaves

The soil treatment or amendment did not indicate any significant difference in the number of leaves for the 3 consecutive weeks of data collection. The F values 0.69, 0.55 and 2.35 respectively for 14, 21 and 28 days are less than 6.39 as shown on the Tables 11-13. The plant type showed a significant difference in the number of true leaves for the 3 consecutive weeks. This is also a result of the possible differences in the growth characteristics of the two plant species.

The F values 41.86, 68.02 and 81.26 for the 3 consecutive weeks of data collection and monitoring are greater than 7.71 as shown on the Tables 11-13. DMRT at 14 days indicated the number of leaves produced on V was significantly more than those produced on Y. At 28 days, the number of leaves produced on W is significantly greater than the ones on the soil without amendments (Y) and the soil amended with inorganic fertilizer (Z).

The number of leaves produced by the plants on the soil amended with piggery bio-slurry (V) is also significantly greater than those produced on Y and Z. The number of leaves on X and Z is as well significantly greater than the number of leaves on Y. The number of leaves on the various soil amendments had no significant difference after three weeks the plantings had been done.

Fresh weight of plant (g)

The freshly harvested plant's weights showed no significant difference for the soil amendments and the plant types two weeks after the planting had been done since F=0.36<6.39 and F=0.91<7.71 (Table 14).

Three weeks after planting, no significant difference was shown in the fresh plant weight for the soil amendments since F=0.83<6.39, but, on the contrary, the plant types showed a significant difference in their weights since F=26.67>7.71 (Table 15). The same trend was observed; four weeks after planting. F=1.92<6.39 and F=42.46>7.71 for the soil amendments and plant types respectively as presented in Table 16. The difference in the fresh plant weight is also as a result of the growth pattern and characteristics of the plant species. DMRT at 21 days after planting showed the weights of the plants grown on W were significantly heavier than the weights of the plants on Y and V after 28 days, the fresh plant weight on the soil amendment W was significantly greater than the weights of the plants on Y, X, and Z.

Crop growth rate (CGR) (g/h/m²)

The statistical analysis showed no significant difference in the crop growth rate for the soil amendments after three weeks the planting was done; since F=0.03<6.39 (Table 17). The same trends were shown after 28 days of planting since F=5.67 is less than 6.39 as shown in Table 18. The plant types, however, showed significant differences in the crop growth rate after 21 days since F=14.08 is greater than 7.71 (Table 17). The crop growth rate of the plant types is also significantly different since F=108 >7.71 as shown in Table 18. The crop growth rate for two weeks after planting was not computed due to the inability to access an oven for the drying of the plant samples. DMRT after 21 days showed the Crop growth rate on the poultry bio-slurry amended soil (W) was significantly greater than the growth rate of the plants on the plots without soil amendments (Y) and the growth rate of the plants planted on W, 28 days after planting was significantly greater than the crop growth rate on X, Z and V. The growth rate of the plants on the piggery bio-slurry amended soil (V) is also significantly greater than the growth rate of the plants on the soil without soil amendments (Y) at this stage.

The residual effect of bio-slurry and inorganic fertilizer on the soil

Table 19 shows the statistical comparison of the chemical analysis of the soil used for the experiments before and after amendments and plantings. There were only slight differences in the pH of the soil after the vegetables were harvested at maturity, this may be due to the fact that the pH values of the bio-slurries added to amend the soil were close to the actual pH of the soil before the experiment. The tested soil pHs were all close to the neutral point of 7.0 on the pH scale but are all on the acidic side of the scale.

However, the pH of the control treatment Y and the bio-slurry treatment X dropped slightly after the experiment while those of the bio-slurries treatment V and W increased slightly after the experiment as compared to the inherent pH of the soil before the experiment. Even though well-decomposed composts and bio-slurry have buffering potentials [5], no significant improvement was noticed in the pH. This may be due to the slow rate of mineralization [5]. Mineralization of organic matter is affected by soil pH [13,14].

The organic matter contents of the soil samples amended with bio- slurries increased by an average of 4.82% while the organic matter content of the control treatment Y and the inorganic fertilizer treatment Z were close to the organic matter content of the soil before the experiment. This can be attributed to the lack of organic matter in inorganic fertilizers. The same trend was also noticed for the organic

Parameters	V			W			X			Y			Z		
	Ẋ	R	SD	Ẋ	R	SD	Ẋ	R	SD	Ẋ	R	SD	Ẋ	R	SD
pH	6.38	0.03	0.01	6.39	0.06	0.03	6.34	0.04	0.02	6.29	0.15	0.075	6.42	0.11	0.055
OM (mg/l	9.51	4.79	2.4	8.91	3.59	1.8	10.16	6.09	3.05	6.6	1.02	0.51	7.27	0.31	0.03
OC mg/l	5.5	2.77	1.38	5.15	2.07	1.04	6.13	3.52	1.5	2.54	0.59	1.56	4.15	0.08	0.04
K^+ (mg/l)	77.35	123.3	61.65	85.85	140.3	70.15	141.3	87.35	15.7	29.65	27.9	13.95	96.85	162.3	81.15
PO_4^{2-} (mg/l	66.9	110.2	55.1	95.9	36.2	18.1	114.3	73.2	36.6	69.4	16.4	8.2	83.5	11.4	5.7
Mg^{2+} (mg/l	15.9	7	3.6	14.4	3.9	1.95	12.95	1.1	0.55	13.35	1.9	0.05	14.85	4.9	2.45
Ca^{2+} (mg/l	26	15.3	7.7	23.35	10.1	5.05	31.3	26	13	19.65	2.7	1.35	26.4	16.2	8.1
NO_3^- (mg/l	175.2	183.4	91.8	159.7	152.6	75.3	188.7	210.6	105.3	87.3	7.8	3.9	108.7	50.6	25.3
Sand (%)	66.7	5	2.5	67.9	7.4	3.7	67.9	7.4	3.7	68.3	8.2	4.1	65.9	3.4	1.3
Silt (%)	19.9	2.6	1.3	19.05	4.3	2.15	19.4	4	2	19.35	3.7	1.85	19.05	4.3	2.15
Clay (%)	13.4	2.4	Jul-80	13.05	3.1	1.55	12.9	3.4	1.7	12.35	4.5	2.25	15.05	0.9	0.45
OM: Organic Matter, OC: Organic Carbon, Ẋ: Mean, R: Range, SD: Standard deviation															
Source: Sasanya and Ogedengbe [13].															

Table 19: Statistical comparison of soil samples before and after soil amendment and planting.

Parameters	Poultry			Piggery		
	Mean	Range	SD	Mean	Range	SD
pH	5.99	0.88	0.44	6.19	0.08	0.04
Carbon: Nitrogen	14.91	8.14	4.07	10.9	2.81	8.08
Organic Carbon (mg/l)	7.78	1.9	0.95	8.82	3.77	1.88
Total Nitrogen (mg/l)	0.55	0.17	0.09	1.6	0.17	0.73
K^+ (mg/l)	0.91	0.55	0.02	0.67	0.2	0.1
PO_4^{2-} (mg/l)	0.4	0.51	0.23	0.46	0.22	0.11
Mg^{2+} (mg/l)	0.14	0.15	0.07	0.09	0.16	0.09
Ca^{2+} (mg/l)	0.78	1.55	0.77	0.66	1.31	1.98
NO_3^- (mg/l	4.2	4.2	0	7.94	7.94	0
Organic Matter (mg/l)	13.42	3.3	1.65	15.25	6.5	3.25
BOD (mg/l)	790	357	178	1124.5	495	247.5
Conductivity	353	270	135	369.5	191	95.5
Source: Sasanya and Ogedengbe [13].						

Table 20: Statistical comparison of chemical analysis of undigested and digested wastes.

carbon content of the soil before and after planting. There was an increase in the organic carbon content of the soil for the treatment V, W, and X, while on the other hand the organic carbon content soil for the treatments Y and Z was close to that which was obtained from the soil before the experimental phase of soil amendments (Table 20).

The potassium content of the soil before the experiment was very low, but this had drastically increased in the soil samples collected from each of the treatment after the experiment. The highest increase in the potassium content of the soil which was noticed in the treatment Z was obviously due to the high potassium content of the inorganic fertilizer (N:P:K15:15:15) which was applied to the soil before the vegetables were planted. The bio-slurries treatments (V, W, and X) also recorded increases in the potassium content of the soil and these increases were close to the that which was noticed from the Z treatment. This implies that potassium contents of the bio-slurries were effectively delivered to the soil. The Y treatment, however, had an increase in its potassium content after the experiment but this was minimal in comparison with the increase recorded by the other treatments.

The increases in the calcium and magnesium contents of the soil are minimal when compared to what was obtained for potassium on each of the treatments after the experiment. The reason for these lower increases was explained by Sankaran and Swaminatiian [15] and Shahabz [5] stating that at pH near the neutral point, many metallic elements such as iron, manganese, aluminum, copper, zinc, and others are as well as phosphorus less available to the plants. Calcium, magnesium, and molybdenum also fall into this category [15].

The nitrate contents of the soil in the treatments (V, W, X, and Z) also increased after the experiments. However, the nitrate content of the treatment Z was lower than those of the bio-slurries treatment (V, W, and X). This may be due to the high organic matter content of the bio-slurries which decomposes in the soil when acted upon by soil microorganisms.

Conclusion

This preliminary research further confirmed bio slurries from biogas digester as an alternative and environmentally sustainable means to improve the growth performance of *Amanranthus hybridus* and *Corchorus olitorius.* Bio slurries, due to the processes have undergone during preparation have very low polluting power, unlike fresh animal manure. The cost of production of bio-slurry is also cheap when compared to inorganic fertilizers. It was evidenced from the study that the poultry bio-slurry (W) had significant plant height at maturity. The parameters which concern the edible (most important) plant part; leaf area index and a number of leaves were most enhanced by the poultry bio-slurry in the experiment. The expressed concerns about poultry waste management with the recent increase in poultry production across the country should, therefore, be laid to rest; since these wastes can be directed towards massive vegetable production after adequate treatment.

Recommendations

A none field experiment (in a greenhouse) is recommended for further study; taking into consideration the differences in plant nutrient uptake when inorganic fertilizers and bio slurries are used as soil amendments. The effects of bio slurries on plant growth taking the feed intake of animals into consideration can as well be investigated. Studies can also be made on the effect of mixing ratio on the use of bio slurries on the growth of plants.

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