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Production Of Nitrogen Rich Pelleted Organic Fertilizer From Animal And Plant Waste Using Bacillus Subtilus As A Catalyst.

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Abstract
Among other things, shortage and cost of fertilizers contributes to food insecurity, especially in developing countries such as Nigeria, hence, affect the economy of the nation and as well contribute to inflation. The study aimed to produce a nitrogen rich pelleted organic fertilizer from animal and plant waste and its application in the growth and development of maize plant. The waste used I this research is the combination of cow dung and saw dust. The waste were compost using anaerobic digestion method I the presence of B. subtilis an anaerobic organism that breakdown the waste into nitrogen rich substance. The proximate analysis of the waste was carried out using standard method. The nitrogen, phosphorus and potassium content were analyzed using standard methods. The performance of the applied fertilizer were carried out using standard method (measuring the parameters). The proximate analysis result showed that the combined waste had a good value for volatile solid (75%), and moisture content of 85.45% that both served as a good media for the microbial activity. The result obtained revealed that the temperature and pH of the compost ranged from 25.5^{O}C -29^{O}C and 5.76-6.24 respectively. The N.P.K result obtained are of the ratio 3:1:3 (0.412, 0.128 and 0.325 ppm). The N.P.K values were within the WHO recommended quality standard. The performance screening carried out in study favored the pelleted organic fertilizer that showed increase in all the parameter measured across the weeks more than that of synthetic fertilizer and the control. This implies the organic fertilizer from the animal and plant waste better than the synthetic and can serve as an alternative fertilizer.

Keywords: *Fertilizer, nitrogen, phosphorus, potassium and waste*

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I. Introduction

Fertilizer is typically given to crops in order to boost yield [1] Nevertheless, the overuse and persistent contamination of surface and ground water by modern synthetic fertilizers has damaged the environment by reducing the number of beneficial soil bacteria that are vital to soil fertility. Chemical fertilizers may have detrimental effects on human health in addition to their effects on the environment if food containing toxic residue is consumed [2]. Nowadays, a lot of garbage is produced by everyday consumption linked to population growth, economic expansion, and home and agricultural expansion. Various fruit peels and plant wastes are among these wastes. Fruit peels and plant debris are a major source of problems during the crop season. A large amount of fruit peels and dried tree leaves are disposed of in landfills, and some are left there without sufficient attention, which poses a serious threat to the environment [3].

Inorganic fertilizers represent serious environmental hazards. Thus, adopting and using organic preparations, such as digestate organic fertilizer produced from locally and renewable bioresources, can help to improve the situation. Because it is a rich source of nutrients and has been shown to be a slow-releasing fertilizer that supplies essential nutrients like nitrogen, phosphorous, and potassium (NPK) as agricultural biomass, and could be of great assistance [4]. Because of its high nutritional content on soil-living microorganisms, crop digestate—a term used to describe composting—is most frequently used as soil conditioners and organic fertilizers in the agricultural sectors. In essence, composting is the process through which organic solid wastes break down [5]. Bacteria like *Bacillus S,* Microorganisms work as a catalyst to break down organic matter throughout the composting process, producing water, carbon dioxide, energy in the form of heat, humus, and a stable organic product [6].

Alternatively, organic fertilizer (nitrogen rich) or biofertilizer from plant and animal waste have been in the front burner as a good substitute to chemical or inorganic fertilizer. It has been identified with the ability to not only increase crop yield, but also increase the fertility of the soil, improve life span and the activities of the soil microorganisms in a sustainable farming, hence, increasing the nutrient assimilation of plant and soil properties such as organic matter and soil nitrogen [7]. Many research have been reported on organic fertilizer including using Fruit and banana peels which have been identified as waste with high nitrogen contents [7]; [8]. In this study, we apply the technique of anaerobic degradation of the organic waste. This is facilitated by *B. subtilis* an anaerobic organism, which has the potential to breakdown biomass (organic waste) into nutrient such as nitrogen needed by plant for maximum productivity.

II. Material And Method

The methods used in this study involved different processes; this include the collection and combination of waste, subjecting them to anaerobic digestion, to initiate the inoculation of anaerobic bacterial *B. subtilis* responsible for the breakdown of the wastes to rich nitrogen containing substance. Finally, it was processed to pelleted organic fertilizer ready for application in the farm for crop production

Sample Collection

Cow dung (Animal waste) was collected from abattoir located in Ilaro, Ogun state, while the sawdust was obtained from local sawmills also in Ilaro. They were both transported to the study site for further processing.

Sample Pre-treatment

The samples were prepare by carefully picking out unwanted substances such as nylon, plastic and metals. Equal amount of the wastes (cow dung and saw dust) was weighed into a bowel and mixed with distilled water with the ratio 1:3 (one to waste and three to water) and was left for 24 hours before subjecting to anaerobic condition.

Anaerobic digestion of the waste

The mixture of the waste to water (1:3) was fed into a containment called bioreactor (Chinese prototype airtight container), up to two-third of the bioreactor (2/3), leaving one-third (1/3) for biogas collection. The cow dung contain microorganisms such as *B. subtilis* among others responsible for the digestion of the waste. Therefore, it served as inoculum of the bacteria. The anaerobic digestion was set up and monitored for forty days. The temperature and pH of the atmosphere and the slurry were monitored and recorded daily, using thermometer and pH meter respectively, according to [9].

Table 1: The ratio and amount of the combined waste in the bioreactor

Digester	Ratio (ws:wt)	Animal Waste (kg)	Sawdust (kg)	Water (liters)
1	3:2	2.3	2.3	13.5

Ws= wastes, Wt= water

Preparation of Feedstock to pellet

The biogas slurry (i.e., the waste gotten from the biogas) was used to produce pelleted organic fertilizer

- Firstly, the collected waste, i.e., biogas slurry was sun dried for eight hours in order to reduce the moisture content. The final moisture content after drying for eight hours was managed.
- The dried materials (i.e., the dried biogas slurry) were then converted to powder using disk mill and was sieved to obtain similar particle size.
- Starch flour was used as an adhesive, which is otherwise known as binder to make it stick together.
- After mixing the contents together, it was molded using a pellet mill (i.e pelleted machine), after which it was sun-dried in natural air.
- The pelleted fertilizer was thereafter used in growing the maize plant.

Nutrient Analysis

The nutrient composition of the produced fertilizers was analyzed using standard methods for determining nitrogen (N), phosphorus (P), potassium (K), and other essential nutrients. Physical properties such as pellet size, density, and durability was assessed. The kit involves following instructions to mix a small sample of the compost unit, a testing solution, and then capering the results to a colour chart to determine nutrient levels.

Alternatively, a laboratory testing was conducted using a slurry sample. The nutrient levels would be analyzed and a detailed report of the NPK content would be provided thereafter.

Field Experiment

Accroding to [10], a field experiment was conducted to evaluate the effects of different pelleted organic fertilizers on maize growth and yield. The experiment involved treatments with varying fertilizer formulations and application rates. Parameters such as plant height, leaf area, biomass production, and grain yield were measured and compared with those of conventionally fertilized plots. Randomized block design with multiple replicates will be employed to ensure statistical validity.

Fertilizer Characterization

[11] This process involves the determination of pH, which was achieved by measuring the quantity of the slurry sample transferred into a beaker. The slurry was left for 24 hours at room temperature, while a pH meter was then used to measure the pH content, i.e., the acidity and alkalinity of the slurry sample.

Also, the moisture content was also determined, by the initial weighed log of the pre-treated sample in a petri-dish, which was placed in an oven at 110^{o}c. The weight was taken thereafter at a 10 minute interval, until a constant weight was obtained (i.e., the final weight). The moisture content was determined by using the equation:

% Moisture content = Equation 1

Too high moisture level lead to condensation and can render the filters completely unstable. The optimum moisture content is between 50% and 70%.

Determination of Volatile Matter

5 gram of the samples were weighed initially in a petri-dish and placed in a muffle furnace at 50^{o}c for 4 hours. The samples were allowed to cool down in a desiccator and reweighed again [11].

Determination of Volatile Solid

The Volatile Solid is the remaining after evaporation or filtration dried, weighed and ignited at 600^{o}c [11].

Procedure

1. The residue obtained from total solid determination was ignited at 600oc for a duration of 30mins using a muffle furnanc
2. The crucible and black mass of carbon were allowed to cool particularly in air before it was transferred to desiccators for completing cooling
3. The sample was weighed once temperature balance is reached.

The percentage volatile was calculated using equation 2

Where: %VS = Percentage Volatile solid
W_4 = Weight of crucible + weight of residue after ignition
Figure 2 shows the experimental setup for determination of percentage total solid.

Determination of Total Solid

In order to calculate the total solid, sample of a given weight was put in ceramic vessel and dry at 1050^{o}c for 24hrs until a constant weigh was observed. The sample was then weighed for total solid measurement after cooling in the desiccators [11].

Determination of Temperature

The temperature of the samples were measured using a calibrated thermometer. The specific procedure depends on the context in which the temperature measurement is needed (e.g., ambient temperature, compost temperature, digestion process temperature).

Data Collection:

Data on Maize growth parameters, including plant height, leaf wrap, stem biomass, and leave development, were collected at regular intervals throughout the growing season.

Data on leave development and the number of leaves on maize planted with pelleted organic fertilizer were determined (measured with a ruler), after one week of planting maize. Also, the leaf ratio was determined using a meter rule which is a tool that can measure the area of leaf. Typically, it was measured in square centimeters per gram or square meters per kilogram.

On the same vein, the leaf development was determined using grid intersect, by removing the plant root from the soil, trace the root on paper, measure each of the tracings and calculating the root length from the tracing. Also, the number of roots were counted and measured in diameter. The leaf development was determined by measuring the root surface area using a root scanner. Similarly, stem development was determined by measuring the length of the stem, although caliper can also be useful in this regard, which is another method used to measure stem [12].

III. Result

Table 4.1: The characterization of the combined animal waste and sawdust before digestion

Parameters	Animal waste and sawdust (%)
Moisture	85.45
Total Solid	32.75
Volatile Solid	75.00
Volatile Matter	50.00

The characterization of the combined waste (cow dung and saw dust) in table 4.1 showed the amount of moisture content (86.5%) present which is high, this indicate that the substrate has a good processibility, shelf life and a good medium for microbial activity. The volatile solid of the waste, indicates the lost portion of the total solid of the substrate when exposed to higher temperature in an anaerobic condition (ignition).Its importance contributes to the assessment of sludge in waste water treatment. It provides the bases of the estimation of the actual organic material present in the sludge and a major source of nutrient for the microorganisms involved in the digestion of the waste. The high amount of the volatile solid (75%) represent the nature of the substrate as a good platform for microbial degradation of the biomass to smaller molecules such as nitrogen.

Table 4.2: Showing average slurry temperature of the combined waste in degree centigrade (^{O}C)

Days	Animal waste and sawdust (^{O}C)	
1-10	25.5	
11-20	25.9	
21-30	26	
31-40	29	

The average temperature of the slurry taken within the 40 retention days as recorded in table 4.2 ranges from 25.5^{O}C (Day 1-10) to 29^{O}C (Day 31-40). The values showed that the slurry temperature was within the atmospheric temperature that is normal for the activity of microorganism in the bioreactor to effectively breakdown the waste into a nitrogen rich substance, suitable for organic fertilizer formulation**.**

Table 4.3: The average pH measured within the retention time of 40 days

Days	Animal waste and sawdust
1-10	5.76
11-20	6.12
21-30	6.24
31-40	5.89

Microorganisms such as B. subtilis in an anaerobic condition are known as decomposers, they have the potential to degrade organic matter into small nutrients such as nitrogen. They are reported to be very effective at the pH range of 6.5-8.5. Table 4.3 above showed that the pH range of the slurry during the 40-day (retention period) is 5.76-6.24. This pH range was found to be within the optimal pH range for effective microbial activity. The slightly acidic pH observed from day 1-10 (5.76) is normal because the activity of decomposers is at the lag (acclimatization stage of the organisms); and that observed for day 31-40 (5.89) is a decline stage (showing decrease in the activity of the organisms) [13].

Table 4.4: Showing the nutrient composition (Nitrogen, Phosphorus and Potassium (NPK)) of the organic fertilizer from the combined waste.

PARAMETERS	Sawdust and Animal Waste (PPM)	Compost quality Standards (WHO, 1993)
Nitrogen (N) Content	0.412	0.1-1.8
Phosphorus (P)	0.128	0.1-1.7
Potassium (K)	0.352	0.1-2.3

The analysis of the nitrogen (N), phosphorus (P) and potassium (K) of the pelleted organic fertilizer (table 4.4), showed nitrogen (0.412 ppm) higher in the fertilizer followed by potassium (0.352 ppm) and then phosphorus with 0.128 ppm. The ratio of nutrient in the pelleted organic fertilizer (N.P.K) is approximately 3:3:1. The result obtained were all within the WHO recommended composting standard **[14].** Organic fertilizer with high nitrogen has been reported to have the potential to meaningfully enhanced crop growth, conserved soil fertility, and enhanced nitrogen use efficiency (NUE) of plants [15].

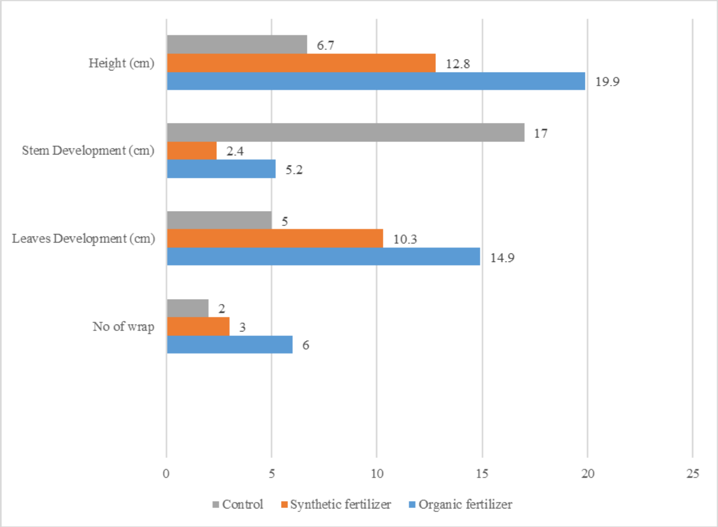

Figure 4.1: The Effect of the fertilizers on maize plant growth for week one

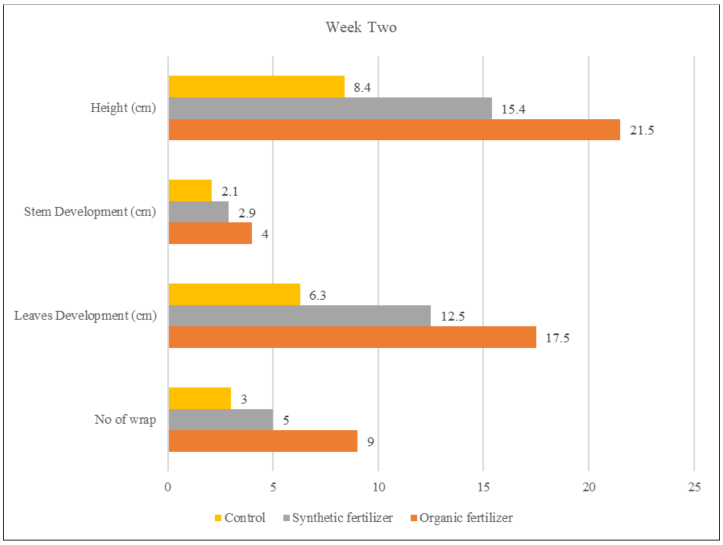

Figure 4.2: The Effect of the fertilizers on maize plant growth for week two

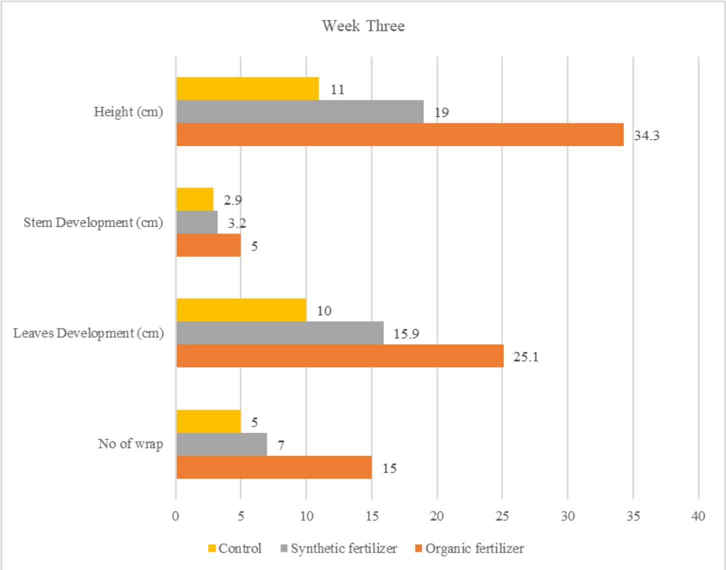

Figure 4.3: The Effect of the fertilizers on maize plant growth for week three

IV. Discussion

Figure 4.1, 4.2 and 4.3 are bar chart showing the effect of the application of the pelleted organic fertilizer on maize plant, growth and development when compares to the synthetic fertilizer against the control for three weeks. The height, stem development, leave development and number of wrap are the parameters measured I centimeter (cm).

The result in week one (figure 4.1) showed 36% and 67.6% increase in height of the maize plant with organic fertilizer application than the synthetic fertilizer and the control. In addition, the stem development result revealed that the control is 70% and 96% bigger than the organic fertilizer and the synthetic fertilizer. This could be because of the reduced growth of the plant (stunted growth) as observed on the large size of the stem. The leave development favored the pelleted organic fertilizer (POF) with 31.1% and 67.5% more than the synthetic fertilizer (SF) and control. To the number of wraps, the POF had 50% and 67% more than the SF and the control. This agree with the report of [15]. In this week one of fertilizer application, the pelleted organic fertilizer (POF) had an increase effect on the maize plant growth and development. This can be attributed to the readily availability of the organic fertilizer to the plant than the synthetic fertilizer.

Week two and three showed similar pattern of increase effect on the parameters measured from the maize plant. The result for the week two (figure 4.2), favored the pelleted organic fertilizer that showed higher value in the height, stem development, leave development and number of wrap of the maize plant with the percentage increase of 28.4% and 61%, 27.5% and 47.5%, 42% and 64%, 44.8% and 66.7% against the synthetic fertilizer and the control respectively. This finding agrees with the assertion of [16] who demonstrated that animal waste and saw dust manure performed better than their counterparts in other manure types on okra and tomatoes growth.

Week three (figure 4.4) result further demonstrated the performance of the pelleted organic fertilizer over the synthetic fertilizer and the control by showing a higher value across the parameters. The POF showed percentage increase of the height of 45.4% and 65.1%, stem development of 42% and 36%, and leave development of 36.7% and 60%, and 53.4% and 66.7% over the synthetic fertilizer and control. This may also be due to the nutrients the animal waste contains, high nitrogen, phosphorus, and organic contents compared to that of the synthetic whose components are chemically formulated [17], [18].

V. Conclusion

The pelleted organic fertilizer produce from the combination of cow dung and saw dust and compost using anaerobic digestion method in the presence of *B. subtilis* had nitrogen, phosphorus and potassium content within the recommended WHO compost quality standard. The application of the organic fertilizer on the growth and development of maize plant, demonstrated that it had etter performance or effect on the growth and development of the plant than the synthetic fertilizer and when compared with the control. This implies that the pelleted organic fertilizer from animal and plant wastes can serve as a good alternative to the synthetic fertilizer.

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