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Comparative effects of two formulated agricultural wastes and inorganic fertilizer on the performance of tomato (*Solanum lycopersicum* l.) on a derived savanna Alfisol

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ABSTRACT

A potted experiment was conducted during the 2020 and 2021 cropping seasons at the screen house of the Research Farm of the Bio-fuel and Alternate Renewable Energy Ltd, Edidi, Kwara State, in the derived savanna of Nigeria, to compare the effects of two formulated agricultural wastes (kola nut pod and cocoa pod) and NPK fertilizer on the performance of tomato. Treatment includes three levels each of formulated kola nut pod and cocoa pod at 5, 10, and 15 t ha^{-1} and 200 kg NPK ha^{-1}. Vegetative and yield parameters were collected. Data collected were subjected to analysis of variance (ANOVA) using GenStat Discovery, 2014. The significant treatment means were compared using Duncan Multiple Range Test (DMRT) at a 0.05 level of probability. Vegetative parameters varied significantly among the applied treatments. There was no significant difference in plant height when 10 t FCP, 10 t FKP, 15 t FCP, 15 t FKP, and 200 Kg NPK ha^{-1} were applied, except in the year 2020, where a significant reduction in plant height was recorded when 15 t FCP and 15 t FKP were applied. Higher levels of the two formulated amendments and inorganic fertilizer delayed flowering. However, there was no significant difference in the number and weight of fruits with the application of 10 t FKP, 15 t FCP, 15 t FKP, and 200 Kg NPK ha^{-1}. Therefore, the use of 10 t FKP (6.40 g/pot) could be regarded as the optimum rate for both vegetative and yield performance of tomatoes in the study area.

1.0 Introduction

Tomato (*Solanum lycopersicum* L.) is one of the most important vegetables in the world. It ranked next to potato and sweet potato but first as the processing crop (FAO, 2010). It is a relatively, short-duration crop which gives a high yield, and it is also economically attractive. Tomatoes are warm-season crops and are sensitive to high humidity. It can be consumed either as raw or as soup, sliced, dried, or juice (Musa et al., 2007). Tomato plays a vital role in the improvement of the diet of humanity. Consumption of tomatoes has been associated with the prevention of cardiovascular diseases, cancers, and several other diseases mainly due to the antioxidants, ascorbic acids, carotenes, lycopene, and phenolic compounds (Periago et al., 2009)

Agricultural wastes are produced from various agricultural operations (United Nations, 1997). Sabiiti et al. (2005) also defined agricultural waste as the by-products of agricultural activities because they are not the primary products. These wastes chiefly form crop residues (residual stalks, straw, leaves, roots, husks, shells, etc.) and animal waste (manures). Agricultural wastes are widely available, renewable, and virtually accessible; hence they can be an essential resource. Agricultural wastes contain high nutrient levels such as nitrogen, potassium, phosphorus, and some micronutrients that would improve soil fertility and increase crop yields, such as vegetables that fetch high prices and hence enhance food security (Nileemas and Sreenivasa, 2011).

Agricultural wastes are readily available to the growers and can be obtained at no cost or at a reduced price than chemical fertilizers (Alam et al., 2007). Additionally, organic wastes improve crop growth, yield, and quality. Additionally, organic wastes improve crop growth, yield, and quality. They also contain essential macro and micronutrients, many vitamins, growth promoters, and some beneficial microorganisms (Natarajan, 2007). Apart from the release of the nutrients in a slow manner, the application of organic fertilizers, which are made from animal excreta or other agricultural wastes, are usually used to improve the structure and stability of the soil and, in addition to enhancing the yield and quality of the crop plants (Marzouka and Kassem, 2011).

On the contrary, inorganic fertilizers are the best way of crop production, but their continuous application increases organic matter depletion and damages soil's chemical and physical properties. Moreover, inorganic fertilizers are expensive, and sometimes they are not readily available to smallholder farmers.

Considering these facts, society is increasingly concerned about environmental hazards, especially concerning health hazards created by the indiscriminate use of agrochemicals (Van der Berge et al., 2000). Consequently, many countries are considering organic agriculture using agricultural wastes as the well-established and certified forms of cropping systems among all the alternative cropping patterns (Adediran et al., 2003). The study aims to identify which agricultural waste will compete favourably with inorganic fertilizer and at what level it will give the best vegetative and yield performance of tomatoes.

2.0 Materials and methods

2.1 Description and Climatology Data of the Study Area

A potted experiment was conducted during the 2020 and 2021 cropping seasons at the screenhouse of the Research Farm of the Bio-fuel and Alternate Renewable Energy Ltd, Edidi, Kwara State, in the derived savanna of Nigeria. The site lies between latitude 8.2334° N and longitude 4.9416° E of the equator, with an annual rainfall of 600 mm and 1200 mm. The temperature of the study area varies between 33°C and 34°C during the year, with a distinct dry season from November to March.

Sandy loam soil was collected from the Research Farm, thoroughly mixed and sterilized to ensure the complete absence of the disease-causing pathogen. Sterilized soil was used for the nursery and filled into the grow bags/pots for the study. Pre-cropping soil samples were randomly collected from four bags per replicate. The samples collected were bulked to obtain a composite sample for a routine soil analysis to determine some physicochemical properties of the soil.

In each experimental year, using different polythene bags and different samples of the soil, 10 kg capacity black polythene bag/pot of size 30 cm x 17 cm were filled with the sterilized soil. The bags were perforated by the sides and base to allow for easy drainage of excess water and were arranged under a drip line in a complete randomized design (CRD), replicated three times

Edidi-72 local, the variety of tomato commonly grown in the study area, was used as the test crop. Tomato seeds were raised in the nursery section of the screen house, watered at intervals and as the need arises. Three weeks after sowing, two healthy seedlings were transplanted per pot which was later thinned down to one after they had established.

Formulated agricultural wastes (cocoa pod/poultry manure and kola nut pod/poultry manure) obtained through microbial decomposition were applied each at 5, 10, and 15 t ha^{-1}, which is equivalent to 3.25, 6.50, and 9.75 g pot^{-1} of formulated cocoa pod/poultry manure (FCP) and 3.20, 6.40, and 9.60 g pot^{-1} of formulated kola nut pod/poultry manure (FKP). Application of the amendments was made 4 days after transplanting to allow for nutrient release, while the application of inorganic fertilizer (NPK 15:15:15) was made two weeks after transplanting to give room for seedling's stability.

Cultural practices such as staking, irrigation through drip lines, weeding by hand-picking of emerged weeds, and de-suckering were observed during the growth of the plant. The goal of de-suckering was to remove excess foliage that could reduce air circulation within the plants, prevent overshadowing of the lower parts of the plants, reduce photosynthetic activity, and discourage fungal infection and flower abortion.

Mature and ripped fruits were harvested at intervals of five days for four weeks before the experiment was terminated. Harvested fruits were counted and weighed with an automated weighing balance of maximum capacity of 2100 g, readable at 0.01 g, and a model by OHAUS Corporation, USA.

Vegetative parameters (plant height, number of leaves, stem girth, and days to flowering) were collected at flowering, while yield parameters (number of fruits/plant and weight of fruit/plant) were collected at harvest.

Data collected were subjected to analysis of variance (ANOVA) using GenStat Discovery, 2014. The significant treatment means were compared using Duncan Multiple Range Test (DMRT) at a 0.05 level of probability.

3.0 Results

3.1 Initial Soil Properties

The pre-planting soil analysis is shown in table 1. The soil is high in the sand with relatively low values in both silt and clay; hence the textural class is Sandy Loam. The pH of the soil was strongly acidic, the Nitrogen content of the soil was very low, the available phosphorus was high, and the exchangeable K was also low, while the exchangeable Na, Ca, and Mg were all suitable. The organic matter was low.

Table 1: Physical and chemical properties of the initial soil

Parameter	2020	2021	Parameter	2020	2021
Sand (%)	69.20	69.00	Organic matter (%)	1.88	1.85
Silt (%)	14.50	14.70	K (cmol·kg)	0.14	0.14
Clay (%)	16.30	16.30	Ca (cmol·kg)	2.45	2.41
Textural class	Sandy loam	Sandy loam	Mg (cmol·kg)	0.34	0.36
pH (H_2O) 1:1	5.62	5.60	Available P (mg·kg)	9.71	8.95
Total nitrogen (%)	0.15	0.14	Zn (mg·kg)	0.33	0.30

Table 2: Chemical composition of the formulated cocoa pod and kola nut pod

Amendments	pH	N	P	K	Ca	Fe	Mg	Zn
Cocoa pod + poultry manure	7.30	9.18	0.62	1.22	14.00	0.14	4.80	3.46
Kolanut pod + poultry manure	7.95	9.36	1.28	1.62	15.88	0.28	9.40	4.68

3.2: Chemical composition of formulated agricultural wastes

Table 2 above shows that the amendments contained nutrient elements suitable for plant growth and development.

3.3 Effects of the formulated cocoa pod, kola nut pod, and inorganic fertilizer on the vegetative parameters of tomato

The measured vegetative parameters were significantly (P < 0.05) affected by the application of the two amendments, as indicated in Table 3. Compared with the control, which gave the least value for vegetative parameters, the application of amendments significantly increased plant height, number of leaves, and stem girth. In 2020, there was no significant difference in plant height when 10 t ha^{-1} FCP, 10 t ha^{-1} FKP, and 200 Kg ha^{-1} NPK were applied. Similarly, in 2021 application of 10 t ha^{-1} FCP, 10 t ha^{-1} FKP, 15 t ha^{-1} FCP, 15 t ha^{-1} FKP, and 200 Kg ha^{-1} NPK showed no significant difference in plant height. There was no significant difference in the number of leaves when 10 t ha^{-1} FCP, 10 t ha^{-1} FKP, 15 t ha^{-1} FCP, 15 t ha^{-1} FKP, and 200 Kg ha^{-1} NPK ha^{-1} were applied in both years. In 2020 and 2021, control gave a significantly lower value for stem girth when compared with other treatments. Inorganic fertilizer also increased vegetative parameters, but the increase was significant when compared to higher levels of formulated organic amendments.

Table 3: Effects of the formulated cocoa pod, kola nut pod, and inorganic fertilizer on the vegetative performance of tomato at flowering in 2020 and 2021 cropping seasons

Treatments (t ha^{-1})	2020			2021		
	Plant height (cm)	Number of leaves	Stem girth (cm)	Plant height (cm)	Number of leaves	Stem girth (cm)
Control	50.33c	12.20c	0.52b	55.21c	13.45c	0.50b
5 t FCP (3.25 g/pot)	73.10b	16.80b	0.62a		16.20b	0.60a
5 t FKP (3.20 g/pot)	73.56b	17.47b	0.62a	67.17b	16.42b	0.60a
10 t FCP (6.50 g/pot)	81.23a	21.78a	0.62a	78.54a	20.40a	0.61a
10 t FKP (6.40 g/pot)	82.54a	23.42a	0.63a	80.05a	21.50a	0.62a
15 t FCP (9.75 g/pot)	70.71b	24.10a	0.62a	77.83a	21.90a	0.61a
15 t FKP (9.60 g/pot)	71.87b	23.80a	0.62a	78.00a	22.14a	0.61a
200 Kg NPK ha^{-1} (5.0 g/pot)	83.00a	22.54a	0.63a	79.80a	22.45a	0.62a

Means with the same letter(s) in a column are not significantly different at $p<0.05$.

3.4 Effects of the formulated cocoa pod, kola nut pod, and inorganic fertilizer on the flowering and yield parameters of tomato

The application of amendments had considerable effects on the number of days to flowering and the yield performance of tomatoes (Table 4). Control plots flowered earlier, but the difference was not significant when 5 t ha^{-1} FCP, 5 t ha^{-1} FKP, 10 t ha^{-1} FCP, and 10 t ha^{-1} FKP were applied. The application of other treatments increased the

Table 4: Effects of the formulated cocoa pod, kola nut pod, and inorganic fertilizer on the number days to flowering and yield performance of tomato in 2020 and 2021 cropping seasons

Treatments (t ha^{-1})	2020			2021		
	Days to flowering	No. of fruits/plant	Weight of fruits/plant (g)	Days to flowering	Number of fruits/plant	Weight of fruits/plant (g)
Control	19.00b	9.33c	410.21c	18.78b	9.70c	425.30c
5 t FCP (3.25 g/pot)	20.51b	12.40b	905.33b	19.66b	12.75b	916.01b
5 t FKP (3.20 g/pot)	20.19b	12.45b	985.45b	19.84b	12.50b	984.55b
10 t FCP (6.50 g/pot)	20.58b	12.50b	990.55b	19.55b	12.88b	1002.25b
10 t FKP (6.40 g/pot)	21.20b	14.50a	1225.20a	20.58b	15.10a	1285.65a
15 t FCP (9.75 g/pot)	24.76a	14.88a	1233.10a	23.65a	14.95a	1298.45a
15 t FKP (9.60 g/pot)	24.55a	15.10a	1245.50a	23.42a	15.00a	1235.48a
200 Kg NPK ha^{-1} (5.0 g/pot)	23.96a	14.56a	1236.25a	23.00a	15.20a	1255.21a

Means with the same letter(s) in a column are not significantly different at $p<0.05$.

number of days to flowering. In both years of study, control plots gave lower values for the number of fruits and weight of fruits/plant. There was no significant difference in the number and weight of fruits/plants with the application of 10 t ha^{-1} FKP, 15 t ha^{-1} FCP, 15 t ha^{-1} FKP, and 200 Kg ha^{-1} NPK. There was no significant difference in yield parameters with the application of inorganic fertilizer and higher levels of formulated organic materials.

4.0 Discussion

Application of agricultural wastes to agricultural soil has been proven to increase nutrient retention, nutrient-uptake efficiency, soil organic matter, microbial biomass, nutrient -uptake efficiency, and reducing soil erosion nutrients (Chowdhury et al., 2013; Fageria, 2007), while the effects of agricultural wastes on soil properties depend upon the amount, type and size of the added organic materials (Zhang et al., 2015).

The laboratory determination of the chemical composition of the amendments used in the study showed that both formulated cocoa pod and kola nut contained nutrient elements in varying proportions suitable for the cultivation of tomatoes. Therefore, the positive response of tomatoes to the application of agricultural wastes and inorganic fertilizer could be attributed to their inherent physical and chemical properties (Aboyeji et al., 2018).

Application of formulated kola nut cocoa pod increased vegetative parameters of tomato, and it is comparable with the application of inorganic fertilizer. Increased vegetative parameters could be attributed to the presence of N and P in both amendments. Increasing P soil content due to the application of organic fertilizers might be a result of its decomposition and production of organic acids, which increased the nutrient availability in the soil. This result confirms the findings of Akande et al. (2010) and Uddin et al. (2009) that the application of organic material could ameliorate soil nutrients to improve crop production. Increased vegetative growth might also be due to efficient absorption and assimilation of nitrogen from the amendments by the plant, which serves as a constituent of chlorophyll which is directly proportional to the photosynthetic potential and yield of any given plant (Biljana and Aca, 2009). Carl and Bierman (2005) reported that applying compost from agricultural wastes supplies 70% organic nitrogen, phosphorus, and potassium uptake required for improving plant growth.

In many tropical soils, organic manures/agricultural wastes, despite their slow release of nutrients, have been reported to be major sources of nitrogen, phosphorus, potassium, calcium, and magnesium (Ojeniyi et al., 2007). An increase in the fruit yield of tomatoes as a result of the application of formulated agricultural wastes could be attributed to some major mineral elements needed for plant growth and development that are present in the treatments. An increase in the number and weight of tomatoes could also be attributed to taller plants and the production of more number of leaves making the plant trap more sunlight for photosynthesis and transporting assimilates to the fruits. An increase in fruit yield could also be a result of better soil physical conditions by increasing soil organic matter and, the availability of both macro-nutrients and micro-nutrients in its composition (Atakora et al., 2014).

5.0 Conclusion

The formulated kola nut pod contains a higher amount of N, P, K, Ca, Fe, Mg, and Zn compared to the formulated cocoa pod. Using 10 t FKP (6.40 g/pot) could be regarded as the optimum rate for both vegetative and yield performance of tomatoes. This rate contained a sufficient amount of needed nutrients hence plants nourished with them have better yield performance.

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