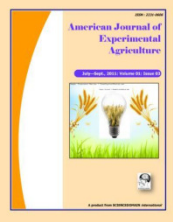

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Comparative Effect of Pig Manure and NPK Fertilizer on Agronomic Performance of Tomato (*Lycopersicon esculentum* Mill)

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Authors' contributions

This work was carried out in collaboration between all authors. Author SOO designed the study. Author OEA performed the statistical analysis. Author MAA wrote the protocol and wrote the first draft of the manuscript, managed the analyses of the study and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Field experiments were performed to investigate the effectiveness of pig manure (PG) used alone and combined with NPK fertilizer on nutrients composition, growth and yield of tomato (*Lycopersicon esculentum* Mill.). Treatments were replicated three times in a randomized complete block design and applied to tomato seedlings grown on beds at Oba-Ile and Iju in the rainforest zone of Southwest Nigeria Six treatments compared were: (a) the control, (b) 25t/ha pig manure, (c) 250kg/ha NPK (15:15:15) fertilizer, (d) 187kg/ha NPK + 6t/ha PG (75:25), (e) 125kg/ha NPK + 12t/ha PG (50:50) and (f) 62kg/ha NPK + 18t/ha PG (25:75) Soil and plant nutrients composition, growth parameters and fruit weight were determined. The test soils were sandy loam, low in organic matter and marginal in Nitrogen. Pig manure, NPK, used alone or combined at reduced rates significantly increased soil N, P, K, Ca, Mg, number of leaves, plant height, stem girth and fruit weight significantly. The 187kg.ha NPK + 6t/ha PG gave highest soil N, leaf N and fruit weight. Combinations of NPK and PG gave relatively high soil N, Ca and Mg and adequate concentrations of leaf N, P, K, Ca and Mg. Mean fruit weight per plant given by the control and 187kg/ha NPK + 6t/ha were 91 and 1016 gm respectively.

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Keywords: Rainforest zone; nutrient composition; marginal; pig manure; adequate concentration.

1. INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) is the most widely grown vegetable in the world; it improves income of growers and supplies vitamins and minerals. It is widely used in the daily diet of Nigerians [1]. However, the current production in Nigeria is estimated at 600,000 tonnes from 50,000 ha indicating low output. The average fruit yield of about 10t/ha lower than the average in tropical Africa and the world of (13.5t/ha) and 21.9 t/ha respectively [2]. Among the factors contributing to the low fruit yield of tomato are depletion of soil fertility, soil acidity and nutrient imbalance, arising from continuous use of chemical fertilizers [3] and high cost and scarcity of fertilizers [4]. High soil bulk density also reduces nutrient uptake, growth and yield of tomato [5]. These problems can be tackled by adequate application of animal manures, such as those of poultry, cattle, pig and goat which pose disposal problems and environmental hazards on accumulation [4]. These manures can be used alone or combination with chemical fertilizers. Olatunji and Oboh [6] asserted that about 75% of farmers in the humid forest zone of Nigeria do rare small ruminants. In Southwest and parts of the Middle belt of Nigeria such as Benue State, pig dung is available in appreciable quantity, but its use as source of crop nutrients has not received adequate research attention [7]. Olatunji et al. [8] investigated the effect of pig manure and its integrated application with NPK fertilizer on soil chemical properties and yield of tomato at Abeokuta in the derived Savannah zone of Southwest Nigeria. The results indicated that pig manure and its combination with NPK fertilizer significantly increased growth and fruit yield of tomato and soil organic matter, P, K and Mg. Ojeniyi et al. [1] found that pig manure increased soil nutrients content and grain yield of maize. Application of pig manures at 4 and 8 t/ha significantly increased growth and pod yield of okra and was more effective than goat manure [7].

The need for the use renewable forms of energy and reduce costs of fertilizing crops has revived the use of organic manures worldwide [9]. Large quantities of organic wastes such as pig and poultry manures which are effective sources of nutrients for vegetables are abundant especially in urban centres [4]. The benefits derivable from using organic materials for crop production have not been fully utilized in the humid tropics, partly due to the huge quantities required to satisfy the nutritional needs of crops, transportation and handling costs. High and sustained crop yield can be obtained with judicious and balanced NPK fertilization combined with organic amendment [10]. In the light of these issues, this study was conducted with this objective: determining the growth, yield and nutrient composition of tomato and soil properties as influenced by integrated use of NPK fertilizer and pig manure in the rainforest zone of Southwest Nigeria.

2. MATERIALS AND METHODS

2.1 Field Experiment

Field experiments were carried out at Oba-Ile and Iju in Akure South and Akure North Local Government Areas in the rainforest zone of Southwest Nigeria. The soil is classified as *Alfisol.* Six treatments which included sole and combined applications of NPK fertilizers (NPK) and pig manure (PG) were applied on soil to tomato seedlings. They were: (a) Control (no NPK, no PG), (b) NPK (15:15:15) fertilizer at 250kg/ha, (c) PG at 25t/ha, (d) 187kg/ha

NPK + 6t/ha PG (75:25), (e) 125kg/ha NPK + 12.5t/ha PG (50:50) and (f) 62.5kg/ha NPK + 18t/ha PG (25:75). Treatments were replicated three times using a randomized complete block design. The sites were manually cleared in June 2010 at both sites. Eighteen beds each 2.5 x 2.5m were made in each site in three blocks. Tomato seeds (Roma variety) were obtained from the State Agricultural development programme (ADP) and were raised in seed trays at pre nursery site. Seedlings were transplanted at 50 x 50 cm inter and intra row spacing's. Treatments were applied two weeks after transplanting using ring method. Each bed carried 25 transplants.

2.1.1 Plant Data Collection

Five plants were randomly selected per treatment plot (bed) for growth determination at 72 days after transplanting. The number of leaves, plant height (by tape rule), stem girth by caliper, leaf area (by graph method) and perimeter were evaluated. The weight of fruits per five selected plants was determined and accumulated between 72 and 90 days after transplanting [11].

2.1.1.1 Leaf analysis

At harvest, leaf samples were collected per plot, oven-dried for 24 hours at 80ºC and ground for analysis for N, P, K, Ca and Mg as described by Tel and Hagarty [12]. Leaf N was determined by Microkjeldahl digestion method. Ground samples were digested with a nitric-perchloric-sulphuric acid mixture [13]. Phosphorus was determined colorimetrically by the Vanadomolybdate method, K by flame photometer and Ca and Mg by EDTA titration. Air-dried pig manure used for the experiment was analysed as described for leaf.

2.1.1.1.1 Soil analysis

Before the making of beds, surface (0-15cm) soil samples were randomly collected from fifteen different points on each experimental site and bulked as described in [11] for physical and chemical analysis. Samples were also collected per plot at harvest for post harvest soil analysis. The particle distribution analysis was done by Bouyoucos hydrometer method [14]. Chemical analysis was done as described by Carter [15] The organic carbon was determined by wet dichromate oxidation method [16], available P was extracted using Bray-1 solution and determined by molybdenum blue colorimetry [17] Exchangeable K, Ca and Mg were extracted using Ammonium Acetate, K was determined using a flame photometer and Ca and Mg by EDTA titration method [18]. Soil pH was determined in a soil-water medium at a ratio of 1:2 using digital electronic pH meters [19].

2.1.1.1.1.1 Statistical analysis

Data were subjected to analysis of variance and treatment means were compared using the Duncan's Multiple Range Test at a 5% probability level.

3. RESULTS AND DISCUSSION

3.1 Pre-trial Soil Analysis

Table 1 presents data on pre-cropping soil analysis for the two experimental sites. The soils were sandy loam, acidic, low in organic matter (OM), available P, marginal in N and

adequate in K, Ca and Mg considering critical levels set for crop production on tropical soils and South-western Nigeria soils [20-22]. Therefore, it is expected that the soils would benefit from addition of chemical and organic fertilizers. While NPK fertilizer would supply N and P, the organic manure was expected to supply organic matter and enhance the levels of other nutrients [3,23,24,]. Also, the acidic nature of the soil was expected to be controlled by the cations supplied by the organic manure.

Table 1. Pre- trial soil analysis data

Site	Sand	Silt %	Clay	pH	OM %	N	P mg/kg	K	Ca cmol/kg	Mg
Oba Ile (Site 1)	61	28	11	4.9	3.8	0.19	6.5	0.64	4.5	1.8
Iju (Site 2)	59	30	11	5.4	3.8	0.19	5.4	0.86	6.2	2.6

3.2 Effects of Treatments on Soil Nutrient Composition

Data on soil nutrients composition are shown in Tables 2 and 3 for Oba Ile and Iju sites respectively. Application of pig manure and NPK alone or combined increased soil N, P, K, Ca and Mg relative to the control. The increases are significant at Oba Ile, and in the case of N, P and Ca at Iju. The combination of 187kg/ha NPK + 6t/ha pH gave the highest soil N at Oba Ile and Iju. Combinations involving NPK and pig manure had relatively high soil Ca and Mg, N and K.

Table 2. Soil nutrient composition at harvest at Oba Ile

Treatment	N %	P mg/kg	K	Ca cmol/kg	Mg
Control	0.14a	3.2a	0.12a	1.6a	0.10a
25t/ha PG	0.20b	6.7b	0.24b	2.8b	0.17b
250kg/ha NPK	0.20b	7.8b	0.24b	2.7b	0.17b
187kg/ha NPK + 6t/ha PG	0.24b	3.4a	0.27b	3.5c	0.16b
125kg/ha NPK + 12t/ha PG	0.21b	6.1b	0.37c	3.6c	0.26c
62Kg/ha NPK + 18t/ha PG	0.20b	7.8b	0.24b	2.7b	0.17b

NPK = NPK fertilizer (15:15:15); PG = Pig Manure

Table 3. Soil nutrient composition at harvest at Iju

Treatment	N %	P mg/kg	K	Ca cmol/kg	Mg
Control	0.16a	2.0a	0.22a	1.8a	0.12a
25t/ha PG	0.26b	4.1b	0.26a	2.6b	0.17b
250kg/ha NPK	018b	6.1c	0.22a	1.8a	0.11a
187kg/ha NPK + 6t/haPG	0.29b	3.6b	0.30b	2.2b	0.19b
125kg/ha NPK + 12t/haPG	0.21b	2.8d	0.26a	3.6c	0.20b
62Kg/haNPK + 18t/haPG	0.19b	3.8d	0.25a	2.4b	0.19b

NPK = NPK fertilizer (15:15:15); PG = Pig Manure

3.3 Effects of treatments on tomato leaf nutrients composition

Data on leaf nutrients composition are on Tables 4 and 5 for Oba-ile and Iju respectively. Pig manure and NPK fertilizer used alone or combined at reduced rates increased leaf N, P, Ca and Mg at both sites of study relative to the control. The increases in N and P were significant at Oba-Ile, and the increases in leaf P, Ca and Mg were significant at Iju. In plots

given manure and NPK treatments, the leaf N was generally less than 2.5%, P varied from 0.28 to 0.63%, K from 1.8 to 2.6%, Ca 1.8 to 3.5% and Mg 1.4 – 2.1%. The sufficiency levels for N given for tomato is 3.2 to 4.8%, P 0.32 to 0.48%, K 2.5 to 4.2%, Ca 1.7 to 4.0% and Mg 0.45 to 0.70% [25]. Therefore the treated plots were adequate in the nutrients except N.

Table 4. Tomato leaf nutrient composition at Oba Ile (%)

Treatment	N	P	K	Ca	Mg
Control	1.40bc	0.30a	1.0a	2.0a	1.46a
25 t/ha PG	1.84abc	0.63b	2.3a	2.3a	1.7a
250 kg/ha NPK	1.74abc	0.37c	2.2a	2.5a	2.1a
187kg/ha NPK + 6t/ha PG	2.26a	0.34c	2.0a	3.5a	1.9a
125kg/ha NPK + 12t/ha PG	2.21a	0.56b	1.8a	3.4a	2.0a
62kg/ha NPK + 18t/ha PG	1.95bc	0.63b	2.3a	3.5a	1.8a

Table 5. Tomato leaf nutrient composition at Iju (%)

Treatment	N	P	K	Ca	Mg
Control	1.69a	0.16c	2.2a	1.81d	1.1c
25 t/ha PG	1.99a	0.38a	2.5a	2.6bc	1.9a
250 kg/ha NPK	1.80a	0.28b	2.6a	1.9d	1.3bc
187kg/ha NPK + 6t/ha PG	1.99a*	0.34ab	2.6a	3.1ab	2.1a
125kg/ha NPK + 12t/ha PG	1.91a	0.33ab	2.5a	3.3a	2.0a
62kg/ha NPK + 18t/ha PG	1.79a	0.39ba	2.3a	2.3cd	1.7ab

NPK = NPK fertilizer (15:15:15); PG = Pig manure

3.4 Effect of Treatments on Tomato Performance

Data on growth and fruit yield of tomato are presented in Tables 6 and 7 for Oba Ile and Iju respectively. Generally, PG and NPK used alone or combined at reduced rates increased number of leaves, plant height, stem girth and fruit weight. At Oba Ile, the increases in number of leaves, plant height and stem girth relative to control were significant. The 187kg/ha NPK + 6t/ha PG gave highest value of fruit weight, and the differences relative to other treatments were significant. The combined treatments had highest values of stem girth and fruit weight. At Iju, the 187kg/ha NPK + 6t/ha PG also had highest fruit weight, number of leaves and plant height and relatively high stem girth. The mean values of fruit per plant given by the control and 187kg/ha NPK + 6t/ha PG were 91 and 1016 g respectively. The treatment combination is recommended.

Table 6. Performance parameters of tomato at Oba Ile

Treatment	No of leaves per plant	Plant height	Stem girth cm	Fruit weight per plant(g)
Control	15c	47d	0.47c	71d
25t/ha PG	28b	64b	0.60bc	106d
250kg/ha NPK	24b	53cd	0.59bc	156d
187kg/ha NPK +6t/ha PG	25b	57bc	0.52bc	481b
125kg/ha NPK + 12t/haPG	22b	62b	0.96a	284c
62kg/ha NPK + 18t/ha PG	37a	76a	0.69b	208a

The sandy loam test soils were low in organic matter and inadequate in total N. This indicates that the soils and tomato crop require application of organic and inorganic fertilizers. The sandy nature of the soil should have enhanced N leaching since N is quite mobile. Pig manure, NPK used alone or combined at reduced rates increased soil N, P, K, Ca, Mg at both sites. However, the increases given by NPK in Ca and Mg were not significant expectedly. The increases could be due to increased mineralization of organic nutrients. The increases in nutrient contents due to pig manure are expected since manure is a natural source of organic matter and nutrients. According to Ano and Ubochi [26] pig manure is composed of 27% OC, 0.52% N, 1.30% Mg and 1.37% Ca and has C:N ratio of 19.8. Because of its relatively low C: N compared to goat, poultry and cow manure, it is expected to decompose faster [26]. At Abeokuta in the derived Savannah zone, Giwa and Ojeniyi [8] also found that pig manure singly or in combination with NPK fertilizer increased soil N, P, K, Ca and Mg. The manure also increased soil pH. The manure used alone in combination with NPK increased N, P, K, Ca and Mg concentrations in tomato leaf which is consistent with the increases in soil nutrient contents. The study by Adekiya and Agbede [12] had found that poultry manure + NPK increased tomato leaf N, P, K, Ca and Mg and the soil nutrients. Similar finding was recorded by Adeniyan and Ojeniyi [27,23], with respect to maize production on alfisol of Southwest Nigeria. The authors also observed residual effect of manure on soil and crop nutrients contents. It was found that pig manure and its combination with NPK aside from ensuring adequate levels of P, K, Ca and Mg in tomato increased the number of leaves, plant height, stem girth and fruit yield of tomato significantly. This observation is also consistent with increased availability of nutrients in soil and crop. Aside from the macronutrients, pig manure was found to contain 10.6% organic matter, 1.0% N, 0.72% P, 2.1% k, 3.3% Ca, 0.04% Mg, 410ppm Zn, 280ppm Fe, 30ppm Al, 50ppm Cu and 420ppm Mn [28]. Adediran et al. [28] also recorded increases in maize N, P and K uptake with application of same manure.

Table 7. Performance parameters of tomato at Iju

Treatment	No of leaves per plant	Plant height	Stem girth cm	Fruit weight per plant (g)
Control	20c	47b	3.0a	111b
25t/ha PG	46ab	71a	3.7a	117b
250kg/ha NPK	30bc	53b	4.0a	309b
187kg/ha NPK +6t/ha PG	49a	60a	3.9a	1552a
125kg/ha NPK + 12t/ha PG	25bc	52b	3.5a	388b
62kg/ha NPK + 18t/ha PG	30c	51b	3.9a	236b

NPK = NPK fertilizer 15:15:15; PG = Pig manure

Other studies (4, 81; 11; 7); affirmed that tomato performance responded positively to applications of organic manures which also served to raise soil pH and control acidity [26] aside from supplying nutrients. This is important because tomato yield and nutrients uptake are adversely affected by soil acidity [3]. Thus, the manures served as liming material because of its Ca component. Ano and Ubochi [26] found that pig manure had highest Ca content compared with rabbit, poultry and cow manure.

It was found that combination of NPK and pig manure at 75:25 (187kg/ha NPK + 6t/ha PG) gave highest fruit yield, and soil and plant N. This indicates that N had most influence on tomato. It was also found that combinations of the two materials most increased crop growth, crop N, Ca, Mg and ensured adequacy of P, k, Ca and Mg in the crop. Hence, there is justification for integrated application of organic and inorganic fertilizers in tomato

production. Ayeni et al. [29] also reported better performance of maize, cassava and melon under poultry manure + NPK fertilizer compared with NPK, poultry manure and control. According to Adekiya and Agbede [11], it can be said that addition of NPK fertilizer to manure aided mineralization of nutrients in manure due to enhanced supply of nutrients, leading to better crop growth and yield. Qian and Schoenan [30] reported that high and sustained crop yield could be achieved with a judicious and balanced NPK fertilizer treatment combined with organic manure amendments. Ayeni, et al. [29] reported that nutrients from mineral fertilizers enhanced establishment of crops, while those from mineralization of manure promoted yield when both materials were combined. Giwa and Ojeniyi [7] also found that combined application of pig manure and NPK fertilizer increased tomato fruit yield compared with pig manure or NPK treatments alone. Adeniyan and Ojeniyi [23] found that integrated application of poultry manure and NPK fertilizer increased maize yield compared with poultry manure or fertilizer alone. Adekiya and Agbede [11] found that combined use of NPK fertilizer and poultry manure increased tomato yield compared to application of NPK or manure alone and is therefore recommended for sustainable productivity. In addition, lesser quantities of manure and NPK fertilizer would be required, thereby reducing expenditure on chemical fertilizer.

4. CONCLUSION

In order to study the use of pig waste (manure) and its combined application with NPK fertilizer as sources of nutrients in tomato cultivation in the rainforest zone of Southwest Nigeria, field experiments were conducted at Oba Ile and Iju. Six treatments involving a control, 25t/ha pig manure, 250kg/ha NPK (15:15:15) fertilizer and the combined use of the materials at reduced levels were applied to tomato crop. The effects of treatments on nutrient availability in soil and crop and tomato performance were studied. The pig manures and its combinations improved availability of N, P, K, Ca and Mg, growth and fruit yield. The combination of 187kg/ha NPK (15:15:15) fertilizer with 6t/ha pig manure improved fruit yield and N availability to the crop most. Pig manure improved soil and crop N, P, K, Ca and Mg. It is indicated that the manure is a suitable source of nutrients for improving performance of tomato especially when combined with NPK fertilizer to combine the attributes of the two materials.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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