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Influence of Poultry Manure and NPK Fertilizer as Amendment on the Performance of Tomato (*Solanum lycoperscum* L. Moench) Varieties at Lapai, Southern Guinea Savannah

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Abstract

Integrated plant nutrition management is an essential way of improving soil fertility and nutritional supplement for growing crops. Field experiments were conducted in 2016 and 2017 cropping seasons at the Ibrahim Badamasi Babangida University Teaching and Research Farm (Latitude 09° 02"N and Longitude 06° 34"E of the equator) to evaluate the influence of sole and mixture of poultry manure with inorganic fertilizer (NPK 15:15:15) at different levels on the growth and yield of two tomato varieties. The experiments were laid out in a 6 × 2 factorial in a Randomized Complete Block Design (RCBD). This consisted of six (6) organic amendment types (Control, poultry manure (12 tonnes/ha) only, NPK 15:15:15 fertilizer (100 kg/ha) only, 50% NPK (50 kg/ha) +50% poultry manure (6 tonnes/ha), 75% NPK (75 kg/ha) +25% poultry manure (3 tonnes/ha) and 25% NPK (25 kg/ha) +75% poultry manure (9 tonnes/ha) and two levels of tomato varieties (UC82, and Roma VF) in three replications. Soil and manure samples were collected for physical and chemical analysis. The results obtained were that application of poultry manure or in mixture with NPK fertilizer were significantly supported higher (P<0.05) vine length, number of leaves, number of fruits and fruit development, and yield of tomato, in the two cropping seasons. Also, the use of UC82 variety of tomato was more preferred than that of Roma VF.

Keywords: Poultry manure; Fertilizer; Yield; Tomato; Fruit

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Introduction

Tomato (*Solanum lycoperscum* L. Moench) is an edible vegetable, often red fruit of the nightshade family known as Solanaceae [1,2]. Tomato species originated from the South American Andes and the use of tomato as a food originated in Mexico, and spread from there throughout the world following the Spanish colonization of the Americas [1]. Its many varieties are now widely grown, sometimes in greenhouses in cooler and warm climates of the tropics.

It is one of the important vegetable crops grown throughout the world and ranks next to Irish potato in terms of the area of cultivation, but ranks first as a processing crop [3]. In Nigeria, tomatoes are grown during wet and dry seasons which attract higher profit during the dry season when demand is higher than supply.

Tomato is one of the most important vegetables in Nigeria as it is consumed by almost every household. Total tomato production in Nigeria was about 1.7 million tonnes [4]. Importation of tomato into Nigeria becomes a necessity especially when the annual population growth rate is about 2% [5] which exceed food production. Among the factors that contribute to low tomato yield in Nigeria were low soil fertility and improper selection of appropriate varieties adaptable to the agro-ecological zones [6]. Therefore, there is need to develop high yielding tomato with elevated nutrients.

Soil organic amendments such as cow dung, goat manure and poultry manure are valuable sources of plant nutrients [7]. Organic manure provides essential nutrients to crops when decomposed and also act as soil conditioners [8]. Most developing countries are trying to get rid of expensive chemical fertilizers by supplementing them with some organic-based sources.

Table 1: Physico- chemical analysis of the experimental field soil and poultry manure.

	Soil		Poultry Manure	
Parameters	**2016**	**2017**	**2016**	**2017**
pH 1:1 H_2O	6.62	6.11	-	-
Organic carbon %	0.32	0.85	1.37	1.39
Organic matter	1.47	1.86	2.36	2.48
Total N %	0.15	0.18	1.06	1.32
Available P mg/kg	18.76	18.25	33.29	30.25
K cmol/kg	0.19	0.26	2.3	2.45
Na cmol/kg	0.23	0.09	0.17	0.17
Ca cmol/kg	4.33	3.29	0.84	0.86
Mg cmol/kg	4.03	6.37	1.84	1.95
Mn cmol/kg	0.8	-	0.14	0.15
EA cmol/kg	0.18	0.15	-	-
CEC cmol/kg	14.58	10.16	4.91	3.96
Sand %	82.6	81.96	-	-
Silt %	7.4	10.56	-	-
Clay %	10	7.48	-	-
Texture	Loamy sand	Loamy sand	-	-

Mixture of organic and inorganic fertilizers is a good method of soil fertility management strategy. Apart from enhancing crop yields, it has a greater beneficial effect that can be derived from the use of organic and inorganic fertilizers. Makinde et al. [8] reported that the combination of synthetic fertilizer and manure improved yield of maize compared with application of manure or NPK fertilizer singly. Akande et al. [9] noted that mixture of ground rock phosphate and poultry manure significantly improved growth and yield of Okra (*Abelmoschus esculentus* L Moench) compared to application of each material separately. Akanbi et al. [10] observed that the combined application of 4 Mt/ha-1 of maize straw compost and N mineral fertilizer at 30 kg/ha-1 improved plant growth and higher tomato (*Lycopersicum esculentum* L.) yield than any other application.

Crop varieties respond differently to a range of climatic conditions, soil characteristics and agronomic management practices [11] Singh and Ram. In Nigeria, there are several varieties of Tomato with varying response to environmental condition, agronomic practices and nutritional management adopted for their growth and yield. Thus, it is imperative to evaluate the response of tomato varieties to different nutritional management.

Many studies have been carried out on the effects of organic or inorganic fertilizers on the productivity of tomato in different agro-ecological zones of Nigeria. However, there were paucity of information on the effect of mixture of organic and inorganic fertilizer on the productivity of tomato is the southern Guinea savanna of Nigeria which necessitates this research. The objective of this study is to examine the effects of poultry manure with or without NPK fertilizers as soil amendment on the growth and yield of tomato.

Materials and Methods

The field experiments were conducted at the Teaching and Research Farm of Ibrahim Badamasi Babangida University, Lapai, Niger State, Nigeria Lapai, located at latitude 09°02''N and longitude 06°34''E of the equator. It has an average temperature of 23°C to 34.4°C with a minimum rainfall of 107.3 mm. The experiment was conducted between 10th of June, and 10th October, 2016 and 2017 cropping seasons.

The experimental site was cleared to remove the shrubs, debris, mechanically ploughed, harrowed and ridged using tractor mounted equipment. The plots sizes were 3 m × 4 m. Tomato seeds were raised in the nursery and transplanted three (3) weeks on to the plots. Transplanting was done early in the morning at the spacing of 40 cm × 75 cm within and between rows respectively. NPK fertilizer was applied in split applications. The first dose was applied using NPK fertilizer at transplanting, while the second dose was supplied four Weeks after Transplanting (WAT) in band application method.

The experiment was laid in 6 × 2 factorial in a Randomized Complete Block Design (RCBD) made up of six (6) organic amendment types (Control, poultry manure (12 tonnes/ha) only, NPK fertilizer (100 kg/ha) only, 50% NPK (50 kg/ha) +50% poultry manure (6 tonnes/ha), 75% NPK (75 kg/ha) +25% poultry manure (3 tonnes/ha) and 25% NPK (25 kg/ha) +75% (9 tonnes/ha) poultry manure) and two levels of tomato varieties (UC 82, and Roma VF) in three replications. Soil and manure samples were analyzed using standard laboratory methods: soil pH (soil: water ratio of 1:25); organic carbon; total nitrogen, available P (using Bray-1 method) [12], exchangeable basic cations; exchangeable acidity and effective cation exchange capacity (by summation method) (Okalebo et al. [6]. Particle size analysis of the soil was determined using Bouyoucos method [13].

Agronomic Practices

Tomato seedlings were provided with a stake at three WAT as a support to protect the fruits from touching the ground and be decayed. Weeding was done manually at 4 and 6 WAT. Insect pests were controlled using Lambdha cyhalotrin. For effective control of *Tuta absoluta*, on noting its infestation tomato stands, a mixture of systemic and contact pesticides were sprayed on daily basis, both late in the evening and early morning.

Table 2: Effects of Poultry manure with or without NPK fertilizer as amendment on Tomato Varieties Vine length (cm).

Parameters	Tomato Vine Length (cm)							
	2016	2017	2016	2017	2016	2017	2016	2017
Amendment Type	**3WAT**		**6WAT**		**9WAT**		**12WAT**	
Control	33.91b	30.80b	50.22b	49.45b	60.31b	60.55b	70.25b	71.20b
P only	39.35a	40.52a	65.76a	65.82a	76.65a	75.80a	94.45a	95.80a
NPK only	42.23a	43.85a	64.34a	65.65a	75.63a	74.92a	95.60a	94.25a
50% NPK+50% P	40.12a	40.20a	61.71a	60.80a	72.37a	71.95a	95.30a	94.80a
25% NPK+75% P	40.12a	40.50a	58.82a	58.90a	72.82a	72.27a	92.50a	92.80a
75 % NPK+25% P	36.94ab	36.85ab	56.73ab	59.25a	71.21a	71.40a	92.30a	93.20a
$LSD_{0.05}$	5.165	5.224	6.31	6.832	8.305	8.432	9.022	9.355
Variety								
UC 82	39.4	40.2	64.00a	65.50a	76.00a	75.50a	94.2	95.26
Roma VF	38.7	38.5	58.40b	59.25b	69.40b	68.80b	83.6	84.85
$LSD_{0.05}$	3.26	3.55	4.52	4.72	6.23	6.324	6.555	6.845
Interaction	Ns	ns	ns	ns	Ns	ns	Ns	Ns

Means followed with the same letter(s) are not significantly different at 5% Probability level
Key: P: Poultry manure; NPK: Nitrogen, Phosphorus and Potassium

Growth and yield parameters evaluated was vine length which was measured with measuring tape from base to the tip of the main shoots at 3, 6, 9 and 12 WAT. The number of leaves was measured by counting the number of leaves on the plant at 3, 6, 9 and 12 WAT. Leaf area (cm^2) was measured using leaf area meter at 3, 6, 9 and 12 WAT. The number of branches were recorded by counting the number of branches on the on the plant at 3, 6, 9 and 12 WAT. Fruit length/plant was measured with the aid of a ruler.

Fruit diameter/plant was measured using a tread rolled round the fruit then use a ruler to measure the length of the rope and recorded. Fruit weight/plot was measured using sensitive weighing balance and converted to fruit weight/hectare.

All data collected were subjected to analysis of variance (ANOVA), using Genstat 2014 software package, Significant means were separated using least significant differences LSD ∞ 0.05.

Results

Soil analysis

The result of the soil analysis of the experimental site showed that the soil is very low in major nutrient elements. The soil is sandy loam, low in organic carbon, nitrogen and phosphorus (Table 1). This implies that cropping the soil without fertilizer or soil amendment use is uneconomical. The result of the poultry manure analysis showed that the manure contained 1.88% total nitrogen, 0.10% available (Bray 1) phosphorus, 0.71% potassium, 5.32% calcium and 0.61% magnesium as shown in Table 1.

Tomato vine length/plant (cm)

Tomato vine length was significantly affected by the application of different types of soil amendment in 2016 and 2017 cropping seasons at 5% probability levels (Table 2). The application of sole poultry manure, sole NPK, and other mixtures of the amendment also significantly affected the vine length at 3, 6, 9 and 12 Weeks after Transplanting (WAT). The sole NPK, sole poultry manure as well as other different mixtures were significantly different from the control in the two cropping seasons (Table 3). Though, the tallest vine length was obtained from the application of sole NPK at 3 WAT and subsequently from 6, 9 and 12 WAT, these were not significantly different from other amendment mixtures in the two cropping seasons. The least vine length was produced by the control. The two varieties of tomato tested were not significantly different from each other based on vine length at 3 WAT across the two cropping seasons. However, at 6, 9 and 12 WAT, the tomato variety UC82 significantly supported tallest vine length when compared with variety Roma VF at 5%. The interaction between amendment types and variety were not significantly different.

Number of leaves/plant

Tomato number of leaves was significant affected by the amendment types n 2016 and 2017 cropping seasons (Table 3). The use of NPK fertilizer only as soil amendment on tomato significantly produced higher number of leaves at 3 WAT, which was significantly superior to poultry manure only, t different mixtures of poultry manure and NPK fertilizers in the both cropping seasons. However, at 6, 9 and 12 WAT, poultry manure only, 50% poultry manure +50% NPK fertilizer and 25% NPK+75% poultry manure were significantly supported highest number of leaves, these were significantly different from NPK only, 25% poultry manure +75% NPK and the control. The least number of leaves was produced by the control. Similarly, there were significant differences between the two varieties of tomato (UC82 and Roma VF) in the number of leaves in both seasons. Variety UC82 significantly produced higher number of leaves at 3, 6, 9 and 12 WAT when compared with variety Roma VF in 2016 cropping season only. The interaction between amendment types and variety were not significantly different.

Number of branches

Table 4 shows the number of branches produced by tomato as influenced by the application of soil amendment. At 3 WAT the application of NPK fertilizer only significantly produced higher number of branches than any other amendments applied across the cropping seasons. Similarly at 6, 9 and 12 WAT in the two cropping seasons, the application of poultry manure significantly supported highest number of tomato leaves which was at par with other mixture of amendments except the application of 25% poultry manure +75% NPK fertilizer and the sole application of NPK fertilizer. The least

Table 3: Effects of Poultry manure with or without NPK fertilizer as amendment on Tomato Varieties number of leaves.

Parameters	Number of Leaves							
	3WAT		6WAT		9WAT		12WAT	
Manure treatments	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Control	8.50b	9.20b	16.70c	18.20c	35.30c	34.50c	45.20b	43.50b
P only	15.30a	15.40a	37.20a	38.40a	49.95a	50.00a	60.80a	61.60a
NPK only	17.05a	18.60a	31.30b	31.50b	40.25b	40.50b	48.20b	50.30b
50% NPK+50% P	15.25a	16.50a	37.60a	37.20a	49.80a	49.20a	60.10a	61.60a
25% NPK+75% P	15.50a	15.20a	37.00a	37.50a	49.72a	50.50a	62.70a	61.50a
75% NPK+25% P	15.10a	15.80a	35.50ab	35.80ab	41.05ab	42.50b	50.10b	50.60b
$LSD_{0.05}$	3.165	3.125	5.55	5.85	7.275	7.3	9.64	9.82
Variety								
UC 82	16.30a	15.80a	39.20a	38.50a	48.65a	48.50a	58.50a	57.20a
Roma VF	12.60b	12.20b	32.20b	32.20b	42.40b	41.80b	48.50b	46.50b
$LSD_{0.05}$	3.55	3.425	5.515	5.35	6.19	6.225	9.925	9.5
Interaction	ns	ns	ns	ns	ns	ns	ns	ns

Means followed with the same letter(s) are not significantly different at 5% probability level

Table 4: Effects of Poultry manure with or without NPK fertilizer as amendment on the Tomato varieties number of Branches.

Parameters	Number of Leaves							
	3WAT		6WAT		9WAT		12WAT	
Manure treatments	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Control	6.20b	6.50b	12.40c	11.90b	18.60b	17.80b	22.30b	23.30c
P only	11.60a	10.80a	22.70a	22.60a	29.90a	29.20a	45.70a	45.2
NPK only	12. 20a	11.90a	15.70b	16.50b	21.80b	21.10b	32.10b	34.60b
50% NPK+ 50%P	9.70a	10.50a	18.20ab	18.30ab	28.00ab	28.50a	41.70ab	43.50a
25% NPK+75% P	11.00a	11.30a	18.80ab	18.20ab	28.40ab	28.90a	42.50ab	45.20a
75% NPK+25% P	11.50a	11.20a	15.70b	15.50b	22.90b	21.6b	34.60b	34.80b
$LSD_{0.05}$	4.78	4.85	6.85	6.55	7.12	7.25	10.54	10.82
Variety								
UC 82	11.3	11.5	18.90a	19.00a	26.90a	25.6	47.60a	48.30a
Roma VF	10.5	11.2	12.60b	12.20b	20.30b	19.9	36.80b	35.80b
$LSD_{0.05}$	2.76	2.85	4.94	4.8	4.11	4.22	10.44	10.55
Interaction	ns	ns	ns	ns	ns	ns	ns	ns

Means followed with the same letter(s) are not significantly different at 5% Probability level

number of leaves was produced throughout the experiment period from the control. In another vein, the tomato number of branches was significant affected by the tomato varieties (UC82 and Roma VF) across the two cropping seasons at 3, 6, 9 and 12 WAT. Variety UC82 significantly produced higher number of branches at 3, 6, 9 and 12 WAT compared with variety Roma VF in both cropping season. The interaction between amendment types and variety were not significantly different.

Tomato fruiting characteristics

Tomato number of fruits: Soil amendment types significantly ($P<0.05$) affected the tomato number of fruit/plant, and number of fruits/hectare in 2016 and 2017 cropping season (Table 5A and 5B). The application of poultry manure only significantly supported higher number of fruits/plant and/ha which was at par with the application 50% NPK and 50% poultry manure and 25% NPK and 75% poultry manure but significantly different from the application of NPK, 25% poultry manure +75% NPK and the control in the two cropping seasons. The highest number of fruits/plant was supported by poultry manure only and the least number of fruits were obtained from the control plots in the two cropping seasons. Similarly, the number of fruits was significantly affected by the varieties. Variety UC82 supported higher number of fruits/plant and number of fruits/hectare in 2015 cropping season. The interaction between amendment types and variety were not significantly different.

Tomato fruit yield: Tomato fruit length/plant, fruit diameter/plant, fruit yield/plant and fruit yield were significantly affected by the type of amendment in 2016 and 2017 cropping seasons. The application of poultry manure only significantly supported higher fruit length/plant, wider fruit diameter/plant, fruit yield/plant, cumulative fruit yield, which was similar to the application of 50% NPK and 50% poultry manure, 25% NPK and 75% poultry manure, but significantly different from the control (no application) in 2015 and 2016 cropping season. Similarly, tomato fruit length/plant, fruit diameter/plant, fruit yield/plant and fruit yield were significantly affected by the tomato varieties throughout 2015 and 2016 cropping seasons. Significantly ($P<0.05$) longer fruit/plant was obtained from

Table 5: A and B) Effects of Poultry manure with or without NPK fertilizer as amendment on Tomato Varieties on number of fruits.

Table 5A:

Parameters	Number of fruits/plant		Number of fruits/Ha	
Amendment Types	**2016**	**2016**	**2017**	**2017**
Control	10.60c	1.03b	1.08b	12.50c
P only	24.00a	3.04a	3.15a	25.30a
NPK only	18.90b	1.23b	1.25b	18.20b
50% NPK+50% P	23.20a	2.96a	3.02a	22.50a
25% NPK+75% P	23.70a	2.97a	3.02	23.80a
75% NPK+25% P	18.30b	1.34b	1.30b	18.20b
$LSD_{0.05}$	4.5	1	1	4.75
Varieties				
UC 82	24.00a	2.96a	2.98a	25.00a
Roma VF	18.00b	1.88b	1.65b	18.00b
$LSD_{0.05}$	4	1	1	4
Interaction	Ns	Ns	Ns	Ns

Means followed with the same letter(s) are not significantly different at 5% Probability level

Table 5B:

Amendment type	Fruit length/plant (cm)		Fruit diameter/plant (cm)		Fruit yield/ plant (g)		Fruit/ hectare (tonnes)	
	2016	**2017**	**2016**	**2017**	**2016**	**2017**	**2016**	**2017**
Control	4.33b	4.25b	7.02c	7.50c	98c	92c	3.10b	3.18b
P only	8.77a	8.80a	11.93a	11.50a	201a	205a	8.70a	8.85a
NPK only	5.81b	5.72b	8.61ab	9.05ab	140b	142b	5.45ab	5.28ab
50% NPK+50%P	8.72a	8.65a	10.89a	10.95a	193a	190a	7.42a	7.65a
25% NPK+75% P	8.04a	8.24a	10.90a	10.75a	196a	192a	7.90a	7.80a
75% NPK +25% P	5.90b	5.86b	9.67a	10.80a	145b	130b	5.75ab	5.90ab
$LSD_{0.05}$	1.632	1.856	2.555	2.625	45.255	46.455	2.375	2.355
Variety								
UC 82	4.32b	4.84b	10.32a	10.50a	155b	165b	4.20b	4.65b
Roma VF	8.44a	8.65a	6.42	6.80b	220a	210a	7.30a	8.05a
$LSD_{0.05}$	1.52	1.85	2.435	2.655	40.245	42.55	2.87	3.1
Interaction	ns	ns	ns	ns	ns	ns	ns	ns

Means followed with the same letter(s) are not significantly different at 5% Probability level

Roma VF variety, wider fruit diameter was obtained from UC82 variety. However, significantly higher fruit yield/plant was supported by Roma VF, in 2016 and 2017 cropping seasons. The interaction between amendment types and variety were not significantly different.

Discussion

The responses of tomato vine length plant, number of leaves/plant, number of branches/plant as a result of the application of poultry manure only, 50% poultry manure +50% NPK as well as 75% poultry +25% NPK could be attributed to the level of nutrients available for plant absorption in the poultry manure. The application of poultry manure as soil amendment provided macro and micronutrients essentially required by tomato. This result is in line with [14]. Who reported that the use of poultry manure alone or in combination with NPK 15-15-15 fertilizer increased tomato yield compared to the application of NPK 15-15-15 fertilizer. Also, the result is in agreement with Ojaniyi et al. [15] who reported higher growth parameter values with the application of sole poultry manure. Agele [16] also found that poultry manure litters resulted in better growth and yield of tomato than NPK fertilizer alone. This study showed than tomato plant significantly performed well under balanced and judicious mixture of poultry manure and NPK fertilizers.

The number of fruits/plant/plot and per hectare significantly favored the application of poultry manure alone or any combinations where the percentage of poultry manure is higher or equal to the percentage of NPK. This result could be attributed to the significant role NPK played in hasten the decomposition of poultry manure in addition to the ability of inorganic fertilizer to stabilize the plant growth while organic fertilizers supported the growth and yield. This result agreed with Ayoola et al. [17] who reported that nutrients from mineral fertilizers enhanced the establishment of crops, while those from mineralization of organic manure promoted yield when both fertilizers were combined. The result is also in line with the findings of Agbede et al. [15] who found out that the number of fruits and leaves of crop significantly increased with increase in the concentration of poultry droppings. It is also tallied the findings of Ghorbani et al. [18] who reported that tomato fruit weight increased with increasing manure source compared with the control.

The superiority of tomato variety UC 82 to Roma VF variety

could be attributed to the fact that UC82 variety when comparing the growth and yield of the two varieties could be attributed to the fact that the UC82 variety is an indigenous variety which has been adapted to environmental condition in the study area, unlike the Roma VF which is an exotic variety. This result corroborates with Isah et al. [19] who discovered that UC82B proves superior over Roma VF on growth indices CGR at 5-7 WAT, Net Assimilation Rate (NAR) at 7-9 WAT, and total fruit yield with 10.6% higher.

Conclusion and Recommendations

The result obtained indicated superiority of poultry manure only over sole NPK application on crops as soil amendment for all parameter evaluated. However, the combination of organic and inorganic fertilizer in ideal quantity can go a long way in improving the growth and yield of tomato in the Southern Guinea Savanna Ecology of Nigeria. Also, the tomato variety UC82 produced prolifically than Roma VF.

Therefore, for sustainable tomato production, the use of poultry manure as soil amendment will be appropriate than the use of NPK fertilizer alone. This is because of beneficial effects on soil and the crop. UC82 is also a very good and high yielding tomato variety.

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