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Effect of NPK and poultry manure on selected soil properties, and performance of snake tomato (*Trichosanthes cucumerina*) in Wukari, Taraba State, Northeastern Nigeria

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ABSTRACT

This study was conducted to investigate the effect of NPK and poultry manure (PM) on selected soil properties and performance of snake tomato. The experiment was laid out in a randomized, complete block design with four treatments and three replicates. The treatments are 240 kg/ha NPK 15:15:15, 20 tons/ha PM, 120 kg/ha NPK 15:15:15 + 10 tons/ha PM, and control. The soil was loamy sand with low OC, N and P. The parameters assessed were leaf area, number of leaves, plant girth, fruit weight, fruit length, fruit girth, and number of seeds/fruit. The data generated were subjected to an analysis of variance (ANOVA) and the means were be separated using LSD. The combined application of NPK and PM significantly improved the fertility status of the soil in terms of organic carbon, total nitrogen, available phosphorus, exchangeable bases, and cation exchange capacity compared to the other treatments, while Zn, Cu and Fe content were improved by poultry manure treatment. Similarly, the combined application of NPK and PM performed better than all the treatments, recording highest leaf area of 6.2, 12.1, 12.3, and 12.7 at weeks 4, 6, 8, and 10, respectively,. Also higher number of leaves at weeks 4, 6, 8, and 10 (40.1, 54.4, 59.9, and 66.6) was also observed with the combined treatment. The combined use of NPK and PM, producing the highest fruit weight (566.7g), dry weight (25.7g), and number of seeds per fruit significantly enhanced the yield components, although fruit length and girth were statistically similar across fertilized treatments. The result show that mixing NPK fertilizer with PM improves soil fertility, plant growth, and yield of snake tomatoes and is hence recommended.

1.0 Introduction

Snake tomato (*Trichosanthes cucumerina*) is a species of the family Cucurbitaceae, which is sometimes used as an alternative to tomatoes when tomatoes are scarce and expensive (Onagoruwa (2002), has received little or no attention in several parts of Nigeria, especially the study area. It only grows in the wild and on the fences of many families where it serves as a hedge. The plant does well in the humid lowlands of the tropics. Characteristically, snake tomatoes are an annual tendril climbers that bear fruit 2-4 months after planting (Atugwu, *et al* 2022). It bears long, narrow, and cylindrical fruits, giving it the shape of a snake. The fruit appears green when unripe but turns orange-red when ripe. Snake tomatoes have high economic importance among vegetables in the world (Atugwu, *et al* 2022).

The plant is grown principally for the immature fruit that can be cooked and served as a vegetable (Olasantan, 2007). Snake tomatoes, locally known as "elojo tomatoes, grow mostly wild in south-western Nigeria. It is found in states like Lagos, Ogun, Oyo, Osun, Ekiti, Ondo, Edo, and River (Oyeleke and Adebisi, 2022). In the eastern part of Nigeria, it is only the ripe pulp that is assumed to be edible. The pulp is very reddish in color and can be used to improve the appearance of food, as it can be blended and used to produce a paste for stew that tastes like tomatoes (Oyeleke and Adebisi, 2022). In Nigeria, the increase in the price of fresh tomatoes and tomato products, especially in the rainy season, is quite alarming. Snake tomato, being a good source of minerals and vitamins with a very bright red color, serves as a substitute for tomatoes.

Long-term studies on variety crops indicated that the balanced use of NPK fertilizer could not maintain the higher yield of crops over the years because of the emergence of secondary and micronutrient deficiencies (Seema *et al* 2017). Hazra (2016) reported that organic manures, when applied with chemical fertilizers, performed significantly better than when inorganic fertilizer was applied alone. The beneficial effects of organic fertilizer for agricultural production has not been completely employed, possibly due to the enormous quantities necessary to satisfy the nutritional demands of crops, (Ayoola and Adeniyan, 2006). In light of this a study was conducted to determine the growth and yield of snake tomatoes as influenced by the application of poultry manure and NPK fertilizer in Wukari, north-eastern Nigeria.

2.0 Materials and Methods

The field trial was conducted at the Teaching and Research Farm of Federal University Wukari during the 2023 rainy season. Wukari is located in the northeastern part of Nigeria. It lies between longitudes 9° 08′ and 10° 23′ east of the Greenwich Meridian and latitudes 7° 35′ and 80° 15′ north of the Equator.

Seedlings of snake tomato were raised in the nursery for 4 weeks, after which the vigorous seedlings were transplanted into the field already ploughed and harrowed. The experiment was laid out in a randomized complete block design comprising four treatments including the control and replicated three times. The experimental plot size was 2 m x 1 m, with a 0.5 m furrow between plots and a 1 m margin between blocks. One seedling was transplanted at a spacing of 50 x 50 cm. The treatments were 240 kg/ha of NPK 15:15:15, 30 tons/ha of poultry manure, 120 kg/ha of N.P.K. 15:15:15 + 15 tons/ha of poultry manure, and the control with neither NPK nor poultry manure applied. Poultry manure was applied two weeks before transplanting to enable the manure to break down and release the nutrients to the soil, as they are not readily available like the inorganic fertilizer.

Soil samples were collected before and after the experiment to determine the physical and chemical properties of the soil. Data on agronomic parameters were collected at a two-week interval beginning from week four after transplanting. These include leaf area, leaf number and stem girth. The leaf area was calculated from the length and breadth measured, the leaf number was counted, and the stem girth was measured using a Vanier caliper. The yield data was taken during and after harvest, and it includes fresh fruit weight, fruit length, fruit girth, and the number of seeds per fruit. The fresh fruit weight was determined using a weighing scale. The fruit girth and length were determined using a measuring tape, and seeds per fruit were counted, while dry weight was determined by oven drying at 105℃ until a constant weight was attained.

The soil samples collected were air-dried, ground and sieved with a 2 mm sieve. The particle size distribution was carried out using the hydrometer method described by Bouyoucos and modified by Gee and Or (2002). The soil pH was determined using a glass electrode pH meter in a 1:1 soil-to-water ratio suspension, as described by Hesse (1971). Organic carbon was determined using the Walkley-Black method as reported by Nelson and Sommers (1982), total nitrogen was determined by the macro-Kjeldahl method, and the available P was extracted by the Bray-1 method and determined using a spectrometer (Nelson and Sommers, 1982). Exchangeable bases (K, Ca, Mg, and Na) were determined using the atomic absorption spectrophotometer (Okalebo *et al.,* 2002).

All the data generated were subjected to an analysis of variance (ANOVA) and the means were be separated using LSD at 5% level of significance.

3.0 Results and Discussion

3.1. Properties of soil composition and poultry manure prior to experiment

Table 1. Showed the physical and chemical properties of the soil and the chemical composition of the poultry manure used for the experiment. The soil was sandy loam and slightly acidic, with a pH range of 6.45–6.60, which is the optimal pH for most crops (Babatunde *et al*., 2019). The soil was low in total N, available P, exchangeable K and organic carbon and low in all the exchangeable bases. The result of the poultry manure used in the experiment was found to have a medium to high amount of major nutrients required for the growth of fruit crops such as tomatoes with 2.47 g/kg of N, 16.22 mg/kg of P, 0.06 cmol/kg of K, and 14.30 g/kg of OC. The micronutrient content was medium in Mn (4.23 mg/kg) and Fe (1.31 mg/kg), high in Cu (2.98 mg/kg), and low in Zn (0.02 mg/kg). The application of poultry manure and NPK fertilizer improved soil fertility, growth, and yield of snake tomato; a similar finding was reported by Aliakira and Peter (2014).

3.2. Effect of the NPK and poultry manure on Leaf Area

Data of the leaf area of snake tomato is presented in Table 2. The result of leaf area of snake tomatoes indicated that 30 ton/ha of poultry manure, 240 kg/ha of NPK fertilizer alone, and 240 kg/ha of NPK fertilizer plus 15 ton/ha of poultry manure significantly increased the number of leaves when compared to the control. At every growth stage, the leaf area was mostly increased by NPK fertilizer and poultry manure. The increase in leaf area observed as

a result of the application of NPK 15:15:15 and poultry manure either alone or in combination.

Table *1*: Properties of soil and composition of poultry manure prior to experiment

Properties	Soil	Poultry manure
Sand	80.8	NIL
Silt	16.8	NIL
Clay	2.4	NIL
Texture	Loamy Sand	NIL
pH	6.45	6.60
OC (g/kg)	1.16	14.3
N (g/kg)	0.14	2.47
K (cmol/kg	4.21	0.68
Na (cmol/kg)	4.17	0.63
Mg (cmol/kg)	0.20	3.70
Ca (cmol/kg)	3.21	4.26
EA (cmol/kg)	1.50	NIL
P (mg/kg)	4.81	16.22
Zn (mg/kg)	0.30	1.31
Fe (mg/kg)	0.20	0.02
Cu (mg/kg)	0.10	2.98
Mn (mg/kg)	0.10	4.23
ECEC (mg/kg)	11.64	NIL

This could be attributed to the nutrient availability provided in both NPK and poultry manure as reported by (Lanki *et al*., 2023). Nitrogen, which is a constituent of NPK fertilizers and poultry manure, plays a crucial role in promoting leaf expansion and photosynthetic activity (Ainika, 2019). The synergistic effect of combining inorganic and organic sources could be due to the complementary supply of nutrients on soil physical and chemical properties which in turn enhanced leaf area of crops (Miah *et. al*., 2022).

Table 2. Effect of the NPK and poultry manure on Leaf Area

Treatment	4	6	8	10
	----------WAS----------			
NPK (240 kg/ha)	5.7b	10.9b	11.4b	11.8b
PM (30 tons/ha)	5.4b	11.0b	11.4b	11.9b
NPK(120 kg/ha) and PM (15tons/ha)	6.2a	12.1a	12.3a	12.7a
Control	3.8c	8.4c	9.3c	10.1c
LSD	0.4	0.57	0.67	0.69

WAS = week after sowing, PM = poultry manure

3.3. Effect of the NPK and poultry manure on leaf number

Table 3 revealed that all the NPK and poultry manure treatments were significant higher when compared with control across the weeks (3, 6, 8 and 10 WAS).

The positive effect of the combined application of NPK 15:15:15 and poultry manure on the number of leaves could be attributed to availability of essential nutrients, which promote vegetative growth and leaf development. The presence of both readily available inorganic nutrients and slow-release organic nutrients from poultry manure may have provided a balanced and continuous supply of nutrients throughout the growing season, supporting leaf production. This is in line with the studies of Babatunde *et al*. (2019), who reported that the combined application of poultry manure and NPK fertilizer enhanced the growth performance of tomato.

Table 3. Effect of the NPK and poultry manure on leaf number

Treatment	4	6	8	10
	----------WAS----------			
NPK (240 kg/ha)	35.5b	44.0b	50.1a	58.1a
PM (30 tons/ha)	35.0b	41.1b	54.1a	57.0a
NPK(120 kg/ha) and PM (15tons/ha)	40.1a	54.4a	59.9a	66.5a
Control	21.9c	32.5c	37.6b	43.3b
LSD	3.95	5.7	12.9	15.1

WAS = week after sowing, PM = poultry manure

3.4. Effect of the NPK and poultry manure on plant girth

The effect of treatments on plant girth shows an increased plant girth observed with the application of NPK 15:15:15 and poultry manure, either alone or in combination (Table 4). This could be attributed to the nutrient availability coupled with good soil properties as a result of NPK and poultry manure amendment. The provision of essential nutrients like nitrogen, phosphorus and potassium in NPK and poultry manure could be responsible for enhancing cell division and expansion, leading to increase stem thickness (Isah *et al*., 2020). In addition, the organic matter from poultry manure improve soil structure, thereby creating a conducive environment for root growth and nutrient uptake (Haynes and Naidu, 1998; Adeyemo, 2019). The outstanding performance of combination of NPK 15:15:15 and poultry manure over other treatments could attributed to the complementary supply of nutrients including organic matter to the soil. Similar finding was also reported by Miah *et al.* (2022) who reported that application of inorganic fertilizers and organic manures enhanced plant growth parameters, including stem girth of crops.

Table 4. Effect of the NPK and poultry manure on plant girth

Treatment	4	6	8	10
	----------WAS----------			
NPK (240 kg/ha)	1.8a	2.7a	3.0a	3.3b
PM (30 tons/ha)	1.8a	2.4a	2.9a	3.4b
NPK(120 kg/ha) and PM (15tons/ha)	2.0a	2.9a	3.1a	3.9a
Control	1.4	1.9c	2.1b	2.7c
LSD	0.21	0.33	0.26	0.28

WAS = week after sowing, PM = poultry manure

3.5. Effect of the NPK and poultry manure on fruit length, girth and weight.

Table 5 showed the effects of NPK and poultry manure on yield parameters. The results showed that there were no significant difference in fruit weight, fruit length, and fruit girth across the treatments, with the exception of the control, which differed significantly from all other treatments. This could be attributed to the adequate supply of nutrients from these amendments during the

vegetative growth stage, although the highest yield parameter was obtained in the NPK 15:15:15 + PM treatment. However, the significant improvement observed compared to the control treatment suggests that application of either NPK or poultry manure can enhance fruit yield and quality through providing essential nutrients for plant growth and development. This result similar to the findings of Iqbal *et al*. (2022), who reported that the integrated application of poultry manure and chemical fertilizers considerably enhanced fruit yield and quality attributes of tomato plant. Similarly, Babatunde *et al*. (2019) reported significant improvements in the fruit yield of tomatoes when poultry manure was applied in combination with inorganic fertilizers improved the soil as opposed to heavy fertilizer doses alone.

Table 5. Effect of the NPK and poultry manure on fruit length, girth and weight

Treatment	length	girth	Fresh weight	Dry Weight	Seeds/Fruit
	←---cm-----→		←----------g----------→		
NPK (240 kg/ha)	44.5a	4.4a	553.3a	22.5a	42a
PM (30 tons/ha)	39.7a	4.3a	543.3a	24.0a	43a
NPK(120 kg/ha) and PM (15tons/ha)	42.1a	4.8a	566.7a	25.7a	46a
Control	29.0b	3.5a	366.7b	17.2b	35b
LSD	7.41	1.8	114.96	6.14	7.2

PM = poultry manure

3.6. Effect of the NPK and poultry manure on soil properties

Table 6 showed increased silt and clay content with the application of poultry manure and combination of NPK 15:15:15 and poultry manure. This could be attributed to binding effect of organic matter which act as a cementing agent, promoting aggregation of soil particles and improving soil structure. This can lead to better water-holding capacity, aeration and nutrient retention, creating a more favorable environment for plant growth (Isah *et. al*., 2020).

Table 6 also showed that all treatments except the control improved the soil organic C, total N, P, and K contents. The improvement in nutrients content observed could be attributed to higher nutrients content of poultry manure. Poultry manure is a valuable source of essential plant nutrients, including nitrogen, phosphorus, potassium and various micronutrients. Organic matter content in poultry manure can also improve soil fertility by enhancing nutrient retention and availability through chelation and cat ion exchange processes. Aliakira and Peter (2014), reported that applying cow dung or a combination of cow dung and urea enhanced the growth and yield of amaranth due to improved soil fertility and nutrient availability.

The combined fertilization using both poultry manure and NPK fertilizers is important for soil organic matter maintenance, long-term soil productivity, and sustainability in the tropics, where soil OM content is generally low. In some studies, it was also found that manure in combination with small fertilizer applications improved the soil as opposed to heavy fertilizer doses alone.

3.7. Effect of the NPK and poultry manure on soil micronutrients

Table 7 showed the effect of NPK and poultry manure on soil micronutrients. The results depict a higher content of zinc, copper and iron in the plot treated with poultry manure than other treatments. The significant increase observed with application of poultry manure and the combination of NPK 15:15:15 and poultry manure could be responsible for higher micronutrients due to the presence of organic matter. Organic matter chelation in the soil increases the availability of micronutrients, making them more accessible for plant uptake.

This agrees with the finding of Mohsin *et al*. (2021), who reported that, the application of poultry manure resulted in a significant increase in DTPA-extractable Cu, Fe, Mn, and Zn contents in the soil, which could be attributed to the chelating ability of organic matter present in the manure.

4.0. Conclusion

The use of NPK 15:15:15 fertilizer and poultry manure, both separately and in combination, improved the growth and yield performance of snake tomatoes. The combination treatment of NPK 15:15:15 (120 kg/ha) and poultry manure (15 tons/ha) had the greatest impact, with increased leaf area, number of leaves, plant girth, fruit weight, and dry weight compared to the other treatments. This synergistic impact can be due to inorganic fertilizers and organic manures playing complimentary roles in providing essential nutrients and also enhancing soil physical and chemical qualities. Poultry manure, as a rich source of organic matter, helped to increase soil organic carbon, total nitrogen, available phosphorus, and exchangeable cations. Furthermore, the combination of poultry manure (15 tons/ha} and NPK 15:15:15 (120 kg/ha) boosted the amounts of micronutrients in the soil, including zinc and copper, which are required for plant development.

Table 6. Effect of the NPK and poultry manure on soil properties

Treatment	pH (H20)	OC ←--g/kg---→	TN	Av.P mg/kg	K ←---------- cmol/kg ----------→	Na	Ca	Mg	ECEC	TEA	Sand ←-------%--------→	Silt	Clay
NPK 240 kg/ha	6.60a	1.39a	0.26a	8.81b	4.46c	4.23a	0.14a	0.150a	3.38b	2.56b	83	13	4
PM 30 tons/ha	6.70a	1.41a	0.17a	9.28a	4.41b	4.32a	0.11b	0.150a	3.96a	3.12a	82.4	12.6	5.0
NPK 120 kg/ha and PM15 tons/ha	6.45a	1.39a	0.37a	9.04ab	4.49b	4.30a	0.13a	0.150a	3.97a	3.05ab	83.5	11.0	5.5
Control	6.44a	1.13a	0.10a	7.63c	4.52a	4.17b	0.10b	0.250b	2.85c	2.06bc	83	13.4	3.6
LSD	0.443	0.730	0.222	0.306	0.830	0.900	0.015	0.115	0.395	0.501	2.19	0.900	1.41

PM = poultry manure

Table 7. Effect of the NPK and poultry manure on soil micronutrients

Treatment	Zn	Cu	Fe	Mn
	←---------- mg/kg----------→			
NPK 240 kg/ha	0.18[a]	0.02[b]	0.05[a]	0.05[b]
PM 30 tons/ha	0.30[a]	0.03[a]	0.05[a]	0.05[b]
NPK 120 kg/ha and PM 15 tons/ha	0.30[a]	0.03[a]	0.04[b]	0.05[b]
CONT	0.25[a]	0.02[b]	0.04[b]	0.02[a]
LSD	0.23	0.008	0.015	0.009

PM = poultry manure

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