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RESPONSE OF SNAKE TOMATO (*Tricosanthes cucumerina)* TO DIFFERENT FERTILIZER SOURCES IN SOUTHERN GUINEA SAVANNA ZONE OF NIGERIA

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ABSTRACT

Snake tomato is gaining popularity due to its nutritional, medicinal and health benefits. Its production is constrained by depleting soil fertility. Recently, there is increased interest in organic food owing to health and environmental benefits. Thus, an experiment on growth and yield of snake tomato as affected by fertilizer sources was conducted at Ponyan and Kabba during the 2019 cropping season. The experiment was laid out in a randomized complete block design with three replications. The treatments consisted of the control, residues from maize, guinea corn and spear grass, residues from soybean, cowpea and black bean, residues from cocoa and kola, pig manure, goat manure, cow dung manure and NPK plus B fertilizer. Data were taken on vine length, number of leaves, vine girth, days to 50% flowering, fruit length, fruit girth, number of seeds/fruit, fresh fruit weight, marketable fruits, non-marketable fruits and fruit yield (t/ha). Analysis of variance results indicated that plants treated with NPK plus B fertilizer significantly ($P<0.05$) recorded the longest vine, more number of leaves and branches. It also produced more fruits, longest fruit and heaviest fruits. Number of seeds/plant and marketable fruits were more in animal base manure. It is pertinent to know that non-marketable yield was highest in NPK plus B fertilizer. Contrarily, NPK plus B fertilizer increased yield, although statistically similar to animal base manure. Therefore, considering the benefits of organic manure on health and the environment, animal manure applied at 10 t/ha is recommended for snake tomato production in the study area.

Keywords: Snake tomato; organic manure and residues; growth; yield

INTRODUCTION

Snake tomato (*Tricosanthes cucumerina)* is an underutilized plant belonging to the family Cucurbitaceae (Adebooye, 2008; Ojiako and Igwe, 2008). It is an annual climber that requires staking for growth. The family consisted of about 70 genera and over 700 species, which are majorly distributed all over the world (Robinson and Decker-Walters, 1997). The plant produced long, narrow and cylindrical fruits similar to the shape of a snake. Unripe fruits appear green but turn orange-red at ripening. The unripe fruit has a sour taste (Ojiako and Igwe, 2008) and sweet taste when ripe. The ripe fruit can be blended to produce a paste used as a substitute for tomato puree (Enwere, 1998; Badejo *et al.*, 2016).

The fruit is mainly consumed as a vegetable (ECHO, 2000), it contains crude protein of 26.6 g/100g, fat of 57.2 g/100g, phosphorus of 81.5 mg/100g and calcium of 46.7 mg/100g (Adebooye and Oloyede, 2005), and ascorbic acid (56.58 mg/100g) (Badejo *et al.*, 2016). Snake tomato fruits are excellent sources of natural antioxidants that reduced the risk of developing cancer and other chronic diseases (Cao *et al.*, 1996; Knekt *et al.*, 2002). The lycopene in tomatoes hinder the growth cancer cells (Zehiroglu and Sarikaya, 2019). Extracted juice from the leaves can stimulate vomiting in case of consumption of toxic substances (Devi, 2017). Snake tomato also possess considerable antidandruff properties (Vishal and Prashant, 2014), vitamin A in it protects both the skin and hair from external damage. Vitamin K and calcium from snake tomato gives strength and rigidity to bones and teeth (Zittermann, 2001; Hamidi *et al.*, 2013).

Despite the enormous benefits of snake tomato, its production is hindered by decline in soil fertility, inadequate knowledge on its nutritional potentials, pests and agronomic practices. Crop management practices, especially soil fertility management sustains the yield and quality of any crop (Ani and Baiyeri, 2008). Loss of organic matter as a result of soil degradation usually leads to soil acidity and low crop yields. Organic manure acts as a liming material thereby reducing soil acidity (Olatunji *et al.*, 2012). Organic, inorganic fertilizers or combination of the two could be used to improve soil fertility (Aba *et al.*, 2020). High cost of synthetic fertilizers necessitated the use of organic manure (Delate and Camberdella, 2004). Organic manures contain macro and micro nutrients required for optimum crop growth and development (Zayed *et al.*, 2013). Adequate use of organic fertilizer improves soil properties (Palada *et al.*, 2004; Khalid and Shafei, 2005). Paul and Mannan

(2006) opined that the use of organic wastes could effectively combat soil nutrient depletion and also enhance crop productivity. There is dearth of information on the effect of application of different organic residues on growth and yield of snake tomato in Southern Guinea Savanna Zone of Nigeria, an agro ecological zone with abundant agricultural land and high potential for crop production. The soils in the region are however, characterized by inherently low soil fertility status and rapid nutrient depletion as a result of speedy organic matter decay (Agele *et al.*, 2015). The objective of this research was therefore; to determine the influence of different fertilizer sources on growth and yield of snake tomato in Ponyan and Kabba in the southern Guinea savanna zone of Kogi State, Nigeria.

MATERIALS AND METHODS

Location

The experiment was conducted in 2019 raining season at the farmer's farm in Ponyan (latitude of 35° 19' N and longitude of 51° 39' E) and Research Site of College of Agriculture, Kabba (latitude of 35° 19' N and longitude of 51° 39' E). The experimental sites are 431 and 435 m above sea level, respectively in southern guinea savannah, Nigeria. The areas have monomodal rainfall pattern and occurs between March and October. Dry season commenced in November and terminates in March (Babalola, 2010).

Field work

Field measured 308 m^2 was used for the study at each location. The area of land used was ploughed, double harrowed and partitioned into 24 plots (4 × 2 m dimensions). Composite soil sample was collected from each plot and mixed together to get a representative sample for pre-planting soil physical and chemical analysis. The treatments consisted of the control (T1), residues of poaceae family (maize, guinea corn and spear grass) (T2), residues from grain legumes (soybean, cowpea and black bean) (T3), residues from cocoa and kola (T4), all the three formed the plant base materials used. The animal base materials used were pig manure (T5), goat manure (T6) and cow dung manure (T7). The organic materials utilized were incorporated into the soil three weeks prior to planting at 10 t/ha. NPK 20:10:10 plus boron (B) Fertilizer at the rate of 180 kg/ha (T8) was used as check and applied two weeks after germination. Two seeds were sown at a spacing of 1m x 1m and at a depth of 1.5-2.0 inches in April, 2019. Sprouting was observed between 7 - 9 days after planting. Thinning was carried out 10 days after germination to produce one plant per stand. Seedlings were supported with bamboo poles of 3 m length. Weeds were controlled manually using hoe at 4 weeks interval. At three weeks after sowing, KARATE 2.5 EC insecticide (Lambda-cyhalothrin) was sprayed at the rate of 500 ml/ha to control pests. Randomized complete block design (RCBD) was used for the experiment and the treatment replicated three times.

Pre-planting soil analysis

Pre-planting soil analysis was done at the Crop, Soil and Pest management Departmental Laboratory, Federal University of Technology, Akure. The physical and chemical properties of the soil samples analyzed were: particle size distribution which was done by hydrometer method (Gee and Bauder, 1986). Digital pH metre was employed to determine soil pH using 1:1 soil/water. Walkley-Black dichromate wet-oxidation method was used to determine organic carbon as recommended by Nelson and Sommers (1982). Micro-kjeldahl distillation technique was used to determine total nitrogen in the sample according to Bremmer and Mulvaney (1982). Dtermination of available phosphorus was by Bray 1 method (IITA, 1982).

Data collection

Data were collected on growth, yield attributes and yield. Growth parameters taken at 90 days after planting include vine length prior to branching, number of leaves and vine girth at 60 cm above ground level. Yield attributes and yield data collected include number of days to flowering, fresh fruit weight per plant, fruit length, fruit girth, number of seeds per fruit, marketable yield, non-marketable yield and fruit yield per land area. Five plants were selected and tagged for data collection. Vine length and stem girth were taken using tape rule and Vernier caliper respectively. Fresh fruit weight $plant^{-1}$ was determined using weighing balance and the average taken. Vernier caliper was used to determine the fruit girth, while fruit length was measured using a meter rule according to Umumarongie *et al.* (2013). Ripe fruits were harvested when the colour changes from green to orange red at 110-120 days after planting.

Data analysis

All the data collected were subjected to analysis of variance (ANOVA) (GENSTAT, 2013 10 Release 4.23 DE, Discovery). The treatment means were separated using the Least Significant difference at 5% level of probability as outlined by Obi (2002).

RESULTS

Soil analysis

Soil physical and chemical properties of the experimental sites is presented in Table 1. The results of the pre-planting soil analysis indicated that the soils are predominantly sandy, with relatively high bulk density and slightly acidic. The soil organic matter (3.36 and 2.16%), total nitrogen (0.09 and 1.87%), available phosphorus (2.76 and 2.53 mg/kg), exchangeable potassium (0.28 and 0.38 Cmol/kg) and calcium (3.36 and 2.78 Cmol/kg) were low at both locations.

Table 1: Physical and chemical properties of the experimental soils at Kabba and Ponyan

Physical properties	Ponyan	Kabba
Sand (g/kg)	663	672
Clay (g/kg)	194	207
Silt (g/kg)	143	121
Total porosity (%)	41.4	42.5
Bulk density (g/cm3)	1.43	1.43
Chemical properties		
Soil pH	5.21	5.62
Total N (%)	0.09	1.87
Organic matter (%)	3.36	2.16
Available P (mg/kg)	2.76	2.53
Available K (Cmol/kg)	0.28	0.38
Exchangeable cations		
Ca (Cmol/kg)	3.36	2.78
Mg (Cmol/kg)	3.36	2.82
Na (Cmol/kg)	1.66	0.97

Analyzed at the Department of Crop, Soil and Pest Management, Federal University of Technology, Akure

Table 1 presents the chemical composition of different organic materials used during the experiments. The results showed variability in the chemical properties of the organic materials as a result of the different types and constituents used. Cereals had higher value of organic carbon. Contrarily, it gave lower values for nitrogen, phosphorus, potassium and calcium relative to the values obtained in other organic materials. This indicated that legume, residues, goat manure and cow dung were relatively suitable for the growth and yield of snake tomato.

Table 2: Chemical composition of different organic materials used during the experiment

Plant materials	Organic carbon (%)	Total N (%)	C/N	P (%)	K (%)	Ca (%)	Mg (%)
Cereal (mixture)	56.1	1.73	32.43	0.56	0.68	0.67	0.38
Legume (mixture)	54.3	3.16	17.18	1.34	1.63	0.96	0.13
Residues (Pod mixture)	50.6	3.41	14.84	1.28	1.51	1.06	0.49
Pig manure	43.8	2.64	16.59	2.36	0.74	3.61	0.51
Goat manure	42.8	2.73	15.68	1.34	2.12	1.23	0.32
Cow dung	42.7	2.63	16.24	1.61	0.74	1.23	0.36

Analyzed at the Department of Crop, Soil and Pest Management, Federal University of Technology, Akure

Growth attributes

The effect of different organic residues on growth characters of snake tomato in Ponyan and Kabba is presented in Table 3. There were significant ($p < 0.05$) differences in length of vine, number of leaves and number of branches of snake tomato as influenced by different organic manure. However, days to 50% flowering in snake tomato did not vary statistically. Plot that received NPK and B fertilizer (T8) produced the longest vine (67.5 cm), highest number of leaves (47.37) and more branches (25.20). This was followed by plots with animal manure (T5, T6 and T7) with the mean values of 51.76 cm, 37.61 and 21.80 for vine length, number of leaves and number of branches, respectively. Plants grown with plant residues were significantly inferior to either the NPK and B fertilizer plots or animal manure plots. The mean length of vine, number of leaves and number of branches of plots treated with grass residues were 45.77cm, 31.61 and 16.14, respectively. Control plots recorded the least vine length, number of leaves and number of branches with respective values of 39.91 cm, 22.14 and 10.11.

Table 3: Effect of different fertilizer sources on vine length, number of leaves, number of branches and 50% flowering of snake tomato in Ponyan and Kabba

Treatment	Vine length (cm)			Number of leaves/ plant			Number of branches			Days to 50% flowering		
	Ponyan	Kabba	Mean	Ponyan	Kabba	Mean	Ponyan	Kabba	mean	Ponyan	Kabba	Mean
T1	44.08d	35.74d	39.91d	21d	23c	22d	10c	10c	10d	87	87	87
T2	46.31c	43.64c		33bc	33b		16b	16b		87	88	
T3	51.43bc	48.61b		33bc	31b		15b	18b		87	87	
T4	44.31c	46.31bc	45.77c	29c	30b	32c	16b	17b	16c	86	87	87
T5	52.61b	47.64bc		37b	38b		22a	20ab	22b	87	87	
T6	54.31ab	49.43b		39b	37b		22a	21ab		86	86	
T7	53.40ab	53.16ab	51.76b	37b	37b	38b	23a	23a		87	88	87
T8	68.43a	66.71a	67.57a	46a	48a	47a	26a	24a	25a	88	86	87
LSD (0.05)	5.41	4.88	3.74	6.41	8.41	5.47	5.13	4.62	2.89	NS	NS	NS

T1- control, T2- grass family (maize, guinea corn and spear grass), T3- grain legumes (soybean, cowpea and black bean), T4- residues from cocoa and kola, T5- pig manure, T6 –goat manure, T7 – cow dung, and T8 - NPK and B fertilizer. NS - non-significant
Source: Field data, 201

Phenology

Table 4 shows the effect of different organic materials on flower characters of snake tomato. Number of flowers produced, number of fruit per plant and number of aborted flowers varied significantly. The number of flowers and fruits produced were highest in plots with NPK and B fertilizer with mean values of 40.71 and 22.87, respectively. Numbers of flowers produced were similar in plot with animal base residues and plots with plant base residues. Plots treated with animal base organic residue exhibited superiority in number of fruits with the mean value of 18.72 when compared with plant base organic residues that has the mean values of 12.85 fruits.

Number of aborted flowers (26.25) were more in the control plots than the treated plots. The number of flowers aborted in plot with NPK and B fertilizer (17.84) and plots with plant base organic residues (18.93) were similar and negatively superior to plots with animal base residues which recorded the least number of aborted flowers (11.74 flowers). Number of flowers produced per plant and number of fruits produced per plant were least in the control plots.

Table 4: Effect of different fertilizer sources on number of flowers produced, number of fruits produced and number of aborted flowers of snake tomato in Ponyan and Kabba

Treatment	Number of flowers produced			Number of fruits produced per plant			Number of aborted flowers		
	Ponyan	Kabba	Mean	Ponyan	Kabba	Mean	Ponyan	Kabba	Mean
T1	25ab	26b	26c	9d	10d	9d	26a	26a	26a
T2	32ab	31b		13c	14c		18bc	17b	
T3	320ab	31b		13c	11c		19b	20b	
T4	33ab	32b	32b	13c	13c	13c	20b	19b	19b
T5	31ab	31b		17b	20b		14c	11c	
T6	31ab	29b		18ab	20b		12c	10c	
T7	30b	31b	30b	17b	19b	19b	12c	11c	12c
T8	40a	42a	41a	22a	24a	23a	17bc	18b	18b
LSD (0.05)	8.61	6.44	2.11	3.89	3.65	1.89	4.88	3.94	3.44

T1- control, T2- grass family (maize, guinea corn and spear grass), T3- grain legumes (soybean, cowpea and black bean), T4- residues from cocoa and kola, T5-pig manure, T6 –goat manure, T7 – cow dung, and T8 - NPK and B fertilizer.
Source: Field data, 201

Yield components and yield

The effect of different organic residues on fruit characters of Snake tomato is presented in Table 5. Significant differences were observed in fruit length, number of seeds per fruit and fruit weight at Ponyan and Kabba but fruit girth was statistically similar. The longest fruits (51.20 cm) and the heaviest fruits (0.55 g) were obtained in plots treated with NPK and B fertilizer. More seeds/fruit were obtained in plots that received animal base residue with the mean value of 48.02, this was not statistically different from the value (44.95) recorded in T8. Plots with no amendment (control) produced the shortest fruits (25.95 cm), least number of seeds/plant (32.00) and lightest fruits of 0.31 g.

Table 5: Effect of different fertilizer sources on length of fruit, fruit girth, number of seeds/plant and fruit weight of snake tomato in Ponyan and Kabba

Treatment	Fruit length (cm)			Fruit girth (cm)			Number of seeds/fruit			Fruit weight (g)		
	Ponyan	Kabba		Ponyan	Kabba		Ponyan	Kabba		Ponyan	Kabba	
T1	27.6d	24.3c	25.95d	5.8	5.0	5.4a	33b	31c	32b	0.29b	0.33c	0.31c
T2	33.1c	30.4c		5.4	6.0		38b	33c		0.38b	0.36c	
T3	41.6b	38.9b		5.3	5.8		35b	35c		0.33b	0.43bc	
T4	36.4bc	37.8bc	36.37c	5.7	6.6	5.8a	36b	33	35b	0.35b	0.40bc	0.38b
T5	43.3b	42.6b		6.4	7.0		44a	48ab		0.46ab	0.46b	
T6	43.6b	40.1b		4.8	4.9		44a	44b		0.41ab	0.41b	
T7	43.4b	42.6b	42.60b	6.2	7.3	6.1a	46a	44b	48a	0.39ab	0.43b	0.43b
T8	49.8a	52.6a	51.20a	6.0	5.6	5.8a	47a	51a	45a	0.51a	0.58a	0.55a
LSD (0.05)	5.66	8.11	6.41	NS	NS	NS	5.44	6.01	4.31	0.11	0.09	0.06

T1- control, T2- grass family (maize, guinea corn and spear grass), T3- grain legumes (soybean, cowpea and black bean), T4- residues from cocoa and kola, T5- pig manure, T6 –goat manure, T7 – cow dung, and T8 - NPK and B fertilizer. NS - non-significant.
Source: Field data, 2019

Table 6 presents the effect of different organic residues on marketable yield, non-marketable yield and total yield of snake tomato. The result shows that marketable yield of snake tomato was similar in all the plots except in the control plots. The percentage of marketable fruit yield was highest in plot with organic residues irrespective of the sources (90 – 90.1%). This was followed by plots with NPK and B fertilizer which recorded marketable yield of 76.4%. Plants grown in plots where fertilizer were not applied (control) gave the least percent marketable yield (74.6%) and the highest percentage of non-marketable yield of 25.4%. Total yield of plots with animal manure and plots with NPK and B fertilizer were not different statistically but better than plots with plant residues. Also, snake tomato plants treated with grass base residues were better than the control plot and produced minimal damaged fruits. The yield of the control plots was as low as 2.91 t/ha.

Table 6. Effect of different fertilizer sources on marketable yield, non-marketable yield and total yield of snake tomato in Ponyan and Kabba

Treatment	Marketable yield (t/ha)			Non marketable yield (t/ha)			Total Yield (t/ha)		
	Ponyan	Kabba	Mean	Ponyan	Kabba	mean	Ponyan	Kabba	Mean
T1	2.83c	1.39b	2.11c (74.6%)	0.74a	0.86a	0.80a (25.4%)	3.14c	2.68c	2.91c
T2	5.06b	5.51a		0.57b	0.63b		5.63b	6.14b	
T3	5.73ab	5.51a	5.45b	0.60b	0.58b	0.59c	6.33b	6.09b	
T4	5.15b	5.71a	(90.1%)	0.56b	0.60b	(9.9%)	5.71b	6.31b	6.04b
T5	6.27ab	6.75a		0.71b	0.66b		6.98ab	7.41a	
T6	6.88a	6.58a	6.66a	0.73b	0.76b	0.74b	7.61a	7.34a	
T7	6.82a	6.65a	(90.0%)	0.82b	0.76b	(10.0)%	7.64a	7.41a	7.39a
T8	5.60a	6.17a	5.89a (76.4%)	1.64a	1.76a	1.70a (23.6%)	7.24ab	7.53a	7.59a
LSD (0.05)	1.34	1.27	0.31	0.31	0.56	0.09	0.91	0.84	0.24

T1- control, T2- grass family (maize, guinea corn and spear grass), T3- grain legumes (soybean, cowpea and black bean), T4- residues from cocoa and kola, T5-pig manure, T6 –goat manure, T7 – cow dung, and T8 - NPK and B fertilizer.
Source: Field data, 2019

DISCUSSION

Growth

Snake tomatoes grown on NPK and B fertilizer plots out-performed other fertilizer sources with respect to vine length, number of leaves and branches. This shows that NPK and B fertilizer were readily made available to plant roots in absorbable form, thus boosting the morphological growth of the plant. The result obtained supports the finding of Afe *et al.* (2020) who stated that inorganic fertilizer increase both plant height and number of leaves of crops more in comparison with organic fertilizer sources. Animal manure base residues plots compete favorably with plots with NPK and B fertilizer. The efficiency of organic manure especially animal base manure in enhancing crop growth and yield components have been reported. Hsieh and Hsieh (1990) reported that high content of cow dung, pig manure, goat manure have the potential to improve soil quality and boost crop growth and yield. Similarly, Adetunji (2004) found high content of nitrogen, organic carbon and potassium in cow dung manure as well as high content of copper (Cu) but lower content of fibrous materials in pig manure.

Although plants in plots that received plant base organic residues were inferior to NPK and B fertilizer and animal base organic residues plots. However, it performed better with respect to growth and yield attributes in comparison with the plants in the control plots. Plant residues may carry large quantity of N, under field conditions, the contribution of plant residues N to crop nutrition is often small and crop recoveries of residual N are less than 20 percent (Giller and Cadish, 1995). Nitrogen added through plant residues suffers from the same losses as nitrogen added through chemical fertilizer. Kirchmann and Bergstron (2001) indicated that leaching losses in relation to unit area are large in plant residues organic as in conventional farming system. This could be responsible for the inferior performance of plots with plant residues application in terms of growth and yield when compared to animal base sources in this experiment. The control plots recorded the least growth and yield characters, this is expected because

the snake tomato in the control plots only depends on inherent nutrients present in the native soil. Hence, low growth and yield characters recorded in the control plots
Numbers of fruits produced in plots with organic residues amendment were higher than the control plots. This could be that plots with organic residues were better furnished with plant nutrient compared to control. All the organic residues used released nutrients to the soil irrespective of the types applied. Fagbenro (2000) reported that organic residues can hold soil particles together thereby improving the structure of the soils and produce better soil physical properties. This could be responsible for the better fruit yield observed in plots with organic amendment.

Snake tomato with organic manure application recorded lower number of aborted flower when compare to plot treated with mineral fertilizer (NPK and B fertilizer). Soil amendment using organic residues, especially animal manure base residues furnishes the crop with both macro and micro nutrients while plot with NPK and B fertilizer supply plant with NPK and B fertilizer alone. Healthy and vigorous plants are obtained when grown with organic residues (Zubairu and Gaya, 2022). This could be the reason behind the low levels of aborted flowers in plots supplied with organic manure. Control plots recorded the highest number of aborted flowers. Available plant nutrients could not support the number of flower initiated by the plant, since the plant depends solely on the inherent nutrient of the soil.

Plots with organic manure produced fruits of better quality and marketable fruits compare to the inorganic fertilizer plots. In general, all the organic residues used had sufficient nutrients to increase the yield and enhance fruit quality compared to plant treated with inorganic fertilizer alone. The work is in consonance with those of Afe *et al.* (2020) who reported that addition of organic manure to the soil improves the soil structure and hence, encourage good root system which leads to higher yield and quality fruit production. The better fruit quality in plots with organic manure could be attributed to the fact that nutrients in organic manure are released gradually through the process of mineralization (Islam *et al.*, 2021).

CONCLUSION

In conclusion, snake tomato with NPK and B fertilizer application recorded the highest fruits yield but also recorded highest percentage of non-marketable fruits compare to plots with organic manure especially animal manure base plots. Yield of all the animal manure plots were significantly similar to the yield of plots with NPK and B fertilizer. Therefore, for optimum production of snake tomato farmers should use any of the animal manure (pig, goat and cow dung) applied at 10 t/ha in the study area.

DECLARATION OF COMPETING INTEREST

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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