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Effect of poultry manure application rates on growth and yield of Saba (*Saba senegalensis)* in Southeastern Nigeria

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An experiment to determine the effect of poultry manure (PM) application rates on growth and yield of *S. senegalensis* was conducted at the Department of Crop Science, University of Nigeria, Nsukka. The experiment was a Randomized Complete Block Design (RCBD) of four rates of poultry manure (0, 10, 20 and 30 t ha–1) replicated three times. Analysis of variance results indicated that PM significantly ($p < 0.05$) influenced most of the growth attributes measured with 20 t ha-1 having the longest vine (106.5 and 140.3 cm) at 4 and 5 MAT, respectively. It also produced more leaves (77.9, 132.1, 175.9 and 250) at 2, 3, 4 and 5 MAT, respectively and had the highest number of branches of 13.85, 22.70, 27.6, 39.2 and 61.1 across the months. Most of the phenological traits were positively influenced by PM rates. Earliest days to 60% (138.0 days) and 100% (167.0 days) flower bud formation, flower bud break (191.0 days) and fruit formation (194.3 days) were associated with 30 t ha–1 of PM. Poultry manure had no significant effect on all the yield components and yield measured. Although, PM applied at 20 t ha–1 had the earliest days (706) to harvest and had the tendency to increase *S. senegalensis* yield. Further increase of PM rate beyond 20 t ha–1 decreased growth and yield traits taken. The use of PM at 20 t ha–1 appeared optimum and could be recommended for the cultivation of *S, senegalensis* in the study area.

Key words: *Saba senegalensis*, poultry manure, food insecurity, growth, yield.

INTRODUCTION

Forest resources play a vital role in the national economy of most developing nations like Nigeria. They provide numerous goods and services to man such as food, medicine, wood, fibre and energy (Mukhtar et al., 2013). Forest resources were taken for granted in the past because they were available almost everywhere but the situation has changed due to the fast rate of deforestation. Food insecurity remains a major challenge in Nigeria and insufficient nutrient intake causes severe malnutrition affecting the populace (Enzonga et al., 2019). The valuation of edible fruits and vegetables that are underutilized is one of the ways out of this impasse.

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Fruits and vegetables are rich in vitamins, minerals, antioxidants and phenolic compounds (Ahodegnon et al., 2018).

Saba senegalensis (A.DC.) Pichon is an indigenous large, woody plant species belonging to Apocynaceae family (Arbonnier, 2000). As a climber, it normally seeks support from the host plant to rest upon and grow, but the seeds germinate in places where there is no support and therefore the plant manages to grow at the place where it sprouted (Baiyeri et al., 2019). The fruit of *S. senegalensis* is known as "malombo" in the Congo Basin, "zaban" in Mali, "wèda" in Burkina Faso, "côcôta" in Côte d'Ivoire and "maad" in Senegal (Tiendrebeogo et al., 2020). It is known as 'Ibo' by Okun-Yoruba of North Central Nigeria and 'Utu' by the Igbo of Southeastern Nigeria (Baiyeri et al., 2019). *Saba senegalensis,* as a wild plant, it is found in many African countries such as Nigeria, Senegal, Burkina Faso, Ghana, Côte d'Ivoire, Gambia, Guinea-Bissau, Mali and Tanzania (Fatim et al., 2019). The plant is majorly distributed close to the river banks and open woodland of Africa (Arbonnier, 2002). *Saba senegalensis* fruit has yellow pulp that is acidulous, tasty, sweet-sour when ripe and can be consumed directly or processed into other products (Arbonnier, 2000; Tanor, 2001). The fruits contain many almonds coated with orange-yellow pulp and are consumed during the lean season (Atato et al., 2012). *Saba senegalensis* fruits are highly prized and in Africa, they contribute to the rural economy and are openly hawked in the cities (Nafan et al., 2013). In Nigeria, the fruits are available from April to August.

Previous studies established that *S. senegalensis* fruit have high nutritional contents such as minerals, phytochemicals and vitamins. Boamponsem et al. (2013) reported that *S. senegalensis* contains 47.5 ppm of magnesium, 810 ppm of calcium and 357.5 ppm of phosphorus. It contains phenol (264.76 mg/100g), phytate (31.18 mg/100g), oxalic acid (381.33 mg/100g) and tannin (198.94 mg/100g) (Fatim et al., 2019). Report of Sarr et al. (2018) indicated that it contains 11.00 to 74.23 g/100g carbohydrate, 0.2 g/100g lipid and 0.8 to 0.3 g/100g protein. Nafan et al. (2013) documented that the fruit is a potential source of vitamin C ranging from 34.8 to 67.5 mg/100g. According to Kini et al. (2012) the fruit contains β-carotene which is estimated at 1.559 mg 100 mg/100g. Consumption of *S. senegalensis* fruit can improve nutrition and health of the household. The availability of active compounds in *S. senegalensis* fruit could play a vital role in preventing and treating certain vitamin deficiencies and metabolic diseases (Kini et al., 2008).

S. senegalensis pulp can be processed into jam and juice. The pulp can be crushed which is used in preparing porridge (Boamponsem et al., 2013). The latex is used as an adhesive in preparing poison for arrows. Ethnobotanical information revealed that the leaves are used for the treatment of vomiting, wounds, food poisoning, chronic headache, adenitis and blindness (Janick and Paull, 2008; Arbonnier, 2009; Baiyeri et al., 2019). *S. senegalensis* could play an important role in improving soil fertility, suppressing weeds, enhancing biodiversity, sequestering carbon, contributing to soil and water conservation as its branches spread to form thick canopy (Baiyeri et al., 2019; Olajide, 2021).

Despite the importance of *S. senegalensis*, the crop has not been brought under regular cultivation culture in Nigeria owing to lack of adequate knowledge on the propagation, fertilizer requirement, climatic requirement, agronomic practices and pests. The major production consideration for a given crop is the fertilizer requirement of such crop. Appropriate soil fertility management is needed in sustaining the yield and quality of a new crop (Ani and Baiyeri, 2008; Ndukwe and Baiyeri 2020). Organic or inorganic fertilizers or both can be utilized in improving soil fertility (Aba et al., 2020). Long term use of inorganic fertilizers to increase soil nutrients could result to reduction in soil organic matter, increase in soil acidity, leaching losses, erosion, degradation of soil physical properties and pollution of the environment (Obi and Ebo 1995; Ojeniyi, 2005; Laird et al., 2010). Soil amendment using organic manure is highly important in order to sustain crop production systems since it is a reliable source of nitrogen and carbon (Liang et al., 2012; Rinaldi et al., 2014) and it also moderates soil pH (Abubakari et al., 2015). Presently, there is dearth of information on agronomic studies of *S. senegalensis* in Southeastern Nigeria. Very few farmers and researchers in this region are familiar with the crop. Hence, investigating into this indigenous crop can provide useful information that could encourage the cultivation of this plant, remedy food insecurity, improve peoples' diet and prevent the crop from going into extinction. Therefore, the objective of this study was to evaluate the impact of poultry manure rates on growth and yield of *S. senegalensis* in Southeastern Nigeria.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at the Department of Crop Science Teaching and Research Farm of University of Nigeria, Nsukka (07° 29'N, 06° 51'E, and 400 m above mean sea level). A study by Uguru et al. (2011) indicated that Nsukka have lowland humid tropical conditions with bimodal annual rainfall ranging from 1155 to 1955 mm with a shift in the second peak of rainfall from September-October. A mean annual temperature of 29°C to 31°C and relative humidity that varied from 69 to 79% also prevails in Nsukka. Generally, the soil is classified as an ultisol (Asiegbu, 1989).

The collection of *S. senegalensis* germplasm

Fully ripened *S. senegalensis* fruits were harvested in July 2019 from the wild at Aiyegunle-Gbede (7.8^{o} E, 5.9 ^{o} N and 381.00 m above sea level) in Kogi State, Nigeria. The fruits were cut transversely and depulping was done in order to extract the seeds Separation of seeds from mucilage was done by squeezing the pulp. mixed with saw dust in cheesecloth (Ndukwe and Baiyeri, 2020). The seeds were air dried and planted in the nursery late 2019 and later transplanted to the field (Appendix II (Figure A, D and E)) in April, 2020 at the onset of rain.

The collection of soil sample

Prior to transplanting, soil samples were collected from the field at 0-15 cm depth, the samples were thoroughly mixed together to form a composite soil sample. It was air dried, sieved through a 2-mm sieve and used for the determination of bulk density and particle size as described by Carter (1993). Total porosity was calculated from the values of bulk density and particle density. Organic matter was determined by the Walkley and Black's dichromate wet oxidation method (Nelson and Sommers, 1982). Total N was determined by Micro-Kjeldahl digestion method. Available P was determined by Bray-1 extraction followed by Molybdenum blue colorimetric (Bray and Kurtz, 1945).

The exchangeable bases (K^+, Ca^{2+} and Mg^{2+}) were extracted by Ethylene Diamine Tetra Acetic Acid (EDTA) titration method (Jackson, 1962). Soil pH was determined in 1:2 soil-water ratios using digital electronic pH meter. The poultry manure utilized was analyzed at the Soil Science Laboratory, Faculty of Agriculture, University of Nigeria, Nsukka.

Experimental design

The treatments included four poultry manure (PM) application rates (0, 10, 20 and 30 t ha^{-1}); the plants received these rates of poultry manure per annum according to Olajide (2021). The experiment was laid out in a Randomized Complete Block Design (RCBD) and replicated thrice. The plant spacing was 3 m x 2 m. planting holes of 30 cm x 30 cm x 30 cm were dug in accordance with the required plant spacing. An alleyway of 3.0 m divided two blocks following Olajide et al. (2022). Poultry manure was applied as top dressing in split doses, 40% of the required amount was applied in June, 2020 as the first dose while the second dose (60%) was applied in September, 2020. Weeding was done with the use of glyphoste at 4 weeks interval.

Data collection

Data on growth traits were taken at 2, 3, 4, 5 and 6 months after transplanting while yield characters and yield were taken at flowering, fruiting and harvesting. Vine lenght as the distance from the ground level to the apex of the longest vine was measured in cm with the use of measuring tape and the average recorded. Number of leaves per plant was counted and the average recorded. Number of branches was obtained by counting and the average recorded. Number of days to flower bud formation was counted from transplanting to when flower buds were noticed. Number of days to 60 and 100% flower bud formation was recorded by counting the number of days the third and the fifth plants from each treatment developed flower bud, respectively. Number of days to flower bud break (anthesis) was counted from transplanting and the average taken. Number of days to fruit formation was counted from transplanting and the average recorded. Number of days to harvest was determined by counting the number of days from transplanting to harvest. Number of fruits $plant^{-1}$ was taken by counting the number of fruits produced $plant^{-1}$. Fruit weight (kg) was determined by weighing fruits from each plot with digital weighing balance and the average taken. Additionally, fruit yield (t ha^{-1}) was determined based on the weight of the fruits (kg) per plot which was converted in to hectare base and expressed in tones (Ndukwe and Baiyeri, 2020).

Statistical analysis

All the data collected were subjected to analysis of variance (ANOVA) following the procedure outlined for the experimental design using GENSTAT (2013). Significant treatment means were separated using least significant difference (LSD) at 5% level of probability as outlined by Obi (2002).

RESULTS

Soil properties of the experimental site before transplanting and the poultry manure utilized in the study

Table 1 showed the soil properties of the experimental site and poultry manure used in the study. The results indicated that the soil is characterized to be sandy clay loam with low pH in water (5.80). The soil organic matter, organic carbon, nitrogen and phosphorus were low at 2.60%, 1.53%, 0.09% and 7.06 ppm, respectively. The K^+, Ca^{2+} and Mg^{2+} were 0.10, 1.00 and 1.20 cmol kg^{-1}, respectively. The poultry manure used shows high contents of organic matter (86.10%), nitrogen (1.35%), phosphorus (0.54%) and potassium (0.19%).

Meteorological data of the experimental site

The meteorological data (Appendix I) from the site of the experiment showed that there was a marked variation in the climatic elements. The total rainfall was 1412.5 mm in 2020. The highest monthly rainfall recorded was in September 2020 with a total of 327.20 mm, while the highest (301.7 mm) was recorded in August 2021. The minimum air temperature of 20. 42 °C was obtained in January 2020 while the minimum air temperature of 20.97°C was recorded in December 2021. The maximum air temperature (33.55 and 31.40 °C) was observed in January 2020 and February of 2021, respectively. The mean relative humidity at 10 am in 2020 and 2021 were 56.80 and 54.05%, respectively.

Growth attributes

Application of poultry manure (PM) had no significant ($p > 0.05$) influence on vine length of *S. senegalensis* at 2, 3 and 6 months after transplanting (MAT) but differed at 4 and 5 MAT (Table 2). Plants that received 20 t ha^{-1} of PM maintained a steady growth with respect to vine length (106.50 and 140.30 cm) at 4 and 5 MAT, respectively. Further application of PM above 20 t ha^{-1} resulted in a decline in vine length of *S. senegalensis*. Plants in the control plots where no PM was applied produced the shortest vine of 60.30 and 77.30 cm, respectively.

Poultry manure application rates significantly ($p < 0.05$) affected number of leaves across the months except at 6 MAT (Table 3). Interestingly, poultry manure applied at

Table 1. Soil properties of the experimental site before transplanting and the poultry manure utilized in the study.

Mechanical properties	Soil particle size	Poultry manure
Clay (%)	27.00	-
Silt (%)	9.00	-
Fine sand (%)	29.00	-
Coarse sand (%)	35 .00	-
Textural class	Sandy clay loam	
Chemical properties		
pH in water	5.8 0	8.4 (%)
pH in KCl	4.20	8.2 (%)
Organic carbon (%)	1.53	57.96 (%)
Organic matter (%)	2.63	86.10 (%)
Total nitrogen (%)	0.09	1.35 (%)
Phosphorus (ppm)	7.06	0.54 (%)
Exchangeable base		
Sodium (Na^{+}) cmol/kg	0.07	0.01 (%)
Calcium (Ca^{2+}) cmol/kg	1.00	6.70 (%)
Potassium (K^{+}) cmol/kg	0.10	0.19 (%)
Magnesium (mg^{2+}) cmol/kg	1.20	5.24 (%)
CEC	15.60	-
Base saturation (%)	52.00	-
Exchangeable acidity in me/ 100 g soil		
Aluminium (Al^{3+})	0.40	-
Hydrogen (H^{+})	5.80	-

Source: Laboratory of the Department of Soil Science, Faculty of Agriculture, University of Nigeria, Nsukka.

Table 2. Effect of poultry manure application rates on vine length (cm) of *S. senegalensis* at 2, 3, 4, 5 and 6 months after transplanting.

Manure rates (t ha^{-1})	Vine length in months after transplanting				
	2	3	4	5	6
0	51.30	51.90	60.30	77.30	91.00
10	58.20	76.80	92.60	112.70	175.00
20	66.00	97.50	106.80	140.30	226.00
30	65.90	94.30	105.10	131.50	181.00
LSD (0.05)	NS	NS	35.46	44.6	NS

NS=non-significant.
Source: Field data, 2020

20 t ha^{-1} increased number of leaves (77.90, 132.10, 175.90 and 250.00) at 2, 3, 4 and 5 MAT, respectively. Increase in PM rate beyond 20 t ha^{-1} led to a decrease in number of leaves. The lowest number of leaves (40.50, 68.20, 78.20 and 108.00) was recorded in plants grown with no PM application at 2, 3, 4 and 5 MAT, respectively. In Table 4, Number of branches across the months were significantly ($p < 0.05$) affected by PM rates. Soil

Table 3. Effect of poultry manure application rates on number of leaves of *S. senegalensis* at 2, 3, 4, 5 and 6 months after transplanting.

Manure rates (t ha^{-1})	Number of leaves in months after transplanting				
	2	3	4	5	6
0	40.50	68.20	78.20	106.00	163.00
10	60.70	89.60	121.70	175.00	280.00
20	77.90	132.10	175.90	250.00	376.00
30	77.80	112.40	173.00	230.00	311.00
LSD (0.05)	28.33	30.47	50.61	83.1	NS

NS=non-significant.
Source: Field data, 2020

Table 4. Effect of poultry manure application rates on number of branches of *S. senegalensis* at 2, 3, 4, 5 and 6 months after transplanting.

Manure rates (t ha^{-1})	Number of branches in months after transplanting				
	2	3	4	5	6
0	4.83	8.00	12.50	17.30	25.70
10	10.47	17.90	18.50	27.40	36.90
20	13.85	22.70	27.60	39.20	61.10
30	13.80	21.30	26.70	39.00	56.60
LSD (0.05)	4.03	9.35	8.22	13.57	17.50

NS=non-significant.
Source: Field data, 2020

Table 5. Effect of poultry manure application rates on number of days to flower bud formation, days to 60 and 100% flower bud formation, days to flower bud break and days to fruit formation of *S. senegalensis.*

Manure rates (t ha^{-1})	DFBF	D_60%_FBF	D_100%_FBF	DFBB	DFF
0	175.30	-	-	-	-
10	158.80	167.00	236.00	233.00	236.50
20	140.30	148.00	195.00	211.00	232.50
30	114.50	138.00	167.00	191.00	194.30
LSD (0.05)	NS	76.30	102.80	79.30	55.10

DFBF – days to flower bud formation, D_60%_FBF – days to 60% flower bud formation, D_100%_FBF – days to 100% flower bud formation, DFBB – days to flower bud break, DFF – days to fruit formation and NS – Non-significant. Note that 0 t ha^{-1} only produced flower but could not fruit. The data above was taken between 3-7 months after transplanting.
Source: Field data, 2020-2021.

amendment using 20 t ha^{-1} of PM had greater number of branches at 2, 3, 4 and 5 MAT with respective values of 13.85, 22.70, 27.60 and 39.20. Number of branches (4.83, 8.00, 12.50 and 17.30) was lowest in plants grown without the application of PM. At 6 MAT, plants that were treated with 20 t ha^{-1} of PM produced more branches (61.10); this was 137.74, 65.58 and 7.9% above plants grown in plots that received 0, 10 and 30 t ha^{-1} of PM, respectively. For all the morphological traits taken across the months, *Saba senegalensis* response to poultry manure application rate was in the following order 20 t ha^{-1} > 30 t ha^{-1}, 10 t ha^{-1} > 0 t ha^{-1}.

Phenology

As shown in Table 5, poultry manure application rates did not significantly ($p > 0.05$) influenced number of days to flower bud formation but all other traits varied statistically. Number of days to 60% and 100% flower bud formation, days to flower bud break and days to fruit formation were earliest when the soil was amended with PM at 30 t ha^{-1}

Table 6. Effect of poultry manure application rates on number of fruit/plant, fruit weight (kg) and fruit yield (t ha^{-1}) of *S. senegalensis.*

Manure rates (t ha^{-1})	Number of days to harvest	Number of fruit/plant	Fruit weight (kg)	Fruit yield (t ha^{-1})
0	796.00	26.70	4.10	7.00
10	765.00	51.30	9.40	15.80
20	706.00	61.00	10.80	18.00
30	737.00	54.70	9.70	16.10
LSD (0.05)	NS	NS	NS	NS

Note that the fruits used to generate this data were harvested between March, 2022 to September, 2022 (2 years and 5 months after seedling transplanting), as shown in Figure F.
Source: Field data, 2022

with respective values of 138.00, 167.00 191.00 and 194.30 days while the longest days (167.00, 236.00, 233.00 and 236.50 days) was recorded when 10 t ha^{-1} of PM was applied. Although, the plants flowered in November 2020 and fruiting followed during the dry season. Most of the flowers aborted and some of the fruits also dried due to long dry spell (Figure B and C). The temperature range between November 2020 to April 2021 was 30.2 to 30.4 °C (Table 2), fluctuations in temperature might have strongly influenced flowering and the development of *S. senegalensis* fruits since the plants are usually found in riverine areas. For optimum production of this crop, irrigation facilities have to be provided.

Fruit yield

In Table 6, number of days to harvest, number of fruits per plant, fruit weight (kg) and fruit yield (t ha^{-1}) were not significantly ($p > 0.05$) affected by the application of poultry manure rates. However, soil amended with PM at 20 t ha^{-1} had the earliest days (706.00) to harvest and it also has the tendency to produce more fruits (61.00) and heaviest fruits (10.80 kg). For fruit yield, plants fertilized with 20 t ha^{-1} of PM had the highest value (18.00 t ha^{-1}) which was 158.14, 13.92 and 11.80% higher than 0, 10 and 30 t ha^{-1}, respectively.

Pattern of fruit yield during the fruiting period (March-September, 2022) as influenced by poultry manure application rates

The pattern of fresh fruit harvested and fruit yield as affected by PM application rates is presented in Figures 1 and 2. Fruit harvesting commenced in March 2022, (21 months after transplanting of seedlings). The fruiting progressively increased as the year was progressing. More fruits were harvested in plots treated with 20 t ha^{-1} of PM in March, May and June, 2022. Fruits harvested from plants grown with 30 t ha^{-1} of PM were more in July while highest number of fruits was harvested from plants fertilized with 10 t ha^{-1} of PM in August and September. However, July 2022 was the peak for highest number of fruits and fruit yield (t ha^{-1}) with the application of 30 t ha^{-1} PM having more number of fruits and highest fruit yield (t ha^{-1}). Harvesting of fruits declined in August, 2022, which was also noticed in September.

DISCUSSION

Growth

The quality of farm produce is a function of the growing environment in which soil fertility management is a major determinant (Lundegardh and Martensson, 2003; Wills et al., 2008; Aba et al., 2020). Addition of poultry manure significantly influenced vine length, number of leaves and number of branches of *S. senegalensis* than the control with no PM application. This is expected because laboratory analysis showed that poultry manure utilized is high in pH, organic matter and nitrogen compared to soil values. Generally, Nsukka soils are known for their acidity (Baiyeri and Tenkouano, 2007), which hinders the amount of nutrients available to plants (Baiyeri and Mbah, 2006). In this context, application of organic manure becomes necessary in order to boost crop yield. The variability observed in the growth of *S. senegalensis* plants could be ascribed to the varying poultry manure applied which may have affected the availability of plant nutrients. It has been established that poultry manure has the potential in reducing soil acidity apart from soil nutrient enhancement (Olatunji and Oboh, 2012; Sunassee, 2001; Stevens et al., 2018). Organic manure is fortified with nutrients and organic matter with the potential to enhance soil biophysical conditions that increases productivity and ensures plant sustainability (Baiyeri and Tenkouano, 2007; Ndukwe et al., 2011; Aba et al., 2011). Chukwuka and Omotayo (2009) observed that soil amendment using organic fertilizers positively increases soil chemical properties and nutrient absorption in plants, resulting to plant growth. Application of PM at

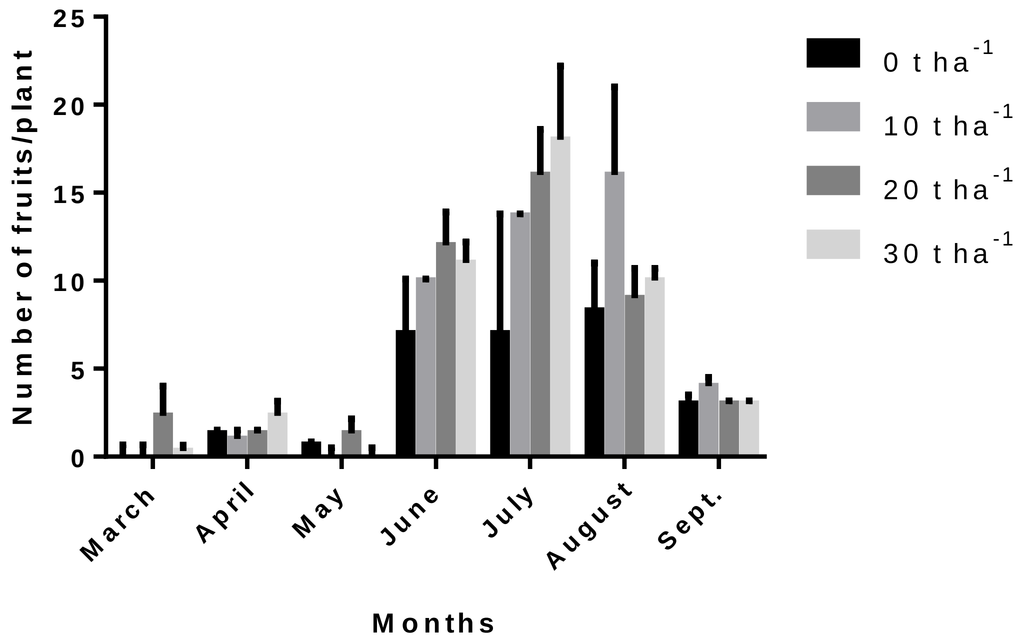

Figure 1. Number of fruits of *S. senegalensis* harvested in months as influenced by PM rates in 2022. Vertical bar indicates LSD 0.05 value.
Source: Field data, 2022

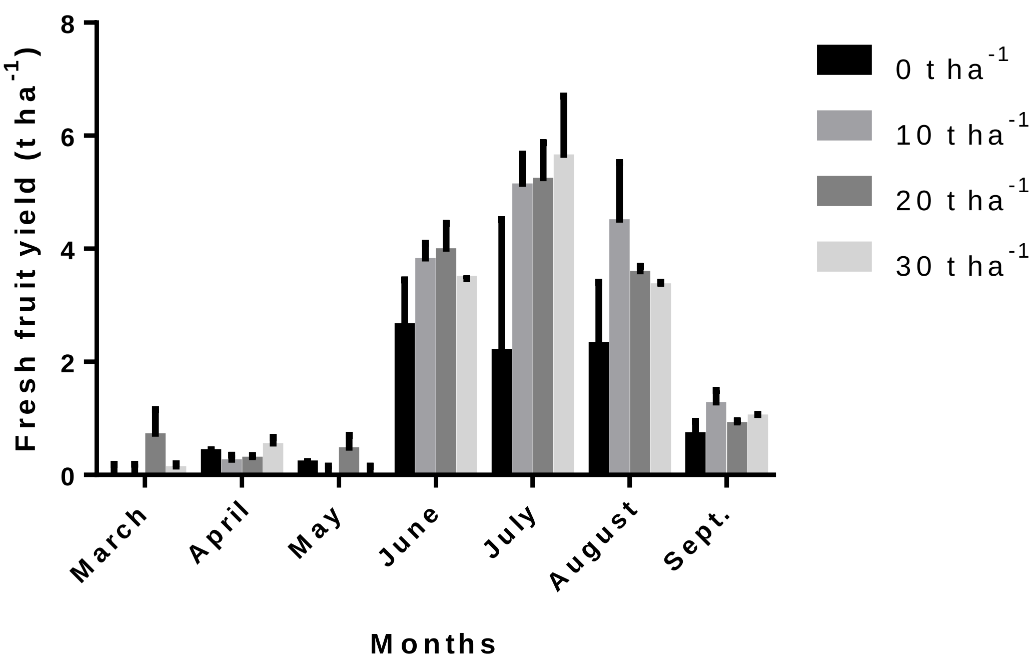

Figure 2. Fresh fruit (yield) of *S. senegalensis* harvested during the fruiting period (2022).
Source: Field data, 2022

20 t ha^{-1} increased vine length, number of leaves and number of branches. This finding is in contrast to the report of Olajide (2021) who amended the soil with the same PM rates and found that soil amendment at 10 t ha^{-1} enhanced all the growth parameters of *Plukenetia conophora*. The decline in growth traits observed at 30 t

ha^{-1} of PM application indicated that sufficient amount of nutrients were released by the 20 t ha^{-1} rate. When nutrients are supplied optimally, it leads to production of plants with high quality and nutritional value (Rice et al., 1994). As reported by Adebayo et al. (2011), when adequate quantity of organic manure is applied, plants tend to grow at their optimal potential. The decrease in growth parameters with increase in poultry manure application rate disagree with the result of Abdullahi et al. (2013) who obtained higher leaf production in *Moringa oleifera* with higher fertilizer rate.

Yield

Plants grown in plots amended with PM performed better in terms of the yield and yield attributes measured in this present work compared to the control. The increase in yield traits measured could be attributed to sufficient nutrients present in the PM which improved the yield of *S. senegalensis*. The higher values of the yield obtained with PM application also suggests that *S. senegalensis* plants are highly responsive to PM application. De-lannoy and Romain (2001) confirmed the superiority and richness of poultry manure as valuable source of nutrients and organic matter over other manures. Hemeng et al. (1995) observed that application of poultry manure was one of the best forms of organic fertilizers that support the production of plantain. Additionally, it has been reported that poultry manure has the potential to increase soil pH (Udoh et al., 2005), therefore poultry manure is known to have liming effect on the soil thereby making nutrients available to plants (Manna et al., 2007). Soil amendment using organic manure has proven to boost soil productivity, enhance the soil organic carbon content, soil micro-organism, improves soil structure, the nutrient status of the soil and increase crop yield (Udoh et al., 2005; FAO, 2000). The PM utilized has high concentration of nitrogen and potassium (Table 1). Poultry manure applied at 20 t ha^{-1} had the least number of days to harvest, it exhibited superiority in producing more fruits, heaviest fruits and highest fruit yield. The increase in yield component and yield by 20 t ha^{-1} of PM implied that this rate released adequate amount of nutrients which was efficiently utilized by *S. senegalensis*, thereby resulting to higher yield. The results obtained in this work corroborates the findings of Baiyeri et al. (2015) who noted that organic manure applied at 20 t ha^{-1} enhanced pod yield in *Moringa oleifera* grown as pot plant in the same study area. Ndukwe and Baiyeri (2020) found that application of PM at 20 t ha^{-1} was optimum for growth and yield of yellow passion fruit in Nsukka, Nigeria. Increase in poultry manure rate resulted to a decrease in *S. senegalensis* fruit yield. This finding is in contrary to the work of Stevens et al. (2018) who recorded increased pod production in *Moringa oleifera* with increase in manure rate. Similarly, Olatunji and Oboh (2012) reported increased pod yield in *Abelmoscus esculentum* with increase in manure rate where pod yield was increased by 52%. Although, *S. senegalensis* plants flowered and fruited at 7 months after transplanting accept the plants that received no poultry manure that had delayed flowering. This indicated that at 0 t ha^{-1} of PM, the soil fertility status was very low to support flowering and fruiting. This is in line with the report of Ani and Baiyeri (2008) who observed that yellow passion fruit grown in Nsukka without poultry manure were not able to flower in the first crop cycle of 12 months. However, high temperature resulted in increase in flower abortion and also led to drying of most of the fruits during the dry season. Fluctuations in temperature might have strongly influenced flowering and the development of *S. senegalensis* fruits since the plants are usually found in riverine areas. Harel et al. (2014) reported that increase in air temperature from 25 to 29°C decreased fruit number, fruit set and fruit weight per plant in tomato.

Conclusion

In this study, poultry manure application rates increased growth and yield parameters studied. Application of 20 t ha^{-1} of PM produced the longest vine, more leaves, greater number of branches and highest fruit yield. Therefore, amending the soil with PM at 20 t ha^{-1} appeared to be optimum and could be recommended for the cultivation of *S. senegalensis* in the study area.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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Appendix

Appendix I. Meteorological data of the experimental site.

Months	2020				2021			
	RF(mm)	Temperature (0^oC)		RH (%)	RF (mm)	Temperature (0^oC)		RH (%)
	Total	Max	Min	10am	Total	Max	Min	10am
Jan.	Nil	33.55	20.42	31.10	Nil	30.20	26.00	45.40
Feb.	Nil	33.05	22.38	31.17	Nil	31.40	25.40	42.90
Mar.	52.57	33.39	24.03	51.07	63.70	31.20	26.10	51.50
Apr.	94.90	32.50	23.10	53.50	147.80	30.30	25.80	53.60
May	307.80	31.10	22.70	54.10	156.70	29.00	24.90	56.30
June	168.20	29.30	22.00	58.20	214.30	26.90	22.90	58.00
July	221.40	28.30	21.70	59.90	153.40	26.50	22.00	61.70
Aug.	98.10	27.50	21.20	60.26	301.70	26.13	22.81	63.03
Sept.	327.20	28.00	21.40	63.90	260.05	26.47	23.33	58.40
Oct.	190.40	30.00	21.90	59.00	91.96	27.16	24.52	61.20
Nov.	4.57	31.30	23.30	53.80	30.99	27.80	24.30	56.43
Dec.	Nil	30.90	25.10	48.30	Nil	28.35	20.97	42.52
Total	1412.50	268.90	202.40	510.90	1420.60	341.40	289.03	432.43
Mean	176.50	29.90	22.40	56.80	157.840	28.450	24.09	54.05

Source: Metrological station of the Department of Crop Science, Faculty of Agriculture, University of Nigeria, Nsukka.

Appendix II. Pictures showing stages of growth of Saba during the experiment

Figure A. Saba plants at 3 months after transplanting.
Source: Field data, 2020

Figure B. Saba plants producing flowers at 5 months after transplanting.
Source: Field data, 2020

Figure C. Dried Saba fruits as a result of long dry spell.
Source: Field data, 2020

Figure D. Saba plants at 11 months after transplanting.
Source: Field data, 2021

Figure E. Saba plants at 23 months after transplanting.
Source: Field data, 2022

Figure F. Saba plants with ripened fruits at 27 months after transplanting.
Source: Field data, 2022