Effect of poultry manure and plant population on productivity of fluted pumpkin (*Telfaiaria occidentalis* Hook F.) in Calabar, Nigeria

John Okokoh Shiyam & Walter Bisong Binang

Department of Crop Science, University of Calabar, Calabar, Nigeria
E-mail: j.shiyam@yahoo.com

Abstract

Field experiments were conducted during the 2010-2011 cropping season at the Crop Science Research Farm of the University of Calabar, Nigeria (04o 57' N and 08o 18' E; 37 meters above mean sea level) to investigate the effect of poultry manure application (0, 6, 12 and 24 t ha-1) and plant population densities (10,000, 20,000 and 40,000 plants ha-1) on leaf productivity of fluted pumpkin (*Telfaiaria occidentalis* Hook F), a vine grown as a leaf vegetable in west Africa. The experimental design was a 3× 4 factorial in a randomised complete block design replicated four times. Results indicated significant (P = 0.05) increase in vine length, leaf proliferation, fresh leaf weight/plant and dry matter production. Longest vines with 256 cm length, bearing 181 leaves/plant, with highest fresh leaf weight of 5,435 kg ha^{-1} and correspondingly highest dry matter yield of 183.5 kg ha^{-1}, were obtained by applying poultry manure at 24 t ha^{-1} to 20,000 plants ha^{-1}. This indicates that the application of poultry manure at 24 t ha^{-1} and a plant population density of 20,000 plants ha^{-1} in fluted pumpkin (*Telfaiaria occidentalis* Hook F) seems optimal and leads to increased vegetative growth and leaf productivity of fluted pumpkin in the Calabar area of Cross River State, Nigeria. Overall, crop management adopting the optimal poultry manure application and the optimal plant population density can boost fluted pumpkin productivity for poverty reduction and improved livelihood of resource poor farmers in Nigeria and comparable socio-agro-economic environments in Sub-Saharan African countries.

Keywords: Fluted pumpkin, poultry manure, organic fertiliser, organic farming, plant population, leaf weight, leaf productivity, Calabar, Nigeria, Sub-Saharan Africa, Africa.

Introduction

There are growing concerns about the long-term agricultural sustainability and meeting global food needs with the global population projected to exceed 7.5 billion by the year 2020 and 9.2 billion by 2050 (Ghrun et al., 2000). The main challenge facing many Sub-Saharan African countries, including Nigeria, is how to increase agricultural production to meet the food and fibre requirement of the growing population without further damage to the already fragile/degraded ecosystems (Henao & Baanante, 2006). Soil quality is of fundamental importance in agricultural production and soil fertility management has become a key issue in food security, poverty reduction and environmental management.

Soils in Sub-Saharan Africa are inherently infertile and characteristically low in soil organic matter content. and cannot support intensive cultivation due to the rapid rate of fertility decline under intensive cultivation (Shiyam et al., 2007). Over the years, traditional farmers have ignorantly resorted to the indiscriminate application of inorganic inputs as a strategy to raise farm yields without consideration of the environment. The sole use of

 ISSN 1177-4258

inorganic fertilizers is often not a viable option of soil fertility management as it may lead to yield gain in the short term but usually it is uneconomical to the resource-poor farmers and does not sustain good yields in the long term. The prolonged abuse of synthetic fertilizers is hazardous to human health, soil productivity, water quality, aquatic life and environmental safety. The adoption of corrective and sustainable cropping practices such as organic farming is desirable to achieve increased agricultural productivity and to solve some problems associated with an over-reliance on external inputs by small scale farmers. Organic agriculture is a low-input sustainable agricultural production management system that promotes the environmentally, socially and economically sound production of food, fibre, timber etc (IFOAM, 2008). Farming organically helps to prevent environmental degradation and can be effectively employed to regenerate degraded land. Organic soil management is guided by the philosophy of 'feed the soil to feed the plant' to achieve the goal of increased food production, food security and safety, economic development, resource conservation, ecological balance, and environmental protection (Henao & Baanante, 2006; Gaskell et al., 2007). Increased soil organic matter makes nutrients more available to the crops, buffers and neutralizes soil pH, improves soil structure, raises soil biological activities, enhances water infiltration and retention, and decreases soil erosion (Brian, 2005).

A traditional source of soil organic matter and primary nutrients for vegetable crops has been animal manures. Poultry farming is also gaining ground in Nigeria and vegetable growers are now frequently using poultry manure as a source of plant nutrition to vegetables, but there are no evidence-based crop-wise recommendations on the optimum poultry manure application. On the other hand, planting of inappropriate plant densities in fluted pumpkin is also common among commercial vegetable farmers who may erroneously believe that high plant populations can increase crop yield indefinitely. Optimum plant population depends primarily on the morphology of the crop while the right quantity of organic resources is determined by the nature of the soil and its fertility status, as well as the source and nutrient composition of the material used and the type of crop grown. The present study aimed at assessing the optimum poultry manure application rate and appropriate plant population density for enhancing the productivity of a vine grown in western Africa as a leaf vegetable, fluted pumpkin (*Telfaiaria occidentalis* Hook F), in a sandy Ultisol soil in the Calabar region of Nigeria.

Materials and Methods

The experimental site was at the Crop Teaching and Research Farm of the University of Calabar, Nigeria (04^{o} 57’N latitude & 08^{o} 18’E longitude; 37 metres altitude above mean sea level). The rainfall in the area is bimodally distributed with the highest peak in July and the lesser peak in September, sandwiched with a short dry spell in August, usually referred to as the ‘August Break’. The rainfall commences in March/April and terminates in October/November. Total annual rainfall is about 2500–3000 mm with maximum and minimum temperatures of 30^{o} C and 23^{o} C, respectively; while the relative humidity is about 70–80% throughout the year.

The field was previously under intercropping with cassava, maize, melon and water leaf (*Talinium triangulare* L.) and fluted pumpkin (*Telfaiaria occidentalis* Hook F.). Surface soil (0–15 cm depth) samples collected randomly were bulked into a composite sample, air-dried and crushed to pass through a 2 mm sieve. Particle size distribution was determined by the hydrometer method (Bouyoucos, 1962) and the soil pH (soil:H2O) was

 ISSN 1177-4258

determined in 0.01M $CaCl_2$. Soil organic carbon and the total N were evaluated by the Walkey & Black (1963) method and the micro-Kjeldahl digestion method (Bremmer & Mulvaney, 1982), respectively. Available P was extracted by the method of Bray and Kurtz (1945), while exchangeable bases (Ca, Mg, K and Na) contents were extracted with neutral 1M NH_4OAc at a soil solution ratio of 1:10 and measured by flame photometry. Magnesium was determined with an atomic absorption spectrophotometer (AAS). Exchange acidity was determined by titration of IM KCl extract against 0.05M NaOH using phenolphthalein as indicator (McLean, 1982). The nutrient profile of the poultry manure used was also analyzed using the relevant procedures.

The land was cleared and tilled flat manually using a spade and demarcated into unit plots measuring 2.0 m × 3.0 m (6.0 m_2). Four poultry manure rates (0, 6, 12 and 24 t/ha) combined with three plant populations (10,000, 20,000 and 40,000 plants/ha) of fluted pumpkin (*Telfaiaria occidentalis* Hook F.) were investigated in a randomized complete block design replicated four times. Seeds were planted at 1.0 m × 1.0 m spacing at 1 seed/hole, 1.0 m × 1.0 m spacing at 2 seeds/hole, and 0.5 m × 0.5 m spacing at 1 seed/hole to achieve 10,000, 20,000 and 40,000 plants/ha, respectively.

Field planting was done during the early or main planting season, on 5th April, 2010 and 9th April, 2011. Cured poultry manure was incorporated into the soil during tilling for rapid decomposition and nutrient release to the crop. All plots were fertilized with urea at 80 kg N/ha in two equal splits i.e. at four weeks after planting and four weeks later. Data collected on vine length, leaf number/per plant, fresh leaf weight and dry matter yield were analysed statistically using analysis of variance (ANOVA) technique (Wahua, 1999). Means were tested using the least significant difference (LSD) at 5% level of probability.

Results and Discussion

The physico-chemical properties of the pre-sowing and post-harvest soil at the experimental site and the nutrient content of the poultry manure used are presented in Table 1. The result showed that the soil is a sandy clay, highly acidic and very low in organic C, total N, and exchangeable bases, but contained moderate P, indicating low fertility status. The poultry manure contained high amounts of plant nutrients indicating that maize being a heavy feeder would benefit from application of the fertilizer.

Table 1. Physico-chemical properties of the pre- and post-cropping soil and nutrient content of the poultry manure fertilizer.

Parameter	**Values**		
	Pre-cropping	Post-cropping	Poultry manure
pH (1:H_2O)	4.9	5.2	6.5
Org.C (%)	1.16	1.19	40.3
Total N (%)	0.09	1.02	7.1
Basic Cations (cmolkg^{-1})			
Ca	1.0	1.3	4.8
Mg	0.6	0.3	3.0
K	0.8	0.2	0.17
Na	0.2	0.8	1.0
ECEC	6.45	2.13	19.2
Base Saturation (%)	45	51	43
Particle Size Analysis (%)			
Sand	80.0	80.0	-
Silt	7.7	7.8	-
Clay	12.3	12.2	-

Fluted pumpkin vine length responded positively to the application of poultry manure at all plant populations (Table 2). Vine growth increased with increasing rates of poultry manure with highest magnitude in plots fertilized with poultry manure at 24 t ha^{-1} and least in non-manure plots. With the application of poultry manure at 24 t ha^{-1}, the longest vine length was exhibited in plots with a plant population density of 40,000 plants/ha, followed by those planted at 20,000 plants/ha. At other levels of poultry manure, vine length was longest at a plant population density of 20,000 plants/ha, followed by 40,000 plants/ha and least in 10,000 plants/ha. Enhanced vine growth was obtained at the plant population density of 20,000 plants/ha across all levels of poultry manure with significantly ($p = 0.05$) longest vines produced by applying poultry manure at 24 t ha^{-1} (Table 1).

Table 2. Influence of poultry manure rates and plant populations on vegetative growth and yield of fluted pumpkin (*Telfaiaria occidentalis* Hook F).

	Poultry Manure Rates (t/ha)			
Plant Population	0	6	12	24
	VINE LENGTH (cm)			
10,000	173	214	230	265
20,000	176	257	268	288
40,000	192	214	258	258
Mean	180	228	238	270
LSD (0.05) A	Ns	Ns	Ns	Ns
B	9.9	9.9	9.9	9.9
A x B	Ns	Ns	Ns	Ns
	LEAVES/PLANT			
10,000	30	64	84	89
20,000	42	88	106	144
40,000	38	54	86	96
Mean	40	69	92	107
LSD (0.05) A	5.6	4.0	4.0	4.0
B	6.5	4.7	4.7	4.7
A x B	6.5	4.7	4.7	4.7
	FRESH LEAF YIELD (kg/ha)			
10,000	202.3	251.0	337.1	372.8
20,000	269.3	414.4	658.0	734.1
40,000	199.2	316.2	489.2	579.2
Mean				
LSD (0.05) A	5.5	7.2	56.6	65.2
B	6.4	8.3	68.4	72.4
A x B	6.4	7.9	64.4	83.0
	DRY MATTER YIELD (kg/ha)			
10,000	66	75	102	107
20,000	64	113	193	210
40,000	93	96	131	142
Mean	75	95	143	157
LSD (0.05) A	5.5	5.6	5.6	5.6
B	6.4	6.4	6.4	6.4
A x B	6.4	6.4	6.4	6.4

Leaf production followed a similar trend with vine elongation and increased with increasing rates of poultry manure applied with more leaves produced in a plant population density of 20,000 plants/ha across all poultry manure levels. The highest leaf

 ISSN 1177-4258

production was obtained by applying poultry manure at 24 t ha^{-1}, followed by poultry manure at 12 and 6 t ha^{-1} and least in the non-manured plots. Leaf production increased by 46, 64, and 102 leaves/plant corresponding to 110%, 152% and 243% increase in plots treated with poultry manure at 6, 12 and 24 t ha^{-1}, respectively. Enhanced vine growth and leaf production obtained by fertilizing 20,000 plants/ ha with poultry manure at 24 t ha^{-1} might indicate availability of balanced plant nutrients and optimum plant population and obvious favourable growing conditions. Increased leaf production in okra attributed to beneficial effect of poultry manure has been reported (Umoetok et al., 2007).

Fresh leaf yield varied significantly ($p = 0.05$) in all treatment combinations and increased with increasing poultry manure rates, and was highest at 24 t ha^{-1} of poultry manure in all plant populations. Like vine length and number of leaves per plant, fresh leaf yield was higher in the plant population density of 20,000 plants/ha, than in other plant populations at the corresponding poultry manure rates. In this plant population, fresh leaf yield was significantly highest in plots applied with poultry manure at 24 t ha^{-1} and lowest in the zero input plots. Across plant populations, fresh leaf production increased from plant population density of 10,000 plants/ha up to 20,000 plants/ha, and declined as the plant population density was increased to 40,000 plants/ha.

The dry matter (DM) yield was also enhanced by the application of poultry manure at 24 t ha^{-1} across all plant populations. Highest DM was obtained in the population density of 20,000 plants/ha, followed by 40,000 plants/ha, and least in 10,000 plants/ha, representing an increase of 108 and 68 kg/ha in DM yield by increasing the plant population from 10,000 to 20,000 and 40,000 plants/ha, respectively. Across the poultry manure levels, DM yield in plant population density of 20,000 plants/ha increased by 69, 129 and 146 kg/ha by raising the quantity of poultry manure to 6, 12 and 24 t/ha, respectively.

The positive interaction effect of poultry manure and plant population on vegetative growth and DM production occurred at all levels of the organic nutrient application and in all plant populations (Table 3). The most beneficial effect of the poultry manure on foliage production and DM yield was obtained by incorporating the manure at 24 t ha^{-1} in plots containing 20,000 plants/ha. Leaf production and DM increased by increasing the plant population from 10,000 plants/ha to 20,000 plants/ha, and declined across all poultry manure levels when raising the plant population to 40,000 plants/ha. Sub-optimal plant density might account for poor productivity of the crop in plant populations lower than 20,000 plants/ha, while the suppressed yield obtained in the plant density of 40,000 plants/ha could be attributed to the adverse effects of over-crowding and competition for space, light, plant nutrients, and water; while optimum plant density might have resulted in reduced competition leading to increased shoot and root parameters, and enhanced photosynthesis efficiency besides better source–sink relationships (Choudhary & Suri, 2013). The decline of crop yields in the traditional farming systems has been attributed largely to soil-related constraints (Aihou et al., 1988, Juo, et al., 1995) and highly variable plant densities including inappropriate cropping practices. Balanced fertilization of soils through synchronized supply of adequate nutrients to growing crops as well as soil organic matter enrichment with long-term usage are major gains realized through the application of organic resources.

Table 3. Interaction effect of plant population and poultry manure on dry matter yield (kg/ha) at 10 weeks after planting.

	Poultry Manure (kg/ha)				
Plant Population Density	0	6	12	24	Mean
10,000	12.1	15.3	20.8	27.1	18.8
20,000	12.1	29.5	40.9	51.7	33.5
40,000	16.2	20.6	37.2	45.8	29.9
Mean	13.5	21.8	32.9	41.5	
LSD (0.05)	6.4	7.8	6.8	2.8	

Conclusion

Poultry manure improved the vegetative growth and dry matter production of fluted pumpkin (*Telfaiaria occidentalis* Hook F) . The application of poultry manure at 24 t ha^{-1} and a plant population density of 20,000 plants ha^{-1} were observed as the optimum agronomic interventions to harness the highest foliage production and dry matter yield, and to thereby boost fluted pumpkin productivity for poverty reduction and improved livelihood for resource poor farmers in Nigeria and comparable socio-agro-economic environments in Sub-Saharan African countries.

References

AGRA (Alliance for Green Revolution in Africa) (2007). AGRA at work. Available at http://www.agra-alliance.org/work.

Aihou, K., Buckles, K., Carsky, I., Dagbenonbakin, G., Eleka, A., Fagbohoun, F., Fassassai, R., Galiba, M., Gokai, G., Osiname, O., Versteeg, M.& Vissoh,P. (1988). Cover Crops in West Africa: Contributing to Sustainable Agriculture. International Development and Research Center, Canada.

Bouyoucos, G.J. (1962). Hydrometer method improved for making particle size analysis of soil. Agronomy. Journal, 54:464-465

Bray, R.H. & Kurtz, L.T. (1945). Determination of total, organic and available form of phosphorus in soils. Soil Science, 59: 39-45.

Bremmer, J.M & Mulvaney, C.S. (1982). Nutrient Total In:Methods of Soil Analysis 2nd ed. Page, A.L. et al.,(Eds) pp 595-624. ASA, SSA Madison Wisconsin.

Brian, B. (2005). Organic Practice Guide. In: Organic Farming Compliance Handbook: A Resource Guide for Western Region Agricultural Professionals. Organic Materials Research Institute, Canada (http://www.sarep.ucdavis.edu/organic/complianceguide/).

Choudhary, A.K. & Suri, V.K. (2013). ‘On-Farm’ participatory technology development on resource conservation technologies in rainfed upland paddy in Himachal Pradesh, India. Communications in Soil Science and Plant Analysis 44 (Accepted version; DOI: 10.1080/00103624.2013.811521).

Gaskell, M., Smith, R., Mitchell, J., Korie, S.T., Fouche, C., Hartz, T., Hortwath, W. & Jackson, L. (2007). Soil fertility management for organic crops. UC ANR Publication 7349 (http://anrcatalog.ucdavis.edu).

Gruhn, P., Golett, F. & Yudelman, M. (2000). Integrated Nutrient Management, Soil Fertility and Sustainable Agriculture: Current Issues and Future Challenges. Food, Agriculture and Environment Discussion Paper 32. International Food Policy Research Institute, Washington DC, USA.

Hennao, J. & Baanante, C. (2006). Agricultural production and soil nutrient mining in Africa: Implication for resource conservation and policy development. IFDC, Alabama, USA.

IFOAM (2008). Basic Standards for Organic Agriculture and Processing. IFOAM (International Federation for Organic Agriculture Movement) Head Office, Oko Zentrum Imbash. Tholey-Tholey.

Jackson, M.L (1967). Soil Chemical Analysis. Prentice Hall of India.Pvt Ltd, New Delhi.

Juo, A.S.R., Franziuebbers., Dabiri A. & Ikhile B. (1995). Changes in soil properties in long term fallow and continuous cultivation after forest clearing in Nigeria. Agriculture. Ecosystem and Environment, 56: 9-18.

Mc Lean, O .E (1982). Soil pH and Lime requirement. In: A.L. Page et al., Methods of soil analysis Part 2 2nd ed. Agronomy Monograph 9. ASA and SSSA, Madison, Wisconsin.

Shiyam, J.O., Eyong, M.O., Uko, A.E., Binang, W.B. & Ojating, I.O. (2007). Soil fertility improvement efficiency of selected woody species grown on an Ultisol in Calabar, Nigeria. UNISWA Research Journal of Agriculture, Science & Technology. 10(1): 37-40.

Umoetok, S., Uko, A., Archibong B., Ukeh, D. & Udo, I. (2007). Effects of application of inorganic fertilizer and poultry manure on insect pests and yield of soybeans (Glycine max.(L)) in the rainforest of Nigeria. .Journal of Food, Agriculture and Environment, 5 (2): 149-152.

Wahua, T.A.T. (1999). Applied Statistics for Scientific Studies. Transparent Earth, Nigeria Ltd., Port Harcourt, Nigeria.

Walkey, A & Black, A.I (1963). An examination of the different methods for determining soil organic matter and proposed modification of the Chromic Acid Titration Method. Soil Science, 24: 65-68.