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Agronomic Response of Fluted Pumpkin (*Telfairia occidentalis* Hook. F.) to Plant Densities and Fertilizer Application in a Tertiary Institution Experimental Farm in Benin City Nigeria

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ABSTRACT: The objectives of this study was to investigate yield, nutrient concentration and uptake of fluted pumpkin (*Telfairia occidentalis Hook.* F.) in response to plant densities and fertilizer application. Two fluted pumpkin plant densities (10,000 and 20,000 plants ha^{-1}) D1 and D2 were evaluated at three levels of NPK fertilizer (F_1, 20 t ha^{-1} poultry manure, F_2, 300 kg ha^{-1} NPK 15:15:15 and F_3, 10 t ha^{-1} poultry manure + 150 kg ha^{-1} NPK 15:15:15) using a factorial arrangement in randomized complete block design (RCBD) with three replications. Leaf length, breadth, number of leaves and stem diameter were significantly increased at both plant densities of 10,000 and 20,000 plants ha^{-1} while herbage yield increased with higher plant density of 20,000 plants ha^{-1} using 300 kg ha^{-1} inorganic NPK 15:15:15 or a combination of 10 t ha^{-1} poultry manure + 150 kg ha^{-1} inorganic NPK 15:15:15. Potassium (K) concentration was significantly ($p < 0.05$) higher at 10,000 plants ha^{-1} and Iron (Fe) uptake was higher with combine application of organic and inorganic fertilizer (F3). To maximize good herbage yield of fluted pumpkin, farmers in this locality should adopt plant density of 20,000 plants ha^{-1} using 300 kg ha^{-1} inorganic NPK 15:15:15 (D2F2) or a combination of 10 t ha^{-1} poultry manure + 150 kg ha^{-1} inorganic NPK 15:15:15 (D2F3).

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Fluted pumpkin (*Telfairia occidentalis* Hook. F) is a member of the curcubitaceae family. It is a leafy and seed vegetable that has been widely accepted as a dietary constituent more popular in the south eastern states of Nigeria (Akwaowo *et. al.,* 2000). Its production and utilization however, has gradually spread into other parts of Nigeria. The leaves and seeds are very nutritious and provide the much needed minerals, vitamins and supplementary protein for majority of the populace that depends largely on starch staples (Tijani-Eniola, 2002). Despite the widespread cultivation of the crop, little attention has been given to the effect of fertilization and spacing on its yield. Tropical soils are inherently low in nutrients and in organic matter content and cannot support intensive cultivation due to the rapid rate of fertility decline under intensive cultivation (Shiyam and Binang, 2014). 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 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. Organic agriculture is a low-input sustainable agricultural production management system that promotes healthy socio economic environment for sound production of food, fibre, timber etc (IFOAM, 2008). Poultry farming is gaining ground in Nigeria and some vegetable growers

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frequently use this manure as a source of plant nutrition to vegetables, but there are no evidence-based crop-wise recommendations on the optimum poultry manure application. Planting of inappropriate plant densities in fluted pumpkin is also common among commercial vegetable farmers who may erroneously believe that high planting densities can increase crop yield indefinitely. The adoption of corrective and sustainable cropping practices such as combined application of organic and inorganic fertilizer with appropriate planting densities is desirable to achieve increased agricultural productivity. The objectives of this study was to investigate yield, nutrient concentration and uptake of fluted pumpkin (*Telfairia occidentalis Hook*. F.) in response to plant densities and fertilizer application in a tertiary institution experimental farm in Benin City, Nigeria.

MATERIALS AND METHODS

Experimental site: The studies were carried out at the Experimental Farm and at the Central Laboratory, Faculty of Agriculture, University of Benin, Benin City, Nigeria and Lies within the geographical coordinates of (5^0 45" and 7^0 34" N) and Longitude (5^0 04" and 6^0 45"E) 88 m above sea level. The climate is tropical and the vegetation is lowland rainforest in the south (with mean annual rainfall of 2300mm) to guinea savanna in Edo North with 1400 mm mean rainfall. The rainfall in the area is bimodal with the highest peak in July sandwiched with a short dry spell in August. The rainfall commences in March/April and terminates in October/November. Temperatures show some variations throughout the years, with average monthly temperature varying between 24^0 C and 33.5 ^{0} C while the relative humidity is about 70–78% throughout the year. The soil is characterized by an ultisol derived from coastal sediments. Prior to planting, the site was dominated by elephant grass *Pennisetum purpureum,* siam weed (Chromoleana odorata (L)) goat weed (*Ageratum conyzoides* (L.), broom weed (*Sida acuta* burn F), guinea grass (*Panicum maximum Jacq)* after the previous growing season.

Land preparation: The site was cleared manually with cutlass, pulverized and planting beds of dimension 3m x 3m (9m ^{2}) with 1 m path between beds were made with hand hoes for ease of agronomic practices. Weeding was carried with local hoe at 4 and 8 weeks after planting (WAP) in all the plots.

Source of planting materials: A local variety of fluted pumpkin seeds were purchased from the market, the manure was obtained from the Faculty of Agriculture project farm, University of Benin, Benin City, Nigeria, while the NPK 15:15:15 fertilizer was purchased from fertilizer shop in Benin City, Nigeria.

Soil sample collection and analysis: Soil samples were taken randomly from 10 spots at (0 – 15 cm depth) over the entire field using soil auger, poultry manure was also collected for chemical analysis before the commencement of the experiment. The samples were bulked and mixed thoroughly, air – dried and passed through a 2 mm mesh sieve before analyzing for physico - chemical properties at the Central Laboratory, Faculty of Agriculture, University of Benin, Benin City, Nigeria. The particle size analysis was done by using hydrometer method (Gee and Bauder, 1986). Soil pH was determined using pH meter (Maclean, 1982). Organic carbon was determined by wet oxidation method (Walkley and Black, 1962) as modified by Jackson (1969). Total nitrogen was obtained by macro Kjeldahl method as modified by Jackson (1969). Available P was extracted by Bray I method (Bray and Kurtz, 1945) and P was estimated by the blue colour method of Murphy and Riley (1962). Exchangeable K and Na were determined using flame photometer, while Ca and Mg were determined using the Atomic Absorption Spectrophotometer.

Treatment application and planting: Poultry manure that had been cured under shade for two weeks was incorporated into the soil thoroughly mixed with the use of spade depending on the treatment. Seed extracted from the pods were sun – dried for two days to reduce moisture and prevent decay and planting was done one week after application of poultry manure. One seed was planted per hole at each plant spacing method. The two plant spacing used were: 50 cm x 100 cm and 100 cm x 100 cm giving plant densities of 10,000 and 20,000 plants ha^{-1} (D1 and D2) respectively.

Experimental design: The experimental treatments consisted of two plant densities D1 (10,000 plants ha^{-1}) and D2 (20,000 plants ha^{-1}) evaluated at three levels of NPK fertilizer (F_1, 20 t ha^{-1} poultry manure, F_2, 300 kg ha^{-1} NPK 15:15:15 and F_3, 10 t ha^{-1} poultry manure + 150 kg ha^{-1} NPK 15:15:15) using a factorial arrangement in randomized complete block design (RCBD) with six treatment combination of D1F1, D1F2, D1F3, D2F1, D2F2 and D2F3 in three replications giving a total of 18 treatments.

Data collection: Four plants were randomly tagged per plot for data collection at 4 WAP and commenced until 7 WAP. The following agronomic parameters: vine length (cm), stem diameter (cm), number of branches, internode length (cm) and leaf area (cm ^{2})

were measured and number of leaves were counted leaf area, was measured (using the length –width method). The unit leaf area was estimated with the equation by Akoroda (1993): LA = 0.9467 + 0.2475lw + 0.9724lwn Where, LA= leaf area; l= length of central leaflet; w= maximum width of the central leaflet; n = number of leaflets per leaf while the marketable fresh shoot yield was harvested by pruning, using sharp knife. Harvesting was done at two weeks interval starting from 60 days after planting. The fresh vine was harvested with a sharp knife and weighed with a weighing balance. The average fresh shoot weights of the four tagged plants were taken per harvest. Ten (10) harvests were carried out throughout the duration of the experiment. The fluted pumpkin fresh shoot (vine) yield was estimated from cumulative fresh weight per plant of the fluted pumpkin harvested at 10 cutting periods. The yield per plant in each treatment was extrapolated to kilogram per hectare (kg ha $^{-1}$) by multiplying by the plant population density of each treatment.

Statistical analysis: Data collected were subjected to analysis of variance (ANOVA), using SAS (Statistical Analysis Software) and least significance difference (LSD) test at 5% level of probability was use to compare the significant treatment

RESULTS AND DISCUSSION

The result of the physical and chemical properties of the soil at the experimental site and the nutrient composition of the poultry manure used is presented in Table 1. The result showed that the soil is a sandy loam, strongly acidic (5.12) and very low in organic matter content (1.25 %), total N (0.03 %), and exchangeable bases, but contained moderate P (14.52 mg kg-1), indicating low fertility status. The poultry manure contained high amounts of plant nutrients indicating that fluted pumpkin (*Telfairia occidentalis*) would benefit from application of the inorganic fertilizer and manure.

Table 1: Physical and chemical properties of the soil and nutrient composition of poultry manure used for the experiment

Properties	Soil	Poultry manure
pH (H_2O)	5.12	6.23
Org matter (%)	1.25	24.79
Total N (%)	0.03	2.16
Total P (mg kg $^{-1}$)	14.52	0.96
K (cmol kg $^{-1}$)	0.12	1.16
Ca (cmol kg $^{-1}$)	0.13	0.80
Mg (cmol kg $^{-1}$)	0.50	0.53
Na (cmol kg $^{-1}$)	-	0.32
Sand (%)	66.43	-
Clay (%)	24.55	-
Silt (%)	9.02	-
Textural class	Sandy loam	-

There were significant differences (P>0.05) in the main vine length, leaf length, breadth, leaf area, number of leaves and stem diameter of *T. occidentalis* as influenced by plant density and fertilizer application Table 2. However, significant difference was not observed for number of branches and internode length. Main vine length increased significantly at plant density of 10,000 plants ha $^{-1}$in combination with 10 t ha^{-1} poultry manure + 150 kg ha^{-1} inorganic NPK 15:15:15 (D1F3), producing the longest vine length (229.75 cm) while the shortest vine (176.83 cm) was produced at 20,000 plants ha $^{-1}$ in combination with 20 t ha^{-1} poultry manure (D2F1). The enhanced vine length of pumpkin could probably be due to the lower plant population with D1F3, so plants in this environment experienced less competition for available growth factors. This results affirmed the report of Akanbi *et al.* (2000) that plant spacing is an important agronomic practice that enhances growth, vigor and the overall development of a crop. Another reason could also be due to the rich nutrient contents in the combination of the poultry manure and the inorganic NPK 15:15:15 fertilizer. Organic manure in addition to the N, P and K contents also contain other nutrients such as Na, Ca, Mg and high organic matter content which are essential for photosynthetic activities and efficiency besides better source - sink relationships (Choudhary and Suri, 2013).

Table 2: Effect of plant densities and fertilizer application on some vegetative characters of fluted pumpkin (*Telfairia occidentalis*)

Treatment	Main vine length (cm)	Leaf breath (cm)	Length Leaf (cm)	Unit Leaf Area (cm^2)	Number of Leaves	Number of Branch	Internode length (cm)	Stem diameter (cm)
D1F1	195.83a	6.26b	9.20b	199.89b	20.16b	3.50a	8.18a	0.71a
D1F2	215.42a	7.80a	12.15a	300.33a	35.58a	2.25a	8.88a	0.81a
D1F3	229.75a	6.96a	10.90a	241.87a	46.25a	3.75a	9.17a	0.78a
D2F1	176.83b	6.48ab	9.17b	182.35b	19.08ab	2.58a	8.47a	0.57b
D2F2	223.42a	6.57ab	9.98a	220.38a	40.92a	3.83a	8.41a	0.66ab
D2F3	200.42a	7.72a	9.81a	225.95a	20.67ab	3.16a	9.05a	0.71a
Significance	*	*	*	*	*	ns	ns	*

*Means with the same letter along the column are not significantly different at 5% level of significance; ns - not significant at 5% level of probability; * - Significant at 5% level of probability*

D1F1 = 10,000 plants ha $^{-1}$in combination with 20 t ha^{-1} poultry manure; D1F2 = 10,000 plants ha $^{-1}$in combination with 300 kg ha^{-1} inorganic NPK 15:15:15; D1F3 = 10,000 plants ha $^{-1}$in combination with 10 t ha^{-1} poultry manure + 150 kg ha^{-1} inorganic NPK 15:15:15; D2F1 = 20,000 plants ha $^{-1}$in combination with 20 t ha^{-1} poultry manure; D2F2 = 20,000 plants ha $^{-1}$in combination with 300 kg ha^{-1} inorganic NPK 15:15:15; D2F3 = 20,000 plants ha $^{-1}$in combination with 10 t ha^{-1} poultry manure + 150 kg ha^{-1} inorganic NPK 15:15:15

The shortest vine produced with D2F1 may be attributed to increased competition for growth factors by plants under this environment and the plants may not have had enough nutrient from the organic poultry manure being a slow releaser of nutrients. Leaf length (12.15 cm, 10.90 cm and 9.81 cm), breadth (7.80 cm, 6.96 cm and 7.67 cm) and leaf area (300.33 cm, 241.87 cm and 225.95 cm) were similar and significantly higher at D1F2, D1F3 and D2F3 respectively. The positive response recorded especially at D1F2 and D1F3 could be attributed to less intra-specific competition of individual plant for growth resources such as available water, light and nutrient. This finding is in agreement with Philip *et.al*. (2010). who observed that less competition for water and nutrients invariably results in good growth. Plant density of 10,000 plants ha $^{-1}$in combination with 20 t ha^{-1} poultry manure (D1F1) and plant density of 20,000 plants ha $^{-1}$in combination with 20 t ha^{-1} poultry manure (D2F1) significantly produced the shortest leaf length (9.20 cm and 9.17 cm and leaf area (182.89 cm ^{2} and 199.35 cm ^{2}). D1F1 produced significantly lower number of leaves (20.16) which was not different from the number of leaves (19.08) produced at D2F1 while the stem diameter (0.57 cm) was lowest at D2F1 however, not significantly different from 0.66 cm produced at higher plant population of 20,000 plants ha $^{-1}$using 300 kg ha^{-1} inorganic NPK 15:15:15 (D2F2). Herbage yield (1642.23 and 1646.16 kg ha^{-1}) increased at D2F2 and D2F3 Table 3, and this could be attributed to the readily available nutrient gained from the inorganic fertilizer at the initial stage of plant growth and greater crop biomass found in higher plant population as supported by Falodun *et al.* (2015). Low plant density reduced yield due to total reduction in plants per hectare and consequently space is not fully utilized.

Table 3: Yield and Nutrient concentration of fluted pumpkin (*Telfairia occidentalis*) as influenced by plant density and fertilizer application

Treatment	Herbage yield (kg ha^{-1})	N (%)	P (mg kg $^{-1}$)	K (mg kg $^{-1}$)	Mg (mg kg $^{-1}$)	Fe (mg kg $^{-1}$)
D1F1	962.11b	1.53a	0.88a	1.31a	0.59b	16.90ab
D1F2	875.08b	1.87a	1.08a	1.55a	0.65b	19.69ab
D1F3	1053.12b	1.68a	1.06a	1.66a	0.84a	21.86a
D2F1	1117.15b	1.39a	0.77a	1.19b	0.55b	16.12ab
D2F2	1642.23a	1.40a	0.81a	1.20b	0.49b	14. 94b
D2F3	1646.16a	1.41a	0.79a	1.16b	0.66ab	18.37ab
Significance	*	ns	ns	*	*	*

*Means with the same letter along the column are not significantly different at 5% level of significance; ns - Not significant at 5% level of probability; * - Significant at 5% level of probability*

D1F1 = 10,000 plants ha $^{-1}$in combination with 20 t ha^{-1} poultry manure; D1F2 = 10,000 plants ha $^{-1}$in combination with 300 kg ha^{-1} inorganic NPK 15:15:15; D1F3 = 10,000 plants ha $^{-1}$in combination with 10 t ha^{-1} poultry manure + 150 kg ha^{-1} inorganic NPK 15:15:15; D2F1 = 20,000 plants ha $^{-1}$in combination with 20 t ha^{-1} poultry manure; D2F2 = 20,000 plants ha $^{-1}$in combination with 300 kg ha^{-1} inorganic NPK 15:15:15; D2F3 = 20,000 plants ha $^{-1}$in combination with 10 t ha^{-1} poultry manure + 150 kg ha^{-1} inorganic NPK 15:15:15

The positive response to combine use of fertilizer by *T. occidentalis* may be due to the fact that mineral fertilizers mineralized quickly, releases its nutrients to crop faster and eventually leached beyond the root zone of crops and organic manure in combination complements this effect by exerting their effect for a longer periods compared to sole application of these fertilizer thereby resulting in better crop growth and yield. Potassium (K) concentration (1.66 mg kg $^{-1}$) was significantly ($p < 0.05$) higher at D1F3 and was statistically similar to D1F2 (1.55 mg kg $^{-1}$) and D1F1 (1.31 mg kg $^{-1}$) while Magnesium (Mg) concentrations (0.64 and 0.66 mg kg $^{-1}$) and Iron (Fe) uptakes 58.00 and 61.03 mg kg $^{-1}$ were higher at D1F3 and D2F3 respectively, this is an indication that fertilizer and spacing affect levels of nutrients in the leaves of *T. occidentalis* Table 3 and 4.

Table 4: Nutrient uptake of fluted pumpkin (*Telfairia occidentalis*) as influenced by plant density and fertilizer application pumpkin

Treatment	N (%)	P (mg kg $^{-1}$)	K (mg kg $^{-1}$)	Mg (mg kg $^{-1}$)	Fe (mg kg $^{-1}$)
D1F1	4.57a	2.60a	3.95a	1.84a	52.03b
D1F2	5.10a	2.98a	4.28a	1.78a	53.76b
D1F3	4.50a	2.63a	4.43a	1.96a	58.00a
D2F1	4.70a	2.60a	4.03a	1.85a	52.50b
D2F2	5.12a	2.93a	4.38a	1.77a	53.80b
D2F3	4.78a	2.73a	3.95a	1.85a	61.03a
Significance	Ns	ns	Ns	ns	*

*Means with the same letter along the column are not significantly different at 5% level of significance; ns - not significant at 5% level of probability; * - Significant at 5% level of probability*

D1F1 = 10,000 plants ha $^{-1}$in combination with 20 t ha^{-1} poultry manure; D1F2 = 10,000 plants ha $^{-1}$in combination with 300 kg ha^{-1} inorganic NPK 15:15:15; D1F3 = 10,000 plants ha $^{-1}$in combination with 10 t ha^{-1} poultry manure + 150 kg ha^{-1} inorganic; NPK 15:15:15; D2F1 = 20,000 plants ha $^{-1}$in combination with 20 t ha^{-1} poultry manure; D2F2 = 20,000 plants ha $^{-1}$in combination with 300 kg ha^{-1} inorganic NPK 15:15:15; D2F3 = 20,000 plants ha $^{-1}$in combination with 10 t ha^{-1} poultry manure + 150 kg ha^{-1} inorganic; NPK 15:15:15

Conclusion: Plant density and fertilizer application maximized good herbage yield of fluted pumpkin (*Telfairia occidentalis*), farmers in this locality should adopt plant population of 20,000 plants ha $^{-1}$using 300 kg ha^{-1} inorganic NPK 15:15:15 or a combination of 10 t ha^{-1} poultry manure + 150 kg ha^{-1} inorganic NPK 15:15:15.

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