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 (F₁, 20 t ha⁻¹ poultry manure, F₂, 300 kg ha⁻¹ NPK 15:15:15 and F₃, 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 cucurbitaceae 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° 45” and 7° 34” N) and Longitude (5° 04” and 6° 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° C and 33.5° 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, sian 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 (9m²) with 1 m path between beds were made with hand hoes for ease of agronomic practises. 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 plantin: 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 (F₁, 20 t ha⁻¹ poultry manure, F₂ 300 kg ha⁻¹ NPK 15:15:15 and F₃ 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 (cm²)

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were measured and number of leaves were counted leaf area, was measured (using the length \(\times\) width method). The unit leaf area was estimated with the equation by Akoroda (1993): 
\[ LA = 0.9467 + 0.2475w + 0.9724lw \] 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 used 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 such as Na, Ca, Mg and high organic matter content indicating that fluted pumpkin (Telfaria occidentalis) would benefit from application of the inorganic fertilizer and manure.

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

| Properties     | Soil       | Poultry manure |
|----------------|------------|----------------|
| pH (H\(_2\)O)  | 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 | -              |

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

| Treatment     | Main vine length (cm) | Leaf breadth (cm) | Length Leaf (cm) | Unit Leaf Area (cm\(^2\)) | Number of Leaves | Number of Branch | Internode length (cm) | Stem diameter (cm) |
|---------------|-----------------------|-------------------|-----------------|---------------------------|------------------|------------------|----------------------|-------------------|
| D1F1          | 195.83a               | 6.26a             | 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                   | 19.09ab          | 2.58a            | 8.47a                | 0.57b             |
| D2F2          | 223.42a               | 6.57ab            | 9.98a           | 202.38a                   | 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             |

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

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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 cm², 241.87 cm² and 225.95 cm²) 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 cm² and 199.35 cm²). 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 Faldodun 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                | 1.08a | 1.55a       | 1.66a       | 0.65b       | 19.69ab     |
| D1F3      | 1053.12b               | 0.59a | 1.31a       | 1.66a       | 0.59b       | 21.86a      |
| D2F1      | 1117.15b               | 2.73a | 1.77a       | 1.19b       | 0.55b       | 16.12ab     |
| D2F2      | 1642.23a               | 2.60a | 1.78a       | 1.19b       | 0.55b       | 16.12ab     |
| D2F3      | 1646.16a               | 2.60a | 1.78a       | 1.19b       | 0.55b       | 16.12ab     |

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      | 5.10a | 2.98a       | 4.28a       | 1.78a       | 53.76b      |
| 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      |

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

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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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