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Leaf Area Development and Vine Growth of Telfairia occidentalis (Hook. F) In Response to Plant Spacing and Liquid Cattle Manure

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Abstract: *The field experiment was conducted in the Crop Farm Section of the Agricultural Science Unit Farm from August to November 2012 in Delta State University Abraka (latitude 5^0 46'N and longitude 6^0 5'E), Nigeria, with the objective of evaluating the optimum liquid cattle manure application rate and appropriate plant spacing for enhancing the leaf area development and vine yield of fluted pumpkin. The experiment was a 4 x 3 factorial in randomized complete block design with three replications. The two factors were liquid cattle manure and plant spacing. The liquid cattle manure was applied at four rates; 0, 120, 240 and 360 litres/ha while three plant spacing of 90 x 90cm, 70 x 70cm and 50 x 50cm were used. Observed results show increased number of leaves, unit leaf area, total plant leaf area and leaf area index with increase in rate of applied liquid cattle manure. Increased vine length and vine girth, fresh weight and dry weight were also observed with higher rate of liquid cattle manure. However closer spacing decreased leaf development parameters, vine length and vine girth, but higher fresh weight and dry weight were achieved at closer spacing. Since there were no observed significant differences between 240litres/ha and 360 litres/ha in fresh marketable yield, it would be more economical to sow the pumpkin plants at a combination of 240litres/ha using medium spacing of 70cm x 70cm.*

Keywords: *liquid cattle manure, fluted pumpkin, leaf area, vine growth*

I. Introduction

The fluted pumpkin (Telfairia occidentalis) is an Africa indigenous vegetable which has significant importance in the traditional and family agriculture due to its nutritive value and is considered of more relevance than the exotic vegetables (Horsfall and Spiff, 2005). It is cultivated for its nutritious leaves and seeds. Though it originated from southeast Nigeria (Schipper, 2000) were it was popularly cultivated, it's currently widely cultivated in various parts of Nigeria throughout the year, during the rain and dry seasons.

Vegetable farming in Nigeria is practiced under a continuous farming system which does not allow for any fallow period, since most vegetable farms are located in urban and peri-urban centres. In view of the fact that vegetables such as Telfairia occidentalis are nutrient demanding, soil nutrient depletion is expected under a continuous cropping without any farm practice that replaces such nutrients. Hence farmers in Nigeria have realized the need for use of materials of organic origin such as animal manure and plant residues as soil amendments (Akanbi et al., 2000; Adeniran, et al. 2003; Ojetayo et al. 2011), as a way of maintaining the soil productivity in other to achieve the expected yield from the Telfairia occidentalis crop and other cultivated vegetables.

Being a leaf vegetable, the leaf area development of Telfairia occidentalis is of great significance to the vegetable farmers, since crops with wide leaf area usually have more fresh weight and are of more commercial value. Photoassimilates production, which is usually the resultant effect of transpiration and photo-energy interception, is the responsibility of the plant leaves (Maller et al., 2013). This implies that the best assimilation and radiation utilization are achieved through better aerial plant growth and leaf development (Larcher, 2004). The number and size of the plant leaves determines the leaf area of the crop and its ability to capture light for photoassimilate production and its final expressed potential crop yield (Tanaka, 2014).

In other to achieve sufficient photoassimilate production for higher crop yield, the plant must be supplied with sufficient nutrients. Organic based sources especially in the form of liquid cattle manure (mixture of excrements, urine and rumen wastes) is an alternative nutrient source that is presently underutilized in Nigeria. The use of liquid organic manure for biofertilizer has been extensively reported by several researchers (Matsi et al., 2003; Sorensen, 2004; Lithourgidis et al., 2007; Bechini & Marino, 2009). Most of the benefits derived from this type of fertilizer are its high level of plant available nitrogen than solid manure, its ability to increase crop macronutrients concentration and uptake. Other benefits also include improved soil total organic carbon, soil biological, chemical and physical properties which provide a conducive soil micro-environment for higher crop growth and yield (Matsi, 2012). Higher growth response, yield and nutrient uptake has been reported for crops that received liquid cattle manure than solid manure (Beauchamp, 1986; Zhang et al., 2006).

For a crop to be able to attain its productive capacity with sufficient supply of nutrients, it must also be sown at appropriate spacing that will allow it to harness the nutrients. Most vegetable farmers into commercial enterprise use inappropriate spacing for their crops, and in most cases plant at very close spacing with the erroneous believe that high crop yield would be achieved. Though the crop morphology determines the optimum plant spacing, the quantity of organic manure applied to a soil is determined by several factors such as soil fertility status, nutrient composition and source of material used (Shiyam and Binang, 2014).

The objective of the present study is to assess the optimum liquid cattle manure application rate and appropriate plant spacing for enhancing the leaf area development and vine growth of fluted pumpkin (Telfaiaria occidentalis Hook F), a leaf vegetable generally cultivated in Nigeria.

II. Materials and Methods

The field experiment was conducted in the Crop Farm Section of the Agricultural Science Unit Farm from August to November 2012 in Delta State University Abraka (latitude 5^0 46'N and longitude 6^0 5'E), Nigeria.

The experiment was arranged in randomized complete block design consisting of two factors, namely: liquid cattle manure (LCM) at four rates and plant spacing at three levels. The LCM was applied at rate 0, 120, 240 and 360 litres/ha while three plant spacing of 90 x 90cm, 70 x 70cm and 50 x 50cm corresponding to wide, medium and closer spacing were used respectively. These were arranged in a 4 x 3 factorial design with three replications.

The liquid cattle manure (LCM) was made through a fermentation process using solid cattle manure mixed water at 10%. The retention time of the fermentation was 25 days. LCM was applied in two equal splits per application rate. Two seeds of fluted pumpkin ((Telfairia occidentalis Hook. F) were sown per stand and were thinned to one after two weeks.

Data collected on foliage development was done at 3, 6 9 and 12 weeks after planting, and this include number of leaves and leaf area (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.

Other derived leaf development indices were total leaf area per plant (product of unit leaf area and number of leaves per plant) and while the formula by Palanisamy and Gomez (1974) was used to estimate the leaf area index. On the 12 WAP, other vine growth parameters were determined and these include vine length, vine girth, number of branches, and fresh marketable yield. The shoot dry matter was obtained by oven drying the plant samples at 65^0C. The percent succulence (relative water content) was also obtained.

Data collected obtained were subjected to analysis of variance (ANOVA), and means found to be significant were separated using the least significant difference (LSD) at 5% level of probability.

III. Results

3.1 Leaf Area Development Indices

Number of Leaves

The number of leaves of pumpkin under the influence of rate of liquid organic manure or plant spacing was not statistically significant at 3 weeks after planting (WAP), however at 6, 9 and 12WAP, liquid organic manure significantly ($P<0.05$) influenced the number of leaves (Table 1). The relationship between rate of organic manure application and number of leaves was linear. Applications of liquid manure at 360 litres/ha were observed to give the highest number of leaves with values of 27.01, 32.36 and 40.05 at 3, 6 and 9 WAP. At 12 WAP, pumpkin plants which received 360 litres/ha had higher number of leaves by 7.3%, 16.9% and 26.54% relative to those crops which received 240 litres/ha, 120 litres/ha and control (no nutrient application) respectively. Closer plant spacing significantly reduced number of leaves at 9 and 12 WAP. Percentage decrease in number of leaves of pumpkin as plant spacing reduced from 90 x 90cm to 50 x 50cm was 22.9% and 20.9 at 9 and 12 WAP respectively. The interactive effects of liquid manure and spacing were significantly different for number of leaves at 6, 9 and 12WAP.

Table 1: Number of leaves of Telfairia occidentalis in response to rate of liquid manure and plant spacing

	Weeks after planting			
	3	6	9	12
Liquid manure (kgN/ha)				
0	13.61	20.13[c]	23.18[d]	29.42[c]
120	13.96	23.61[b]	27.10[c]	33.27[b]
240	14.01	25.11[ab]	29.41[b]	37.11[a]
360	14.83	27.01[a]	32.36[a]	40.05[a]
LSD ((5%)	ns	2.33	1.92	3.71
Spacing				
90 x 90cm	14.15	24.82	31.61[a]	39.57[a]
70 x 70cm	13.93	23.95	28.06[b]	34.02[b]
50 x 50cm	14.22	23.14	24.36[c]	31.29[c]
LSD (5%)	ns	ns	2.81	2.60
Manure x spacing	ns	5.44*	7.40*	6.07*

Means with the same letters within the column are not significantly different (P <0.05)
* Significant at 5% level of probability, ns- not significant

Unit Leaf Area

The data on unit leaf area or leaf area per leaf of pumpkin plants are shown in Table 2. The results showed a significant (P<0.05) response of pumpkin plants to liquid organic manure application throughout the period of the experiment. Increase in unit leaf area of pumpkin from 3WAP to 6WAP was observed to be highest in 240 litres/ha (81%), followed by 360 litres/ha (76%), 120 litres/ha (60%) and the least in control (59%). The highest rate of liquid organic manure application consistently maintained higher unit leaf area with values ranging from 141.10cm^2 (3WAP) to 370.06cm^2 (12WAP), while lower number of leaves were observed in pumpkin plants that did not receive any liquid organic manure, with values within the range of 118.14cm^2 (3WAP) to 286.05cm^2 (12WAP). Unit leaf area decreased with closer spacing of pumpkin plants. Closer plant spacing significantly (P<0.05) decreased the unit leaf area of pumpkin plants at 6, 9 and 12WAP by 6.9%, 7.0% and 2.5% respectively as plant spacing reduced from 90 x 90cm to 50 x 50cm. Liquid cattle manure and spacing indicated significant effects on unit leaf area of plants at throughout the crop growth period.

Table 2: Unit leaf area (cm^2) of Telfairia occidentalis in response to rate of liquid manure and plant spacing

	Weeks after planting			
	3	6	9	12
Liquid manure (litres/ha)				
0	118.14b	188.11[b]	261.17[c]	286.05[c]
120	122.16[b]	200.32[b]	290.13[b]	310.17[b]
240	138.17[a]	250.20[a]	320.17[a]	361.12[a]
360	141.10[a]	248.77[a]	324.10[a]	370.06[a]
LSD (5%)	12.70	19.61	18.31	14.33
Spacing				
90 x 90cm	130.15	230.18[a]	311.62[a]	336.08[a]
70 x 70cm	129.66	221.04[b]	295.11[b]	331.92[b]
50 x 50cm	129.86	214.33[c]	289.94[c]	327.55[c]
LSD (5%)	ns	3.15	4.22	3.07
Manure x spacing	11.03*	7.13*	12.05*	11.34*

Means with the same letters within the column are not significantly different (P <0.05)
* Significant at 5% level of probability, ns- not significant

Total Plant Leaf Area

The results on total leaf area per plant are shown in Table 3. The earlier contributions of the number of leaves and unit leaf area resulted in significant (P<0.05) increase in total plant leaf area of pumpkin plants which received liquid organic manure. At 3 WAP, pumpkin plants with organic manure applications had higher total leaf area per plant over the control treatment by 6.1%, 20.4%, and 30.2% in 120 litres/ha, 240 litres/ha, 360 litres/ha respectively, while at 12 WAP the percentage increase over the control was 22.6%, 59.3% and 76.1% respectively for the same liquid organic nutrient rates. Total leaf area per plant significantly (P<0.05) decreased with reduction in plant spacing. At 12WAP, reducing plant spacing from 90 x 90cm to 70 x 70cm resulted in significant decrease of total plant leaf area by 15.1%, while a further reduction in plant spacing to 50 x 50cm reduced the total leaf area by 22.9%. The interactive effects of liquid cattle manure and spacing showed significant effects on total plant leaf area at 3, 6, 9 and 12WAP.

Table 3: Total plant leaf area (cm^2) of Telfairia occidentalis in response to rate of liquid manure and plant spacing

	Weeks after planting			
	3	6	9	12
Liquid manure (litres/ha)				
0	1607.87^d	3786.63^d	6053.91^d	8415.59^d
120	1705.35^c	4729.55^c	7862.52^c	10319.36^c
240	1935.77^b	6757.90^b	9416.18^b	13401.16^b
360	2092.51^a	6719.28^a	10487.88^a	14820.90^a
LSD (5%)	27.71	82.63	57.82	67.13
Spacing				
90 x 90cm	1841.63^a	5718.07^a	9850.31^a	13298.69^a
70 x 70cm	1806.18^b	5293.91^b	8280.79^b	11291.92^b
50 x 50cm	1846.61^a	4959.60^c	7062.94^c	10249.04^c
LSD (5%)	21.62	75.30	44.12	98.31
Manure x spacing	35.03*	79.32*	26.51*	35.65*

Means with the same letters within the column are not significantly different (P <0.05)
* Significant at 5% level of probability, ns- not significant

Leaf Area Index

The leaf area index (LAI) of pumpkin plants was statistically altered by liquid organic manure application and plant spacing as shown in Table 4. LAI of pumpkin increased with increasing rate of liquid organic manure applied. The least LAI of 0.37, 1.23, 1.68 and 2.19 at 3, 6, 9 and 12WAP respectively was obtained from the control, while liquid organic manure application of 135 kgN/ha indicated the highest LAI of 0.51, 0.41, 2.40 and 3.65 at 3, 6, 9 and 12WAP respectively. At 12WAP, liquid organic manure application increased LAI of pumpkin leaves relative to the control by 19.2%, 55.3% and 66.7% in 120 litres/ha, 240 litres/ha and 360 litres/ha respectively. Closer plant spacing significantly (P<0.05) reduced LAI. Plant spacing of 90 x 90cm had the highest LAI of 5.12, while 50 x 50cm had the least LAI of 1.27. Leaf area index of fluted pumpkin was significantly affected by the interaction of liquid cattle manure and spacing at 3, 6, 9 and 12WAP.

Table 4: Leaf area index (LAI) of Telfairia occidentalis in response to rate of liquid manure and plant spacing

	Weeks after planting			
	3	6	9	12
Liquid manure (litres/ha)				
0	0.37^b	1.23^b	1.68^c	2.19^d
120	0.43^{ab}	1.29^b	2.27^b	2.61^c
240	0.48^a	1.38^a	2.32^a	3.40^b
360	0.51^a	1.41^a	2.40^a	3.65^a
LSD (5%)	0.10	0.07	0.11	0.09
Spacing				
90 x 90cm	0.74^a	2.25^a	3.94^a	5.32^a
70 x 70cm	0.37^b	1.08^b	1.69^b	2.30^b
50 x 50cm	0.23^c	0.61^c	0.87^c	1.27^b
LSD (5%)	0.09	0.25	0.22	0.11
Manure x spacing	7.01*	5.11*	4.93*	6.01*

Means with the same letters within the column are not significantly different (P <0.05)
* Significant at 5% level of probability, ns- not significant

Vine growth Indices

Other indices of shoot development beside foliage, such as vine length, vine girth, fresh weight, dry weight and succulence are shown in Table 5. Vine length showed a linear significant (P<0.05) increase with increased rate of applied organic liquid manure. Highest vine length of 225.17cm was achieved at 360 litres/ha. Increase in vine girth was not statistically significant with applied liquid organic manure. The fresh marketable yield of pumpkin was significantly increased by application of organic based nutrients. Least fresh marketable yield of 5812.01kg/ha was observed in the control, while the 360 litres/ha recorded the highest yield of 7016.11kg/ha. However, though the control still indicated the least dry weight of 1791kg/ha, the 240 litres/ha, showed a more profound dry matter yield in the study. The relative water content of the pumpkin plants was highest in 360 litres/ha (73%) and least in both control and 240 litres/ha. Closer spacing of 50cm x 50cm reduced vine length and vine girth by 13.6% and 13.8% respectively relative to wider spacing of 90cm x 90cm, while higher fresh marketable yield and dry matter yield were achieved at closer spacing. The interaction of liquid organic manure and spacing showed significant effects on vine length and girth, fresh and dry matter yield of pumpkin plants.

Table 5: Vine growth indices of Telfairia occidentalis in response to rate of liquid manure and plant spacing

	Vine length (cm)	Vine girth (cm)	Fresh marketable yield (kg/ha)	Dry matter yield (kg/ha)	Succulence (%)
Liquid manure (litres/ha)					
0	189.61[c]	0.86	5821.01[d]	1791.00[c]	69.24
120	206.11[b]	0.91	6310.53[c]	1802.06[c]	71.47
240	221.36[a]	0.97	6963.70[b]	2053.11[a]	70.55
360	225.17[a]	0.99	7016.11[a]	1890.31[b]	73.00
LSD (5%)	9.11	ns	63.07	68.17	
Spacing					
90 x 90cm	211.21[a]	1.01	7110.21[a]	1790.22[c]	70.12
70 x 70cm	200.60[a]	0.92	6480.03[b]	1891.33[b]	70.83
50 x 50cm	182.38[b]	0.87	5993.28[c]	1970.05[a]	72.30
LSD (5%)	11.57	ns	99.13	75.33	
Manure x spacing	8.01*	5.10*	5.21*	5.32*	

Means with the same letters within the column are not significantly different ($P < 0.05$)
* Significant at 5% level of probability, ns- not significant

IV. Discussion

The significant lower values obtained for leaf area development indices and vine growth parameters between the control (0 litres/ha) and the various rates of liquid organic manure explains the role of nutrients for improved growth of these parameters. The increased number of leaves, unit leaf area, total plant leaf area and LAI confirms earlier reports of other researchers (Akanbi et al., 2000; Shiyam and Binang, 2014; Usman, 2015), that nutrient availability is a major determinant of the crop photosynthetic capacity. The higher leaf area development indices and vine growth parameters observed with increased liquid organic manure application suggests that these crop parameters can produce their potential capacity when soil nutrients are made available. Cechin and Fumis (2004) also observed high leaf development and shoot dry matter production in sunflower with increased nutrient supply. The enhanced growth in pumpkin in this study is due to the rich nutrient content of liquid organic manure. Liquid organic manure contains nitrogen, phosphorus and potassium (Zhang et al., 2006; Matsi, 2012) which are essential for photosynthetic activities and enhance dry matter accumulation. The improved performance with liquid cattle manures with high rate may also be attributed to increase in soil quality. Since considerable part (20%) of LCM exist in the liquid phase (Japenga et al. 1992), high rates of application increase the organic matter in the soil, improving soil structure, enhancing solubility of micronutrients through their bonding with dissolved organic matter and resulting in more availability of nutrients to the crops (Mellek et al., 2010; Nikoli & Matsi, 2011).

Irrespective of the level of liquid organic manure application, the development of leaf area indices and vine vegetative growth indices (vine length, vine girth) declined as the spacing between the plants gets closer. Conversely, the fresh marketable yield and dry matter production increased with closer spacing between the pumpkin crops. This shows that despite the intense competition of the crops for soil and other environmental resources within the crop farm system, at the highest plant population as evidenced by closer spacing, utilization of available soil resources were optimally achieved at that population. These observations may be attributed to more assimilate partitioning into vegetative components at higher plant populations. Earlier reports (Adelana, 1982; Akanbi et al., 2000; Shiyam and Binang, 2014) confirm these observations.

V. Conclusions

The application of liquid organic manure and crop spacing in this study influenced the leaf area development and vine growth of Telfairia occidentalis. From the results, the application of 360litres/ha at 50 x 50cm spacing gave higher fresh marketable yield. However, since there were no observed significant differences between 240litres/ha and 360 litres/ha in fresh marketable yield, it would be more economical to sow the pumpkin plants at a combination of 240litres/ha using medium spacing of 70cm x 70cm. This will allow for proper development of plant attributes essential for maximum fresh marketable yield.

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