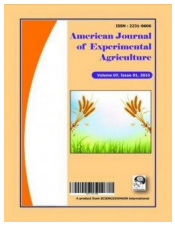

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Green Manure Source Affects Growth and Vegetative Yield of Fluted Pumpkin

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Authors' contributions

This work was carried out in collaboration between all authors. Author AIM designed the study, wrote the protocol and wrote the first draft of the manuscript. Author MOO reviewed the experimental design and all drafts of the manuscript. Authors KSA and OOJ managed the laboratory analyses of the study. Authors OEA and KSA performed the statistical analysis. All authors read and approved the final manuscript.

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ABSTRACT

Application of green manure to the soil can improve soil quality and increase crop yields, especially in organic farming. An experiment was conducted between April and October 2014 to determine nutritional potential of the soil amendments: Aleshinloye grade B organic manure; Mexican sunflower manure [*Tithonia diversifolia* (Hemsl.) A. Gray]; Neem (*Azadirachta indica* A. Juss) manure; *Moringa* (*Moringa oleifera* Lam.) manure, compared to a non-manure control. On growth and vegetative yield of Fluted pumpkin (*Telfaira occidentalis* Hook.F). At 2 week intervals, from 2 to 12 weeks after transplanting, number of leaves per plant, vine length per plant and number of branches per plant were determined. At harvest, fresh and dry leaf, stem and root weights were determined. Growth of Fluted pumpkin was generally enhanced by manures compared with untreated plants. *Moringa*, Mexican sunflower and Neem manures produced similar numbers of leaves, vine length and numbers of branches which were higher than Aleshinloye manure and the

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controls. Mexican sunflower manure had leaf dry weights, 38.19 g/plant, similar to *Moringa* manure, 24.76 g/plant, which were higher than Neem and Aleshinloye manures. Control plants had the lowest yield, 15.19 g/plant. Mexican sunflower manure could be an adequate source of nutrition in cultivation of Fluted pumpkin.

Keywords: Telfaira occidentalis; botanicals; leaf dry weight; manure.

1. INTRODUCTION

Fluted pumpkin (*Telfaira occidentalis* Hook.F), a herbaceous climbing annual plant [1,2], is cultivated for the edible leafy shoot and immature edible seed. Fluted pumpkin is rich in minerals and vitamins [3]. It can be propagated by seed or vine cuttings [1]. The major challenge in production of Fluted pumpkin is that indigenous production in Nigeria is rapidly decreasing due to poor soil fertility, inaccessibility to fertilizer and lack of water during the cropping season [4].

Besides controlling weeds and erosion, conserving moisture, sustaining soil productivity by improving physical and biological soil conditions, and preventing degradation of the soil, plant materials serve as nutrient sources for subsequent crops upon mineralization and help to attract earthworms [5]. Green manure use can increase production of vegetables under tropical conditions by maintaining soil moisture, soil fertility and productivity. Apart from the economic cost, use of chemical fertilizers under continuous cultivation in the tropics is not adequate to sustain crop yield [6]. Most plant products are non-polluting, less toxic and biodegradable with no hazardous residues in soil, water and air. They are environmentally safe and generally do not leave residues in stored food products [7]. Plant materials can be used as soil amendments [8] and can improve soil fertility [9]. Fabunmi et al. [10] reported that *Moringa* leaves has potential to furnish nitrogen, phosphorus and potassium in production of vegetable amaranth (*Amaranthus hybridus* L.). *Tithonia* can increase yield of crops [11]. Usually, most small holder farmers cannot afford to apply fertilizer, making it necessary to identify cheap and accessible means of replenishing nutrients in the soil. Farmers rely on native fertility and leave the land fallow over time to be restored**.** According to Sanchez et al. [12], soil fertility depletion in small holder production systems is the fundamental cause of declining per capita food production. The shortage and high cost of inorganic fertilizers have limited their use for crop production among small holder farmers in Nigeria [13]. With increasing demand and consumption of fluted pumpkin, it is necessary to identify potential plant materials as alternatives to synthetic fertilizer. This project was undertaken to assess effects of green manures on growth and vegetative yield of fluted pumpkin.

2. MATERIALS AND METHODS

A rain fed experiment was conducted at the Federal College of Agriculture, Ibadan, Nigeria, latitude 7^{o}22N and longitude 3^{o}50E, from April to October in 2014. Fluted pumpkin seed were sown into a degraded loamy sand soil in polythene bags and the soil moistened to allow plant establishment. Weeding was at 3 and 6 weeks after transplanting. One week after sowing, 10 kg of degraded soil was weighed into 20 polythene bags, 20 by 20 cm, into which were added either Mexican sunflower leaves [*Tithonia diversifolia* (Hemsl.) A. Gray]: 17.1 g/pot; Neem leaves (*Azadirachta indica* A. Juss): 26.9 g/pot, or Moringa leaves (*Moringa oleifera* Lam.): 14.4 g/pot, all of which were collected during vegetative growth of plants. Two weeks after application of green manures, 3 week-old seedlings were transplanted into the polythene bags. Soil around the seedling collar was firmed to stabilize seedlings. The control was no soil amendment, as usually practiced by farmers.

Tissues of green manures were air dried for 4 weeks and ground into a powder for analysis. Soil samples were air-dried for 72 hrs, ground and passed through 2 and 0.5 mm sieves. The 2 mm sieved soil was used to determine pH and the 0.5 mm sieved soil used for nitrogen and organic carbon determination. Phosphorus was determined by the Bray 1 method [14]; nitrogen by the Kjeldahl method [15], and potassium and sodium by flame photometry. A completely randomized design was used with treatments replicated 4 times. Data collected included: number of leaves per plant, vine length, and number of branches per plant. At harvest: fresh and dry weights of leaves, roots and stems were determined. The data were subjected to analysis of variance, and where appropriate, means separated using Duncan multiple range test.

Data that were quantitative and continuous were analyzed with linear regression.

3. RESULTS AND DISCUSSION

Results of plant analysis showed that Mexican sunflower had 2.61%N, 0.47%P, 2.89%K and 0.63%Na; Neem had 1.66%N, 0.12%P, 1.49%K and 0.50%Na and Moringa had 3.11%N, 0.38%P, 2.04%K and 0.52%Na. The Alesinloye grade B organic manure had 1.52%N, 3.00%P, 2.00%K and 3.50%Na.

The available phosphorus, total nitrogen, and organic matter content in the soil were low; soil pH was slightly acidic (Table 1). This qualifies the soil for nutrient study as it mimics the usual practice of small-holder farmers in Nigeria, which should not be encouraged in a sustainable farming system. Vine length, number of leaves and number of branches per plant was affected by fertilizer type and sampling time but not by the interaction (Table 2).

Growth of Fluted pumpkin was generally enhanced by the green manures compared with untreated plants. *Moringa*, Mexican sunflower and Neem manures produced similar numbers of leaves, vine length and numbers of branches which were higher than Aleshinloye manure and the controls (Table 3). Treated plants produced more leaves than controls, indicating the green manures can enhance growth of fluted pumpkin. Treatment with Mexican sunflower manure and Moringa manure were similar and greater than the Neem, the Aleshinloye and the control. The green manures produced more leaves than the Aleshinloye and the control which had the least leaves compared with highest leaf production from Moringa manure. Taiwo and Makinde [8] reported that weed residues increased crop yield than the conventional manure. This may be due to higher soil moisture, improved soil fertility and reduced weed competition [5]. Organic poultry manure enhanced growth of fluted pumpkin [16] where there were increases in numbers of leaves, vine length and number of branches while green manures gave better yield than conventional manure which could be beneficial due to nutrients available being released slowly [17].

Table 1. Physical and chemical properties of the soil

Parameter	Value
pH	6.4
Organic carbon	11.5 $g \cdot kg^{-1}$
Total N	1.1 $g \cdot kg^{-1}$
Available P (Bray-1)	8.18 $mg \cdot kg^{-1}$
Exchangeable Ca^{++}	6.0 $cmol \cdot kg^{-1}$
Exchangeable Mg^{++}	0.8 $cmol \cdot kg^{-1}$
Exchangeable K^{+}	0.3 $cmol \cdot kg^{-1}$
Exchangeable Na^{+}	0.3 $cmol \cdot kg^{-1}$
Sand	856 $g \cdot kg^{-1}$
Silt	52 $g \cdot kg^{-1}$
Clay	92 $g \cdot kg^{-1}$
Textural class	Loamy sand

Vine length due to treatment with Moringa was greater than the control. The remaining treatments were intermediate and similar to either the Moringa treatment or the control as reported by Foidle et al. [18] where application of Moringa increased crop production even though this was achieved under a different environment. Green manures produced longer vines than the control and the Aleshinloye manure which are similar in vine length extension. Crop residues have been used to supplement inorganic fertilizer for vegetable crops [19]. This probably occurred because of earlier mineralization than the other nutrient sources [5].

Application of manures encouraged production of more branches than on unfertilized plants. All green manures produced the same number of branches. Treatment with Moringa was greater than the control; the remaining treatments were intermediate and similar to either the Moringa treatment or the control. However, all green manures were similar and greater than the Aleshinloye manure and the control which produced the lowest number of branches. Liasu and Achakzai [20] reported that *Tithonia* leaf mulch produced higher biomass and increased crop yield than other organic manure sources [11].

Table 2. Results of ANOVA for vine length, and numbers of leaves and branches for Fluted pumpkin

Source of variation	Df	Vine length	Number leaves	Number branches
Fertilizer type (F)	4	10382.9**	23499.7**	4.8**
Sampling time (S)	5	49349.2**	70537.7**	28.8**
F × S	20	463.5NS	779.8NS	0.43NS

*NS, ** = Not significant or significant at P≤0.05 or P≤0.01, ANOVA*

There was a positive correlation between plant age and number of leaves produced. The number of leaves increased with increase in weeks after transplanting through week 12 (Fig. 1). According to Adeniji and Aremu [21], as plants aged and plant growth and development factors were adequate, photosynthetic activity is enhanced leading to production of more leaves per plant. The vine length of the Fluted pumpkin increased for every week increase in age of the Fluted pumpkin (Fig. 2). Vines increased in length more quickly from 2 to 6 weeks after planting than from 6 to 12 weeks after transplanting indicating the plant has transitioned to production of reproductive structures. This agreed with Makinde [22] where plant height, stem diameter and number of leaves of Amaranthus increased with time as the plant had more time to grow. Number of branches of Fluted pumpkin increased with age for every week after transplanting (Fig. 3).

Fresh yield of fluted pumpkin was not affected by green manure type (Table 4). Fresh yield of treated and untreated plants were similar at harvest which may be due to the slow release of green manure [17], or as a result of morphological characteristics of the fluted pumpkin [23].

Except for leaf dry weight, root, stem and total plant dry weights were not affected by green manures (Table 4). Mexican sunflower and Aleshinloye manures produced the greatest dry leaf weight (Table 5). According to Olaniyi and Oyelere [24] yield, and yield components, of *Telfairia* were increased by application of green manure; Neem manure, *Tithonia* manure; than organic manures. The highest yield and yield components of *Telfairia* were from Neem manure followed by Mexican sunflower manure.

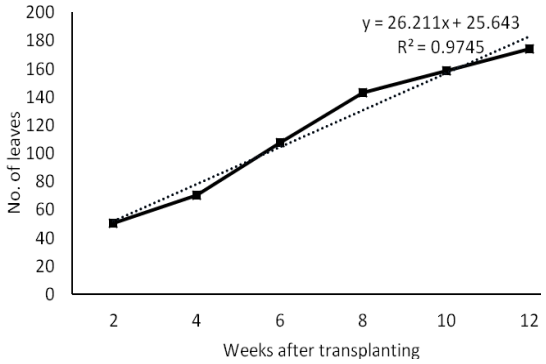

Fig. 1. Number of leaves of Fluted pumpkin across weeks after transplanting, dotted line is the regression line

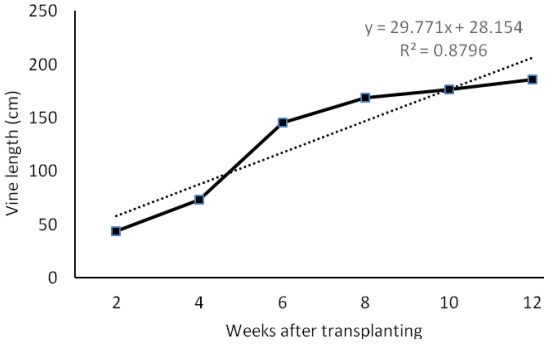

Fig. 2. Vine length of Fluted pumpkin across weeks after transplanting, dotted line is the regression line

Table 3. Effects of fertilizers on the growth of Fluted pumpkin

Fertilizer type	No. of leaves	Vine length (cm)	No. of branches
Control	90.08d[a]	99.13c	2.33c
Mexican sunflower manure	133.00a	162.00a	3.21ab
Neem manure	120.71b	133.94b	3.21ab
Moringa manure	140.21a	164.41a	3.50a
Aleshinloye manure	102.92c	102.29c	2.88b

[a] *values in columns followed by the same letter(s) are not significantly different, 5% level of probability Duncan's multiple range test*

Table 4. Results of ANOVA on yield and yield components of Fluted pumpkin (g/plant)

Source of variation	df	Fresh leaf weight	Fresh stem weight	Fresh root weight	Fresh plant weight	Dry leaf weight	Dry stem weight	Dry root weight	Dry plant weight
Treatment	4	12310.2ns	10550.8ns	1774.7ns	65054.4ns	7899.4*	94.5ns	204.1ns	9393.1ns

*ns, * = Not significant or significant at P≤0.05, ANOVA*

Table 5. Effects of fertilizers on leaf dry weight (g/plant) of Fluted pumpkin

Treatment	Leaf dry weight
Control	15.19b
Mexican sunflower manure	38.19a
Neem manure	15.56b
Moringa manure	24.75a
Aleshinloye manure	16.81b

[a] *Values followed by the same letter in a column are not significantly different, 5% level, Duncan's multiple range test*

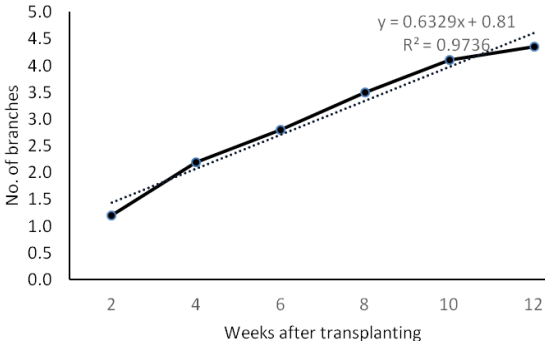

Fig. 3. Number of branches of Fluted pumpkin over time number of leaves of Fluted pumpkin across weeks after transplanting, dotted line is the regression line

4. CONCLUSION

Fluted pumpkin growth was generally enhanced by the green manures. Mexican sunflower leaves appear to be better replacements for highly expensive Moringa leaves in cultivation of Fluted pumpkin. The green manures can be used to support growth where soil nutrition is marginal. It is necessary to determine if the green manures can be used if soil nutrition is adequate to support the crop. Inorganic fertilizers and health issues can result from agro-chemical residues and plant materials can be used as an alternative to synthetic fertilizer.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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