



## EFFECT OF TILLAGE PRACTICES AND STAKING METHODS ON THE PERFORMANCE AND NUTRITIONAL COMPOSITION OF FLUTED PUMPKIN

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### ABSTRACT

A field experiment was conducted during 2018 rainy season at the Teaching and Research Farm of Bayero University in Kano (11°58' N, 8°25' E), and Kano Institute of Horticulture in Bagauda, Kano (11°33' N, 8°34' E) to study the effects of tillage practices (no tillage, conservation tillage, and conventional tillage) and staking methods (individual stakes, no stakes, and pyramidal stakes) on the growth, yield, and seed quality of fluted pumpkin. A split-plot design with four replicates was employed, with tillage practices occupying the main plots and staking methods assigned to subplots. Findings revealed that leaf area was not significantly ( $P>0.05$ ) affected by either tillage or staking methods. Minimum or zero tillage resulted in the highest leaf fresh weight (30.58 and 31.58) at later growth stages at Bagauda and BUK. Tillage and staking methods individually had minimal impact on the number of fruits per plant, fruit diameter, fruit length, and fruit weight at both locations. Furthermore, seed nutrient composition was minimally affected by tillage practices, except for protein content under conservation tillage. Staking methods, particularly individual staking, decreased the seed protein content. These findings suggest that the optimal combination of tillage and staking methods for fluted pumpkin production may vary depending on location and desired outcome. Further research is recommended to explore mechanisms behind the observed interaction effects and to investigate strategies for mitigating decrease in seed protein content associated with staking.

**Keywords:** staking, tillage practices, growth, yield, seed quality, fluted pumpkin

### INTRODUCTION

The post COVID-19 pandemic era and recent emphasis on healthy living have made people more interested in eating healthy foods. This has led to a rise in vegetable consumption, as many believe vegetables can naturally strengthen the immune system (Mello Rodrigues *et al.*, 2019; Calder, 2022; Lee *et al.*, 2022). Studies show a clear link between diet and immune function. Certain nutrients, alone or together, can influence the immune system by triggering cell activity, altering the production of signalling molecules, and even affecting gene expression (Valdés-Ramos, 2010).

Vegetables are essential for a healthy diet. They provide not only protein and fiber, but also a wealth of vitamins, minerals, and unique plant chemicals (like phenolics, flavonoids, and bioactive peptides) that have been shown to benefit our health (Zhang *et al.*, 2019). Maximizing your vegetable intake is a great way to boost your health and lower your risk of chronic illnesses (Deng *et al.*, 2013). Fluted pumpkin seeds boast anti-inflammatory properties, potentially aiding cancer patients and prostate health. Their zinc content may also help regulate hormones, promoting hair growth (Bassino *et al.*, 2020).



Fluted pumpkin thrives from seeds. It can either start from the nursery and later transplanting or sow them directly in raised mounds in the main field. Raised beds improve drainage, preventing root rot. It is cultivated in Slovenia and Australia while in Nigeria it is mostly cultivated in the southern part of the country. According to Udo and Alozie (2016), Fluted pumpkin can be harvested throughout the growing season based on vine health and fruit maturity. Look for deep, solid green coloration and a firm root. In areas with frost, harvest before late September or early October. Use pruning shears or a sharp knife to carefully cut the vines, leaving 3-4 inches of stem attached. Tomesh (2011) stated that staked plants produced the highest number of leaves and the longest vine length. Staked parts of plants are both nutritious and palatable, making them a target for goats. Staking, as endorsed by Lamptey and Koomson (2012), also simplifies harvesting of the leaves and pods. In another development, studies by Udo and Alozie (2016) analyzed the properties of oil extracted from *Telfairia occidentalis* seeds. The seeds contained a high amount of oil (nearly 99.8%) with low moisture and protein content. The golden-colored oil had a good quality profile, indicated by a low free fatty acid value. This suggests the oil's potential as a healthy edible source (Udo and Alozie 2016). Despite its immense benefit to mankind, Fluted pumpkin, a staple food in Nigeria, faces production hurdles in Sudan Savanna soils. A lack of research on suitable tillage and staking methods hinders optimal growth. The region's soil also suffers from rapid nutrient depletion and poor physical structure, further limiting crop production. Proper tillage techniques are crucial to maintain soil nutrients in Sudan's savanna region. While various planting methods using tillage and staking can boost fluted pumpkin production, these practices are rarely implemented in this area. Fluted pumpkin is becoming a popular income source for small farmers in northern Nigeria, despite its traditional cultivation in the south. However, a lack of information on suitable tillage, staking methods, and other agronomic practices specific to this region hinders yield improvement for these farmers. This study therefore aimed to investigate how different tillage and staking methods affect the growth and yield of fluted pumpkin cultivated in Kano, Nigeria's Sudan Savanna zone. Additionally, it will analyze the impact of these treatments on the nutritional composition of the fluted pumpkin seeds.

## **MATERIALS AND METHODS**

### **Experimental sites**

The experiment took place during the 2018 rainy season at two locations within the Sudan Savanna zone of Nigeria. The first site was the Teaching and Research Farm at Bayero University in Kano (11°58'N, 8°25'E), and the second was the Kano Institute of Horticulture in Bagauda, Kano (1°33'N, 8°34'E).

### **Treatment and Experimental design**

The experiment tested the effects of two factors on fluted pumpkin: staking methods and tillage methods. Which were arranged and laid in a split-plot design and replicated four times. The main plots received three different tillage practices (no tillage, conservational, and conventional tillage) while the three staking methods (individual stakes, no stakes, and pyramidal stakes) were assigned to subplots.

### **Cultural Practices**

The experimental area was divided into two sections. In one section, the land was cleared, tilled with a plow, and smoothed with a harrow. The other section was cleared manually using cutlasses and hoes. In both sections, measuring tape, pegs, and ropes were used to carefully mark



out individual plots and determine the total land area. Sowing involved manually placing one large or medium-sized seed per hole at a depth of about 6 centimeters. Seed holes were spaced 1 meter apart in both rows and between rows. Planters ensured the helium (likely a misspelling of hilum, the seed scar) faced downwards during sowing.

At six weeks after sowing, vines were supported using three different methods: no staking (control), individual staking, and pyramidal staking. For the staked methods, long, 2-meter bamboo stakes were used to create a trellis system for the plants to climb. Plant stems were gently tied to the stakes with thread. At eight weeks, the topmost growing tip (apex) of each vine was carefully pruned using secateurs. This practice, called apical dominance control, encouraged lateral branching and fruit development on the trellis. Weeds were managed in two stages: first, by hoeing three weeks after sowing to remove early weeds. Then, regular hand pulling was done to maintain a clean field throughout the growing season. Before planting, all plots received a uniform application of poultry manure. To supplement nutrients, NPK fertilizer (15-15-15) was side-dressed at a rate of 45 kg of nitrogen per hectare at 21 days after sowing. Insect pest was managed using an organic neem extract. Neem leaves were soaked in water for two weeks, allowing fermentation to create a natural pesticide. This fermented neem solution was then sprayed onto the fluted pumpkin leaves.

#### **Data Collection and Analysis**

Data were collected on leaf length, leaf fresh weight, number of fruits per plant, and proximate composition of the seed of a fluted pumpkin using standard procedures as described by Ayo *et al.* (2012). The data collected were subjected to analysis of variance (ANOVA) to identify significant differences between the various treatment groups using the SAS statistical software (version 9.1). Significantly different treatment means were compared using Least Significant Difference (LSD) 5% probability.

## **RESULTS AND DISCUSSION**

### **Physical and Chemical Properties of Soil at the Experimental Sites**

The soil at both experimental locations (Bagauda and Bayero University Kano, BUK) differed slightly in texture. Bagauda had clay sandy loam soil, while BUK's soil was sandy loam (Table 1). Both locations had neutral pH (around 7.1-7.3) and medium organic carbon content (7.8% for BUK and 13.2% for Bagauda). Bagauda had a higher level of total nitrogen (0.28%) compared to BUK (0.13%). Available phosphorus was also higher in Bagauda (23.2 mg kg<sup>-1</sup>) than BUK (13.6mg/kg). The organic carbon as well as total nitrogen content in both sites and both locations were medium according to the rating of Okonmah (2011). This showed that the soil was moderate in supplying organic carbon for soil biota and also as a source of mineralized nitrogen for uptake of mineral nitrogen by crops (Hazelton and Murphy, 2007). Hence, it requires the application of nitrogen for fluted pumpkin production. The soil at the experimental sites was medium in available phosphorus. This shows that the application of an external source of phosphorus is important for growing fluted pumpkins.

The exchangeable cations (calcium (Ca) and magnesium (Mg)) were medium at BUK and high in Bagauda. Potassium (K) levels were medium in both locations. The sodium (Na) content was also moderate. Overall, the soil cation exchange capacity (CEC) was medium, ranging from 6.40 cmol (+) kg<sup>-1</sup> for BUK to 9.21 cmol (+) kg<sup>-1</sup> for Bagauda. The salinity of the soil (EC) at the experimental sites was also low. According to Hazelton and Murphy (2007), soil having an EC



less than  $4\text{dsm}^{-1}$  is considered non-saline and suitable for vegetable production. The soil of the experimental sites was observed to be medium in potassium content, which is adequate for *Telfairia occidentalis* production.

**Table 4:** Physical and Chemical Properties of the Soil at Experimental Sites during 2018 Rainy Season

Soil properties	BUK 0-30	Bagauda 0-30
<u>Physical composition (<math>\text{g kg}^{-1}</math>)</u>		
Sand	780	500
Silt	130	220
Clay	90	280
Textural class	Sandy loam	Sandy clay loam
<u>Chemical composition</u>		
pH ( $\text{H}_2\text{O}$ )	7.12	7.34
Organic Carbon ( $\text{g kg}^{-1}$ )	7.82	13.3
Total Nitrogen ( $\text{g kg}^{-1}$ )	0.13	0.28
Available Phosphorus ( $\text{mg kg}^{-1}$ )	13.6	23.2
Exchangeable base ( $\text{c mol}^+ \text{kg}^{-1}$ )		
Ca	3.76	4.95
Mg	0.39	0.95
K	0.36	0.18
Na	0.41	0.47
CEC	6.40	9.21

### Leaf area ( $\text{cm}^2$ )

Table 2 shows how tillage practices and staking methods affected the leaf area of fluted pumpkin plant. The results showed no significant difference in leaf area due to tillage practices at either of the locations (Bagauda or BUK) during the sampling period. Similarly, staking methods had no significant impact on leaf area at either location. There was also no evidence of a combined effect between tillage practices and staking methods on leaf area at both locations. The lack of significant differences in leaf area due to tillage practices aligns with some previous findings by Wu *et al.* (2020) and Romano *et al.* (2023) while investigating the effects of tillage on winter wheat observed minimal variations in leaf area across different tillage treatments. This suggests that, for certain crops, leaf area may not be the most responsive parameter to variations in tillage practices, particularly when focusing on a moderate range of tillage intensity. Xu *et al.* (2024) also reported a similar finding. The absence of a significant effect of staking methods on leaf area is somewhat surprising and contradicts the findings of Nweke (2013), who showed that staking methods influence the leaf area of cucumber, where the staked cucumber exhibited larger leaf areas compared to those grown on the ground. The observation that minimum or zero tillage resulted in the highest leaf weight at 12 WAS could be attributed to improved soil aeration and water infiltration associated with minimal soil disturbance. This finding corroborates those of Zhao *et al.* (2022), who found that reduced tillage practices in pumpkin cultivation can promote early vegetative growth and leaf area expansion.



**Table 2:** Effect of Tillage Practices and Staking Methods on Leaf Area per Plant (cm<sup>2</sup>) of Fluted Pumpkin (*Telfairia occidentalis*) at Bagauda and BUK During 2018 Rainy Season.

Treatment	Bagauda		BUK	
	Weeks after sowing (WAS)			
	14	16	14	16
<u>Tillage Practices (TP)</u>				
Minimum	435.63	663.93	369.95	536.62
Conservational	625.30	857.63	465.98	792.86
Conventional	595.65	768.38	453.46	687.54
LSD	45.680	57.336	52.816	48.921
<u>Staking Method (SM)</u>				
Individual	532.76	783.56	562.44	633.30
Non-staked	553.36	646.72	657.46	640.56
Pyramidal	637.53	854.33	563.00	693.67
LSD	35.022	38.775	36.865	53.450
<u>Interaction</u>				
TP x SM	0.221	0.339	0.466	0.649

#### Leaf fresh weight (g)

The effect of tillage practices and staking methods on the fresh weight of leaves of fluted pumpkin is shown in Table 3. The results revealed that tillage practices significantly influenced leaf weight at 12 WAS. Plants grown with minimum or zero tillage had the highest fresh weight at Bagauda (30.58 g) and BUK (31.58 g) compared to other tillage methods. Similarly, staking methods had a significant effect on leaf weight at 6 was in Bagauda where the non-staked and pyramidal staked significantly had higher leaf fresh weight than the individual staked plants. A significant interaction between TP and SM was observed at 10 and 12 WAS in BUK (Table 4). The results showed that the zero tillage with pyramidal staking produced the highest fresh leaf weight, although at par with the rest of the interactions at 10 and 12 WAS, respectively.



**Table 3:** Effect of Tillage Practice and Staking Methods on Leaf Fresh Weight (g) of Fluted Pumpkin (*Telfairia occidentalis*) at Bagauda and BUK during 2018 Rainy Season.

Treatment	Bagauda				BUK			
	Weeks After Sowing (WAS)							
	6	8	10	12	6	8	10	12
<u>Tillage Practices (TP)</u>								
Minimum	21.83	25.16	27.66	30.58a	23.75	26.00	28.50	31.58a
Conservational	19.83	23.41	26.25	28.75b	20.75	23.33	26.16	29.03b
Conventional	19.66	23.58	26.25	28.75b	22.58	24.66	26.66	29.41b
LSD	0.838	0.927	1.0036	1.793	0.942	0.638	0.942	1.697
<u>Staking Methods (SM)</u>								
Individual	19.50b	23.50	26.16	28.83	22.66	24.33	27.25	30.25
Non staked	20.83a	24.50	27.41	29.75	20.83	23.16	25.75	28.66
Pyramidal	21.00a	24.16	27.08	29.66	23.58	26.00	28.33	31.16
LSD	1.021	10.866	0.980	1.057	1.158	1.169	0.813	1.164
<u>Interaction</u>								
TP x SM	0.170	0.614	0.670	0.939	0.692	0.276	0.0031	0.014



**Table 4:** Interaction between Tillage and Staking Methods on Leaf Fresh Weight per Plant of *Telfairia occidentalis* at BUK at 10 Weeks After Sowing

	Minimum	Tillage Practices	
		Conservational	Conventional
<b>Staking Method</b>		<b>10 WAS</b>	
Individual	28.00 <sup>abc</sup>	26.50 <sup>bc</sup>	27.25 <sup>abc</sup>
Non-staked	28.00 <sup>abc</sup>	23.50 <sup>d</sup>	25.75 <sup>bc</sup>
Pyramidal	29.50 <sup>a</sup>	28.50 <sup>ab</sup>	27.00 <sup>bc</sup>
		<b>12 WAS</b>	
Individual	31.25 <sup>ab</sup>	30.50 <sup>ab</sup>	29.00 <sup>abc</sup>
Non-staked	31.50 <sup>ab</sup>	26.25 <sup>c</sup>	28.25 <sup>ab</sup>
Pyramidal	32.00 <sup>a</sup>	31.50 <sup>ab</sup>	30.00 <sup>ab</sup>

Means with the same superscript (s) in across row and column are not significantly different at 5% LSD.

### Number of Fruits per Plant, Fruit Diameter, Fruit Length and Fruit Weight

The effects of tillage and staking on number of fruits per plant, fruit diameter, fruit length, and fruit weight of fluted pumpkin is presented in Table 5. Results indicated that the aforementioned yield-related characters were not significantly influenced by tillage practices and staking methods at both Bagauda and BUK, respectively. The absence of a significant impact of tillage practices on yield components could be linked to the soil disturbance, which was within a moderate range and might not significantly affect overall yield components. This aligns with the findings of Adesida *et al.* (2020), who reported minimal variations in fruit number and weight of *Cucumis melo* across various tillage treatments. The lack of a strong effect of staking methods on yield components is somewhat unexpected. This discrepancy could be due to several factors, including the fact that the staking methods used in this study might not have provided sufficient support, particularly for fruit development. Additionally, the environmental conditions at the experimental locations might have been favorable for fruit set and development even without staking. This, however, contradicts the findings of Oga and Umekwe (2015) and Adesida *et al.* (2020), who reported an increase in fruit size of water melon and cucumber, respectively, due to staking methods.



**Table 5:** Effect of Tillage Practices and Staking Methods on Number of Fruits per plant, Fruit diameter, Fruit length and Fruit weight of Fluted Pumpkin (*Telfairia occidentalis*) at Bagauda and BUK during 2018 Rainy Season.

Treatment	Number of Fruits Plant <sup>-1</sup>		Fruit Diameter (mm)		Fruit Length (cm)		Fruit Weight (g)	
	Bagauda	BUK	Bagauda	BUK	Bagauda	BUK	Bagauda	BUK
<u>Tillage Practice (TP)</u>								
Minimum	4.956	3.885	33.54	32.97	27.33	31.10	2.377	2.550
Conservational	4.663	4.017	35.64	32.69	27.63	31.30	2.311	2.350
Conventional	4.205	4.250	31.88	30.75	24.47	27.56	1.999	2.160
LSD	1.594	1.194	0.469	2.495	6.955	3.112	0.525	28.69
<u>Staking Methods (SP)</u>								
Individual	4.878	4.222	32.19	32.06	28.17	30.65	2.096	2.661
Non-staked	4.160	4.012	31.65	30.03	23.48	30.02	2.078	2.291
Pyramidal	4.788	3.917	33.23	33.32	27.80	29.29	2.513	2.752
LSD	1.051	1.073	3.467	3.577	3.564	3.452	0.452	24.74
<u>Interaction</u>								
TP x SM	0.374	0.046	0.746	0.437	0.410	0.052	0.100	0.435





However, interaction between tillage practices and staking methods was significant in terms of the number of fruits per plant at BUK only (Table 6). The combination of conventional tillage practice and individual staking significantly increased the number of fruits per plant, which was statistically similar to other interactions. The significant interaction obtained via the combination of conventional tillage practice and individual staking on the number of fruits per plant could be attributed to the fact that conventional tillage at BUK might have created a specific soil environment that benefited fruit production when combined with the support provided by individual staking. This finding agreed with those of Dayou *et al.* (2017), Pradhan *et al.* (2021), and Singh *et al.* (2023).

**Table 6:** Tillage practices x Staking Methods on Number of fruits per plant at BUK BUK

Staking methods	Tillage Practices		
	Minimum	Conservational	Conventional
Individual	3.25 <sup>c</sup>	4.50 <sup>ab</sup>	4.52 <sup>a</sup>
Non-staked	3.67 <sup>bc</sup>	4.38 <sup>ab</sup>	4.15 <sup>abc</sup>
Pyramidal	4.22 <sup>abc</sup>	4.30 <sup>ab</sup>	4.50 <sup>ab</sup>

Means with the same superscript (s) in across row and column are not significantly different at 5% LSD.

### Proximate Composition of the Seed

The proximate composition of fluted pumpkin seed in the different tillage/staking method is presented in Table 7. The result indicates that there is no significant difference among the three tillage/staking methods in the moisture content, ash content, fat content, fiber and carbohydrate composition except in protein content in which conservational tillage has the higher percentage (38.53%). This suggests that for certain crops, including fluted pumpkin, tillage practices within a moderate range might not significantly impact the overall seed nutrient profile, except for specific components. This aligns with the findings of Cheṭan *et al.* (2021), who reported a minimal effect of tillage practices on soybean seed quality, such as protein, fat, and fiber content, across different tillage treatments. Staking methods seem to be the main factor affecting protein content. Both Bagauda and BUK displayed a decrease in protein content with all staking methods compared to the non-staked control. Individual stakes showed the most significant decrease. This suggests that staking methods might influence seed protein accumulation. However, the mechanisms behind this effect are unclear and require further investigation.



**Table 5:** Percentage Proximate Composition of Seed of Fluted Pumpkin (*Telfairia occidentalis*) at Bagauda and BUK During 2018 Rainy Season.

	Bagauda						BUK					
	MC	Ash	Protein	Fat	Fibre	CHO	MC	Ash	Protein	Fat	Fibre	CHO
<u>Tillage Practice (TP)</u>												
Minimum	3.40	3.40	37.8	39.8	3.44	12.51	3.40	3.40	37.7	39.4	3.45	12.52
Conservational	3.42	3.40	38.5	39.9	3.44	12.52	3.42	3.41	38.4	39.9	3.43	12.62
Conventional	3.40	3.41	37.8	39.8	3.44	12.51	3.40	3.41	37.9	39.8	3.46	12.61
<u>Staking Method (SM)</u>												
Individual	3.34	3.40	26.9	39.6	3.33	12.48	3.35	3.40	26.8	39.5	3.36	12.53
Non-Staked	3.45	3.39	28.0	39.8	3.35	12.50	3.47	3.40	27.5	39.8	3.33	12.55
Pyramidal	3.40	3.38	27.3	39.5	3.38	12.49	3.40	3.35	27.2	39.6	3.34	12.56

MC= Moisture content, CHO= Carbohydrate.



## CONCLUSION AND RECOMMENDATIONS

Findings from the studies revealed that tillage and staking methods did not significantly influence leaf area at either location. However, minimum or zero tillage resulted in the highest leaf weight at later growth stages, potentially due to improved soil aeration and water infiltration. A significant interaction between tillage and staking methods was observed at BUK, with zero tillage and pyramidal staking producing the highest leaf weight. Furthermore, tillage and staking methods individually had minimal impact on the number of fruits per plant, fruit diameter, fruit length, and fruit weight at both locations. However, an interaction effect was observed at BUK, where the combination of conventional tillage and individual staking increased the number of fruits per plant. Similarly, tillage practices showed minimal impact on seed nutrient composition, except for protein content under conservation tillage. Staking methods, particularly individual staking, decreased the seed protein content. Based on these findings, the combination of conservation tillage with pyramidal staking could be adopted by fluted pumpkin farmers in the study area. There is also a need to investigate the impact of staking methods on protein quality (amino acid profile) and potential strategies to mitigate the decrease in protein content.

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