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Seed size and planting position influence growth and fresh yield of fluted pumpkin (*Telfairia occidentalis* Hook. f.)

El tamaño de la semilla y la posición de plantación influyen en el crecimiento y el rendimiento fresco de la (*Telfairia occidentalis* Hook. f.)

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Abstract

The increase in food production through innovative seed management practices is an option. Three seed sizes (big, small and control – any size), two planting positions (flat and slant) and their interactive effects on the growth and yield of fluted pumpkin (*Telfairia occidentalis* Hook. f.) were assessed. There was a significant ($p<0.05$) effect of seed size and planting position and an interaction between seed size and planting position on the emergence, vine length and fresh marketable weight (yield) of fluted pumpkin. The seed emergence increased significantly ($F_{2,6} = 16.82$, $p<0.01$) only when the seeds were slanted at planting and ranged from 72.2 % to 100 %. The same trend was observed across the two planting positions for the small seeds with the highest (100 %) recorded in (small x flat and big x slant) and the lowest (72.2 %) recorded in (small x slant). At 11 weeks after sowing the shortest vine length (135.83 cm) was observed on the small seed sizes slanted at planting and the longest when small seeds were planted flat. Additionally, there was a significant ($p < 0.01$) interaction between seed size and planting position on the yield which increased significantly only when the seeds were slanted at planting, but not for seeds planted in the flat position. At 11 weeks after sowing, the fresh marketable yield ranged from 0.49 $t.ha^{-1}$ for slant x small – 0.71 $t.ha^{-1}$ for flat x small and slant x big respectively. Overall, planting fluted pumpkin seeds in the flat position can improve emergence, growth and fresh marketable yield.
Keywords: *Fluted pumpkin, seed quality, production practices.*

Resumen

Una opción para el aumento de la producción de alimentos a través de prácticas innovadoras de manejo de semillas. Se evaluaron tres tamaños de semilla (grande, pequeña y control – cualquier tamaño), dos posiciones de plantación (plana e inclinada) y sus efectos interactivos sobre el crecimiento y rendimiento de la calabaza estriada (*Telfairia occidentalis* Hook. f.). Hubo un efecto significativo ($p<0.05$) del tamaño de la semilla y la posición de plantación y una interacción entre el tamaño

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de la semilla y la posición de plantación en la emergencia, la longitud de la vid y el peso fresco comercializable (rendimiento) de la calabaza estriada. La emergencia de semillas aumentó significativamente ($F_{2,6}$ = 16.82, $p < 0.01$) solo cuando las semillas se inclinaron al momento de la siembra y osciló entre 72.2 % y 100 %. La misma tendencia se observó en las dos posiciones de siembra para la semillas pequeñas, con la más alta (100 %) registrada en (pequeña x plana y grande x inclinada) y la más baja (72.2 %) registrada en (pequeña x inclinada). A la 11 semanas después de la siembra se observó la longitud más corta de la vid (135.83 cm) en los tamaños de semilla pequeños inclinados al momento de la siembra y la mayor longitud cuando las semillas pequeñas se plantaron planas. Además, hubo una interacción significativa ($p < 0.01$) entre el tamaño de la semilla y la posición de siembra en el rendimiento, que aumentó significativamente solo cuando las semillas se inclinaron en la siembra, pero no para la semillas plantadas en la posición plana. A las 11 semanas después de la siembra, el rendimiento fresco comercializable osciló entre 0.49 $t.ha^{-1}$ para inclinado x pequeño y 0.71 $t.ha^{-1}$ para plano x pequeño e inclinado x grande, respectivamente. En general, plantar semillas de calabaza estriadas en posición plana puede mejorar la emergencia, el crecimiento y el rendimiento fresco comercializable.

Palabras clave: *Calabaza estriada, calidad de la semilla, prácticas de producción.*

Introduction

According to Food and Agriculture Organization of the United Nations (FAO, 2021), undernourishment and severe food insecurity have increased in many countries of Africa where, in 2020, 21 % of the population were undernourished. This situation seems critical in Cameroon where the North and South West regions conflicts has led to thousands of internally displaced people who must be fed with a well-balanced diet, particularly children under five and pregnant women. Furthermore, in Cameroon, 3.9 million people are food insecure, representing 16 % of households with a higher proportion for rural (22 %) than urban (10.5 %) households (FAO, 2021).

Vegetables constitute an important portion of food in a balanced human diet and well-being. They have nutritional and medicinal importance at all the human life stages, due to their health benefits (Amao, 2018; Ahsan et al., 2019; Johnson et al., 2019) and richness in minerals and vitamins (Akpasi et al., 2023). In Cameroon, the production of fresh vegetables has gradually gained ground from 675000 t in 2010, to 769 563 t in 2018 (FAOSTATS, 2023). Fluted pumpkin (*Telfairia occidentalis)* is an indigenous and green creeping leafy vegetable of significant importance to human diet in Africa and particularly in West (Samson & Isaac, 2019; FAO, 2021; Osuji et al., 2022) and Central African countries.

The leaves and seeds of fluted pumpkin are consumed as food and are also used in African traditional herbal medicine for the treatments of several illnesses (Igbozulike, 2015; Aiyelaagbe, 2011; Giami et al., 2003). They have high iron content, dietary fibre (Ibironke & Owotomo, 2019) and are rich in both vitamins A and C and protein content (Fasuyi & Nonyerem, 2007; Obembe et al., 2021). Furthermore, they have antioxidant and antimicrobial properties (Kaur et al., 2020). The demand for this vegetable is rising in countries like Nigeria, Sierra-Leonne, Ghana and Cameroon (Odiaka et al., 2008) and is fast becoming an important food source in these countries, due to continuous increase in population and urbanization. Urban centers however are becoming more important markets for fluted pumpkin as it is now being sold in modern supermarkets in major cities of Cameroon.

The production of fluted pumpkin is constrained by scarcity, recalcitrant nature and high cost of seeds (Odiaka et al., 2008; Nwonuala, 2020), soil fertility (Okonkwo et al., 2019) and crop management (Ogar & Asiegbu, 2005). There is a need to transforming agriculture systems, particularly in sub-Saharan Africa and Cameroon, through the reduction of the cost of nutritious foods to contribute to the quest of achieving food security. This will be possible if nutritious foods such as fruits and vegetables, including fluted pumpkin, are more available and affordable.

The optimum production of fluted pumpkin (leaves and seeds) is determined by agronomic practices and factors such as fertilizer application (Okonkwo et al., 2019), harvesting frequency (Ogar & Asiegbu, 2005), the harvesting season (Asiegbu, 1985; Ossom, 1986), the stage of fruit harvest and storage (Odiaka & Akroda, 2009). Nonetheless, information on the appropriate seed size and their planting position to increase the productivity of fluted pumpkin is scarce. Meanwhile, among the most important factors and inputs that accounts for optimum crop performance for an eventual increase in agricultural production at all scales is the use of good quality seeds (Kumar et al., 2023). A fluted pumpkin fruit contains different seed sizes, are classified as recalcitrant seed which may not all be performant and good for its production (Flynn et al., 2004; Ekwere, 2023). Poor seed quality coupled with inappropriate planting practice may account for low germination, growth and yield. It was therefore hypothesized that (i) big seed size of fluted pumpkin will improve plant growth and yield, (ii) the planting position will influence plant growth and yield and (iii) the combined effect of seed size and planting position will affect the growth and yield of fluted pumpkin. Understanding the factors that influence the growth and yield of fluted pumpkin is crucial for optimizing production practices. This research paper aims to investigate the effect of planting position and seed size on growth parameters and yield of fluted pumpkin.

Materials and methods

Field site and experimental setup

Field trial was conducted between July and September 2017 at the Institute of Agricultural Research for Development (IRAD) Nkolbisson Yaounde, latitude 3˚47'- 3˚57' North; longitude 11˚10' - 11˚45' East and altitude 760 m - 769 m above sea level. Yaounde is within the humid forest agro-ecological zone, characterized by a bimodal rainfall pattern with four seasons: long rainy season from September to November, long dry season from December to February, short rainy season from March to June and a short dry season from July to August (Ngome et al., 2013). The average daily temperature is estimated at 23 °C - 24 °C and the mean annual rainfall is situated between 1 600 mm and 2 000 mm. The dominant soils are ferralsols, which are generally acidic, low in organic carbon content, total nitrogen and deficient in exchangeable potassium and available phosphorus (Ngome et al., 2013; Yerima & Ranst, 2005b).

Whole fruits of traditional landrace (locally called yellow variety) of fluted pumpkin, containing seeds were purchased from the Mokolo market in Yaounde, Cameroon and tested if they were mature and viable before planting. Seeds were submerged in a bucket of water for a floating test. Seeds found floating were classified either as immature or non-viable, meanwhile viable seeds sank to the bottom. Viable seeds were thereafter classified as small (200 mm to 210 mm and 7 g to 9 g) or big (≥ 210 mm diameter and ≥ 11 g) using a Vernier caliper and a sensitive electronic scale balance. The field experiment was established on a 310 m^2 land area, cleared with cutlass and demarcated into 18 plots (4 m × 4 m each) separated from each other by a 1 m alley and a 2 m buffer surrounding the experimental site. Selected seeds were directly sown at 100 cm x 50 cm and 5 cm deep, giving 24 000 plants per hectare. It was a 3 x 2 factorial experiment established as randomized complete block design, where the main plot was the seed size (large seeds, small seeds and control) and the sub-plots were the planting position (flat or slant). Treatments included T_1 = big x flat, T_2 = big x slant, T_3 = small x flat, T_4 = small x slant, T_5 = control x slant, T_6 = control x flat; (control was any seed size) and three replicates each.

Field maintenance

As amendments, cattle manure (cow dung) gotten from IRAD Nkolbisson in Yaounde was incorporated in the soil at tillage at the rate of 5 $t.ha^{-1}$. In addition, chemical fertilizers purchased from an agricultural shop in Yaounde, NPK 20-10-10 was applied two weeks after planting and urea applied after first harvest (three weeks after planting), at the rate of 200 $kg.ha^{-1}$ and 100 $kg.ha^{-1}$ respectively to boost the growth. Routine weed control and irrigation were carried out accordingly.

Data collection

The following parameters were taken into consideration in data collection.

- *Seed size (cm)*: the diameter and weight of seeds (a total of 300 seeds) were determined using Vernier caliper and a sensitive electronic scale balance respectively.

- *Seed emergence and days to 50 % emergence*: After the first plant emerged about 10 days after sowing, emerged seeds were counted after every three days for a period of two and a half weeks (17 days). The number of days to attain 50 % germination was noted and the percentage emergence was then calculated. The following parameters were evaluated 5, 8 and 11 weeks after planting.

- *Vine, petiole and internodes length (cm):* the lengths were measured using a flexible tape. The length of the vine was measured from the soil surface to the tip of the vine. Petiole length was measured from the point of attachment of the leaf and the vine to the leaflet. The length of internode was measured from internodes chosen at the middle of the plant.

- *Number of nodes*, branches and leaves: The number of branches, nodes and leaves were counted on the main vine.

- *Stem diameter (mm):* The diameter was measured on the main stem (vine) using a Vernier caliper.

- *Leaf area*: The length (L) and width (W) of the largest leaflets were measured and the leaf area calculated using the following formula.

  Where n=number of leaflets, (Akoroda, 1990a).

- *Fresh leave yield and fresh marketable weight (yield) of fluted pumpkin*: Hand harvesting was done by pruning plants at the internode position between the last leaf from the vine apex (Muoneke et al., 2011), for each treatment. The total fresh marketable weight (leaves and vines) for each treatment was weighed and fresh marketable yield was expressed in tons per hectare by dividing the total weight of the harvest to get the average yield per plant. The yield per plant was multiplied by the number of plants per hectare (24,000 plants) to have the yield in tons per hectare. For the fresh leave yield, the edible leaves were separated from the vines and the same procedure as for the fresh marketable yield was used to obtain the fresh leave yield. The evaluation of fresh leave yield and fresh marketable yield was done separately at 5, 8 and 11 weeks after planting.

Data Analysis

All statistical analyses were done using SPSS (Ver. 25). All data sets were analysed for normality and homogeneity using Kolmogorov-Smirnov and Levene's tests, respectively. All data sets were subjected to a multifactorial analysis of variance (MANOVA, $p<0.05$) to test the main effect and interactions of seed sizes and planting position on the growth and yield parameters of fluted pumpkin. In case of significance after the MANOVA, data sets were subjected to an analysis of variance (ANOVA, $p<0.05$) to test the effects of seed size on the different parameters collected. Significantly different means were separated using Tukey's HSD Test (Tukey's HSD, $p<0.05$) when the ANOVA showed significance. A T-test was also performed to determine the effect of the different planting positions on the growth and yield of fluted pumpkin.

Results and discussion

Emergence of fluted pumpkin

There was a significant ($p<0.05$) main effect of seed size and planting position on the seed emergence of fluted pumpkin. Also, a multi-factorial analysis revealed a significant ($p<0.05$) interaction between seed size and planting position on the seed emergence (Table 1).

The seed emergence ranged from 72.2 % to 100 % and increase significantly ($F_{2,6} = 16.82$, $p <0.01$) only when the seeds were slanted at planting, but not for seeds planted in the flat position. The seeds of fluted pumpkin obtained from the pods were separated into big and small seeds according to their size, suggesting that in the same fruit or pod, different seed sizes are present. The quality of seed takes into consideration

Table 1: Analysis of variance for the effect of planting position and seed size on the seed emergence of pumpkin

Source	Df	Significance
Planting Position x Seed Size	2	0.005**
Planting Position	1	0.015*
Seed Size	2	0.004**

Values are significant at * = $p<0.05$, ** = $p<0.01$, and *** = $p<0.001$

genetic and physical purity, germination rate, uniformity in sizes, and freedom from seed-borne diseases (Ekwere, 2023; Bareke, 2018; Elias, 2018). This means that to get fluted pumpkin seed of good quality, farmers have to separate big seeds from the small ones, for the uniformity. To obtain good emergence in the field during the production of fluted pumpkin, farmers plant up to three seeds of any size per hole (Odiaka et al., 2008), to increase the chances to get one that will germinate. The lowest emergence (72.2 %) was observed when small seed sizes were slanted at planting, followed by the control (86.11 %), observed when the control seeds were planted flat and the highest (100 %) was observed when small and big seed size were planted flat and slanted at planting respectively. Also, seed emergence increased significantly ($F_{1,4}$ = 22.94, $p<0.01$) across the two planting positions for the small seeds (Figure 1), with the highest (100 %) recorded in (small x flat and big x slant) and the lowest (72.2 %) recorded in (small x slant). These results suggest that small seed size of fluted pumpkin negatively influence its emergence, when these small seeds are planted in a slant position.

Vine length of fluted pumpkin

There was a significant ($p<0.05$) main effect of seed size on the vine length at 5 WAS but no significant ($p>0.05$) main effect of planting position on the vine length of fluted pumpkin was observed. Additionally, a multi-factorial analysis revealed a significant ($p<0.05$, $p<0.01$, $p<0.001$) interaction between seed size and planting position on the vine length at all periods of observation (Table 2).

The shortest (63.79 cm) vine length observed at 5 WAS, was recorded on the control seeds planted in flat position and the longest (89.70 cm) recorded on the big seeds planted flat, (Table 3). This differed significantly across the different seed sizes using the flat ($F_{2,6}$ = 5.06, $p<0.05$) and slant ($F_{2,6}$ = 8.14, $p<0.01$) seed planting positions. At 8 WAS, the shortest vine length (105.62 cm) was observed on small seeds slanted at planting

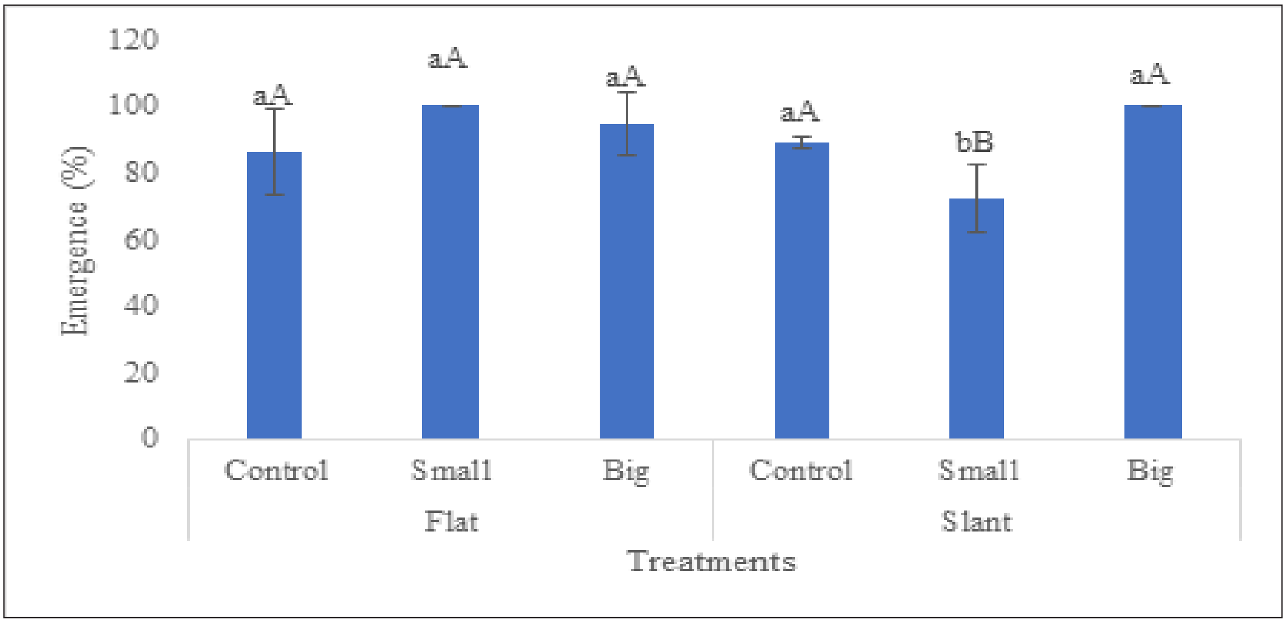

Figure 1: Effect of seed position and seed size on the seed emergence of pumpkin at 5, 8 and 11 weeks after sowing (WAS).

Data (means ± s.d) within bars with different letters are significantly different (Tukey HSD, $p<0.05$) while data means with different uppercase letters are significantly different (Tukey HSD, $p<0.05$). Seed emergence is a critical initial stage in the growth of plants (Bareke, 2018) such as fluted pumpkin, and in this work, it was significantly influenced by both seed size and planting position. Results indicates that large seeds positioned at flat exhibit higher emergence rates compared to smaller seeds positioned slant at planting. This can partially be attributed to the larger food reserves in big seeds, which provide the necessary energy for the initial growth stages.

and the longest (150.89 cm) was observed on the same seed size but planted flat. A significant increase ($F_{2,6}$ = 36.04, p<0.05) was observed at 8 WAS only when the seeds were slanted at planting. Also, at 11 WAS the shortest vine length (135.83 cm) was observed on the small seed sizes slanted at planting and the longest was observed where small seeds were planted flat. However, at 11 WAS, significant differences ($F_{2,6}$ = 33.22, p<0.01) were only observed where the seeds were slanted at planting, but not when seeds were planted in the flat position. Vine length increased significantly across the different planting positions at 5 WAS for the control seed size ($F_{1,4}$ = 7.69, p<0.05) and the small seed size ($F_{1,4}$ = 9.27, p<0.05), and at 11 WAS for the small seed size ($F_{1,4}$ = 14.71, p<0.02). These results follow the same trend as emergence, indicating that, small seed size of fluted pumpkin negatively influence the vine length, when planted in a slant position. The length and diameter of the vines are crucial indicators of the plant's overall health and growth potential (Pandey et al., 2017). Results has shown that seeds planted with the pointed (micropylar) end place horizontally tend to produce longer and thicker vines. This planting orientation ensures that the emerging shoot can grow upwards without obstruction, facilitating better growth.

Vine diameter of pumpkin

There was a significant (p<0.01) main effect of seed size on the vine diameter of fluted pumpkin at 8 WAS and 11 WAS but no significant main effect of planting position on the vine diameter of pumpkin was observed. In addition, a multi-factorial analysis revealed a very significant (p<0.01, p<0.001) interaction between seed size and planting position on the vine length of pumpkin at all periods of observation (Table 2).

The vine diameter varied significantly (p<0.05) across treatments and time (Table 3). At 5 WAS, the vine diameter ranged from 3.32 cm (slant x small) to 4.95 cm (slant x control) with a significant increase ($F_{2,6}$ = 23.00, p<0.01) observed only when the seeds were slanted at planting. Again, there was a significant increase in the vine diameter at 8 WAS for both the slant ($F_{2,6}$ = 23.94, p<0.01) and flat ($F_{2,6}$ = 16.34, p<0.01) planting positions with the smallest vine diameter (5.48 cm) observed on the small seed size planted slant and the largest (8.65 cm) observed when small seeds were planted flat and also when big seeds were slanted at planting. Furthermore, at 11 WAS the largest (15.59 cm) vine diameter was observed on plots where small seeds were planted flat and on plots where the big seeds were slanted at planting. The smallest vine diameter was observed on plots with small seeds slanted at planting (8.55 cm) with significant differences occurring both when the seeds were slanted at planting ($F_{2,6}$ = 11.75, p<0.01) and when the seeds were planted in the flat position ($F_{2,6}$ = 17.02, p<0.01). Also, planting position across the two seed sizes significantly increased the number of nodes only at 5 WAS ($F_{1,4}$ = 32.96, p<0.01), 8 WAS ($F_{1,4}$ = 115.52, p<0.001) and 11 WAS ($F_{1,4}$ = 23.95, p<0.01) all when small fluted pumpkin seeds were planted. These results reveal that vine diameter of fluted pumpkin is negatively affected by small seed size, when planted in the slant position.

Table 2: Analysis of variance for the effect of planting position and seed size on the vine length, vine diameter and number of nodes of pumpkin at 5, 8 and 11 weeks after sowing (WAS)

Source of Variation	Weeks After Sowing (WAS)	Vine Length		Vine Diameter		Number of Nodes	
		F	p-value	F	p-value	F	p-value
Planting Position x Seed Size	5WAS	7.216	0.009**	6.859	0.010**	5.072	.025*
	8WAS	17.115	0.000***	21.314	0.000***	3.188	NS
	11WAS	3.952	0.048*	17.356	0.000***	7.873	0.007**
Planting Position	5WAS	0.106	NS	0.719	NS	1.444	NS
	8WAS	1.817	NS	4.442	NS	0.007	NS
	11WAS	1.210	NS	0.062	NS	0.533	NS
Seed Sizes	5WAS	4.309	.039*	3.672	NS	0.013	NS
	8WAS	0.768	NS	17.877	0.000***	0.594	NS
	11WAS	2.368	NS	10.869	0.002**	1.857	NS

Values are significant at * = p<0.05, ** = p<0.01, and *** = p<0.001; NS = not significant

Table 3: Effect of planting position and seed size on the vine length and vine diameter of pumpkin at 5, 8 and 11 weeks after sowing (WAS)

Weeks After Sowing	Seed Size	Vine Length (cm)		Vine Diameter (cm)	
		Flat	Slant	Flat	Slant
5 WAS	Control	63.79±11.37aA	82.92±3.65aB	3.98±0.91aA	4.95±0.38aA
	Small	82.56±7.33abA	66.74±5.22bB	4.55±0.26aA	3.32±0.27bB
	Big	89.70±11.64aA	82.56±7.33aA	4.91±0.66aA	4.55±0.26aA
8 WAS	Control	131.68±3.45aA	130.44±4.11bA	5.96±0.65bA	7.16±0.82bA
	Small	150.89±7.03aA	105.62±2.79cA	8.65±0.17aA	5.48±0.48cB
	Big	122.72±22.45aA	148.89±9.65aA	8.50±0.90aA	8.65±0.17aA
11 WAS	Control	146.94±29.91aA	149.98±4.41bA	7.74±1.31bA	10.61±1.96bA
	Small	171.06±14.52aA	135.83±6.50cB	15.59±2.13aA	8.55±1.28bB
	Big	161.91±11.24aA	171.06±4.84aA	12.04±1.38aA	15.59±2.13aA

Data sets within rows with different uppercase letters are significantly different, while data within columns with different lowercase letters are significantly different (Tukey's HSD, $P<0.05$).

Number of nodes of pumpkin

There was no significant ($p>0.05$) main effect of seed size and planting position on the number of nodes of pumpkin at all periods of observation. However, a multi-factorial analysis revealed a significant interaction between seed size and planting position on the number of nodes at 5 WAS and 11 WAS (Table 2).

At 5 WAS, the total number of nodes observed on the pumpkin plant ranged from 11.00 (flat x big) to 13.67 (slant x big), (Table 4) with a significant increase ($F_{2,6} = 5.53$, $p<0.05$) observed only when the seeds were slanted at planting. However, seed sizes and planting position did not significantly increase the number of nodes at 8 WAS. On the other hand, at 11 WAS the smallest number of nodes were observed on plots where small seeds were slanted at planting (12.83) and the largest number (18.72) observed on plots where small seeds were planted flat and the big seeds slanted at planting (Table 4) with a significant difference observed only when the seeds were slanted at planting ($F_{2,6}$ = 29.60, $p<0.01$). Also, planting position across the different seed sizes significantly increased the number of nodes when small pumpkin seeds were planted at 5 WAS ($F_{1,4}$ = 32.97, $p<0.01$) and 8 WAS ($F_{1,4}$ = 115.52, $p<0.001$), and 11 WAS when ($F_{1,4}$ = 23.95, $p<0.01$) when larger seed sizes were planted. The number of nodes and the length of internodes are essential for the structural integrity and productivity of the plant (Pandey et al., 2017). Results have observed that fluted pumpkin seeds planted in a flat or horizontal position, result in an optimal number of nodes and internodes. This positioning may help in balanced growth, preventing the plant from becoming too leggy or too compact.

These results join the previous observations suggesting that the number of nodes in fluted pumpkin plant is negatively influenced by small

Table 4: Effect of planting position and seed size on the number of nodes and internode length of pumpkin at 5, 8 and 11 weeks after sowing (WAS)

Weeks After Sowing	Seed Size	Number of Nodes		Internode Length (cm)	
		Flat	Slant	Flat	Slant
5WAS	Control	11.22±2.53aA	13.33±0.58Aa	5.04±0.76bA	5.77±0.68aA
	Small	13.33±0.58aB	11.06±1.27aA	6.74±0.92aA	5.67±0.12aA
	Big	11.00±1.73aA	13.67±1.15aA	7.30±0.41aA	6.74±0.92aA
8WAS	Control	13.67±1.15aA	13.33±1.53aA	8.16±0.99aA	8.90±1.21bA
	Small	13.78±1.60aA	12.00±1.73aA	9.57±2.84aA	8.23±0.90abA
	Big	11.50±0.33aA	13.78±1.60aA	10.92±0.96aA	10.63±0.26aA
11WAS	Control	14.50±3.77aA	13.89±1.71bA	11.07±1.25aA	9.29±1.25abA
	Small	18.72±2.87aA	12.83±1.15bB	10.63±0.26aA	10.40±0.46abA
	Big	14.50±1.01aA	18.72±1.25aA	11.10±1.35aA	11.90±1.40aA

Data sets within rows with different uppercase letters are significantly different, while data within columns with different lowercase letters are significantly different (Tukey's HSD, $p<0.05$).

seed size, if these small seeds are planted in a slant position.

Significant main effect of seed size obtained for several parameters evaluated, where big seed size improved the emergence, vine diameter, leaf area, fresh yield, and fresh marketable yield, partially agrees with the hypothesis that the big seed size of fluted pumpkin will improve plant growth and yield. Farmers usually plant all seeds from the pod of fluted pumpkins (Odiaka et al., 2008), be they small or big size. This can compromise the emergence and growth of fluted pumpkins as observed in this study.

Number of branches, number of leaves, and petiole length of pumpkin

There was no significant main effect of seed size and planting position on the number of branches, number of leaves, and petiole length of pumpkin at all periods of observation. Meanwhile, a multi-factorial analysis revealed a significant (p<0.05) interaction between seed size and planting position only on the number of branches at 11 WAS with no significance observed on the number of leaves and petiole length at all periods of observation (Table 5). The branching pattern of plants can be influenced by the planting arrangement and density (Haque & Sakimin, 2022), the seed size, and its planting position. Fluted pumpkin seeds, when planted at an appropriate position, tend to produce more branches. This could be because the appropriate position or angle allows better root establishment and nutrient uptake, promoting more vegetative growth.

Leaf area, fresh leave yield and fresh marketable yield of pumpkin

There was a significant (p<0.05) and very significant (p<0.001) main effect of seed size and planting position on the leaf area of pumpkin at 8 WAS and 11 WAS but no significant main effect of seed size and planting position was observed at 5 WAS. Furthermore, a multi-factorial analysis revealed a very significant (p<0.001) interaction between seed size and planting position on the leaf area of pumpkin at 8 WAS and 11 WAS (Table 6).

Leave yield There was a significant (p<0.01) main effect of seed size on the leave yield of pumpkin at all periods of observation. Also, planting position significantly (p<0.01) influences the leave yield of pumpkin only at 11 WAS. Additionally, a multi-factorial analysis revealed a significant (p<0.01) interaction between seed size and planting position on the leaf yield of fluted pumpkins at all periods of observation (Table 6).

The significant main effect of seed size was obtained for several parameters, where big seed size improved the emergence, vine diameter, leaf area, fresh yield, and fresh marketable yield, although not for the number of branches, number of leaves, and petiole length. This partially agrees with the hypothesis that the big seed size of fluted pumpkin will improve plant growth and yield, which also corroborates the results obtained by Fayeun et al. (2021). At maturity, fluted pumpkin plant bear fruits that contain averagely 60 seed

Table 5. Analysis of variance for the effect of planting position and seed size on the number of branches, number of leaves, and petiole length of pumpkin at 5, 8, and 11 weeks after sowing (WAS)

Source of Variation	Weeks After Sowing	Number of Branches		Number of Leaves		Petiole Length	
		F	P-value	F	P-value	F	P-value
Planting Position x Seed Size	5 WAS	0.392	NS	1.212	NS	1.737	NS
	8 WAS	0.099	NS	1.850	NS	0.540	NS
	11 WAS	4.053	0.045*	0.916	NS	0.347	NS
Planting Position	5 WAS	0.026	NS	0.176	NS	0.008	NS
	8 WAS	0.055	NS	0.002	NS	0.581	NS
	11 WAS	1.969	NS	0.560	NS	0.065	NS
Seed Sizes	5 WAS	0.692	NS	0.692	NS	0.020	NS
	8 WAS	0.851	NS	0.210	NS	0.142	NS
	11 WAS	0.156	NS	0.825	NS	0.152	NS

Values are significant at * = p<0.05, ** = p<0.01, and *** = p<0.001; NS = not significant

(Akoroda, 1990b), but these seeds are of different sizes.

Figure 2 shows the effect of seed size and planting position on the leave yield of fluted pumpkin. The lowest (0.06 $t.ha^{-1}$) leave yield observed at 5 WAS, was recorded on the control seeds planted flat and the highest (0.09 $t.ha^{-1}$) leave yield was recorded on the small and big seeds planted flat and slanted at planting respectively. Also, there was a significant increase in leave yield at 5 WAS across seed sizes planted flat ($F_{2,6}$ = 18.98, p<0.01) and slanted at planting ($F_{2,6}$ = 13.74, p<0.01). Comparable observations were made at 8 WAS where the leave yield increased significantly when the seeds were planted flat ($F_{2,6}$ = 13.50, p<0.01) and also when the seeds were slanted ($F_{2,6}$ = 24.34, p<0.01) at planting with the smallest (0.046 $t.ha^{-1}$) leaf yield observed in the control seed size planted flat and the highest (0.092 $t.ha^{-1}$) leaf yield observed when the big seed sizes were slanted at planting. Furthermore, the same observation was made at 11WAS where the leave yield increased significantly when the seeds were planted flat ($F_{2,6}$ = 16.28, p<0.01) and also when the seeds were slanted at planting ($F_{2,6}$ = 25.23, p<0.01) with the smallest (0.03 $t.ha^{-1}$) leave yield observed in the control seed sizes planted flat and the highest (0.05 $t.ha^{-1}$) leave yield was observed when the small seed sizes were planted flat. In addition, leave yield increased significantly across the different planting positions at 5 WAS ($F_{1,4}$ = 113.54, p<0.05) for the control seed size, at 8 WAS for the small seed size ($F_{1,4}$ = 20.94, p<0.05) and big seed size ($F_{1,4}$ = 87.49, p<0.01) and at 11 WAS ($F_{1,4}$ = 44.88, p<0.01) for the big seed size. Previous results obtained in this study are related to this on leave yield of fluted pumpkin which is negatively affected by small seed size (Fayeun et al., 2021), if planted in a slant position. Furthermore, both the control and big seed sizes planted in the flat position positively influenced the leaf yield of fluted pumpkin at 11 WAS.

Fresh marketable weight (yield) There was a significant (p<0.01) main effect of seed size on the fresh marketable yield of pumpkin at all periods of observation. Also, planting position significantly influences the fresh marketable yield of pumpkin only at 8 WAS. Also, a multi-factorial analysis revealed a significant (p<0.01) interaction between seed size and planting position on the fresh marketable yield of pumpkin at 8 WAS and 11 WAS (Table 6).

Figure 3 shows the effect of seed size and planting position on the fresh marketable yield of fluted pumpkin. The fresh marketable yield ranged between 0.11 (flat x control and slant x control) and 0.15 t/ha (flat x small and slant x big) at 5 WAS and increased significantly ($F_{2,6}$ = 59.17, P<0.001) only when the seeds were slanted at planting. At 8 WAS, the fresh marketable yield of fluted pumpkin ranged between 0.41 $t.ha^{-1}$ (slant x small) and 0.69 $t.ha^{-1}$ (flat x small and slant x big) and increased significantly when the seeds were slanted ($F_{2,6}$ = 128.79, p<0.01) during planting and when the seeds were planted flat ($F_{2,6}$ = 42.54, p<0.001). Similar observations were made at 11 WAS where the fresh marketable yield ranged from 0.49 (slant x small) – 0.71 $t.ha^{-1}$ (flat x small and slant x big). Furthermore, the different seeds sizes either

Table 6: Analysis of variance for the effect of planting position and seed size on the leaf area (cm^2) of pumpkin at 5, 8 and 11 weeks after sowing (WAS)

Source of Variation	Weeks After Sowing	Leaf Area		Leave Yield		Fresh Marketable Yield	
		F	p-value	F	p-value	F	p-value
Planting Position x Seed Size	5 WAS	1.412	NS	19.503	0.000***	3.052	NS
	8 WAS	31.104	0.000***	30.936	0.000***	156.998	0.000***
	11 WAS	100.653	0.000***	39.428	0.000***	50.140	0.000***
Planting Position	5 WAS	0.003	NS	0.325	NS	1.068	NS
	8 WAS	4.931	0.046*	0.856	NS	17.119	0.001***
	11 WAS	40.008	.0000***	10.566	0.007**	0.050	NS
Seed Sizes	5 WAS	0.107	NS	13.570	0.001***	6.037	0.015*
	8 WAS	25.659	0.000***	5.225	0.023*	70.169	0.000***
	11 WAS	628.461	0.000***	4.209	0.041*	14.199	0.001***

Values are significant at * = p<0.05, ** = p<0.01, and *** = p<0.001; NS = not significant

https://doi.org/10.21704/pja.v8i2.1997

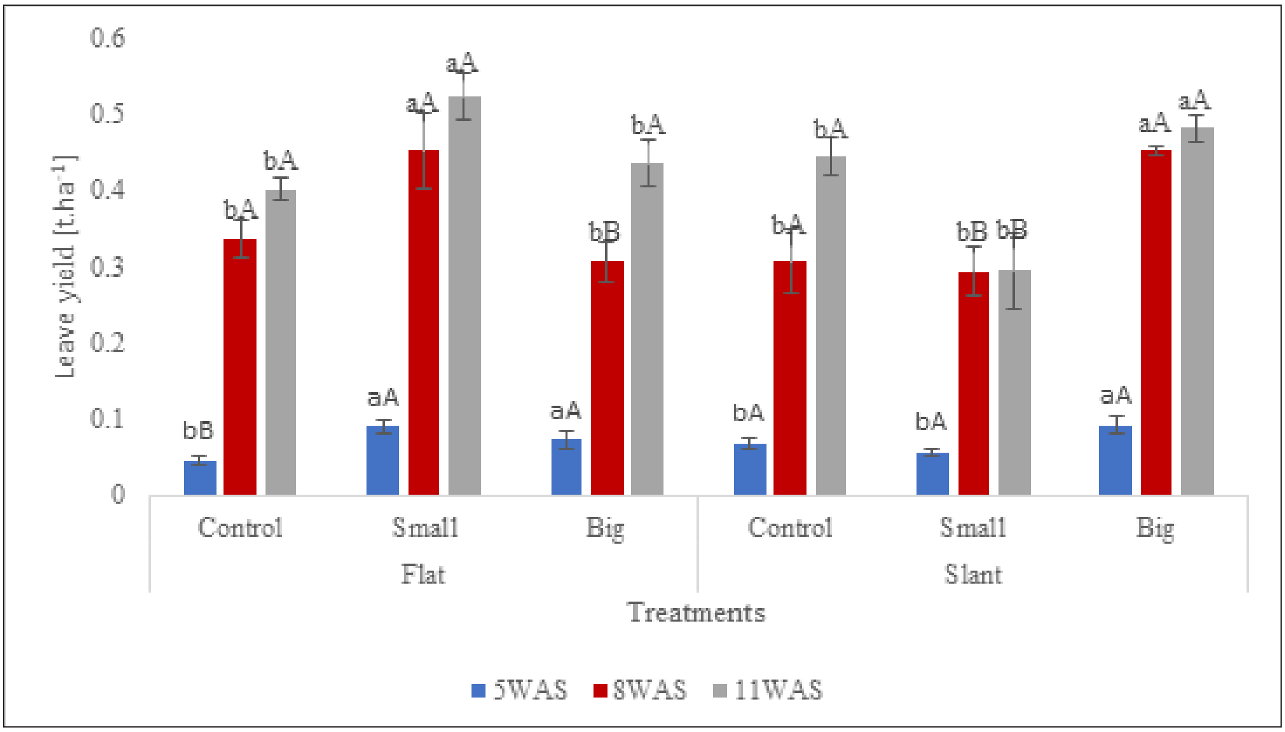

Figure 2: Effect of seed position and seed size on the leave yield ($t.ha^{-1}$) of pumpkin at 5, 8 and 11 WAS (weeks after sowing).

Data (means ± s.d) within bars with different letters are significantly different (Tukey HSD, $p<0.05$) while data means with different uppercase letters among colors are significantly different (Tukey HSD, $p<0.05$).

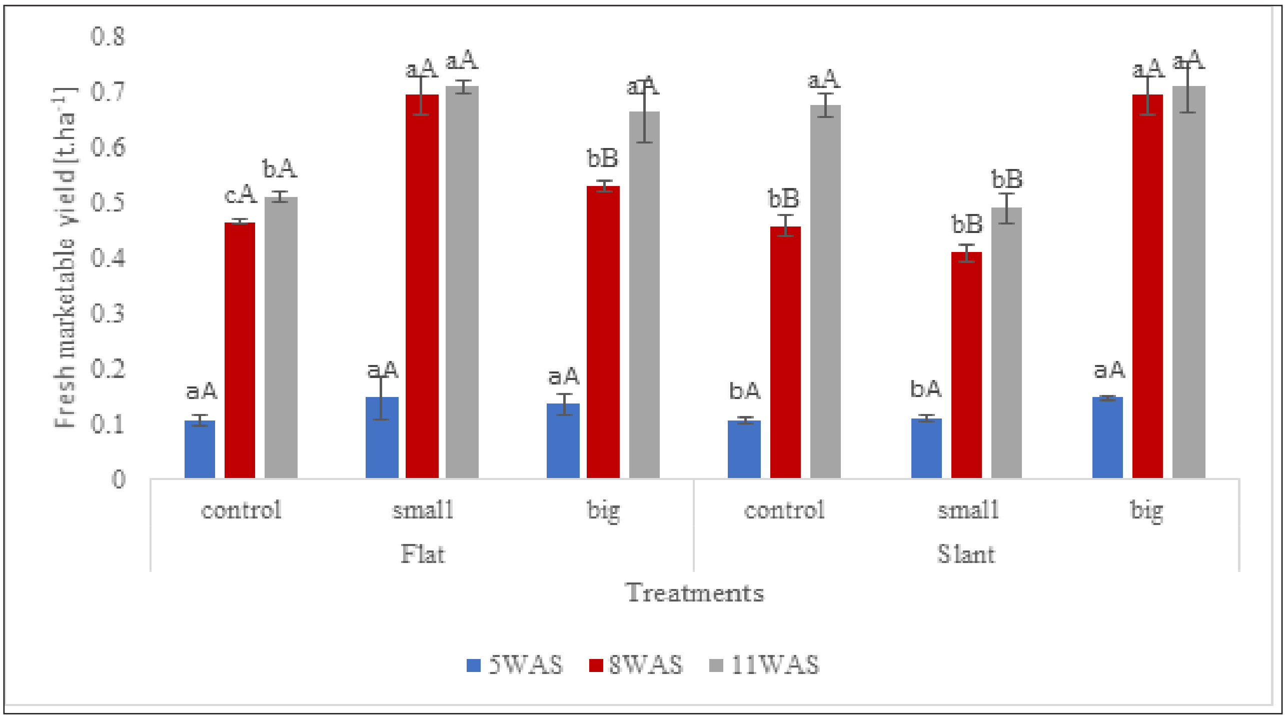

Figure 3: Effect of seed position and seed size on the fresh marketable yield ($t.ha^{-1}$) of pumpkin at 5, 8 and 11 WAS (weeks after sowing).

Data (means ± s.d) within bars with different letters are significantly different (Tukey HSD, $p<0.05$) while data means with different uppercase letters among colors are significantly different (Tukey HSD, $p<0.05$).

planted flat ($F_{2,6}$ = 43.81, p<0.001) or slanted ($F_{2,6}$ = 54.34, p<0.001) at planting significantly affected the fresh marketable yield at 11 WAS. Also, there was a significant main effect of planting position at 8 WAS for the control ($F_{1,4}$ = 145.03, p<0.001), small ($F_{1,4}$ = 179.20, p<0.001) and big ($F_{1,4}$ = 64.84, p<0.01) seed sizes, and at 11 WAS only for the small seed size ($F_{1,4}$ = 162.82, p<0.001). These results reveal that like for the other parameters evaluated in this study, the fresh marketable yield of fluted pumpkin was also not positively affected by small seed size, when slanted during planting.

Planting seed in a slant position may not ease contact between seed and the soil and this slows down the emergence and growth of the fluted pumpkin plants as observed in this study. On the contrary, planting fluted pumpkin in a flat position allowed a better performance as compared to the slant position because of the direct contact of the germ with the soil, which supports our hypothesis that the planting position influences plant growth and yield. Odiaka et al. (2008) revealed that seeding method is one of the factors that caused variations in the shoot yield of fluted pumpkin. Fluted pumpkin seeds have flat and oval shape and classified as quite large with a length of 3.4 cm to 4.9 cm (Okoli & Mgbeogu, 1983). These features may facilitate the germination of fluted pumpkin seed positioned flat during planting.

This study revealed a significant interaction between seed size and planting position. Small seed size of fluted pumpkin negatively influenced its emergence (Kumar et al., 2023), the length and diameter of vine, the number of branches at 11 WAS, the leaf yield and the fresh marketable yield when these small seeds are planted in a slant position. These results agree with the hypothesis that the combined effect of seed size and planting position will affect the growth and yield of fluted pumpkin. These findings are significant because they highlight the fact that a good combination of small seed size planted in the flat position can improve the performance of such seeds, particularly for small scale farming communities where access to high quality seed (with 100 % homogeneity) is limited and often unaffordable for many small-scale farmers with limited means (Osuji et al., 2022). It is the case for Cameroon where in general, small holders' farmers rarely use certified seeds and particularly for vegetable production (Tata et al., 2016). The use of poor seed quality, with respect to the small size as demonstrate in this study will not allow farmers achieve the expected yield of fluted pumpkin (Kumar et al., 2023). Farmers usually plant all seeds from the pod of fluted pumpkin, and in any position, without caring about the position of the hilum (hilum up, hilum down or hilum sideways) (Odiaka et al., 2008). In this study, we demonstrated the effectiveness of seed management practices on the emergence, growth and yield of fluted pumpkin leading to significant increase of leaves production.

Leaf area is a direct indicator of the photosynthetic capacity (Hirose et al., 1997) and overall growth and health of the plant. Results indicate that seeds planted with the flat position produce leaves with a larger surface area. This orientation likely facilitates better root-soil contact, leading to enhanced nutrient absorption and leaf development. Ultimately, the yield of fluted pumpkin is the most important parameter for farmers. Results showed that a combination of small or large seeds and flat planting position yields the highest production. This combination ensures robust initial growth, better vine development, and an optimal number of branches and leaves, all contributing to higher yields.

Conclusion

Authors have studied in isolation the effect of seed size and the position of hilum on the germination of fluted pumpkin, but most of these works have not looked at the combination of the seed size and planting position. This research aimed to investigate the effect of planting position and seed size on growth parameters and yield of fluted pumpkin. It has provided compelling evidence of how seed management practices can improve the fluted pumpkin seed system and contribute to its good transformation. This work has shown the effect of the position of fluted pumpkin seed in the soil during planting on the emergence and growth. This result is important and can be use while developing recommendations for fluted pumpkin seed system. All the viable seeds, either big or small from the fluted pumpkin pod evaluated emerged and performed well during growth, as far as they are planted in the flat position.

Results from this work have revealed that the flat position of fluted pumpkin seed during planting positively influences the emergence, growth and yield. The yield of fluted pumpkin at 11 weeks after planting was significantly high when big seeds were planted in the flat position as compare to small seeds also planted flat. But on the contrary, no difference was observed between the same big seeds and small seeds all planted in the slant position; in this case, the seed size does not affect the emergence and growth, meanwhile, the position appears to be a very important factor to be taking into account during planting. These findings can help farmers optimize their planting strategies to achieve maximum productivity. By understanding and applying these insights, fluted pumpkin cultivation can be improved, leading to enhanced food security and economic benefits for the regions that produce and consume this important crop. There is a need to carry out more work to understand the reasons behind the good performance of seeds planted in the flat position and how to recommend such practice to farmers.

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Conflict of interest

The authors declare that they have no conflict of interest.

Author contribution

DML, FAE, CSUH: conceptualized the study and drafted the manuscript, BTN, AN-BA, BMI, MA, DA: conducted analyses and literature review, DM-L, SC: coordinated the study and manuscript preparation. All authors read and approved the final manuscript draft.

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