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Assessment of Seed Position as Index of Selection for Superior Seed Morphometric Attributes in Fluted Pumpkin (*Telfairia occidentalis*) Fruit

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ABSTRACT

Pumpkin production in Nigeria is affected by non-availability of high quality seeds and information on seed position effect on seed morphometric parameters for judicious selections of seeds which is essential for pumpkin production. Matured fruits of ten pumpkin morphotypes were selected and then cut linearly at both ends of stigmatic scar and stalk joints. Seeds from anterior, middle and posterior positions were carefully removed from the fruits, cleaned using wood shavings and thereafter evaluated for five seed metric and five seed physiological parameters in a completely randomized design in three replicates. Data obtained were then subjected to statistical analysis using analysis of variance and significant means were separated using Tukey's HSD test at 5% probability level. The results revealed significant differences in seed metric and physiological parameters of the 10 morphotypes and seed positions in the fruit. Seeds of Ogun, Isa-1 and Abia morphtypes were found to have significant highest seed weight, seed length, seed width and seed thickness than other morphotypes across the seed positions. Seeds at the posterior position in the fruit had highest seed weight, seed length, seed width and number of seeds than those at the anterior and middle portions. Seed weight, seed length, seed width and number of seeds from the posterior portion within fruit was 9-11, 4-7, 5-9 and 48-52 %, respectively superior than those obtained from the middle and posterior portions. Seeds from posterior portion had moderate to highest seed width and number of seeds in Isa-1 and Isa-2 morphotypes. With regards to seed physiological performance, Isa-1 had a consistent superior seedling emergence (69%), seedling vigour index (10.71), leaf length (4.13cm), vigorous vine length (15.51cm) and number of leaves (12). Seeds from the posterior of fruit were significantly superior in seedling emergence, seedling vigour, number of leaves, leaf length and vine length than those values obtained in seeds from anterior and middle portions. The superiority gain in seeds from posterior portion of pumpkin fruit across morphotypes was 10.7-11% in seedling emergence, 8-13 % in seedling vigour index, 12-14 % in number of leaves, 7-13 % in leaf length and 2-12 % in vine length than seeds from middle and anterior portions. Based on superior performance of seeds from the posterior position of pumpkin fruit, in terms of seed metric and physiological parameters, they are therefore recommended for use to obtain an enhanced emergence and growth performance in highly sought fluted pumpkin. Morphotypes Isa-1 and Isa-2 had outstanding performance in seed quality parameters and recommended for future seed improvement strategy.

Keywords: Seed quality, seed emergence, seed physiological quality, seedling vigour and seedling growth.

INTRODUCTION

Fluted pumpkin (*Telfiaria occidentalis* Hook F.) is an important vegetable crop which belongs to the cucurbitaceous group of vegetables. It is an important commercial crop which grows well in low land humid tropics of West Africa especially Nigeria, Ghana and Sierra Leone, which are the major producer of the species (Nkang *et al.*, 2002). In Nigeria, the crop is widely grown in the eastern part of the country, especially in Imo, Anambra, Ebonyi and Abia States. But in recent times, the crop has gained a wide acceptance in South-western Nigeria (Schippers, 2002).

Pumpkin vegetable is available and affordable at a cheaper cost but rich in nutrients especially calcium and phosphorus (TNAU, 2008). The crop is grown mainly for the leaves which constitute an important component of the diet of the people in many West African countries (Gill, 1988). Pumpkin possesses numerous advantageous characters but the production is less due to lack of quality seeds materials. Crop production is affected by the availability of high quality seeds. Pumpkin seeds are extracted from the pods for further regeneration but the seed recovery potential from the fruit is very low (10-30%) (TNAU, 2008).

Seed position in fruit has been reported to affect the quality of seed of pumpkin. Ogbonna (2008) observed differences of pod portions on number of sprout per portion. The effect of seed position on vigour performance was reported by Aremu and Akinwale (2012). The authors observed significant differences in seedling vigour trait among the three seed positions (anterior, middle and posterior portions) examined and found that seedlings from the anterior position had best vigour performance. Ogunmefun (2013) and Adeyemi and Odiaka (2005) reported considerable variations in pod sizes of fluted pumkin for seed metric and physiological quality traits. The authors concluded that pod characteristics could be used as an index of selection for good seed quality in pumpkin.

Exploring seed positions in fruit of pumpkin may provide a judicious way of selecting high quality seeds to pumpkin farmers in order to enhance better land area utilization and

more leaves production and thereby improve their livelihoods. However, there is dearth of information in literature on the effect of seed position on seed metric and physiological quality parameters in some morphotypes of pumpkin grown in Nigeria. Consequent upon this, the research work was initiated to investigate the relative effect of three seed positions in fruit of pumpkin on seed metric and physiological parameters of the morphotypes of the species grown in South-western Nigeria.

MATERIALS AND METHODS

Seed Material and Source

Matured fruits of 10 morphotypes (*Igbara1, Akure, Ondo, Igbara2, Ibule, Ogun, Isa-1, Abia, Isa-2 and Isa-2*) of fluted pumpkin were used for the study. These genetic materials were collected in January, 2013 from the Crop Production Unit of the Federal University of Technology, Akure, Ondo State, Nigeria. Ten large sized fruits were selected for each of the morphotypes.

Seed Preparation

The fruits were cut linearly at both ends of stigmatic scar and stalk joints. Seeds from anterior, middle and posterior positions were carefully removed from the fruits. Seeds from each position were cleaned using wood shavings and then allowed to dry for 24 hrs and thereafter prepared for seed quality evaluation.

Evaluation of Seed Metric Characteristics

There were two factors, namely morphotype at 10 levels and seed position in fruit at 3 levels. In all, there were 90 experimental units (i.e. 10 morphotypes x 3 seed position x 3 replicates). Following the procedure of Kaushik *et al* .(2007) using digital verneir caliper, the following seed characteristics were evaluated on 25 randomly selected clean seeds from each seed position in each morphotypes in three replicates:

i. **Seed length (mm)**: Distance measured between the two ends parallel to the hilum.
ii. **Seed width (mm)**: Distance on the seed measured perpendicular to the seed length.
iii. **Seed thickness (mm):** Thickness of the seed lots was determined from the middle portion of the seed.
iv. **100-seed weight (g):** Mass of 100 randomly selected seeds taken from the total seed in each seed portion in the fruit were weighed.
v. **Number of seeds:** Number of seeds in each position in fruit for each morphotype was counted.

Evaluation of Seed Physiological Quality Characteristics

Clean seeds from each seed position in fruit were evaluated for seed quality traits in the screen house of the College of Plant Science and Crop Production, Federal University of Agriculture, Abeokuta, Ogun State, South-western Nigeria. The experiment was arranged in a 10 x 3 factorial in a completely randomized design with three replicates. There were two factors, namely morphotype at 10 levels and seed position in fruit at 3 levels. In all, there were 90 experimental units (i.e. 10 morphotypes x 3 seed position x 3 replicates). Each replicate consisted of 50 seeds for each seed position and morphotype.

Fifty clean seeds in three replicates were sown in wood boxes for each morphotype in each seed position. Sown seeds were sufficiently supplied water every evening and emerged seedlings were counted daily till when no seedling emerged. The following seed physiological characters were assessed:

i. **Seedling emergence:** At two weeks after sowing, the total number of seeds that sprouted were counted for each morphotype in each replicate. Emerged seedlings were expressed as percentage of seed sown.
ii. **Seedling vigour index (SVI)**: Seedling vigour was calculated by multiplying percentage seedling emergence by the average of seedling shoot length and divided by 100 as was done by Adebisi (2004).
iii. **Number of leaves per seedling:** This was determined by counting number of leaves on 20 randomly selected seedlings for each seed position in each of the morphotype per replicate and average value recorded.
iv. **Leaf length per seedling**: Lengths of 20 randomly selected leaves of 20 seedlings from each seed position in each morphotype per replicate were taken in centimeter (cm) by measuring the horizontal distance from the tip of the leaf to the edge or end of the nodes and average values recorded.
v. **Vine length per seedling:** The vine lengths of 20 randomly selected seedlings from each seed position in each morphotype per replicate were taken in centimeter (cm) by measuring the horizontal distance from the tip of the leaf to the edge or end of the nodes and average values recorded.

Data analysis

Percentage data collected on seedling emergence were first transformed using arcsine transformation before subjecting them to statistical analysis. Data on each parameter were subjected to a two-way analysis of variance and significant morphotype and seed position means were separated using Tukey's HSD test at 5% probability level.

RESULTS

Mean values of seed metric characters for 10 morphotypes of fluted pumpkin across three seed positions within fruit are presented in Table 1. The result revealed that seed weight of *Ogun, Isa-1, Abia and Isa-2* morphotypes (57.37 and 60.18 g) were not significantly higher and they were significantly higher than the weights of the seeds from the other morphotypes seed weight. But *Ogbese* and other morphotypes had statistically similar values except *Igbara-2* with lowest value (42.98 g). Seed length values were

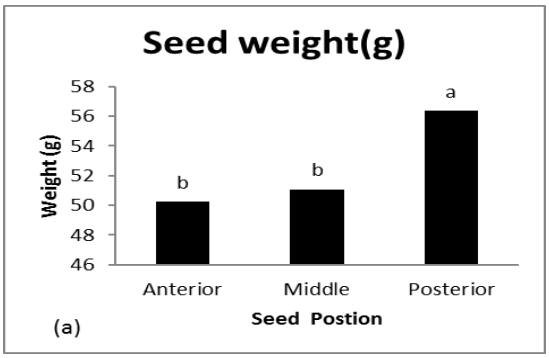
statistically similar among morphotypes (Table 1). Seed width differed significantly between morphotypes. Seed of *Isa-1* recorded the highest value of 36.91 cm which was significantly similar with seed width values of other morphotypes (ranged from 30.07 cm for *Akure* to 36.64 cm in *Abia*) except *Igbara-1* with seed width of 30.07 cm Seed thickness values also differed significantly among various morphotypes. Although *Igbara-1* had the highest seed thickness value, it was only significantly higher than seed thickness value of *Igbara-2* morphotype (Table 1). In terms of number of seeds, *Isa-1 and Igbara-2* had highest values of 39 and 38 seeds, respectively, but they were not significantly different from value of 35 recorded for *Ondo* while *Igbara-1* and *Abia* had significantly lowest values of 22 and 21, respectively, which were significantly lower than the number of seeds recorded for other morphotypes. The ANOVA result indicated that morphotype effect was highly significant ($P \leq 0.01$) on seed width, seed thickness and number of seeds but was significant ($P \leq 0.05$) on seed weight whereas it had non-significant effect on seed length. Seed position effect was significant ($P \leq 0.05$) on seed weight, seed length and seed width but had highly significant ($P \leq 0.01$) effect on number of seeds. The interaction effect of morphotype x seed position was highly significant ($P \leq 0.01$) on seed width and number of seed only.

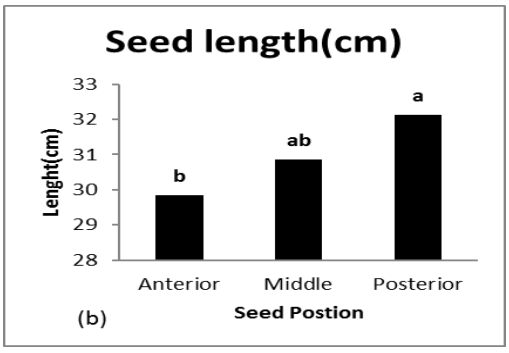
Table 1: Mean values of seed metric parameters of 10 morphotypes of fluted pumpkin across three seed positions in fruit and summary of analysis of variance (ANOVA).

Morphotypes	Seed weight(g)	Seed length(g)	Seed width(cm)	Seed thickness(mm)	Number of seeds
Igbara1	47.21 ^{bc}	29.00 ^{a}	30.07 ^{b}	16.76 ^{a}	22 ^{d}
Akure	48.08 ^{bc}	29.51 ^{a}	30.94 ^{ab}	14.82 ^{ab}	30 ^{bc}
Ondo	47.41 ^{bc}	30.22 ^{a}	32.83 ^{ab}	15.67 ^{a}	35 ^{ab}
Igbara2	42.78 ^{b}	31.15 ^{a}	32.70 ^{ab}	12.75 ^{b}	38 ^{a}
Ibule	49.98 ^{b}	30.70 ^{a}	32.16 ^{ab}	15.44 ^{ab}	23 ^{c}
Ogun	57.37 ^{a}	32.17 ^{a}	35.03 ^{ab}	15.81 ^{a}	26 ^{bcd}
Isa-1	58.09 ^{a}	31.68 ^{a}	36.91 ^{a}	15.84 ^{a}	29 ^{bc}
Abia	57.44 ^{a}	33.20 ^{a}	36.64 ^{ab}	16.23 ^{a}	21 ^{d}
Isa-2	60.18 ^{a}	30.41 ^{a}	36.01 ^{ab}	16.63 ^{a}	39 ^{a}
Ogbese	53.60 ^{ab}	31.44 ^{a}	36.06 ^{ab}	13.95 ^{ab}	27 ^{c}
SE	3.98	1.18	1.42	0.61	3.23
Summary of ANOVA					
Morphotype(M)	*	ns	**	**	**
Seed position(S)	*	*	*	ns	**
MxS	ns	ns	**	ns	**

Means followed by the same alphabet along the column are not different from one another according to Tukey's HSD test at 5% probability level.
** Significant at 1% probability level, * Significant at 5% probability level, SE Standard error, ns Not significant

Results in Figure 1 show that seeds from the posterior end of fruit had statistically highest seed weight compared to two seed positions which recorded statistically similar seed weight. For seed width, posterior portion had the highest values, followed by seeds from the anterior portion while the middle portion showed statistically value lowest. Seed length was highest for seed of posterior end of fruit, followed by seeds from the middle portion of fruit. Highest number of seeds was recorded in the posterior portion of fruit while the two other seed positions had statistically similar values.





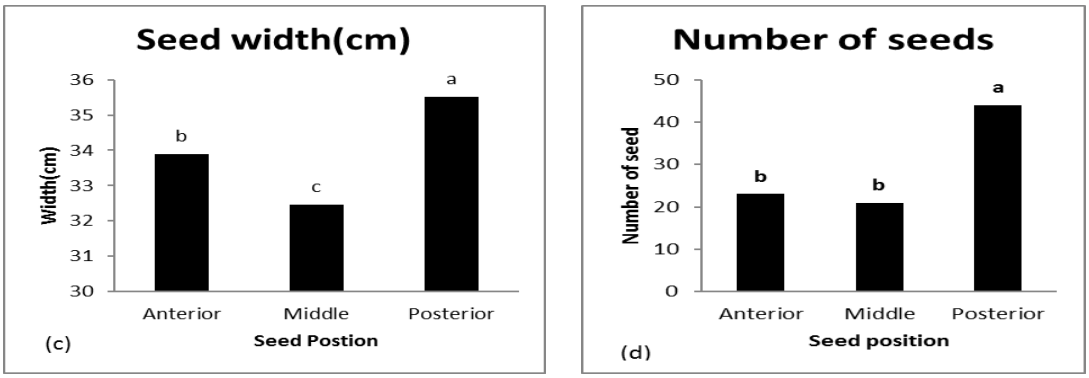


Figure 1: Influence of seed position in fruit on seed metric characters in fluted pumpkin across morphotypes. Bars with same alphabet are not different from one another.

Table 2: Influence of morphotype and seed position in fruit on seed width and number of seeds in fluted pumpkin.

Morphotypes	Seed width(cm)			Number of seeds		
	Anterior	Middle	Posterior	Anterior	Middle	Posterior
Igbara1	33.33^{bc}	24.47^{c}	32.40^{b}	20^{bc}	14^{b}	34^{c}
Akure	30.27^{bc}	31.05^{b}	31.50^{b}	17^{c}	23^{a}	49^{b}
Ondo	33.87^{bc}	29.80^{b}	34.83^{b}	29^{ab}	18^{ab}	59^{a}
Igbara2	31.73^{bc}	31.80^{b}	34.57^{b}	32^{a}	24^{a}	58^{a}
Ibule	30.12^{c}	31.58^{b}	34.77^{b}	19^{c}	15^{b}	36^{b}
Ogun	32.78^{bc}	35.20^{a}	37.10^{a}	18^{c}	21^{ab}	37^{b}
Isa-1	40.20^{a}	33.40^{ab}	37.13^{a}	24^{bc}	24^{a}	38^{b}
Abia	34.77^{b}	35.80^{a}	37.36^{a}	16^{c}	19^{ab}	29^{c}
Isa-2	36.38^{ab}	35.70^{a}	36.53^{ab}	38^{a}	27^{a}	53^{a}
Ogbese	35.45^{b}	35.81^{a}	36.90^{ab}	16^{c}	22^{ab}	42^{b}
SE	2.46	2.46	2.46	5.59	5.59	5.59

Means followed by the same alphabet along the column are not different from one another according to Tukey's HSD test at 5% probability level. SE= Standard Error

Data on the influence of morphotype and seed position on seed width and number of seeds are shown in Table 2. The result indicated that seeds of *Isa-1* at the anterior position had mean seed width of 40.20 cm that was significantly higher than other morphotypes, except *Isa-2*. The width of the seeds of other morphotypes were statistically similar except *Ibule* morphotype seed with statistically lowest value. Also, seeds of *Ogun, Isa-1, Abia, Isa-2 and Ogbese* from the middle position in fruit were found to have statistically highest seed width values (range:33.40 to 35.81cm) with greater seed width values while *Igbara-1* seeds had the lowest middle portion seed width (24.47 cm). Seed width of seeds from the posterior portion of fruit from O*gun, Isa-1, Abia, Isa-1 and Ogbese* morphotypes (range: 36.53 to 37.10 cm) which were statistically similar, were significantly higher than those of the other morphotypes. With respect to number of seeds in each portion of fruit, highest number of seed at the anterior portion of fruit were recorded in *Abia* (38), *Igbara-2* (32) and Ondo (29). Also, the middle portion of fruit from *Isa-2, Isa-1, Igbara-2 and Akure* had highest number of seeds (range: 23 to 27), which were not significantly different from values obtained in *Ogbese, Abia, Ogun and Ondo. Igbara-2* and *Ibule* morphotypes had statistically lowest number of seeds at the middle portion of fruit. In the posterior end of fruit, highest number of seeds were recorded in *Ondo, Igbara-2, and Isa-2* with values of 59, 58 and 53, respectively whereas *Igbara-1* and *Abia* morphotypes had the lowest number of seeds of 34 and 29, respectively.

Table 3: Mean values of seed physiological parameters in 10 morphotypes of fluted pumpkin across seed positions in fruit and summary of analysis of variance (ANOVA).

Morphotypes	Seedling emergence (%)	Seedling vigour index	Number of leaves	Leaf length(cm)	Vine length(cm)
Igbara1	55 [c]	4.50 [e]	8 [c]	2.34 [c]	8.10 [c]
Akure	52 [c]	4.65 [e]	8 [c]	2.36 [c]	9.28 [c]
Ondo	53 [c]	4.59 [e]	10 [b]	2.90 [c]	8.24 [c]
Igbara2	43 [d]	2.42 [f]	5 [e]	1.71 [d]	5.40 [d]
Ibule	46 [d]	6.18 [d]	8 [c]	3.56 [b]	13.74 [b]
Ogun	60 [bc]	8.59 [b]	10 [b]	3.84 [b]	15.98 [a]
Isa-1	69 [a]	10.71 [a]	12 [a]	4.13 [a]	15.51 [a]
Abia	36 [e]	4.74 [e]	7 [d]	3.56 [b]	13.40 [b]
Isa-2	67 [ab]	7.98 [c]	8 [c]	2.39 [c]	11.66 [c]
Ogbese	50 [c]	8.16 [b]	10 [b]	2.72 [c]	16.53 [a]
SE	4.85	0.92	0.46	0.36	1.35
Summary of ANOVA					
Morphotype(M)	**	**	**	**	**
Seed position(S)	**	**	**	*	**
MxS	**	**	**	**	**

Means followed by the same letter along the column are not different from one another according to Tukey's HSD test at 5% probability level.. SE= Standard Error. ** Significant at 1% probability level, * Significant at 5% probability level,

In Table 3, seedling emergence values among morphotypes differed across seed positions within fruit. Morphotypes *Isa-1* (89 %) and *Isa-2* (67 %) recorded statistically highest values when compared with other morphotypes but seeds of *Ogun* with 60 % emergence was stastically higher than values obtained in other morphotypes. With respect to seedling vigour, significantly highest value was recorded in *Isa-1* (10.71) compared to other morphotypes, but O*gbese* (8.16) and *Ogun* (8.59) were still statistically higher in seedling vgour over other morphotypes while *Igbara-2* had significantly lowest vigour value of 2.42. Number of leaves statistically varied among some morphotypes. *Isa-1* morphotype had significantly highest value of 12, but *Ondo, Ogun and Ogbese* with value of 10 leaves were statistically higher compared to other morphotypes. Similarly, leaf length values statistically differed among some morphotypes. *Isa-1* had highest value of 4.13 cm, followed by *Abia, Ogun and Ibule* with values ranging from 3.36- 3.84cm while other morphotypes had statistically similar values except *Igbara-2* with statistically lowest value of 1.71 cm. For vine length, O*gbese, Isa-1 and Ogun* had significant highest values of between of 15.51 and 16.53 cm when compared with other morphotypes, followed by *Ibule* (13.74 cm) and *Abia* (13.40 cm) but *Igbara-2* had statistically lowest vine length value of 5.40 cm. The ANOVA result revealed that morphotypes effect were highly significant ($P \leq 0.01$) on the five seed physiological parameters examined whereas the seed position effect was highly significant ($P \leq 0.01$) on seedling emergence, seedling vigour index, number of leaves and vine length but had significant effect $P \leq 0.05$) on leaf length. The interaction effect of morphotypes x seed position was highly significant ($P \leq 0.01$) on all the five seed physiological attributes examined.

Mean values of seed physiological parameters as affected by three seed positions of fruit of pumpkin across morphotypes are displayed in Figure 2. The result revealed that seeds from the posterior portion of fruit had significantly highest seedling emergence (56%) than other morphotypes but seeds of other two positions had statistically similar values. For seedling vigour index, seeds from posterior and anterior positions of fruit gave significantly highest vigour level of 6.79 and 6.11, respectively than seed in the middle end of fruit. With respect to number of seeds, significantly highest value was recorded in posterior portion of fruit with value of 9.47 seeds but the two other seed positions in fruit had statistically similar values. Seeds from the posterior portion of fruit had significantly highest leaf length of 3.04 cm, which was not significantly different from value of 2.48 cm from anterior position in fruit. Also, seeds from posterior end of fruit had statistically highest vine length (12.37 cm), which was not statistically different from value of 12.45 cm from middle portion of fruit but seeds from anterior end of fruit recorded significantly lowest vine length value.

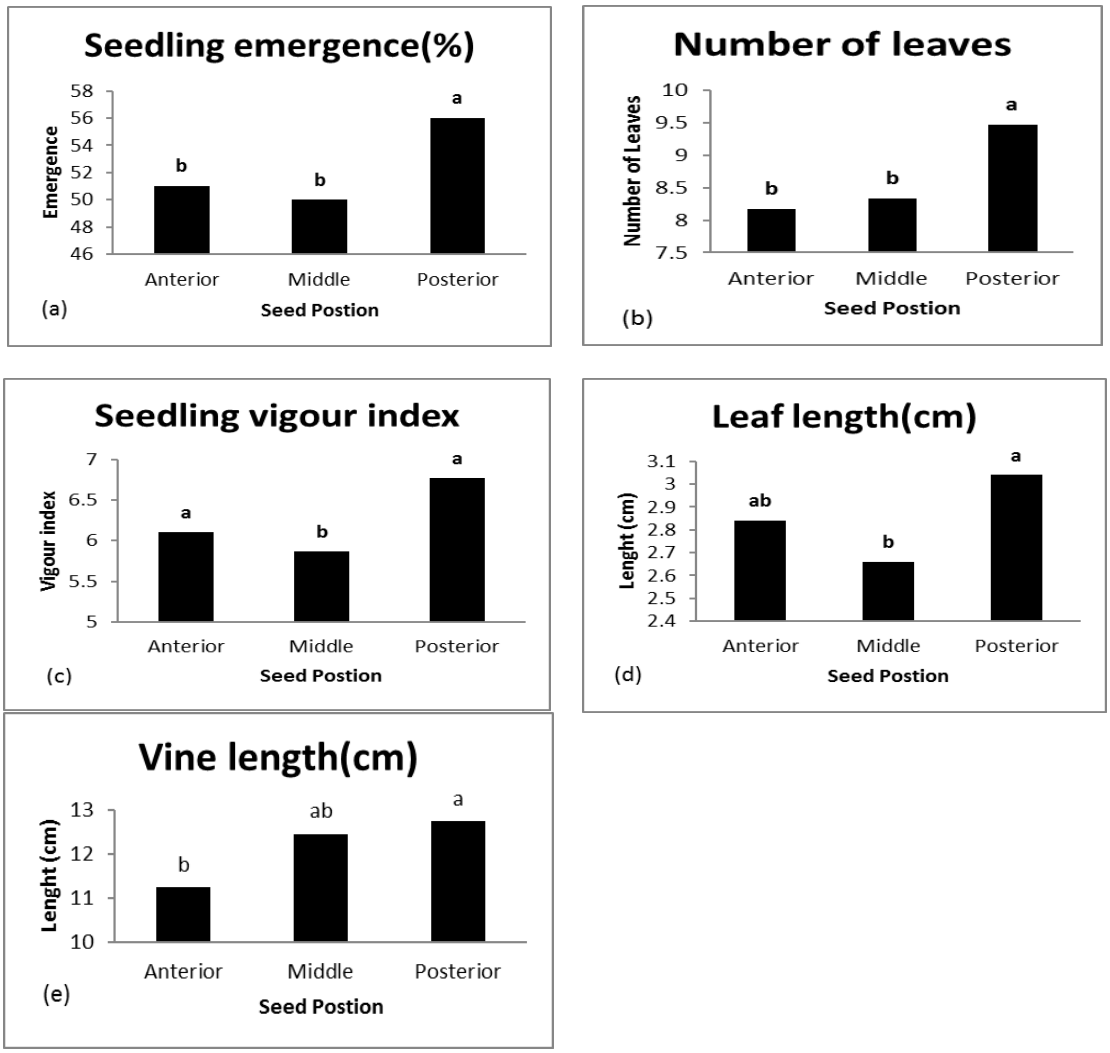


Figure 2: Influence of seed position in fruit on seed physiological parameters in fluted pumpkin across morphotypes. Bars with same alphabet are not different from one another.

Results in Table 4 revealed significant differences in seedling emergence and seedling vigour values among some morphotypes under each of the three seed positions in fruit. A perusal of data on seedling emergence showed that seed from the anterior part of fruit had highest emergence in *Isa-1* (69%) and *Isa-2* (67%) than other morphotypes, which were not statistically different from value of 58 % in *Igbara-1 and Akure* but other morphotypes had statistically similar values, except *Igbara-2* and *Abia* with significant lowest values of 33 and 27 %, respectively. For middle portion of fruit, significantly highest seedling emergence values of 67 and 69 %, respectively were recorded in in *Isa-1 and Isa-2* morphotypes, which was not statistically different from value of 58 % in *Ogun* but *Ibule* recorded significantly lowest value of 27 %. In posterior end of fruit, significant highest seedling emergence value of 71 % from *Isa-1* morphotype, which was not statistically different from values of between 58 and 65 % from *Isa-2, Ondo, Igbara-2 and Ibule* but *Akure and Abia* gave significantly lowest value of 47 and 40 %, respectively. A close perusal of data on seedling vigour index revealed that seeds from anterior end of fruit in four morphotypes (*Ibule, Ogun, Isa-1 and Isa-2*) were statistically found with highest vigour level (range: 7.07 to 10.17) than other morphotypes, followed by *Ogbese* with 6.90 vigour level but seeds of *Igbara-2* and *Abia* morphotypes from posterior portion of fruit had significantly lowest vigour values of 1.83 and 2.43, respectively. For middle portion of fruit, significant highest seedling vigour were recorded in *Isa-1* (11.17) and *Ogbese* (9.83) than other morphotypes while other morphotypes had statistically similar vigour values, except *Igbara-2* which had significantly lowest value of 1.80. Also, seeds from the posterior end of fruit had significantly highest seedling vigour level in *Ogun* (11.07) and *Isa-1* (10.80), followed by values of 7.97, 7.20 and 7.70 in *Ibule, Isa-2 and Ogbese* morphotypes, respectively but other morphotypes recorded statistically lowest seedling vigour values.

Table 4: Influence of seed position in fruit on seedling emergence and seedling vigour index of 10 morphotypes of fluted pumpkin.

Morphotypes	Seedling emergence (%)			Seedling vigour index		
	Anterior	Middle	Posterior	Anterior	Middle	Posterior
Igbara1	58 ^{ab}	54 ^{b}	53 ^{bc}	4.90 ^{c}	4.67 ^{cd}	3.80 ^{c}
Akure	58 ^{ab}	51 ^{bc}	47 ^{cd}	4.27 ^{c}	4.83 ^{cd}	4.57 ^{c}
Ondo	47 ^{b}	49 ^{bc}	62 ^{ab}	4.57 ^{c}	3.53 ^{d}	5.67 ^{c}
Igbara2	33 ^{c}	38 ^{cd}	58 ^{ab}	1.83 ^{d}	1.80 ^{e}	3.63 ^{c}
Ibule	53 ^{b}	27 ^{d}	58 ^{ab}	7.07 ^{a}	3.47 ^{d}	7.97 ^{b}
Ogun	55 ^{b}	58 ^{ab}	67 ^{ab}	8.93 ^{a}	5.77 ^{bc}	11.07 ^{a}
Isa-1	69 ^{a}	67 ^{a}	71 ^{a}	10.17 ^{a}	11.17 ^{a}	10.80 ^{a}
Abia	27 ^{c}	40 ^{c}	40 ^{cd}	2.43 ^{d}	6.93 ^{bc}	4.87 ^{c}
Isa-2	67 ^{a}	69 ^{a}	65 ^{ab}	10.00 ^{a}	6.70 ^{bc}	7.20 ^{b}
Ogbese	51 ^{b}	51 ^{bc}	49 ^{bc}	6.90 ^{b}	9.83 ^{a}	7.70 ^{b}
SE		8.42			1.60	

Means followed by the same alphabet along the column are not different from one another according to Tukey's HSD test at 5% probability level. SE= Standard Error

Table 5 presents the effect of seed position in fruit on leaf and vine length of ten morphotypes of fluted pumpkin. The resulted showed that significant differences in leaf and vine lengths were recorded under each of the three seed positions in fruit among some morphotypes. Seeds from anterior portion of fruits had significantly highest leaf length in *Isa-1* (4.47 cm) than other morphotypes, which was not statistically different from values in other morphotypes, except *Igbara-2* which had significant lowest value of 1.33 cm. Also, seeds in the middle portion of fruit had significant highest leaf length in *Ogun* and *Isa-1* with values of 4.03 and 4.00 cm, respectively, but these values were not statistically different from other genotypes except *Igbara-2* and *Isa-2* morphotypes with significant lowest values of 1.68 and 1.93 cm, respectively, Similarly, seeds in the posterior portion of fruit were found with significantly highest leaf length values of 4.63 and 4.53 in *Isa-1* and *Ogun* morphotypes, respectively but these values were not statistically different from other genotypes, except *Igbara-1* which had significantly lowest value of 2.00 cm. A cursory look on data on vine length showed that the values statistically differed among some morphotypes under each of the three seed positions in fruit investigated. Significant highest vine length of 15.77 cm was recorded in *Ogun* and *Isa-2* morphotypes, closely followed by *Isa-1* with vine length of 14.50 cm but *Akure* morphotype had significantly the lowest value of 7.20 cm. Also, seeds of *Ogbese* in the middle portion of fruit had significant highest vine length of 19.80 cm, followed by *Abia* morphotype with value of 18.60 cm whereas *Ibule*, *Ogun* and *Isa-1* morphotypes had vine length values greater than 10 cm but *Igbara-2* recorded a significant lowest value of 4.77 cm. For seeds in the posterior end of fruit, significant highest vine length values of 16.50 and 16.23 cm were recorded in *Ogun* and *Ogbese* morphotypes, respectively, followed by value of 15.40 cm in *Isa-1* but *Igbara-2* recorded a significant lowest value of 6.27 cm.

Table 5: Influence of seed position in fruit on seedling leaf length and vine length of 10 morphotypes of fluted pumpkin.

Morphotypes	Leaf length (cm)			Vine length (cm)		
	Anterior	Middle	Posterior	Anterior	Middle	Posterior
Igbara1	2.53^{ab}	2.50 ^{ab}	2.00 ^{b}	8.20 ^{e}	8.73 ^{h}	7.37 ^{g}
Akure	2.30 ^{ab}	2.23 ^{ab}	2.27 ^{ab}	7.20 ^{f}	9.87 ^{g}	10.77 ^{e}
Ondo	3.10 ^{ab}	2.93 ^{ab}	2.67 ^{ab}	9.23 ^{d}	6.77 ^{i}	8.53 ^{f}
Igbara2	1.33 ^{b}	1.68 ^{b}	2.13 ^{ab}	5.17 ^{g}	4.77 ^{j}	6.27 ^{h}
Ibule	3.13 ^{ab}	3.37 ^{ab}	3.27 ^{ab}	13.50 ^{c}	13.93 ^{e}	13.80 ^{c}
Ogun	3.87 ^{ab}	4.03 ^{a}	4.53 ^{a}	15.77 ^{a}	15.67 ^{d}	16.50 ^{a}
Isa-1	4.47 ^{a}	4.07 ^{a}	4.63 ^{a}	14.50 ^{b}	16.63 ^{c}	15.40 ^{b}
Abia	3.23 ^{ab}	3.70 ^{ab}	3.73 ^{ab}	9.43 ^{d}	18.60 ^{b}	12.17 ^{d}
Isa-2	2.97 ^{ab}	1.93 ^{b}	2.37 ^{ab}	15.77 ^{a}	9.50 ^{f}	10.30 ^{e}
Ogbese	2.47 ^{ab}	2.33 ^{ab}	3.37 ^{ab}	13.57 ^{c}	19.80 ^{a}	16.23 ^{a}
SE		1.34			0.45	

Means followed by the same letter along the column are not different from one another according to Tukey's HSD test at 5% probability level. SE- Standard Error

Results in Table 6 showed the influence of seed position in fruit on number of leaves in ten morphotypes of fluted pumpkin. The result revealed that number of leaves statistically differed among the morphotypes under each of the three seed positions in fruit. For the seeds in the anterior end of fruit, significant highest number of leaves was found in *Isa-1* morphotype with 13 leaves, followed by *Ogbese* and *Ondo* with 10 leaves but *Abia* morphotype recorded significant lowest number of leaves (5). Similarly, seeds in the middle portion of fruit showed significant highest number of leaves in *Isa-1* morphotype with 11 leaves, this value was not statistically different from values of 10 and 9 leaves

recorded in *Ogun* and *Igbara-1* morphotypes, respectively, but *Igbara-2* morphotype had a significant lowest value of 4 leaves. For seeds in the posterior end of fruit, significant highest number of leaves was found in *Isa-1* and *Ogbese* morphotypes with values of 13 and 12 leaves, respectively, these values were not significantly different from value of 11 leaves in *Ogun* and *Ondo* morphotypes but *Abia* and *Igbara-1* morphotypes had significant lowest value of 6 leaves.

Table 6: Influence of seed position in fruit on number of leaves of seedling from 10 morphotypes of fluted pumpkin.

Morphotypes	Seed position in fruit		
	Anterior	Middle	Posterior
Igbara1	8 bc	9 ab	7 cd
Akure	7 cd	8 b	10 bc
Ondo	10 b	8 b	11 ab
Igbara2	6 d	4 c	6 d
Ibule	9 bc	8 b	8 cd
Ogun	9 bc	10 ab	11 ab
Isa-1	13 a	11 a	13 a
Abia	5 d	8 b	7 cd
Isa-2	9 bc	6 bc	9 b
Ogbese	10 b	8 b	12 a
SE		1.54	

Means followed by the same letter along the column are not different from one another according to Tukey's HSD test at 5% probability level. SE: Standard Error

DISCUSSION

Seed Metric Characteristics

Seeds extracted from the fluted pumpkin fruits for further regeneration usually have low recovery potential from the fruits (TNAU, 2008). The search for criteria for judicious selection of seeds for cultivation is imperative. The result of this study revealed considerable differences in seed weight, seed width, seed thickness and number of seeds per seed position among the fruits of pumpkin morphotypes. Significant differences were observed among the three seed positions of fruit for all the seed metric characters evaluated except seed thickness. This suggests that selection is possible among the 10 pumpkin morphotypes for superior seed metric characters. The variation in these seed metric characteristics among these fluted pumpkin morphotypes may be due to variation in genetic make-up of the morphotypes examined.

Ogunmefun (2013) had earlier observed significant differences in some mophotypes of fluted pumpkin in respect to seed metric characters across pod sizes and suggested that variation could be due to differences in the genetic constitutions. Significant differences in seed metric characteristics observed among the three seed positions in fruit revealed ample opportunity for selection of seeds within fruit position that can give superior characteristics. The results also showed that seeds of *Ogun, Isa-1, Abia* and *Isa-2* morphotypes were found with higher seed weight, seed length, seed width and seed thickness than the other morphotypes whereas *Igara-2* and *Isa-2* had greater number of seeds (38-39) in fruit than other morphotypes.

The performance of the three seed positions in the fruits brought out the significant superiority of seeds at the posterior end of the fruit, since it had highest seed weight, seed length, seed width and number of seeds per fruits. This was followed by seeds from the middle position of the pods in terms of seed length and width. The increment in seed weight, seed length, seed width and number of seeds in fruit obtained from the posterior portion than seed characters from the middle and anterior portions of pumpkin fruits was 9-11, 4-7, 5-9 and 48-52 %, respectively.

The study also identified significant differences among morphotypes under each of the three seed positions in pumpkin fruits examined with respect to seed width and number of seeds characteristics considered in this study. Seeds from fruits of *Isa-1, Isa*-2, *Ogun, Abia* and *Ogbese* morphotypes obtained from the anterior, middle or posterior portions of the fruits had significant higher mean seed width values of between 35.00 and 40.20 cm than other morphotypes. Similarly, seeds from fruits of *Isa-1, Isa*-2, *Igbara 2, Akure* and *Ondo* morphotypes from the anterior, middle and posterior portions of the fruits had significant higher number of seeds of between 23 and 59 seeds than other morphotypes. In most cases, *Igara-1* had significantly lowest values of seed width and number of seeds under each of the three seed positions in the pumpkin fruits.

Seed Physiological Characteristics

Successful crop production depends on availability of quality seed. Judicious selection criteria for making high quality seeds available to pumpkin growers are desirable. The present study revealed significant differences among the 10 morphotypes for seedling emergence, seedling vigour, leaf length and vine length, thereby providing opportunity to select for morphotypes with good seedling emergence and early seedling growth characteristics and that selection of seeds from different positions in the fruits with superior seed quality is possible. Aremu *et al.* (2013) observed significant differences in seedling characters among three seed positions in pumpkin fruit which is in consonance with our results. Also, significant interaction effect of morphotype x seed position indicated that morphotype exerted significant influence on the variation observed among the three seed positions for all the five seed physiological parameters

examined. Considerable variation in seed quality parameters of different fractions of seeds and pods have been documented by Adebisi *et al.* (2013) and Ogunmefun (2013) in pepper species and pumpkin morphotypes, respectively.

In terms of seed physiological quality performance among the morphotypes across the seed position in fruit, *Isa-1* morphotype had consistent superior seedling emergence, seedling vigour, number of leaves, leaf length and vigorous vine length whereas *Ogun* and *Ogbese* morphotypes had significant higher values of vine length. On the performance of seed physiological quality with respect to three seed positions in fruit across morphotypes, seeds from the posterior portion of fruit were significantly superior in seedling emergence, seedling vigour, number of leaves, leaf length and vine length than the two other seed positions considered in this study. The superiority gain in seeds from posterior portion of fruit was 10.7 to 11 % in seedling emergence, 8 to 13 % in seedling vigour, 12 to 14 % in number of leaves, 7 to 13 % in leaf length and 2 to 12 % in vine length than seeds from middle and anterior portions of pumpkin fruits. The study also revealed that differential responses were observed among some morphotypes under each of the three seed positions investigated with respect to the seedling emergence and seedling growth parameters considered in this study. Seeds in fruit from *Isa-1* and *Isa*-2 morphotypes from the anterior, middle or posterior portion of the fruits had superior seedling emergence than other morphotypes.

CONCLUSION

Variability was observed among morphotypes and three seed positions within fruits evaluated in fluted pumpkin fruits. The performance of the three seed portions in the fruit brought out the significance superiority of seeds from posterior portion (highest seed weight, seed length, width and number of seeds) than other two seed positions (anterior and middle portions of fruit). Four pumpkin morphotypes (*Ogun, Isa-1, Abia* and *Isa-2*) were identified with highest seed weight, length, width and thickness than other morphotypes whereas *Igbara* 2 and *Isa-2* had more seeds in the fruit than other morphotypes.

Seeds from posterior end of fruit from *Isa-1* and *Isa-2* morphotypes had significant highest seed weight and number of seeds. Seeds of *Isa-1* morphotype consistently showed significant highest seed physiological quality (emergence and seedling vigour traits) across three seed positions in fruits. Seeds from posterior portion of fruit were found with significant superior seed physiological quality parameters. Seeds from posterior portion of *Isa-1* morphotype fruit were significantly superior in seedling emergence, seedling vigour, leaf length, vine length and number of leaves. Therefore, based on the superior performance in seed metric and physiological quality parameters across seed positions, seeds from *Isa-1* and *Isa-2* morphotypes are desirable for use. Consequently, these two morphotypes are recommended for future seed improvement programme.

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