

Estimates of Genetic Variability for Seedling Traits in Fluted Pumpkin (*Telfairia occidentalis* Hook. F)

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ABSTRACT An experiment was conducted to evaluate genetic variation among twenty-one fluted pumpkin genotypes for seedling traits. The seeds of the fluted pumpkin were germinated in nursery bags filled with saw dust at the Federal University of Agriculture, Abeokuta and the Federal University of Technology, Akure, Nigeria between July and August, 2013. The experiment was laid out in completely randomized design with three replications. Characters evaluated were emergence percentage (E%), emergence index, emergence index rate, vine length (cm), leaf area (cm²), number of leaves, shoot dry weight (g), and seedling vigour index (SVI). Significant ($P \leq 0.05$) differences were observed among the fluted pumpkin genotypes for the evaluated characters. High E% was observed for genotypes Ftn45 (94.80%), Ftn43 (93.30%), Ftn57 (93.30%), Fte41 (90.0%), Ftn61 (86.70%), and Ftm11 (83.30%). Also, these genotypes had above average values for SVI. High phenotypic coefficients of variation and genotypic coefficients of variation were observed for leaf area (75.44%) and dry shoot weight (55.85%), respectively while heritability estimates above 50% was observed for leaf area (82.0%), dry weight (77.78%), E% (70.84%), and SVI (51.98%). The genetic advance was high for E% (38.37), SVI (38.09), and leaf area. SVI, E%, vine length, and leaf area had significant positive correlation with most of the traits therefore, they can be used as selection criteria in fluted pumpkin. Therefore, genetic improvement of early seedling can be used for selection programme in fluted pumpkin.

Keywords Emergence, Genetic variability, Heritability, Correlation coefficient, Seedling vigour index

INTRODUCTION

Fluted pumpkin, *Telfairia occidentalis* (Hook F.) is one of the most important leaf and seed vegetables of West Africa. It is an indigenous crop of economic, nutritional and medicinal importance in the socio-cultural life of the people of southern Nigeria. Apart from consumption, the crop has significant use for sustainable land management and reclamation. Fluted pumpkin is a very fast growing crawler that branches profusely when the apical dominance is removed (Fayeun 2011) thereby encouraging good ground coverage which suppresses weeds and prevents direct impact of the sun on the soil. In addition, its root system ramifies in the top surface of the soil, thus preventing soil erosion. According to Asian Vegetable

Research Development Centre (1981), planting the crop in raised beds can reduce the effect of flooding during rainy seasons. Soyingbe *et al.* (2012), reported that its waste has potential for improving compost nutrient quality and thus useful as organic manure. Also, it has been reported that it can be used in bioremediation of heavy metal-polluted soil (Obute *et al.* 2001; Wegwu *et al.* 2002).

Despite the importance of this crop, its large scale production is limited by several factors including; inability to distinguish sex at early stage and the preponderance of males in natural populations (Ajayi *et al.* 2006), its recalcitrant nature (Akoroda 1990) and easy loss of viability due to its bulkiness and high moisture content which limit its long-term storage. These problems are compounded by the propensity of the seeds to germinate in

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situ while in fruit. All these affect planting materials and seedling establishment. Limited research work has been directed at solving these identified problems. At present, seed is the only and reliable source of planting material used by farmers in this crop. Some proposed alternatives to seed might not be practicable and seem to be beyond the capability of small holder farmers. For instance, Esiaba (1982), Obiefuna (1995), and Sakpere *et al.* (2011) proposed the use of seed sections, rooted shoot tips, and rooting hormone (IBA) on vine cuttings, respectively.

Seedling parameters play important role in obtaining desirable crop stand (Malik *et al.* 2011). Good seedling vigour influences seed rate and gives crops competitive advantages over weeds and other environmental stresses which could consequently lead to reduced cost of production. Possibly, leaf and seed yield in fluted pumpkin can be predicted at the seedling stage which could help in predicting crop performance at maturity stage. Therefore, knowledge of genetic variability of seedling traits is needed for improvement of this crop. Information on the genetic components of variation, heritability and character association are needed for effective selection in plant breeding.

Reported research work on seedling traits of fluted pumpkin is rare. However, some works have been reported on fruit and seed traits. Odiaka *et al.* (2008) identified size of fruit, seed, leaf, and thickness of vine as trait indicators for quality seed for fluted pumpkin. Chukwudi and Agbo (2014) observed that large sized fruits gave higher seed sizes but medium sized fruits gave higher emergence rate. Attempts to improve the seedling traits of any crop can only be achieved if there is sufficient genetic variability in such traits. Crop improvement is dependent not only on the magnitude of phenotypic variability but also on the extent to which the desirable characters are heritable (Okelola *et al.* 2007). Therefore, it is important to partition phenotypic variation into heritable and non-heritable components and determine how heritable traits associate among themselves. Therefore, this study was carried out with the objective of determining the magnitude of genetic variation of seedling traits and character association in the twenty one fluted pumpkin genotypes across two locations.

Table 1. Places of collection and seed characteristics of the twenty one fluted pumpkin genotypes.

Genotype	Places of collection			Seed weight (g)	Seed length (cm)	Seed width (cm)
	Agro-ecology	State	Town			
Fts33	Rainforest	Osun	Ikeji	20.35	3.37	3.67
Fty28	Rainforest	Oyo	Ibadan	22.45	4.50	4.67
Ftn46	Rainforest	Ondo	Igbara-Oke	16.0	4.20	4.50
Ftn45	Rainforest	Ondo	Akure	24.67	3.20	3.99
Ftm11	Rainforest	Imo	Orlu	19.0	3.30	3.70
Ftk16	Rainforest	Ekiti	Emure	8.0	3.0	2.90
Fte42	Derived savannah	Enugu	Enugu	11.0	3.20	3.40
Ftg22	Derived savannah	Ogun	Abeokuta	8.0	3.30	3.30
Ftk21	Rainforest	Ekiti	Emure	13.20	4.0	3.80
Fte41	Derived savannah	Enugu	Enugu	21.0	3.60	4.50
Ftn44	Rainforest	Ondo	Akure	11.0	3.20	3.50
Fty29	Rainforest	Oyo	Ibadan	17.60	4.0	4.80
Ftn43	Rainforest	Ondo	Igbara-Oke	16.0	3.80	3.70
Ftr15	Rainforest	Anambra	Onitsha	11.80	3.40	3.60
Ftn57	Rainforest	Ondo	Akure	3.20	3.40	1.0
Fte40	Derived savannah	Enugu	Enugu	11.0	3.20	3.50
Ftn54	Rainforest	Ondo	Akure	11.90	30.73	3.14
Ftn60	Rainforest	Ondo	Igbara-Oke	20.68	31.70	3.94
Ftn62	Rainforest	Ondo	Ondo	15.40	3.10	3.80
Fty31	Rainforest	Oyo	Ibadan	21.0	3.90	4.0
Ftn61	Rainforest	Ondo	Ogbese	19.30	33.48	3.61

MATERIALS AND METHODS

Twenty one genotypes of fluted pumpkin were collected from two agro-ecological zones (rainforest and derived savannah) in Nigeria. The genotypes used were freshly harvested fruits that were relatively of the same age. Their seeds were extracted on the same day and divided into two groups for use in the two experimental locations. The seeds characteristics of the 21 genotypes are presented in Table 1. The experiment was carried out between July and August, 2013 at the Teaching and Research Farm Directorate of the Federal University of Agriculture, Abeokuta, and Teaching and Research Farm of the Federal University of Technology, Akure. The two sites represent the main Agro-ecological zones of south western Nigeria. Abeokuta and Akure belong to the derived savannah and rainforest, respectively. The genotypes were grown in nursery bags (12×10 cm) arranged in completely randomized design with three replications. The bags were separated from one another by 20 cm spacing, whereas the replications were separated by 50 cm spacing. A total of 105 bags were utilized at each location. The nursery bags were filled with white saw dust as suggested by Akoroda and Adejoro (1990) and watered. One seed was planted per bag under rain fed condition. However, supplementary watering was carried out as needed. Each plot contained five nursery bags and data were collected on four of them. Observations were made on eight different seedling traits. These are:

- i. Emergence index (EI): Seedling emergence was recorded at 9, 11, 13, 15, 17, and 19 days after planting (DAP) and used to compute EI according to modified formula of Fakorede and Ojo (1981).

$$EI = \sum \frac{(\text{Plants emerged in a day})(\text{Day after planting})}{\text{Plants emerged by 19 days after planting}}$$

- ii. Emergence percentage (E%): This was calculated as the percentage of seedling emerged 21 DAP relative to the number of seeds sown per plot.

$$E\% = \frac{\text{Seeding emerged by 21 DAP} \times 100}{\text{Number of seeds planted}}$$

- iii. Emergence rate index (ERI): This was computed by expressing EI as a proportion of E% as follows:

$$ERI = \frac{EI}{E\%}$$

- iv. Seedling vigour index (SVI): This was computed according to the modified formula of Kharb *et al.* (1994).

$$SVI = \frac{(\text{Vine length} + \text{root length}) \times E\%}{100}$$

- v. Vine length: The length of the vine was measured in centimetre from the base of the plant to the tip with meter rule at 21 DAP.
- vi. Number of leaves: The total number of leaves per plant was counted at 21 DAP.
- vii. Leaf area: The leaf area was measured in square centimetre by scanning leaf samples with HP scanner and the area of scanned images were determined using a Leaf Area software (Bakr 2005) at 21 DAP.
- viii. Shoot dry weight: Fresh shoot samples from each genotype were oven dried at 105°C for 24 hours and weight of the dry shoot samples were measured in gram with electronic balance.

The data obtained were subjected to analysis of variance (ANOVA) using PROC GLM of SAS ver. 9.1 (SAS Institute, Cary, NC, USA; Statistical Analysis System 2000). Mean effects that showed significant F-tests were separated with Duncan Multiple Range Test. Estimates of phenotypic and genotypic variances were calculated from the ANOVA. Broad sense heritability estimates (H_B) was computed for each environment as the proportion of phenotypic variances that is due to genetic differences among genotypes; the broad sense heritability for the combined locations was estimated according to Tenkouano *et al.* (2002) as:

$$H_B = \sigma^2_g / (\sigma^2_g + \sigma^2_{ge/l} + \sigma^2_{e/rl})$$

Where:

H_B = the broad sense heritability,

σ^2_g = the genetic variance,

σ^2_{gl} = the variance associated with genotype x location interaction,

σ^2_e = the experimental error.

The terms g, l and r indicates the number of genotypes, location and replication.

Genetic advance (GA) was computed according to the formula given by Johnson *et al.* (1955) and as used by Fayeun *et al.* (2012).

$$GA = \frac{\sigma_g^2}{\sqrt{\sigma_p^2}} \times K$$

Where:

K=2.06 (selection differential at 5%)

Genotypic and phenotypic coefficients of variation were computed according to Singh and Chaudhury (1985) as follows.

$$\text{Genotypic coefficients of variation (GCV)} = \frac{\sqrt{\sigma_g^2}}{\bar{\chi}} \times 100$$

$$\text{Phenotypic coefficients of variation (PCV)} = \frac{\sqrt{\sigma_p^2}}{\bar{\chi}} \times 100$$

Where:

σ_g^2 =Genotypic variation

σ_p^2 =Phenotypic variation

$\bar{\chi}$ =Sample mean of the character

Analysis of covariance was carried out on pairs of variables and the resulting values were used to estimate the phenotypic correlation coefficients as suggested by Singh and Chaudhary (1985):

$$\text{Phenotypic correlation coefficient (rp)} = \frac{COV_p(X_1, X_2)}{\sqrt{\sigma_p^2(X_1) \times \sigma_p^2(X_2)}}$$

Where:

$COV_p(X_1, X_2)$ =Phenotypic covariance among trait X_1 and X_2 .

$\sigma_p^2(X_1)$ and $\sigma_p^2(X_2)$ =Phenotypic variance for traits X_1 and X_2 , respectively.

Test of significance of correlation was done by comparing the computed values against table 'r' values given by Fisher and Yates (1963).

RESULTS

The analysis of variance indicated significant ($P \leq 0.01$) differences among the 21 genotypes of fluted pumpkin for all the seedling characters evaluated in the study (Table 2). Significant location effect was observed for all the characters except for E% and ERI. Also, significant genotype×location effect was observed for all the characters and this accounted for differential performance of the genotypes across the two locations. The mean value of the fluted pumpkin genotypes for the seedling characters evaluated across the two locations are presented in Table 3. High values of E% and SVI was observed for genotypes Fte41 (90.0% and 32.2, respectively), Ftn57 (93.3% and 31.2, respectively), and Ftn45 (94.8% and 31.98, respectively). Genotype Ftn46 had the highest ERI of 29.8 but performed poorly in most of the other seedling traits. Genotype Ftm11 had the highest value for number of leaves (9.0) and shoot dry weight (1.3 g) and had above average values for all the seedling characters except ERI (15.4).

Estimates of genetic parameters of the eight seedling traits of 21 fluted pumpkin genotypes evaluated across two locations are presented in Table 4. Differences observed

Table 2. Mean squares for eight seedling traits evaluated in twenty one fluted pumpkin genotypes at two locations.

Source of variation	DF ²⁾	Emergence percentage (%)	Emergence index	Emergence rate index	Seedling vigour index	Vine length (cm)	Leaf area (cm ²)	Number of leaves	Dry shoot weight (g)
Replicates	2	248.40	11.00	8.75	6,351.41	21.30	4.77	0.67	0.01
Genotypes (G)	20	1,688.90**	35.26**	176.80**	28,084.17**	58.13**	219.79**	2.75**	0.44**
Locations (L)	1	1,467.50	10.77**	77.22	42,936.24**	1,560.11**	869.81**	5.37**	1.07**
G×L	20	817.50**	17.67**	93.23**	22,688.55**	58.91**	86.62**	2.32**	0.24**
Error	82	199.60	8.97	62.00	5,602.20	17.68	15.01	0.74	0.04
CV (%)		20.03	23.13	39.27	32.45	23.39	21.18	10.69	29.04

**Significant at $\alpha=0.01$.

²⁾CV: coefficient of variation; DF: degree of freedom.

Table 3. Mean performance of 21 fluted pumpkin genotypes for seedling characters evaluated across two locations.

Genotype	Emergence (%)	Emergence index	Emergence rate index	Seedling vigour index	Vine length (cm)	Leaf area (cm ²)	Number of leaves	Dry shoot weight (g)
Fts33	76.70a-d	20.18a	26.08a-d	23.70a-e	17.89a-e	23.37a-c	7.67b-d	0.64e-j
Fty28	50.0f-h	11.71cd	27.82ab	13.96ef	16.69b-f	19.33b-e	8.33a-d	0.55j-l
Ftn46	65.0c-g	18.32ab	29.84a	18.26c-f	15.94b-f	5.93f	8.50a-c	0.46h-m
Ftn45	94.80a	15.15bc	15.81c-d	31.98a	18.47a-d	16.35e	8.88ab	0.72d-h
Ftm11	83.30a-c	13.0cd	15.39c-d	29.42ab	20.44ab	23.84ab	9.0a	1.30a
Ftk16	66.70c-f	11.22cd	18.35b-e	16.47d-f	11.60f	9.86f	7.50cd	0.48j-m
Fte42	40.0h	11.50cd	26.61a-c	17.15c-f	21.75ab	21.07a-d	8.0a-d	0.61f-i
Ftg22	70.0b-e	14.08cd	21.30a-e	25.74a-d	21.49ab	23.07a-d	7.83a-d	0.92b-d
Ftk21	46.70g-h	12.39cd	27.03ab	12.62f	12.62ef	6.70f	6.0d	0.23m
Fte41	90.0a	12.56cd	12.67e	32.15a	20.76ab	18.22c-e	7.83a-d	0.70d-i
Ftn44	66.70c-f	11.82cd	19.44a-e	27.20a-c	19.92a-c	24.10ab	8.67a-c	0.69d-i
Fty29	46.70gh	11.13cd	27.78ab	13.31f	17.65a-e	18.20c-e	8.0a-d	0.45i-m
Ftn43	93.30a	13.36cd	14.02e	28.94ab	16.08b-f	15.38e	7.83a-d	0.43j-m
Ftr15	76.70a-d	11.99cd	17.01b-e	20.99b-f	16.98a-f	18.04de	7.67b-d	0.76c-g
Ftn57	93.30a	11.52cd	12.17e	31.21a	20.81ab	25.43a	8.33a-d	1.07b
Fte40	83.30a-c	12.47cd	17.17b-e	31.25a	22.79a	22.35a-d	8.67a-c	0.88b-e
Ftn54	56.70e-h	11.93cd	21.25a-e	18.58c-f	17.75a-e	19.03b-e	7.17d	0.31lm
Ftn60	56.70e-h	9.92d	17.81b-e	20.07b-f	13.83d-f	8.53f	7.67b-d	0.36lm
Ftn62	76.70a-d	13.08cd	20.21a-e	23.48a-e	18.47a-d	25.69a	7.50cd	0.83b-f
Fty31	63.30e-g	10.84d	17.01c-e	16.29d-f	14.47c-f	19.23b-e	8.50a-c	0.56g-i
Ftn61	86.70ab	13.77cd	16.12c-d	31.91a	20.88ab	21.93a-d	8.50a-c	1.0bc
Mean	70.55	12.95	20.05	23.06	17.98	18.29	8.0	0.66

Means in a column with the same letters are not significantly different by Duncan Multiple Range Test ($P \leq 0.05$).

Table 4. Estimates of genetic parameters of 8 seedling traits of 21 fluted pumpkin genotypes evaluated across two locations.

Characteristic	Phenotypic coefficient of variability (%)	Genetic coefficient of variability (%)	Broad sense heritability (%)	Genetic advance
Emergence (%)	37.31	31.40	70.84	38.37
Emergence index	69.86	39.43	31.85	2.35
Emergence rate index	50.01	30.76	37.82	7.82
Seedling vigour index	49.41	35.62	51.98	38.09
Vine length (cm)	31.65	20.74	42.94	5.01
Leaf area (cm ²)	75.44	24.57	82.0	15.42
Number of leaves	15.93	9.67	36.88	0.96
Dry shoot weight (g)	63.32	55.85	77.78	0.68

between PCV and GCV were higher for EI (30.4) and leaf area (50.9). Relatively high values (>40%) of PCV were indicated for EI, leaf area, ERI, SVI and dry shoot weight while moderately high values (20% to 40%) were observed for E% and vine length. Dry shoot weight had high GCV value of 55.85% while had moderately high values except number of leaves. Heritability estimates (broad-sense)

above 50% were observed for leaf area (82.0%), dry shoot weight (77.8%), E% (70.8%), and SVI (52.0%). High heritability estimates were accompanied by high genetic advance for E% (38.4%), SVI (38.1%), and leaf area (15.4%) while other traits had relatively low genetic advance values.

The phenotypic correlation coefficients among the eight

Table 5. Phenotypic correlation coefficients among the eight seedling traits in fluted pumpkin genotypes.

Characteristic	Location	Emergence index	Emergence rate index	Vine length (cm)	Leaf area (cm ²)	Dry shoot weight (g)	Number of leaves	Seedling vigour index
Emergence (%)	Abeokuta	0.40**	-0.88**	0.94**	0.34*	0.20	0.75**	0.37*
	Akure	0.30*	-0.67**	0.43**	0.37**	0.44**	0.23	0.89**
Emergence index	Abeokuta		-0.03	0.34*	0.30*	-0.39*	0.13	0.05
	Akure		0.44**	0.18	0.22	0.16	0.11	0.27*
Emergence rate index	Abeokuta			-0.83**	-0.17	-0.26*	-0.70**	-0.33*
	Akure			-0.26*	-0.19	-0.25*	-0.01	-0.61**
Vine length (cm)	Abeokuta				0.56**	0.05	0.77**	0.41**
	Akure				0.88**	0.83**	0.38*	0.67**
Leaf area (cm ²)	Abeokuta					-0.07	0.60**	0.47**
	Akure					0.70**	0.27*	0.57**
Dry shoot weight (g)	Abeokuta						0.50**	0.28**
	Akure						0.56**	0.61**
Number of leaves	Abeokuta							0.60**
	Akure							0.29*

*, **Statistically significant at 0.05 and 0.01 probability levels, respectively.

seedling traits of fluted pumpkin genotypes evaluated at two locations is presented in Table 5. At both locations SVI had positive and significant correlation with all the traits except ERI that had negative significant correlation with SVI. However, EI was not significant with SVI in Abeokuta. Generally, E%, vine length, and leaf area had positive significant correlations with most of the traits across the two locations. Whereas, ERI had negative significant correlations with all the traits across the two locations except with EI in Akure. Locational differences were obtained in the values of correlation coefficients among some of the traits. For instance different results were obtained for EI and ERI in both locations.

DISCUSSION

Early seedling vigour is important to predict performance of individual plants in terms of survival, establishment, competition, and yield. Therefore, knowledge of genetic variability of seedling traits would aid in the choice of effective and efficient breeding method that will accelerate the pace of improvement in seedling traits. The genotypes used in this study were highly variable for the evaluated seedling traits. Hence, there is a potential for

selection among the fluted pumpkin genotypes used in the study. Genetic variation in seedling traits among genotypes of crops like maize, cowpea, and rice have been reported by Fakorede and Ojo (1981), Ajala *et al.* (2003), and Okelola *et al.* (2007), respectively. Existence of large genetic variations have also been reported for some growth and yield traits in the crop (Aremu and Adewale 2012; Fayeun *et al.* 2012; Chukwudi and Agbo 2014; Fayeun and Odiyi 2015). It was observed that no single fluted pumpkin genotype had the highest value for all the seedling characters evaluated in the study. Therefore, this information on the variability of seedling characters among the genotypes will help guide hybridization in the breeding programme of fluted pumpkin. Accordingly, genotypes Ftn45, Ftn43, Ftn57, Fte41, Ftn61, and Ftm11 which had above average values for most of the seedling traits might be regarded as promising genotypes on which improvement can be based.

The relative values of PCV and GCV give an idea about the magnitude of variability present in a genetic population. The high values of PCV and GCV for the evaluated traits revealed that the genotypes used have broad base variation for these traits. Knowledge of heritability influences the choice of selection procedures used by the plant breeder to decide which selection methods would be most useful to

improve the character, to predict gain from selection and to determine the relative importance of genetic effects (Waqar-Ul-Haq *et al.* 2008; Laghari *et al.* 2010). Therefore, the traits (leaf area, dry shoot weight, E%, and SVI) with high heritability values have good selection potentials. The closer the heritability estimate of a character is to 100%, the less the character is subjected to the environmental influence and the easier it is to make progress through selection (Ojo *et al.* 2006). Furthermore, the expression of these seedling traits (leaf area, dry shoot weight, E%, and SVI) were under genetic factors, indicating low environmental influence. However, it has been emphasized that heritability alone has no practical importance without genetic advance (Najeeb *et al.* 2009). In this study, the high heritability estimates that accompanied high genetic advance for E%, SVI, and leaf area is an indication that these traits are governed by additive gene action and, therefore provides the most effective condition for selection (Tazeen *et al.* 2009). The moderate heritability estimates observed for EI and ERI might be due to the fact that they depend on other variables which are under environmental influence. According to Falconer (1980) more variable conditions reduce the heritability, whereas uniform conditions increase it.

Information on characters association in crop makes simultaneous selection of more than one character possible and the information is derived from correlation analysis. The fact that SVI E%, vine length, and leaf area had positive and significant correlation with most of the traits might implies that, selection for any of these traits might lead to improvement of most other traits and they can be used as selection criteria in fluted pumpkin when breeding for improved seedling vigour and yield. Adeyemo and Fakorede (1995) have shown that seedling vigour can be used as a selection criterion when breeding for improved yield in maize. Also, Fayeun and Odiyi (2015) suggested that marketable leaf yield can be improved by selecting for vine length and leaf area in fluted pumpkin. The locational differences obtained in the values of correlation coefficients among some of the traits especially EI and ERI might due to significant location by genotype interaction observed in this study. Significant environment (location) by genotype interaction have been reported to complicate

selection of superior genotypes (Magari and Kang 1993; Ebdon and Gauch 2002) and reduces correlation between phenotypic and genotypic values, thereby reducing selection progress (Fan *et al.* 2007). Therefore care must be taken when selecting for these type of traits (EI and ERI) because they appear to be highly influenced by the environment and would not be good selection criteria for the crop.

In conclusion, the study revealed wide genetic variability for E%, EI, ERI, vine length, leaf area, SVI, and dry shoot weight. Genotypes Ftn45, Ftn43, Ftn57, Fte41, Ftn61, and Ftm11 which had above average values for most of the seedling traits evaluated in the study were the best genotypes. The estimates of heritability with genetic advance revealed that E%, SVI, and leaf area had high selection values with less environmental influence. SVI, E%, vine length, and leaf area had significant association with most of the traits and they can be used as selection criteria in fluted pumpkin. Therefore, genetic improvement of early seedling vigour will be possible for the breeding programme in fluted pumpkin.

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