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Heterotic Performance of *Telfairia occidentalis* Hook (Fluted Pumpkin) F_1 Hybrids

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Abstract **– Two field experiments were conducted in the early cropping season of 2013 and 2014 at the teaching and research farm of the Federal University of Technology, Owerri, to select and hybridize *Telfairia occidentalis* landraces for increased productivity and market value improvement and also to determine the performance of the first filial (F_1) hybrids. The experiments were laid out in a Randomized Complete Block Design (RCBD) replicated three times. In the first experiment, the treatments were made up of five *Telfairia occidentalis* landraces while in the second experiment there were ten treatments made up of five hybrids and five selfed landraces. There were significant difference among the landraces and the hybrids in almost all the vegetative and reproductive yields. Most of the hybrids showed positive heterosis in vine length, leaf area, leaf yield per hectare, number of female flowers per plant, number of matured fruits per hectare, and number of seeds per fruit. This positive heterosis displayed by the hybrids form the basis for the selection of the hybrids EN/AB and EN/AN, for further studies in vegetative yield and the hybrids EN/RV, EN/AN for reproductive yields.**

Keywords **– F_1 Hybrids *Telfairia occidentalis*, Heterotic Performance.**

I. INTRODUCTION

Telfairia occidentalis like other cucurbits belong to the group of crops known as the vine crops (Okoli, 1983; Nwonuala *et al.,* 1995). It is a vigorous creeping or climbing dioecious plant that stem up to 10m or more in length (Okoli, 1987, Lucas, 1988, Nwonuala *et al.*, 2015). The leaves are compound and have petioles of up to 3cm in length. The flowers are dioecious. The male and female flowers are confined to separate male and female plants. Report on the nutritive content of *Telfairia occidentalis* plant have shown that the leaves are nutritiously important. They contain up to 11% crude protein, 28% carbohydrate, 3% oil, 11% ash and 700 ppm of iron (Nwonuala, 2008; Sanni, 1982; Achinewhu, 1983; Taylor, *et, al.,* 1983) *Telfairia occidentalis* is the most popularly grown commercial vegetable in Nigeria and in some extent, help to alleviate poverty. The hectarage for *Telfairia occidentalis* farm is increasing tremendously at a very fast rate with the expansion of individually owned farms distributed all over the country but the major producing areas are the Southern and Eastern parts of the country. The crop is also grown sporadically in other parts of the country mostly as small farms or gardens (Ndor *et al.,* 2013). These plant is cultivated mostly by women as annual crops for its palatable and nutritious leaves, immature and mature seeds. Recently, *Telfairia occidentalis* is used in traditional African herbal medicine for the treatment of anaemia (Ehiagbonare, 2008), protection from devastating blood pressure, cholesterol and diabetes (Aiyelaegbe, 2011). The individual plants of *Telfairia occidentalis* is unique, resulting in morphological and yield variability among the landraces (Thompson, 1976). Farmers and recently researchers (Akoroda & Adejoro, 1990; Nwonuala, et al, 2015) credit landraces in different South Eastern State of Rivers, Abia, Anambra, Enugu and Imo with high yield and nutritive content qualities. By planting seeds of acclaimed quality landraces of *Telfairia* only, farmers are actually involved in selection to improve the yield and nutrient quality of *Telfairia occidentalis* (Odiaka & Schipper, 2004; Nwonuala *et al.,* 2015).

The breeding history of melon in America dates back to the selection of the green flash types of cultivar "Ro-

-cky Ford" Selection for orange flesh cultivar began in the early 1900s. Disease resistant cultivars were developed in the 1930s and the first F1 hybrid was introduced in 1955, becoming the predominant type of melon cultivars (Robinson and Decker-Walters, 1997). High proportion of male plants of *Telfairia occidentalis* in the field with inherent lesser vegetative characteristics and inability to produce fruits is a major factor limiting the increase in productivity of *Telfairia occidentalis* despite the high economic potentials of the crop (Nwonuala, 2008).

The difficulties in obtaining steady supply of leaves and seeds and poor storability of its recalcitrant seeds pose another great constraint in the production of *Telfairia occidentalis* at commercial levels. A study of the quality and quantitative traits of the genotypes and yield of both sexes was considered useful for possible commercial boost.

This study was aimed at the selection and hybridization of *Telfairia occidentalis* landraces and assessment of the F1 hybrid for increased productivity and market value improvement.

II. Materials and Methods

I. *Experiment*

Growth and Reproductive Characteristics of *Telfairia occidentalis* landraces.

The experiment was conducted in 2013 and 2014 at the Federal University of Technology Teaching and Research Farm, Owerri, in the Tropical rainforest of Southeastern, Nigeria. The rainfall is heavy (>1000mm) and bimodal. The temperature is high (20°- 30°C) while the soil is an ultisol.

A. *Treatments*

Four fruits each of traditional landrace morphotypes of *Telfairia occidentalis* were obtained locally from selected home gardens within five states in Southeastern Nigeria and named after the states thus: Imo (IM), Abia (AB), Anambra (AN), Enugu (EN) and Rivers (RV). The fruits were characterized for length, width and circumference. These were split open and the seeds scooped processed counted and bulked.

B. *Preparation of Planting Materials and Planting*

The seeds were weighed and drawn to treatment lots and fairly uniform seeds for the various replicates were selected. There were 15 seeds per plot and replicated four times in a Randomized Complete Block Design (RCBD). These gave a total of 60 seeds per treatment. The seeds were then planted on ridges 2.0 x 2.0m between and within rows. One seed was planted per hole of 5cm depth. These translated to 2,500 seeds per hectare. The remaining seeds were used for proximate analysis.

C. *Fertilizer Application and Weeding*

Compound fertilizer (NPK 20:10:10) was applied at 3 weeks after planting using ring application method at a rate of 24g/stand. Weeding was done manually at 3 and 6 weeks respectively after planting. As the seeds germinated and developed, plants with superior vegetative characteristics from each treatment lot were duly tagged as potential parents (male and female).

D. *Flowering Synchronization of Telfairia occidentalis Hook*

The pattern of flowering that is the normal time and method of blooming of the flowers and the length of time that the pistil will remain receptive was also studied. For this study, six male plants and six female plants were tagged and observed. The observation was carried out for 24 hours, at 3 hourly intervals of 6-9am; 10-1pm; 2-5pm and 6-9pm.

E. *Hybridization*

Controlled pollination among selected male and female plants from treatment lots was carried out in the field in 2013. The hybrid produced were planted out the following year, 2014 and compared with their parents. Selection of parents for hybridization was based on superior morphological and phenological characteristics.

Parents were selected on the basis of superior growth rate, early flowering and increase in leaf yield which involve increase in the number of leaves and leaf size (IITA, 1991). In addition, the female parents were selected for fruitfulness, while the male parents were selected for fewer number of tendrils and flowers. Selection for flowering ability was done one week before hybridization. Prior to hybridization, immature buds of the female parents, were protected with pollination bags. The bags remained on the flower buds until when they mature and are receptive. Receptivity was recognized by the whitish colour of the stigma. Pollen from the selected male parents were then collected and shed on the receptive stigmas. The pollinated plants were labeled, indicating date of pollination, name and number of both male and female parents. When the stigmas finally changed colour from white to pink receptivity had probably been achieved, it was then safe to remove the pollination bags. The hybrid fruits were collected at maturity and labeled accordingly.

F. *Data Collection*

Phenological and morphological data were obtained from five (5) experimental *Telfairia* plants per plot, for growth parameter assessments and measurements at 6 weeks after planting and at flowering. The remaining 10 plants in each plot were nurtured to crop maturity and sampled for yield and yield components analysis.

II. *Experiment*

Genetic Studies and field Assessment of F_1 Hybrids and their Parents.

The experiment was carried out to compare the performance of the hybrids with that of the parents. The site for this experiment had similar environmental and soil characteristics with that of Experiment I.

A. *Treatments*

There were ten treatments comprising of 5 hybrid fruits each of F1 hybrids of Enugu x Abia (EN/AB); Abia x Anambra (AB/AN); Enugu x Rivers (EN/RV); Enugu x Anambra (EN/AN) and Anambra x Rivers (AN/RV) and the five fruit -selected each of the five self pollinated parents of Enugu (EN); Rivers (RV), Abia (AB) Imo (IM) and Anambra (AN).

The fruits were processed for seeds and 15 hybrid seed lots each and 15 each of those of the parents were laid out in a Randomized complete Block Design with four replications. The experimental Area was 350m2 (70 x 50m). Cultural practices were similar to those carried out in Experiment I. Data were collected on phenological and morphological traits of the hybrids and their parents. Similar parameters as in Experiment 1 were measured and analyzed.

B. *Data Analysis*

All the data collected were subjected to statistical analysis. The data were analyzed using the analysis of variance of General Linear Model of Statistical Analysis System (SAS, 1985) for Randomized Complete Block Design (RCBD). The Least Significant Difference (LSD) at 5% level probability was used to compare treatment means for each parameter. Mid-Parent Heterosis (MPH) was calculated as described by Falconer and Mackay, 1996, for the different traits. Formula used was as follows:

$$\text{MPH} = \frac{\text{H}-(\text{P}_\text{H}+\text{P}_\text{L})/2}{(\text{P}_\text{H}+\text{P}_\text{L})/2} \times 100$$

Where H, PH and PL are the observed values for hybrid, the parent with highest mean, and the parent with lowest mean respectively for the traits under consideration.

III. RESULTS

A. *Phenological and Growth Characteristics of Parents*

The five selfed parents emerged simultaneously (9.3 to 9.8 days) after sowing. However, the number of days to 50% flowering varied among the parents and between the sexes of the male and female plants of the parents. AB male and female plants flowered earliest (88 and 95.3 days after sowing respectively). IM male and female parents flowered late (121.3 and 148.7days after sowing). EN and AB parents had more female plants (55 and 52%) than male plants while IM and AN had more male plants than female plants (68 and 67%). The vine parameters of the sexes also varied significantly. The female plants had longer vines than the males. The females of EN, AN, 1M, RV and AB had longer vines than their males by 33.4, 23.4, 17.9, 13.2 and 11.0 percent respectively. Between the parents, the males and females of RV parents had the longest vines (418.1 and 473.3cm) while the male and females of AB had the shortest (251.8 and 279.5cm). The increase in leaf area is relatively high among the parents and also between the sexes (Table 1).

Table 1. Phenological and growth characteristics of landrace *Telfairia occidental* at flowering.

Sources landrace	**Days of 50% Emergence**	**Days of 50% Flowering**		**% Male Plants per Landrace**	**% Female Plants per Landrace**	**Vine length (cm) per Landrace at Flowering**		**Leaf area (cm^2) Landrace at Flowering**	
		Male	**Female**			**Male**	**Female**	**Male**	**Female**
EN	9.5	106.0	112.0	45.0	55.0	271.7	352.5	140.3	206.5
AN	9.3	116.3	135.7	67.0	33.0	304.6	375.8	105.2	259.3
AB	9.8	88.0	95.3	48.0	52.0	251.8	279.5	192.1	163.0
1M	9.8	121.3	148.7	68.0	32.0	337.0	397.3	107.2	223.3
RV	9.8	111.3	128.3	53.0	47.0	418.1	473.3	165.7	393.3
LSD (0.5)	ns	13.34	8.43	ns	ns	55.7	162.4	50.3	3.38

The female plants had larger leaf area than the males with exception of the AB parents where the males leafs were larger than the females. RV females had the broadest leaves (393.2cm^2) whole the AB males had the broa-

-dest (192.1 cm^2).

B. *Vegetative and Reproductive yield of the Parents*

Table 2 showed that the leaf yield and the number of flowers per plant varied among the parents. The RV parents had the highest leaf yield (193.50 and 482.50 kg/ha) at 6WAP and at flowering while the IM plants had the lowest yield at 6WAP (123.3kg/ha) and the AN parents had the least yield (220kg/ha) at flowering. RV plants initiated the highest number of fruits per treatment followed by EN and AB. The least number of fruit initiation per treatment was IM parents. RV plants had the highest number of female flowers per plant and also had the greatest number of matured fruits per treatment while IM had the least number of matured fruits. The EN plants produced the highest number of seeds per fruit, while RV plants had the least number of seeds per fruit (Table 2).

Table 2. Vegetative and reproductive yields of parents *Telfairia occidental*.

Sources landrace	**Number of female per plant**	**Number of Mature Fruits**		**Fruit weight (kg)**	**Number of seeds per fruits**	**Leaf yield (Kg ha^{-1})**	
		Per Plant	**Per Treatment**			**6 WAP**	**Flowering**
EN	62.0	2.0	80	6.20	84.0	169.0	237.5
AN	72.0	4.0	55	4.80	71.0	123.3	220.0
AB	65.0	4.0	70	4.80	66.0	127.0	459.5
1M	57.0	2.0	50	6.50	54.0	108.0	481.3
RV	83.0	3.0	100	8.60	48.0	193.5	482.5
LSD (0.5)	5.91	0.48	7.61	1.81	22.41	20.06	18.18

C. *Phenological and Growth Characteristics of F_1 Hybrids*

The hybrids differ in number of days to 50% emergence. AB/AN hybrid emerged earliest (10.0 days) followed by EN/RV and EN/AN (10.30). AN/RV and EN/AN emerged late (11.0 days) (Table 3). The male and female plants of the hybrids attained flowering differently. Among the males, EN/AN flowered earlier than other hybrids (62.3 days). AN/RV took the longest day to flower (96 days). The EN/RV females flowered earlier (75.3 days). EN/AN hybrids had more male plants than female plants followed by EN/RV (56% and 53%) while AB/AN and EN/AB had more female plants than males (52% and 61%) respectively (Table 3).

The vine length differed amongst the hybrids at flowering. EN/AN male hybrids produced the longest vines (465.5) while EN/AB produced the shortest vines (345.8) EN/AB female hybrids however produced the longest vines (570.8) while EN/RV hybrids produced the shortest (427.3) EN/AN male hybrids produced the highest leaf area at flowering (183.0) while the AB/AN male hybrids produced the least (101.0). AB/AN female hybrids however produced the highest leaf area at flowering (132.0) while AN/RV female hybrids produced the least (86.0) (Table 3).

Table 3. Phenological and growth characteristics of *Telfairia occidental* hybrids.

Hybrid	Days of 50% Emergence	Days of 50% Flowering		% Male Plants per Hybrid	% Female Plants per Hybrid	Vine length (cm) per Hybrid at Flowering		Leaf area (cm^2) Hybrid at Flowering	
		Male	Female			Male	Female	Male	Female
EN X AB	11.00	73.30	94.30	48.00	52.00	345.80	570.80	144.00	100.00
AB X AN	10.00	68.00	93.30	39.00	61.00	387.30	469.00	101.0	132.00
EN X RV	10.30	68.30	75.30	53.00	37.00	375.30	427.30	147.00	110.00
AN X RV	11.00	96.00	98.00	18.00	46.00	384.80	515.50	141.30	86.00
EN X AN	10.30	62.30	99.00	56.00	35.00	465.50	556.80	183.00	113.00
LSD (0.5	1.92	5.23	12.26	1.68	1.43	137.70	56.60	34.64	24.52

D. *Vegetative and Reproductive yields of Hybrids*

The leaf yield was similar among the hybrids, however, EN/AB hybrid had the highest yield of 393.6 kg/ha at 6WAP and 562.5 Kg/ha at flowering while the AB/AN hybrids had the least. The number of female flowers per plant differs among the hybrids EN/RV hybrids had the highest number (181.0) and also the highest number of fruits per plant. This is followed by AN/RV hybrid. AB/AN hybrid had the least number of female flowers while the EN/AB and EN/AN had the least number of matured fruits per plant. Fruit weight ranged from 6.0 to 8.0kg and differed among the hybrids. The hybrid AN/RV produced the heaviest fruits (8.2 kg) followed by EN/RV hybrids. AB/AN hybrids produced light fruits and least number of seeds. EN/AN produced the highest number (85) of seeds per fruit.

Table 4. Vegetative and reproductive yields of *Telfairia occidental* hybrids.

Hybrids	Leaf yield ($Kgha^{-1}$)		Number of Female Flowers per hybrid plant	Number of mature fruits per hybrids plant	Fruit weight per hybrid plant	No. of seeds per fruit
	6 WAP	Flowering				
EN X AB	393.60	562.50	127.00	3.00	6.60	42.00
AB X AN	213.00	454.30	107.00	5.00	6.00	24.00
EN X RV	242.00	551.00	181.00	6.00	7.00	84.00
AN X RV	278.50	518.80	140.00	5.00	8.20	46.00
EN X AN	327.60	503.50	120.00	3.00	6.40	85.00
LSD (0.5	15.24	48.60	9.98	0.82	1.90	13.67

E. *Comparison of Hybrids and their Parents*

The hybrids demonstrated vigor in some traits while in some others total reduction. Jones *et al.*, (1977) explained heterosis as the vigor of F_1 cross dependent upon the interaction of dominant favourable growth

factors, part of which were obtained from each of the two parents. The hybrids at flowering displayed positive heterosis for most growth characteristics and reduced vigor or negative heterosis in leaf area of mostly the female hybrids. Here the parents performed better. At flowering, the male hybrids demonstrated hybrid vigor in vine length, and in leaf area with exception of AB/AN hybrid and EN/RV hybrids (Table 5).

Table 5. Heterotic performance of F_1 Hybrid in some agronomic and yield traits.

Parame-ter	Mid parent EN, AB	Hybrid (EN /AB)	Hetero -sis %	Mid parent Average AB, AN	Hybrid (AB /AN)	Hetero -sis %	Mid parent average EN. RV	Hybrid (EN /RV)	Heter-osis%	Mid parent Average AN, RV	Hybrid (AN /RV)	Heteo -sis%	Mid parent Average EN, AN	Hybrid (EN /AN)	Hetero -sis %
VL (6WAP)	119.8	133.0	11.02	96.3	78.0	-19.0	150.3	97.0	-35.46	126.8	122.0	-3.79	134.8	135.0	0.15
VL (Males)	261.8	345.8	32.09	278.2	384.3	38.14	344.9	375.3	8.8	361.4	384.8	6.47	288.2	465.5	61.5
VL (Female)	321.0	570.8	77.8	327.7	469.0	43.12	417.9	427.3	2.25	424.6	515.5	21.41	369.2	556.8	50.81
VL (6WAP)	53.1	78.3	47.46	38.3	55.5	44.90	73.4	91.9	25.2	58.7	92.2	57.07	53.1	99.7	87.76
VL (Males)	166.2	144.0	13.36	148.7	101.0	-32.1	153.0	147.0	-3.9	135.5	141.3	4.3	122.8	183.0	49.0
VL (Female)	184.8	100.0	45.9	211.2	132.0	-37.50	299.9	110.0	-63.32	326.3	86.0	-73.64	232.9	113.0	-51.48
LYPH (6WAP)	148.0	394.0	166.2	125.0	213.0	70.4	182.0	242.0	32.97	159.0	279.0	75.5	146.0	328.0	124.66
LYPH (flower--ing)	349.0	563.0	61.3	340.0	454.0	33.5	361.0	551.0	52.6	352.0	519.0	47.4	229. 0	504.0	120.1
NFFPP	64.0	127.0	98.4	69.0	107.0	55.1	73.0	181.0	148.0	72.0	140.0	94.4	67.0	120.0	79.1
NMFPT	75.0	80.0	6.7	63.0	98.0	53.6	90.0	102.0	13.3	78.0	94.0	20.51	68.0	63.0	-7.35
FWT	5.5	6.6	20.0	4.8	6.0	25.0	7.4	7.0	-5.4	6.7	8.2	22.4	5.5	6.4	16.36
NSPF	7.5	42 .0	-44.0	69.0	24.0	-65.2	66.0	84.0	27.3	60.0	46.0	-23.33	78.0	85.0	8.97

VL - Vine Length

LA - Leaf Area

LYPH - Leaf Yield Per Hectare

NFFPP - Number of Female Flowers per Plant

NMFPT - Number of Matured Fruits per Treatment

FWT - Fruit Weight

NSPF - Number of Seeds per Fruit

IV. DISCUSSION AND CONCLUSION

Growth analysis is a relatively easy tool to evaluate advanced selection and parental materials (Powar *et al.*, 1980). In this study, the method (tool) permitted a comparative evaluation of the production potentials of the parents, and the hybrids of fluted pumpkin (*Telfairia occidentalis*). Fluted pumpkin is dioecious with the female plants producing only pistillate flower and the male plants producing only staminate flowers, this natural mechanism has made out breeding mandatory and has resulted in large genetic variability in landrace accessions of *Telfairia occidentalis* in the South Eastern Nigeria (Akoroda and Adejoro, 1990, Nwonuala *et al.*, 2015). Flowering in *Telfairia occidentalis* is genetic and since the parents and hybrids were grown under same environmental factor, the parents AB and EN are early flowering while IM and AN are late flowering and the hybrids of EN also displayed earliness in flowering. The ratio of male and female plants per treatment varies among the parents and the hybrids. It is 2:1 for AN and IM parent and 1:1 for others and the hybrids. The distribution of sexes in plants is determined by heritable nuclear genes (Ng, 1993). The distribution of sexes is also caused by hormonal changes (Galum and Alsmon, 1963), day length (Opukiri *et al.*, 2011; Rudich *et al.*, 1972), temperature (Atsman and Long, 1968). Since the plants were grown under the same temperature, day length and fertilizer conditions, the distribution of sexes is critically due to genes and hormonal changes. Similarly, the seeds used for the experiment were of similar size range and therefore had minimal effect on the male and female ratio of the landraces and the hybrids. However, plants with more females are preferred because of expected high yields of both leaf and seed (Opukiri *et al.*, 2011).

The increased leaf yield, earliness and sex expressions are highly remarkable in the hybrids. The increased vigor of F_1 hybrids may have been contributed by the dominant genes of the parents, AN, EN and RV (Nwonuala, *et al.*, 2015; Ng, 1993). The hybrids AB/AN had more female plants while EN/AN hybrids had more male plants.

Most hybrids showed positive heterosis in most reproductive yields. Three of the hybrids EN/AB, AB/AN, AN/RV displayed hybrid vigor in three of the reproductive traits (number of female flowers per plant, number of matured fruits per plant and fruit weight) while the hybrid EN/RV displayed vigor in three traits number of female flowers, numbers of seeds and numbers of matured fruits. EN/AN hybrids had positive heterosis in number of female flowers, number of seeds per fruit and fruit weight.

The genetic basis for improvement in fruit weight and number of seeds per fruit was due to accumulation of favourable alleles. Heterosis for reproductive yield in the derived hybrids was associated with reduced time to flowering and faster growth rate compared to those of the landraces.

Hence genes for improvement of yield potential and growth habit may have been incorporated in a more useful way. The hybrids superseded the parent's in traits like the fruit length, fruit width, number of seeds per fruit and fruit weight. This agrees with the findings of Patil and Shete 1987 who also reported hybrid vigor in pod length, number of seeds per pod and pod weight in cowpea.

This study has demonstrated that genetic gains (Hybrid vigor) can be achieved in *Telfairia occidentalis* through selection and cross breeding of potential traits.

Hybrid vigor was also reported for maize hybrids in almost all the traits (Jugenheinier, 1976), when compared to their open pollinated parents or varieties. Hybrid maize, according to Russel (1985), has been grown on a

large scale for many years because of hybrid vigor.

This result showed that *Telfairia occidentalis* hybrids exhibited considerable vigor for many traits which are attributable to the complementary action of favourable genes which could be exploited further to develop potential commercial hybrids. These positive heterosis exhibited by the hybrids formed the basis for their selection and multiplication especially the hybrids EN/AB and EN/AN for increased vegetative yield and the hybrid EN/RV for increased reproductive yield.

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