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Influence of Gender and Spacing on Weed Smothering Potentials of Fluted Pumpkin (*Telfairia occidentalis* Hook F.) In Southeastern Nigeria

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Authors' contributions

This work was carried out in collaboration between all authors. Author BWB designed the study, wrote the protocol and wrote the first draft of the manuscript, authors OEN and TOO managed the field experimental process, author DAO reviewed the first draft, author FE identified the weed species and reviewed the first draft, authors JOS, AEU and JDN analyzed the data and managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

A two year field study was conducted in 2013 and 2014 at the farms of the Cross River State Agricultural Development Project (CRADP), Calabar (latitude 05°3′ and 04°27′ North and longitude 07°15′ and 09°28′ East), to evaluate the plant gender and spacing effects on the potential use of fluted pumpkin as a smother crop. Fruits were carefully opened, and the seeds extracted, cleaned of the perispemic tissues and air-dried under shade for 72 hours. 'Large' seeds from the peripheral portion of each fruit were classified as 'female', 'smaller' seeds from the middle portions as 'male', and a combination of 'male' and 'female' seeds as 'mixed'. The seeds were sown in flat-tilled beds;

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one seed per hole and at the appropriate spacing. 'Rogue' plants (suspected off-gender types appearing on plots where they were unwanted) were routinely culled. Treatments were control (melon sown at 1.0 × 1.0 m spacing), and factorial combinations of three pumpkin genders (male, female, mixed) and three plant spacing {0.50 m × 0.50 m (close spacing), 0.75 m × 0.75 m (medium spacing), 1.0 m × 1.0 m (wide spacing)}, laid out in randomized complete block design with three replicates. Seedling emergence, seedling vigor index, vine girth, leaf area index, and fresh shoot weight were significantly higher for female plants, followed by mixed plants, but neither emergence nor vigor were significantly affected by plant spacing. Weed density and dry weight were in the order female plants < mixed population < male plants, indicating a greater smothering ability of female plants. Only widely spaced female *Telfairia* populations were as effective in suppressing weeds as the melon treatment. Close spacing reduced the leaf area index and vine growth of female plants and to a lesser extent, those of the mixed population, but did not adversely affect the male plants. Percent ground coverage was significantly affected by plant gender, spacing and their interaction, such that at 9 WAP, the area covered by either the female or mixed plant populations was statistically similar to that of the melon (control) treatment, and was in the order: closely-spaced female > melon > medium-spaced female > widely-space female > closely-spaced mixed > medium-space mixed > widely-spaced mixed. The prevalence of members of the *Asteraceae* (*Compositae*) family was low in plots with fluted pumpkin relative to the control, suggesting an allelopathic potential of the smother crop which could enhance weed suppression.

Keywords: Fluted pumpkin; gender; spatial deployment; weed suppression; allelopathy.

1. INTRODUCTION

Vegetables are an integral component of diets in Africa because they are essential ingredients in soups and sauces that accompany carbohydrate staples. Most vegetables are highly nutritious with some having medicinal and industrial values [1]. The growing awareness of the health promoting and protecting properties of vegetables, especially in the many urban and semi-urban areas of Nigeria in recent years has led to intensive cultivation of a wide range of these crops, usually in small-holder, intercropping systems. However, an important constraint to attainment of higher productivity in peri-urban vegetable farming is the prohibitive cost of weed control especially for resource-poor, small-holder farmers.

Crop yields and quality are frequently reduced by weeds competing for water, nutrients, space and sunlight [2], and weeds are frequently rated as the most important pest of crops [3]. [4] reported that weeds and shortage of labour for their control are two of the most important production constraints in small holder agriculture in Nigeria. At present, cultural weed control methods are the mainstay of these farmers and the methods often adopted for controlling them include hand (hoe) weeding, manipulation of plant spacing, and intercropping [5-9]. Manual weed control is laborious and time consuming, and depending on the number of individuals in the household and the size of the farm, it can take several weeks during which a large portion of crop yield could be lost. The incorporation of creeping crop species in crop mixtures as well as the manipulation of plant spacing would be a promising 'farmer-friendly' strategy of controlling weeds in small holdings. In this regard, it has been suggested that smother crops such as egusi melon (*Colocynthis citrullus* (L.) O. Kitz) and fluted pumpkin (*Telfairia occidentalis* Hook F.) could be effective in suppressing weeds in crop mixtures [10,9,7].

Smother cropping which refers to the use of a living plants to reduce the growth, development, and/or reproduction of weeds through competition for resources especially light [11,12] have been shown to be effective in suppressing annual and perennial weeds [13,14]. In order to obtain optimal results, regard must be paid to the selection, spatial and temporal deployment of smother crop species. For instance, plant density of intercropped wheat (*Triticum aestivum* L.) and field beans (*Vicia faba* L.) affects suppression of weed populations [15], while [16] have demonstrated the efficacy of spatial and temporal deployment of rice cultivars on weed suppression. [14] reported that the suppression of the smooth pigweed (*Amaranthus hybridus* L.) is a function of planting density, and the subsequent effect of light attenuation through the canopy. According to [17], allelopathic potential of smother crops may also be implicated in weed suppression.

Fluted Pumpkin which is indigenous to Nigeria [18] is a leaf and seed vegetable of the family *curcubitaceae*. It is a popular and highly prized vegetable in many parts of country, for its high nutritional value and palatability. Its tender shoots, succulent leaves and immature seeds are cooked and consumed as a vegetable. The iron-rich leaves are an effective cure for anemia [19] and the protein-rich seeds contain essential amino acids that compare favorably with those of some legumes [20]. It is propagated by seeds of different sizes usually sown at variable depths (often based on empirical whims of the farmer), and at different plant spacing, depending on the main crop or whether it is cultivated for its leaves or fruit [21]. Each crop has an optimum plant population at which it yields best, and for many horticultural crops, the size and quality of the vegetable or fruit are important considerations when determining plant populations. There are two cultivars; 'Ugwu-ala' (wide succulent leaves, thick stem, small fruit size, white/cream pulp colour, small black seeds), and 'Ugwu-elu' (small leaves, thin stem, large fruit size, light to deep orange pulp, brown large seeds) [22], as well as several landraces [23,24].

Fluted pumpkin is a dioecious species with distinct male and female plants. The male plants produce only staminate flowers and female plants only pistillate flowers [25]. The female plants produce succulent and fleshy leafy vegetables with a higher nutrient content than the male types, and are therefore preferred at groceries [26]. It is however, difficult to differentiate the male from female plants at the seed and seedling stages of growth [25,27], but the phenomenon of sexual dimorphism in the species has been explained using morphological and molecular markers [28], biochemical content of leaf, vine and roots [29], cytogenetic investigations [30], and phenotypic studies [31-34]. In their contributions, [25] reported that seeds that germinate to female plants are larger in size than those that germinate to male plants. On the basis of seed size and position of seed in the pod, the above mentioned authors generally agree that large seeds as well as those positioned at the peripheral portion of the pod germinate to produce mostly female plants, while the smaller seeds and those that occupy the middle part of the pod germinate to produce mostly male plants.

The objective of this study was to evaluate the smothering potential of fluted pumpkin as influenced by plant gender and spacing in a humid agroecological zone.

2. MATERIALS AND METHODS

A two year field experiment was conducted at the farms of the Cross River State Agricultural Development Project (CRADP), Calabar to evaluate the smothering potential of fluted pumpkin as affected by plant gender and spacing. Calabar is co-ordinated by latitude 05° 3' and 04°27' North and longitude 07°15' and 09° 28' East. The area is located in the humid tropical rainforest characterized by high temperatures and relative humidity, with an annual, bimodal rainfall of about 3,000 mm.

Fruits of the local *Telfairia occidentalis* land race 'Edem Aran' {light green exocarp and light purple seed coat [35]} sourced from Ika Ika Oqua market in Calabar were carefully opened, and the seeds extracted, cleaned of the perispemic tissues and air-dried under shade for 72 hours [36]. Large seeds from the peripheral portion of each fruit were classified as 'female', smaller seeds from the middle portions as 'male', and a combination of 'male' and 'female' seeds as 'mixed'. The land was cleared with machete, raked, tilled with hoe, and divided into three replications. The seeds were sown in flat-tilled beds [37], one seed per hole and at the appropriate spacing. Treatments were factorial combinations of three pumpkin genders (male, female, mixed) and three plant spacing {0.50 m × 0.50 m (close spacing), 0.75 m × 0.75 m (medium spacing), 1.0 m × 1.0 m (wide spacing)}, laid out in randomized complete block design replicated thrice. The treatment combinations were as follows:

a) Melon seeds sown at a spacing of 1.0 × 1.0 m (control)
b) Male *Telfairia* seeds sown at 0.5 × 0.5 m
c) Male *Telfairia* seeds sown at 0.75 × 0.75 m
d) Male *Telfairia* seeds sown at 1.0 × 1.0 m
e) Female *Telfairia* seeds sown at 0.5 × 0.5 m
f) Female *Telfairia* seeds sown at 0.75 × 0.75 m
g) Female *Telfairia* seeds sown at 1.0 × 1.0 m
h) Mixed *Telfairia* seeds sown at 0.5 × 0.5 m
i) Mixed *Telfairia* seeds sown at 0.75 × 0.75 m
j) Mixed *Telfairia* seeds sown at 1.0 × 1.0 m.

All treatments received a combined application of 2 t/ha poultry manure incorporated into the soil at

2 weeks before sowing, plus 200 Kg/ha NPK 15-15-15 applied once at 3 WAP, as described by [38]. Weeding of all plots was done by hand pulling once at 3 WAP, while suspected rogue plants (off-gender plants growing in plot where they were unwanted) were routinely culled from the field. Nipping (harvesting of shoots) was at fortnightly intervals beginning from 5 WAP.

Field data collected on *Telfairia* were seedling emergence percentage and seedling vigor index (using the method of [32], as follows:

Emergence % = 100 ×No. of emerged seedlings/Number of seeds sown

Seedling vigor index = SL × Emergence %

Where, SL is the seedling length (cm).

The number of leaves per plant was obtained by counting, while the leaf area per plant was obtained following the method of [39] as follows:

$$LA = 0.9467 + 0.2475lw + 0.972lwn$$

Where:

LA = Leaf area
L = Length of central leaflet
W = Maximum width of central leaflet
N = Number of leaflets per leaf.

Other parameters measured were leaf area index (LAI) [40], vine length (measured with tape from the base to the tip of the main vine), vine girth (measured at the base of the plant, with a vernier caliper), fresh shoot yield (estimated following the procedure of [41] as the cumulative total of nipped shoots (vines plus leaves) cut at a length of 1.0 m from the base of the plant an weighed with a sensitive (Mettler Toledo JL 602-GE) electronic weighing scale), pod length, and pod width.

Weed density was taken from a 1.0 m^2 quadrat placed at the centre of each plot before weeding. The weeds so collected were washed and dried in an oven at 80°C for 24 hours to obtain the dry weight. The percentage ground cover occupied by the smother crop was evaluated at 3, 6, and 9 WAP using the beaded string method [42].

All data collected were subjected to analysis of variance using GenStat Release 10.3 DE [43] statistical software, and mean comparison at 5% probability was by Fisher's Least Significance Difference (F-LSD) method as described by [44].

3. RESULTS AND DISCUSSION

3.1 Growth and Yield of Telfairia

Seedling emergence was unaffected by gender and/or spacing of fluted pumpkin plants, but the seedlings of female plants grew more vigorously than those of the mixed population which also performed better than the male plants. Seedling vigor was highest in female plants, followed by the mixed population and least by the male plant, but was unaffected by plant spacing (Table 1), and the most vigorous plants were the females sown at a spacing of 1.0 × 1.0 m, followed by those sown at the narrower spacing of 0.50 × 0.50 m and 0.75 × 0.75 m, both of which did not differ significantly from each other.

Plant gender, spacing and their interactive effect significantly influenced vine (Table 1) and leaf growth (Table 2), with the best performing combination being that of female plants spaced 1.0 × 1.0 m apart. Closer plant spacing caused a significant reduction of the LAI, vine length and girth of female as well as mixed plants, while not affecting the male plants, an outcome that is similar to the findings of [21]. Based on their higher seedling vigor and LAI, female *Telfairia* plants are potentially suitable for use as smother plants since a successful smother plant must emerge from the soil rapidly and quickly establish canopy to compete with early emerging weeds.

The effect of plant gender, spacing, and their interaction on marketable fresh shoot weight was significant (Table 3). Although closely space plants gave higher shoot weights relative to other treatments, widely- space female plants followed by medium-spaced mixed plant populations gave the best results. However, plant gender did not affect pod characteristics (length and width) (Table 3) and the failure of male plots to bear fruits underscored the effectiveness of off-field determination of fluted pumpkin gender based on seed size [28,34] and seed position in the fruit [31,32]. However, significantly larger fruits were borne by wider- than closely- spaced plants.

3.2 Smothering Effect of Telfairia

The predominant weeds observed at the study site were *Chromolaena odorata, Ageratum conyzoides, Panicum maximum, Euphorbia heterophylla, Amaranthus spinosus, Cyperus* *esculentus, Pennisetum purpureum, Talinum triangulare, Bidens pilosa, Cynodon dactylon, Eleucine indica, Digitaria horizontalis, and Solanum nigrum.* It was observed that the occurrence of *Ageratum conyzoides* and *Bidens torta*, both of which are members of the *Asteraceae* (*Compositae*) family was low in plots with *Telfairia occidentalis*, relative to the melon plots (control treatment), suggesting that apart from suppressing weeds by smothering, Fluted pumpkin may also have allelopathic properties averse to the proliferation of members of some plant species. This may hold out hope for improvements in crop production through such means as discovering eco-friendly herbicides with new sites of action, harmless to crops, but toxic to weeds and without formation of dangerous residues [45]. Allelopathic properties have also been reported in the genus *Brassica* which contains numerous vegetable crops [46] and in rice [47], among other crop plants. Further field research could investigate this observation in order to identify these allelochemical(s), the plant organ(s) containing them, and their mode of action.

The gender and spacing of *Telfairia* plants influenced the crop's weed suppressive ability significantly, and in this regard, female plants were much more effective than either the male ones or the mixed population (Table 4). Wide plant spacing favored higher weed incidence in male plots and those with a mixed population of fluted pumpkin plants, but not that of female plants, and weed density and weed biomass were lowest in the order female plants < mixed population < male plants. As shown in Table 4, the weed suppressing ability of female *Telfairia* plants was higher than that of others, and was comparable to that of melon. Compared to the control treatment (2.13 gm^{-2}), the weed dry weight of female, mixed population and male *Telfairia* was respectively 2.30, 3.27, and 5.47 gm^{-2} i.e. 8.0%, 53.5%, and 156.8% increase above the control. Similar to melon, widely-spaced female *Telfairia* plants (1.0 × 1.0) were more effective in smothering weeds because of faster canopy closure due to their higher vigor (Table 1) and LAI (Table 2).

Neither the gender of the plant, its spacing nor the effect of their interaction significantly affected percentage ground coverage at 3 WAP (Table 5). However, beginning from 6 WAP, there were statistically significant differences between various genders, plant spacing, and the effect of their interactions on percentage ground cover of the smother crops. At 6 WAP, all female plants

Table 1. Gender and spatial deployment effects on seedling emergence, seedling vigor, vine length and vine girth of *Telfairia occidentalis*

Treatment	Seedling emergence (%)	Seedling vigor index	Vine length (cm)	Vine girth (cm)
Gender				
Male	80.2	7.23	95.22	0.73
Female	94.7	11.66	134.81	2.90
Mixed	87.8	9.67	116.90	1.07
F-LSD	2.34	0.62	5.09	0.24
Spacing (m)				
0.50 × 0.50	91.3	11.12	115.07	1.90
0.75 × 0.75	92.6	10.89	118.04	2.03
1.0 × 1.0	90.9	11.0	126.73	2.09
F-LSD	Ns	Ns	1.79	0.11
Interaction				
Male × 0.50 × 0.50	83.6	10.21	103.83	0.77
Male × 0.75 × 0.75	87.1	10.40	104,0	0.79
Male × 1.0 ×1.0	90.3	9.85	104.31	0.97
Female × 0.50 × 0.50	92.8	11.0	118.50	2.19
Female × 0.75 × 0.75	93.0	10.85	133.17	2.33
Female × 1.0 × 1.0	93.6	11.12	144.0	2.84
Mixed × 0.50 × 0.50	90.1	9.40	108.94	1.82
Mixed × 0.75 × 0.75	91.0	10.42	114.0	1.99
Mixed × 1.0 × 1.0	90.3	10.66	117.73	2.05
F-LSD	Ns	0.23	8.83	0.03

Table 2. Gender and spatial deployment effects on leaf area index of *Telfairia occidentalis*

Treatment	2 WAP	4 WAP	6 WAP	8 WAP	10 WAP
Gender					
Male	0.28	0.67	1.99	2.57	4.04
Female	0.33	1.59	3.23	5.51	7.20
Mixed	0.30	1.13	2.51	3.97	5.60
F-LSD	Ns	0.52	1.05	1.33	1.11
Spacing (m)					
0.50 × 0.50	0.32	1.25	1.90	2.28	3.87
0.75 × 0.75	0.30	1.33	2.46	4.09	4.51
1.0 × 1.0	0.33	1.40	3.19	4.75	7.63
F-LSD	Ns	Ns	1.44	1.06	1.25
Interaction					
Male × 0.50 × 0.50	0.25	0.96	1.79	2.82	4.07
Male × 0.75 × 0.75	0.29	0.83	1.90	2.99	4.11
Male × 1.0 × 1.0	0.29	0.90	1.94	2.95	4.09
Female × 0.50 × 0.50	0.38	1.22	2.51	2.92	4.72
Female × 0.75 × 0.75	0.33	1.36	3.03	4.12	5.26
Female × 1.0 × 1.0	0.38	1.67	3.27	5.27	7.81
Mixed × 0.50 × 0.50	0.35	1.19	2.33	3.48	5.77
Mixed × 0.75 × 0.75	0.37	1.27	2.99	4.71	6.19
Mixed × 1.0 × 1.0	0.33	1.25	2.53	4.50	6.33
F-LSD	Ns	0.39	1.46	1.88	1.47

Table 3. Gender and spatial deployment effects of *Telfairia* on pod production and marketable shoot yield

Gender	Pod length (cm)	Pod width (cm)	Fresh shoot weight (t/ha)
Male	0.0	0.0	0.354
Female	148.0	88.5	0.599
Mixed	136.3	86.4	0.457
F-LSD	Ns	Ns	0.17
Spacing (m)			
0.50 × 0.50	134.8	59.0	0.602
0.75 × 0.75	140.0	74.5	0.579
1.0 × 1.0	144.4	93.0	0.552
F-LSD	1.36	5.63	0.33
Interaction			
Male × 0.50 × 0.50	0.0	0.0	0.436
Male × 0.75 × 0.75	0.0	0.0	0.366
Male × 1.0 × 1.0	0.0	0.0	0.375
Female × 0.50 × 0.50	127.3	65.8	0.579
Female × 0.75 × 0.75	139.0	82.6	0.612
Female × 1.0 × 1.0	148.3	99.2	0.616
Mixed × 0.50 × 0.50	139.0	69.0	0.393
Mixed × 0.75 × 0.75	139.8	78.3	0.400
Mixed × 1.0 × 1.0	145.3	86.0	0.414
F-LSD	Ns	4.28	0.09

sown at the various spacing evaluated achieved 30% or more ground cover, which was significantly higher than other treatments, but similar only to the melon (control) treatment. At 9 WAP, female plants as well as the mixed Telfairia populations produced statistically similar ground cover as melon, all of which were statistically higher than the other treatments. The percentage ground coverage at 9 WAP was in the order: female × 0.5 × 0.5 m > melon > female × 0.75 × 0.75 m > female × 1.0 × 1.0 m > mixed × 0.5 × 0.5 m > mixed × 0.75 × 0.75 m > mixed × 1.0 × 1.0 m.

Table 4. Gender and spatial deployment effect of *Telfairia occidentalis* on weed density and weed dry weight (gm^{-2})

Gender	Broad leaf (no.m-*2*)	Grasses (no.m^{-2})	Sedges (no.m^{-2})	Dry weight
Male	22.33	3.67	7.33	5.47
Female	12.00	1.67	5.67	2.30
Mixed	18.35	2.00	6.33	3.27
Control	9.33	2.00	6.00	2.13
F-LSD (0.05)	2.05	Ns	Ns	0.51
Spacing (m)				
0.50 × 0.50	11.05	1.67	5.34	3.00
0.75 × 0.75	18.33	2.00	6.33	4.06
1.0 × 1.0	20.00	2.00	7.67	5.24
Control	9.33	2.00	6.00	2.13
F-LSD (0.05)	4.02	Ns	Ns	0.94
Interaction				
Male × 0.50 × 0.50	19.52	2.67	7.33	4.13
Male × 0.75 × 0.75	20.73	2.68	7.67	5.22
Male × 1.0 × 1.0	22.00	3.14	8.14	7.00
Female × 0.50 × 0.50	12.03	1.41	5.33	2.30
Female × 0.75 × 0.75	11.00	2.04	5.60	3.03
Female × 1.0 × 1.0	10.05	2.33	6.22	2.19
Mixed × 0.50 × 0.50	16.27	2.55	7.00	3.97
Mixed × 0.75 × 0.75	18.60	2.32	7.21	4.00
Mixed ×1.0 × 1.0	18.53	3.00	7.96	4.16
Control	9.33	2.00	6.00	2.13
F-LSD (0.05)	1.12	Ns	Ns	0.33

Table 5. Gender and spacing effects on percentage ground cover of smother crops at 3, 6, and 9 WAP, in Calabar, Nigeria

Treatment	3 WAP	6 WAP	9 WAP	MEAN
Gender				
Male	1.53	13.44	53.0	22.66
Female	3.29	30.49	90.67	41.48
Mixed	1.68	21.75	71.64	31.69
Melon (control)	3.51	35.72	91.0	43.41
F-LSD (0.05)	NS	6.04	4.11	4.02
Spacing (m)				
0.50 × 0.50	3.44	37.19	90.05	43.56
0.75 × 0.75	3.05	33.35	87.42	41.27
1.0 × 1.0	2.96	30.19	85.62	39.59
Melon (control)	3.51	35.72	86.06	41.76
F-LSD (0.05)	NS	4.22	3.07	
Interaction effect				
Male × 0.50 × 0.50	1.55	10.89	65.36	25.93
Male × 0.75 × 0.75	1.50	10.77	60.40	24.22
Male × 1.0 × 1.0	1.53	10.12	50.95	20.87
Female × 0.50 × 0.50	3.15	37.38	92.71	44.41
Female × 0.75 × 0.75	3.20	35.22	90.67	43.03
Female × 1.0 × 1.0	3.19	32.90	90.11	42.07
Mixed × 0.50 × 0.50	2.02	31.77	87.90	40.56
Mixed × 0.75 × 0.75	1.95	28.13	85.32	38.47
Mixed ×1.0 × 1.0	1.88	25.05	85.0	37.31
Melon (control)	3.51	35.72	91.0	43.41
F-LSD (0.05)	NS	10.23	6.49	

A high LAI meant that these plants were better able to compete for space and light which is a mechanism that improves the suppressive ability of smother crops (Holt, 1995). This result is however, at variance with that of [48] who, working apparently with a mixed fluted pumpkin population associated a higher weed density with wide plant spacing. Collins et al. [14] had also found that the suppression of smooth pigweed (*Amaranthus hybridus* L.) was a function of smother crop density and the subsequent effect of light attenuation through the canopy.

4. CONCLUSION AND RECOMMENDATION

Fluted pumpkin could be integrated into the farming systems of resource-poor farmers in the humid rainforest region of Nigeria as a smother crop, but its effectiveness for weed suppression is a function of its gender and spacing. Female or mixed gender pumpkin plants at the various spacing evaluated were as effective in suppressing weeds as melon treatment, but superior to the male plant populations. Apart from smothering weeds, pumpkin may also have allelopathic effects on members of some plant species. Future studies could verify this observation. Considering the difficulty in sorting seeds into male or female gender, the use of mixed plant populations at spacing of 0.5 m × 0.5 m is recommended if *T. occidentalis* is to be used as a smother crop. However, sowing female Telfairia seeds at 1.0 m × 1.0 m, or mixed seeds at 0.75 × 0.75 m is preferable if the purpose is to obtain high fresh shoot yield as well as smother weeds. It would be necessary to select appropriate companion crops to include in mixtures in which T. occidentalis will serve as smother crops since it tends to entangle such crops and there may be difficulties in managing such intercrops.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Akubue PI, Kar A, Nnacheta FN. Toxicity of extracts of roots and leaves of *Telfairia occidentalis* Hook. F. Planta Medica. 1980; 38:339-3.
2. Food and Agriculture Organization of the United Nations (FAO). Integrated Weed Management; 2013; (Accessed 12 September; 2016) Available:www.fao.org/agriculture/crops/core-themes
3. Ayeni AO. Hand / mechanical weed management as an option in Nigerian agriculture. Nigerian Journal of Weed Science. 1991;4:71-78.
4. Weber G, Elemo K, Lagoke STO. Weed communities in intensified crop-based cropping systems of the Northern Guinea Savanna. Weed Research. 1995;35:167-178.
5. Zuofa K, Tariah NM, Osoromah NO. Effects of groundnut, cowpea and melon on yield of intercropped cassava and maize. Field Crops Research. 1992;28: 309-314.
6. Okeleye KA, Salawu RA. Use of low growing crops as an alternative weed control measure in cassava-based cropping systems in Southern Nigeria. Nigerian Journal of Weed Science. 1999; 12:17-22.
7. Nwagwu FA, Tijani-Eniola H, Chia MH. Influence of tillage and cover crops on weed control in cocoyam field at Ibadan, Southwestern Nigeria. Nigerian Journal of Weed Science. 2000;13:39-44.
8. Iyagba AG. Effect of weeding regime on crop yield in cassava/fluted pumpkin intercrop in Rivers State, Nigeria. Nigerian Journal of Horticultural Science. 2005; 10:75-81.
9. Muoneke CO, Mbah EU, Orji U. Weed control and yield of sweet corn (*Zea mays* (L.) *var Sacchrata*) / egusi melon (*colocynthis citrullus* (L.) O. Kitz) intercrop as influenced by plant population of egusi melon in the humid tropics. Book of Abstracts, 1st National Annual Conference of Crop Science Society of Nigeria (CSSN) Held at University of Nigeria, Nsukka, September 15-19; 2013.
10. Akobundu IO. Weed Science in the Tropics: Principles and Practice, New York: John Wiley and Sons; 1987.
11. Teasdale JR. Cover crops, smother plants, and weed management. In: Integrated weed and soil management. Hartfield JL, Buhler DD, Stewart BA, Editors. Chelsea, MI, Sleeping Bear Press; 1998.
12. Holt JS. Plant responses to light: A potential tool for weed management. Weed Science. 1995;43:474-482.
13. Udensi UE, Akobundu IO, Ayeni AO, Chikoye D. Management of congograss (*Imperata cylindrica*) with velvetbean

(*Mucuna pruriens var utilis*) and herbicides. Weed Technology. 1999;13:201-208.

14. Collins AS, Chase CA, Stall WM, Hutchinson CM. Optimum densities of three leguminous cover crops for suppression of smooth pigweed (*Amaranthus hybridus*). Weed Science. 2008;56:753-761.
15. Bulson HAJ, Snaydon RW, Stopes CE. Effects of plant density on intercropped wheat and field beans in an organic farming system. Journal of Agricultural Science. 1997;128:59-71.
16. Binang WB, Ekeleme F, Ntia JD. Management of weeds of rainfed lowland rice using cultivar mixture strategies. Asian Journal of Agricultural Research. 2011; 5(6):306-311.
17. Barberi P. Weed management in organic agriculture: Are we addressing the right issues? Weed Resource. 2002;41:177-193.
18. Akoroda MO. Ethnobotany of *Telfairia occidentalis* (Curcubitaceae) among Igbos of Nigeria. Economic Botany. 1990;44(1): 29-39.
19. Egbekan MK, Ada-Suleiman EO, Akinyeye O. Utilization of Fluted Pumpkin fruit (*Telfairia occidentalis* Hook. F.) in Mamalade manufacturing. Plant Foods for Human Nutrition. 1998;52(2):171-176.
20. Asiegbu JE. Some biochemical evaluation of Fluted Pumpkin seeds. Journal of Science, Food and Agriculture. 1987;40: 152-155.
21. Oke FO. Leaf area development and vine girth of *Telfairia occidentalis* (HOOK F.) in response to plant spacing and liquid cattle manure. IOSR Journal of Agriculture and Veterinary Science. 2015;8(12):05-10.
22. Odiaka NI, Akoroda MO, Odiaka EC. Diversity and production methods of fluted pumpkin (*Telfairia occidentalis* HOOK F.); experience with vegetable farmers in Makurdi, Nigeria. African Journal of Biotechnology. 2008;7(8):944-954.
23. Nwonuala AI, Alagba RA, Okoli NA, Ojiako FO, Ofor MO, Ibeawuchi II, Obiefuna JC. Reproductive yield and nutritive quality of landrace accessions of Fluted Pumpkin (*Telfairia occidentalis*) in Southeastern Nigeria. Book of Abstracts, 1st National Annual Conference, Crop Science Society of Nigeria, University of Nigeria, Nnsuka, 15-19 September; 2013.
24. Iboko KU. Characterization and genetics of Fluted Pumpkin (*Telfairia occidentalis* HOOK F.) accessions in Southeastern Nigeria. Unpublished Ph.D Dissertation, University of Calabar, Calabar; 2016.
25. Asiegbu JE. Characterization of sexes in Fluted Pumpkin (*Telfairia occidentalis*): Growth and yield in the male and female sexes. Gaetenbauwissenchaft. 1985; 50:151-155.
26. Odiaka NI, Schippers RR. *Telfairia occidentalis* Hook. F. In: Plant Resources of Tropical Africa 2: Vegetables, Grubben, GJH, Denton OA, Editors. Leiden/ Wageningen, PROTA Foundation, GJH, Denton OA, Editors. Leiden / Wageningen, PROTA Foundation, Netherlands / Backhugs Publishers, Netherlands / CTA Netherlands; 2004.
27. Emebiri LC, Nwufo MI. Occurrence and detection of early sex-related differences in *Telfairia occidentalis*. Sex Plant Reproduction. 1996;9:140-144.
28. Ndukwe BC, Obute GC, Wary-Toby IL. Tracking sexual dimorphism in *Telfairia occidentalis* HOOK F. (Curcubitaceae) with morphological and molecular markers. African Journal of Biotechnology. 2005; 4:1245-1249.
29. Ajibade SR, Balogun MO, Afolabi OO, Kupolati MD. Sex differences in biochemical contents of *Telfairia occidentalis* HOOK F. Food, Agriculture and Environment. 2006;4(1):155-156.
30. Uguru MI, Onovo JC. Gender in fluted pumpkin (*Telfairia occidentalis* HOOK F.). International Journal of Plant Breeding. 2010;5(1):64-66.
31. Agwu BOE, Obiefuna JC. The effect of within seed position on the sex expression of Fluted Pumpkin (*Telfairia occidentalis*). Proc. of the 10th Annual Conf. Hort. Soc. Nig., Owerri, Nov.8 -13. 1987;37-39.
32. Aremu CO, Adewale DB. Origin and seed positional effect on sex ratio of *Telfairia occidentalis* HOOK F. grown in savanna agro-ecology. International Journal of Plant Breeding and Genetics. 2012;6(1):32-39.
33. Uyoh EA, Ntui VO. Effect of seed position on sex expression and some agronomic features in Fluted Pumpkin (*Telfairia occidentalis* HOOKER FIL). African Journal of Horticultural Science. 2011;4:7-12.
34. Modupeola TO, Olaniyi JO, Abdul-Rafiu AM, Akinyode ET, Taylor OO, Bidmos FA, Oyewusi AO. Effect of seed size and

position in pod on the early seedling growth of Fluted Pumpkin (*Telfairia occidentalis* Hook. F.) in Southwestern Nigeria. Research Journal of Seed Science. 2014;7:26-30.
35. Umoh EO, Sampson EE. Effect of nipping and shading on vegetative growth in two local varieties of *Telfairia occidentalis* (Curcubitaceae) in Nigeria. Boletin da Sociedade Broteriana, LXIV (2 aserie). 1991;149-158.
36. Ajayi SA, Berjak P, Kioko JI, Dulloo ME, Vodouhe RS. Responses of Fluted Pumpkin (*Telfairia occidentalis* HOOK F., Curcubitaceae) seed to dessication, chilling and hydrated storage. South African Journal of Botany. 2006;72:544-550.
37. Idowu O, Agele SO. Effect of tillage practices and decapitation methods on flute pumpkin (*Telfairia occidentalis*) grown in an inland swamp (fadama). Proceedings of International Soil Tillage Research Organisation (ISTRO) Nigeria Symposium, Akure, November 3-6; 2014. Akure, Nigeria.
38. Shiyam JO, Binang WB. Effect of poultry manure and plant population on productivity of Fluted Pumpkin (*Telfairia occidentalis* Hook F.) in Calabar, Nigeria. Journal of Organic Systems. 2013;8(2):29-35.
39. Akoroda MO. Non-destructive estimation of area and variation in shape of leaf lamina in the Fluted Pumpkin (*Telfairia occidentalis* HOOK F.). Science Horticulture. 1993;53(3):261-267.
40. Palanisamy KM, Gomez KA. Length – width method for estimating leaf area of rice. Agronomy Journal. 1974;66:430-433.
41. Fayeun LS, Odiyi AC, Makinde SCO, Aiyelari OP. Genetic variability an correlation studies in the Flute Pumpkin (*Telfairia occientalis* Hook F.). Journal of Plant Breeding and Crop Science. 2012; 4(10):156-160.
42. Serrantino M. Methodologies for screening soil improving legumes. Kutstown PA. Rhodale Institute Research Centre; 1991.
43. GENSTAT Release 10.3DE. VSN International LTd (Rothamsted Experimental Station); 2011.
44. Obi U. Statistical Methods of Detecting Difference between Treatment Means for Field and Laboratory Experiments, Enugu; AP Publishers Co Nigeria LTD; 2002.
45. Haig T. Allelochemicals in plants. In: Zeng RS, Malik AU, Luo SM, Editors. Allelopathy in sustainable agriculture and forestry New York; Springer Science + Business Media, LLC; 2008.
46. Rosa EAS, Heaney RK, Fenwick GR, Portas CAM. Glucosinolates in crop plants. Hort. Rev. 1997;19:93-99.
47. Kato-Noguchi H, Ino T. Rice seedlings release allelopathic substances. Biol. Plant. 2003;46:157-159.
48. Omovhude S, Udensi EU, Orluchukwu JA. Effect of plant spacing on weed suppression and yield of Fluted Pumpkin (*Telfairia occidentalis* HOOK F.) in Port Harcourt, Nigeria. Nigerian Agricultural Journal. 2016;46(2):42-50.

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