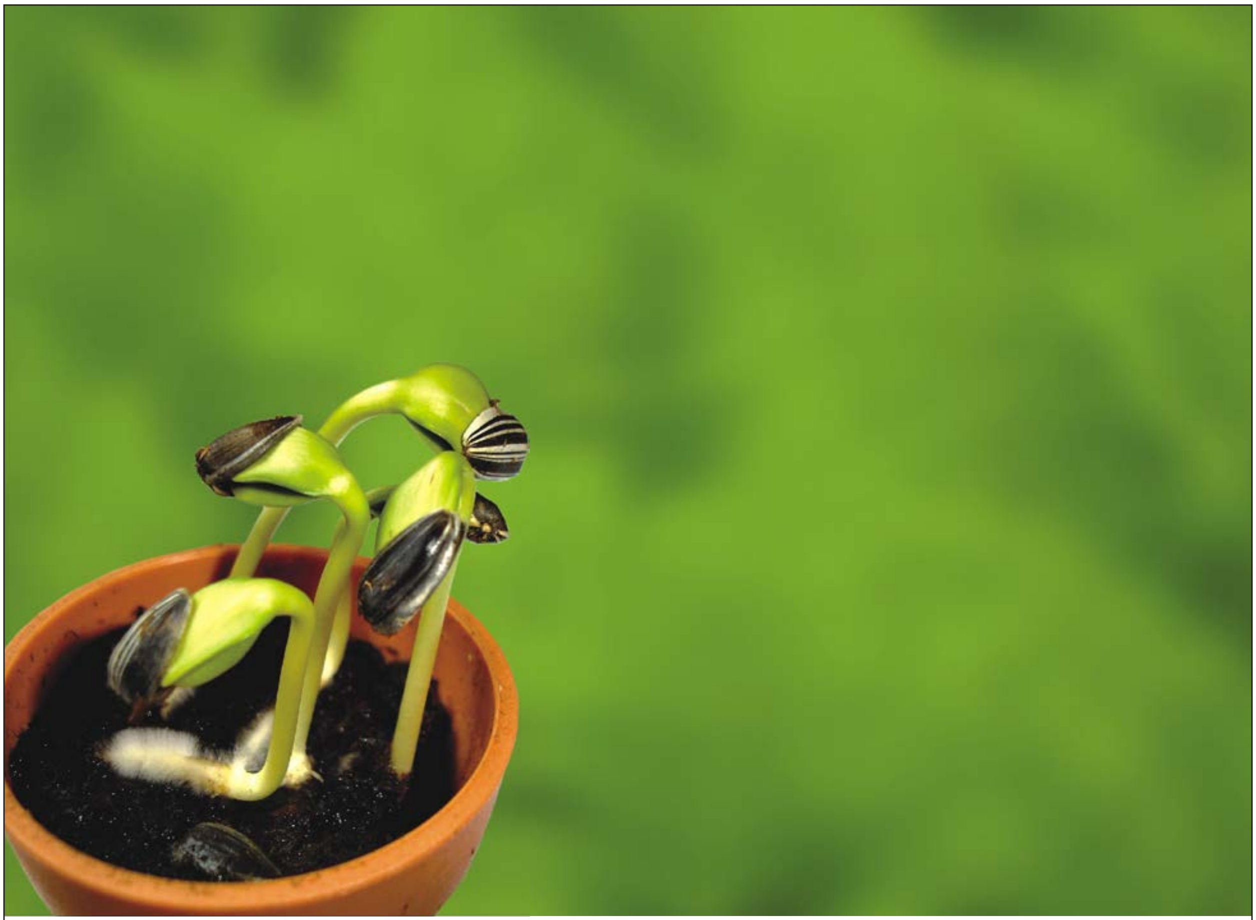

International Journal of

Plant Breeding and Genetics

ISSN 1819-3595

Academic Journals Inc.

www.academicjournals.com

International Journal of Plant Breeding and Genetics 2 (1): 19-27, 2008
ISSN 1819-3595

Hybridization and Heterosis of Desirable Metric Characters of *Talinum triangulare* Land-Races in South Eastern Nigeria

[1]E.J. Nya and [2]M.J. Eka
[1]School of Life Sciences, Heriot Watt University, Edinburgh, United Kingdom
[2]Department of Agronomy, Michael Okpara University of Agriculture, Umudike, Umuahia, Nigeria

Abstract: The aim was to study their cross ability and heterosis of their desirable metric characters, so as to facilitate selections of parental cultivars for incorporation in breeding program for *Talinum triangulare* improvement in South Eastern Nigeria. The 42 resultants F_1 hybrids and the parents were evaluated in a Randomized Complete Block Design (RCBD) at the Teaching and Research farms of the Michael Okpara University of Agriculture in 2003/2004. Significant differences at $p>0.01$ were observed in the morphological characters of the 7 land races and also among the F_1 hybrids. All the cultivars were cross compatible and the F_1 seeds were highly viable with highest means viability of 70% and lowest of 60%. Some of the F_1 hybrids showed positive heterosis over mid-parents and beter-parents for such metric characters as plant height at flowering, number of branches per plant and at flowering, days to 50% flowering, number of leaves per plant, leaf area and fresh shoot yield. Heterosis was negative for characters like final plant height per plant, basal diameter and number of leaves at flowering. The positive heterosis observed in some of the hybrids is discussed as a good phenomenon for *Talinum* improvement.

Key words: F_1 hybrids, heterosis, hybridization, *Talinum triangulare* (Jacq.) willd

INTRODUCTION

Talinum triangulare (Jacq.) Willd, commonly known as waterleaf is a dicotyledonous plant belonging to the family Portulacaceae (Tindall, 1983). There are 19 genera and 1580 species in this family (Gill, 1988). In West Africa, it is represented by two genera namely *Talinum* and *Portulaca*. In the genus *Talinum*, only two species are identified namely *T. triangulare* (Jacq.) Willd also known as *T. fruticosum* (L.) Juss and *T. portulacifolium* (Rahl) in the west coast of Africa (Hutchinson and Dalziel, 1994). *T. portulacifolium* serves as ornamentals, while *T. triangulare* is cultivated for food. It serves as a major leaf vegetable in view of its many uses and nutritional contribution to human diets. It is a major source of Vitamins and minerals needed for growth and development especially for children and pregnant women (Denton, 1997).

Nigeria has a rich *Talinum* germplasm resource. Different cultivars of the genus have been in cultivation for decades. The exact origins of these cultivars are still in doubts. The varietals differentiation stem from the inherent genotypic variations attributed to their free natural hybridization within and between species. Generally, *Talinum triangulare* are self-pollinated crop, but there is the tendency for the population to be heterogeneous due to their floral propensity for insect pollinations (Gill, 1988). This necessitates controlled pollinations and emasculations as fundamental to breeding work (Dowker, 1990).

Corresponding Author: E.J. Nya, School of Life Sciences, Heriot Watt University, Edinburgh, United Kingdom
Tel: +44 (0) 7506840602

Most of the Nigerians grown cultivars are not traits specific in term of yield, quality; resistant to drought and diseases, probably due to interactions between genotypes and environments which tend to modifies heterosis (Chapman *et al*., 2000). Heterosis or hybrids vigour is evaluated as the increased performance of hybrid plants over its parental inbred in terms of viability, growth and productivity (Yi Zhang *et al*., 2007). A major problem with the indigenous leaf vegetables of Nigeria and in deed Africa is that most of them have not been selected for desirable metric characters and no genetic or biotechnological research has been done on them (Opabode and Adebooye, 2005). No studies have been performed on heterosis or heterotic pattern within the *Talinum* germplasm, which includes *T. fruticosum* (L.) Juss, *T. paniculatum* (Jacq.) Gaertn, *T. crassifolium* and *T. cuneifolium*. Some of these are early maturing with some degree of acceptable yield and tolerant to drought. The concept of heterosis in plants or animals breeding is very important in identifying progenies with high yielding characters as it could only be established through testing of the F_1 of each parental combination (Ashton, 1949). Heterosis or hybrid vigour is the converse of inbreeding depression. (Falconer and Mackay, 1996). It evaluation is dependent on the parental performance in terms of the parameters in considerations (Riday and Brummer, 2002). Vegetables have been used for many years as major food components, highly cherished by about 90% of humans as a good source of plant protein, vitamins and minerals, immunostimulants and herbal medicines. To feed the growing world population, the required quantum leap in vegetables production will have to come from hybrids that can be expected to increase productivity by 50% in heterotic combinations. Heterotic hybrid cultivars of many crop plants have been used in making high contribution to the world food supply for decades (Duvick, 1997).

However, this research focuses on the use of genetically diverse land races to generate hybrids which would be evaluated for metric characters and studied the heterosis of these traits in different cross combinations. Information about their metric characters, cross compatibility and heterosis would play a vital role in hybrid improvement. Reciprocal diallel crosses provides the basis for generating such preliminary information (Gimelfarb, 1986).

MATERIALS AND METHODS

The study was conducted at the Michael Okpara University of Agriculture Teaching and Research Farms, Umudike, Nigeria in 2002 and 2003 cropping seasons. Umudike is situated in the Nigeria agro-ecological zone with latitude $05°29^{N}$ and longitude $07°32^{E}$ and altitude of 122 m above sea level in the forest zone of South Eastern Nigeria, with an average temperature of 30±2°C and mean annual rainfall of 2500-3000 mm (NRCRI, 2001). Atmospheric humidity and precipitation usually exceeding evapotranspiration for more than half of the year (Okafor *et al*., 1997).

The seven cultivars of *Talinum triangulare* used in this study were obtained from local fadama farming projects in Akwa Ibom, Cross river, Ebonyi states and horticultural garden, Umuahia in Abia state, Nigeria. The experiment was set up in a Randomized Complete Block Design (RCBD) with 4 replications. Each replicate contained 7 experimental units. A plot consisted of 4 rows. Stem cutting measuring 10 cm were planted slantingly and spaced 30 cm within and between rows. This gave a total plant population of 111,111.0 per ha. Missing stands were supplied, 2 weeks after planting. Crosses were done in all possible combinations, after 100% flowering. Florets were emasculated manually with the use of forceps and scalpel at early hour of 7.00 am, to prevent self-pollination. The F_1 hybrid seeds were harvested at maturity. They were germinated in the nursery separately, polythene bags and 4 weeks later, the seedlings were transplanted to the field and grown till maturity.

We studied heterosis in Talinum triangulare by testing the parental land races and their progenies or crosses for desirable metric characters. Observations were made on plant height at flowering, final plant height per plant, number of days to 50% flowering, basal diameter, number of branches at flowering, number of branches per plant, number of leaves at flowering, number of leaves per plant, leaf area and fresh shoot yield.. Random sampling methods were used in selecting 10 plant stands per plot for measuring these parameters. The data were analysed using the procedure for RCBD as outlined by Steel and Torries (1980). Duncan's Multiple Range Test (DMRT) was used to separate the means where significant differences existed according to Little and Hills (1972). Heterosis was calculated for each metric character for both better-parents and mid-parents using the formula outlined by Nwofia and Ene-Obong (2001) as follows:

$$^{H}Bp = \frac{F_1 - Bp}{Bp} \times \frac{100}{1}$$

$$^{H}Mp = \frac{F_1 - Mp}{Mp} \times \frac{100}{1}$$

Where:

F_1 = First filial generation value
Bp = Better-parent values
Mp = Mid-parent values
H = Heterosis

Hybridization success and germination percentage was calculated as outlined by Ariyo (1989).

RESULTS

Hybridization Success and Germination Percentage

Hybridization was generally successful. And it ranged from 52% (P_{12}) to 92% (P_{34}). The germination percentage of the F_1 seeds ranges from 60 to 70% in P_{12} and P_{34} and its reciprocal, respectively (Table 1). All traits showed directional dominance and maternal effects common to the progenies of a particular parent.

Morphological Characters of the Parental Land Races

The highest mean plant height at flowering of 30.15 cm was recorded for parent P_2, followed by P_4 with 24.80 cm. Final plant heights on the other hand ranged between 33.73 cm (P_3) and 9. 58.08 cm (P_2) among the parental cultivars (Fig. 1a-g).

The total mean number of branches at flowering was low in P_6 and P_7 with 1.25 and 1.4, respectively and high in P_3 (7.5), followed by P_1(4.5) and P_4(4.0). The result also showed that parental land races P_3 and P_4 had the highest mean number of leaves per plant with 108.65 and 61.96, respectively. This culminated into the overall fresh shoots yield which was high in P_3 (113.2 g), followed by P_4(71.0 g), P_2 (51.70 g) and P_1 (39.7 g) and low in P_7 with 20.5 g and P_5 with 22.8 g.

Morphological Characters of the F_1 Hybrids

Highly significant differences were recorded for such characters as final plant height per plant and at flowering, number of branches per plant and at flowering, number of leaf area and fresh shoots yield at ($p<0.01$) and basal diameter showed non significance. The number of branches at flowering and per plant, the numbers of leaves at flowering and per plant were high in some hybrids, with the highest in P_{43} (7.9), P_{34} (55.50), P_{25} (38.10) and P_{43} (88.66), respectively. The hybrids P_{34} (91.30) and its reciprocal P_{43} (88.0 g) gave a high fresh shoots yield, followed by P_{54} (68.2 g) and P_{72} (68.1 g).

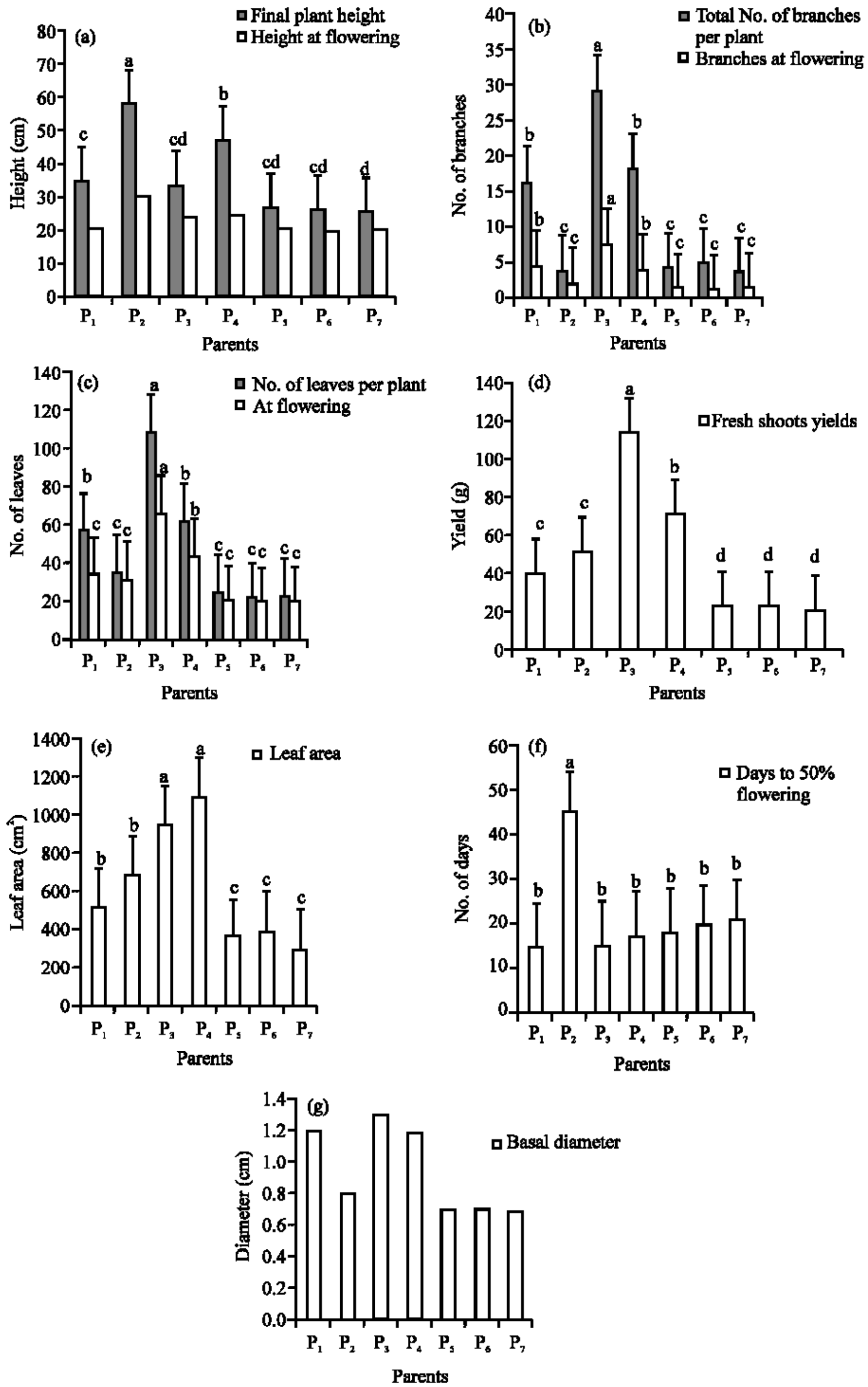

Fig. 1: Mean value of the Morphological characters of seven parents of *Talinum triangulare* studied. Bars with different superscripts are significantly different ($p<0.05$, n =10). Mean values = mean±SE. Bars with the same superscripts are not significantly different ($p<0.05$, n = 10). Mean values = Mean±SE

Table 1: Hybridization success and germination percentage of F_1 hybrids of *Talinum triangulare*

Cross combinations	No. of flowers	Pollination success (%)	Germination (%) of F_1 seeds
P_{12}	50	52	60
P_{13}	50	90	68
P_{14}	50	60	67
P_{15}	50	56	66
P_{16}	50	58	66
P_{17}	50	58	64
P_{21}	50	80	65
P_{23}	50	64	69
P_{24}	50	70	68
P_{25}	50	64	69
P_{26}	50	74	68
P_{27}	50	56	62
P_{31}	50	60	68
P_{32}	50	56	66
P_{34}	50	92	70
P_{35}	50	60	62
P_{36}	50	64	69
P_{37}	50	80	66
P_{41}	50	72	68
P_{42}	50	80	66
P_{43}	50	90	70
P_{45}	50	70	68
P_{46}	50	74	68
P_{47}	50	66	62
P_{51}	50	57	64
P_{52}	50	56	66
P_{53}	50	70	68
P_{54}	50	68	66
P_{56}	50	67	64
P_{57}	50	72	62
P_{61}	50	60	62
P_{62}	50	70	68
P_{63}	50	72	65
P_{64}	50	64	66
P_{65}	50	56	68
P_{67}	50	70	62
P_{71}	50	70	68
P_{72}	50	80	64
P_{73}	50	60	63
P_{74}	50	64	67
P_{75}	50	70	69
P_{76}	50	80	62

P_1= Ntokmfang, P_2 = Ndana, P_3 = Nteoka, P_4 = Ikpomfang, P_5 = Afia mfri, P_6 = Ofa bake, P_7 = Ngbolodi

Percentage Heterosis

It is showed that 2 out of 42 hybrids possesses positive better-parent heterosis for plant height at flowering ranging from 5.0% ($P_{14)}$ to 10% (P_{43}). The mid-parent heterosis was positive in five parental combinations ranging from 2% (P_{43}) as the lowest to 31.2% (P_{27}) as the highest. In others, heterosis was negative, even in all the crosses for final plant height. More so, 34 crosses out of the 42, showed positive better-parent heterosis for number of branches per plant ranging from 1.0% (P_{42}) as the lowest to 93.4% (P_{12}) as the highest. The mid-parent heterosis for this trait was all positive. The better-parent heterosis for number of leaves per plant was positive in P_{12} (3.6%) and its reciprocal 15.0 (23.2%), P_{24} (5.3%) and reciprocal P_{42} (5.7%) as the lowest heterotic values and in P_{67} (38.1%) 16.0 and P_{64} (35.2%) as the highest. The fresh shoots yield showed positive better-parents heterotic values in 11 parent combinations with P_{53} (48.1%) and its reciprocal (40.1%) as the highest and 14 18.0 positive mid-parent heterosis from parent combinations P_{12} (36.3%) and its reciprocal (26.3%), P_{26} 19. (26.0%) and it reciprocal (11.5%) and P_{27} (40.6%) and its reciprocal (12.7%) as shown in Table 2.

Table 2: Percentage heterosis for Morphological Characters of Talinum triangulare studied: (a) Mid-parent heterosis (b) Better-parent heterosis

	Plant height at flowering		Final plant height		No. of branches at flowering		No. of branches per plant		Days to 50 (%) flowering		No. of leaves per plant		Leaf area (cm^2)		Shoot yield	
Genotype	a	b	a	b	a	b	a	b	a	b	a	b	a	b	a	b
P_{12}	-22.5	34.4	-27.1	-41.5	24.2	-10.7	217.8	93.4	-5.5	-37.0	28.9	3.6	7.1	-5.6	36.3	21.0
P_{13}	-17.4	-22.4	-27.2	-28.6	-29.7	-43.8	118.0	09.9	62.7	60.0	-38.8	-53.2	19.7	-7.3	-23.5	-48.2
P_{14}	14.1	5.0	-26.9	-36.2	65.8	55.1	69.1	59.8	42.5	31.4	-19.9	-22.8	-31.	-49.2	-35.9	-50.9
P_{15}	-22.5	-17.3	-13.2	-14.7	22.3	27.2	45.2	76.2	-19.2	-41.2	-18.2	-32.1	9.5	-15.1	-32.6	-47.6
P_{16}	-27.4	-40.1	-26.9	-41.2	12.6	22.7	60.4	35.2	42.3	40.2	35.1	-51.2	-42.5	-52.3	-46.2	-35.2
P_{17}	-17.2	-14.2	-34.2	-36.2	24.2	28.1	68.9	-4.6	61.5	31.4	16.1	-35.2	-21.6	-36.2	-25.2	-24.7
P_{21}	-27.0	-39.1	-34.6	-47.6	70.8	22.7	190.1	76.6	-2.1	-34.8	53.3	23.2	18.5	4.4	26.3	11.9
P_{23}	-33.1	-40.3	-49.0	-59.7	6.1	-33.1	67.9	-5.7	-5.5	-37.0	-76.4	-60.3	-73.7	-47.9	55.2	-45.9
P_{24}	-45.7	-50.5	-52.3	-56.8	36.5	2.5	34.7	-19.5	-6.4	-34.8	34.7	5.3	-47.7	-57.6	-25.3	-35.4
P_{25}	-41.6	-21.6	-26.1	-27.6	25.1	22.6	43.2	34.3	-8.1	-32.0	28.1	4.6	-15.6	-36.7	-23.6	-11.6
P_{26}	-23.0	-40.1	-13.6	-14.6	13.6	12.7	60.2	52.6	-16.2	-42.1	36.2	6.2	-30.7	-47.6	26.0	10.2
P_{27}	31.2	-26.1	-41.9	-45.2	37.6	2.8	67.6	-15.2	-19.1	-45.6	-17.6	-35.1	19.6	-8.2	40.6	-45.7
P_{31}	-6.9	-12.5	-13.3	-14.9	12.8	-9.7	88.3	46.7	42.3	40.0	-18.7	-32.9	9.5	-15.2	-35.9	-50.0
P_{32}	-35.0	-14.9	-14.1	-57.4	22.0	-23.1	96.7	90.3	-19.0	-46.0	-36.2	-57.8	-6.0	-21.0	-55.9	-67.9
P_{34}	-23.7	-25.4	-35.0	-44.2	38.1	5.0	117.8	77.3	31.4	-42.5	-54.2	-18.0	-22.8	-28.0	-5.7	-23.2
P_{35}	-7.6	-12.6	-46.1	-50.6	36.1	8.6	95.2	51.2	-6.6	-37.6	35.2	8.6	22.6	4.6	33.2	40.2
P_{36}	17.1	-25.1	-14.1	-49.1	69.7	28.1	68.1	32.1	-19.0	40.2	16.2	12.1	26.7	19.6	-5.6	-25.2
P_{37}	-11.1	-17.9	-31.1	-44.1	34.2	-10.6	69.0	2.7	41.2	30.3	-36.2	5.7	-16.3	-31.2	-25.6	-36.2
P_{41}	-10.2	-17.3	-41.9	-49.2	90.9	78.5	43.1	35.2	13.5	60.0	16.0	11.7	-15.9	-38.0	-33.2	-47.8
P_{42}	-41.7	-35.4	-34.8	-41.0	70.6	28.2	69.2	1.0	-16.1	-41.5	35.2	5.7	38.1	-46.8	-33.1	-42.2
P_{43}	2.0	10.0	-26.3	-36.8	-36.7	-57.8	86.1	51.4	42.5	31.4	-59.8	-66.8	-32.6	-37.1	-32.8	-45.3
P_{45}	-25.1	-31.2	-27.1	-45.2	21.1	-32.6	80.1	45.2	-20.2	-45.1	36.2	7.8	9.2	-18.2	-46.2	-41.2
P_{46}	-33.1	-25.1	-13.6	-44.1	-36.2	-50.7	77.6	42.7	-18.6	-48.6	28.1	5.2	18.2	-10.7	26.0	10.7
P_{47}	-10.1	-18.2	-11.2	-41.2	38.2	6.2	22.6	90.9	-6.3	-38.2	16.2	13.7	-47.2	-61.2	-41.3	-61.2
P_{51}	-23.1	-41.2	-26.2	-31.2	23.2	15.2	110.6	86.2	-6.1	-38.2	35.1	-60.2	8.2	-6.7	35.2	20.6
P_{52}	-46.1	-36.6	-13.1	-14.7	24.3	-20.1	102.1	67.6	42.1	61.2	28.1	4.2	18.2	-8.3	36.1	44.1
P_{53}	-41.7	-35.1	-42.3	-13.8	-28.2	-41.3	59.1	61.2	54.3	26.7	-38.1	-51.2	-30.1	-50.2	-23.4	48.2
P_{54}	-10.7	-18.2	-26.7	-47.1	22.4	27.3	60.5	30.1	-21.3	40.1	-18.2	-33.6	9.6	-16.2	-35.1	-50.7
P_{56}	-35.2	-6.1	-49.2	-14.3	12.7	24.1	58.2	-6.7	-2.1	-35.1	34.7	5.3	-21.6	-37.3	-46.2	-31.3
P_{57}	-45.1	-21.2	-50.1	-12.1	67.2	21.3	121.2	76.1	-5.6	41.6	-18.2	-36.3	18.6	4.7	26.1	10.7
P_{61}	-60.1	-41.1	-27.1	-42.1	7.2	-27.1	35.2	-19.4	-8.7	-30.1	16.2	12.2	-36.3	-25.3	-46.1	-31.2
P_{62}	-33.1	-17.1	-44.3	-45.1	25.6	22.6	34.1	-18.4	-6.8	-41.8	-35.2	-36.2	4.8	18.5	11.5	26.1
P_{63}	-6.2	-12.3	-41.1	-28.2	13.7	12.3	44.2	35.1	40.2	40.1	27.0	16.0	-41.2	-56.2	-40.1	-45.2
P_{64}	-11.2	-17.2	-35.1	-27.2	36.4	3.9	68.6	45.2	19.2	-45.1	28.6	35.2	-15.1	-37.3	-25.7	-24.3
P_{65}	-41.0	-35.2	-13.2	-16.2	6.5	-31.2	95.2	80.2	41.2	30.2	-74.9	-51.7	-30.7	-48.6	-51.2	-41.7
P_{67}	7.1	-12.6	-46.1	-13.1	13.1	41.2	67.7	-18.5	-19.9	39.2	-36.2	38.1	19.7	-8.2	-5.8	-23.1
P_{71}	-31.2	-26.1	-31.2	-41.2	36.2	-23.1	34.2	17.6	41.6	-41.2	16.2	13.6	9.5	-16.2	22.6	-25.6
P_{72}	-45.7	-50.2	-26.1	-51.2	8.2	37.1	85.3	44.6	-20.1	-55.2	28.1	5.2	-22.9	-27.0	12.7	-35.7
P_{73}	-23.4	-14.2	-36.1	-41.6	27.1	8.7	43.2	31.2	-18.6	47.2	36.2	8.3	-21.2	-55.9	26.0	-40.3
P_{74}	-10.4	-18.7	-35.1	-42.1	34.2	-11.2	61.7	51.2	-6.8	-37.2	-59.2	-60.2	19.6	-8.1	-51.2	-40.4
P_{75}	-25.7	-32.1	-34.2	-47.6	69.2	28.1	86.1	17.8	-49.2	31.2	35.2	6.2	-38.1	31.7	-6.2	-51.2
P_{76}	-27.1	-40.0	-41.2	-27.1	22.1	18.1	77.6	39.7	-20.6	45.2	16.3	12.8	-10.3	27.0	-41.2	27.1

P_1 = Ntok mfang, P_2 = Ndana, P_3 = Nte oka, P_4 = Ikpo mfang, P_5 = Afia mfri, P_6 = Ofa bake, P_7 = Ngbolodi, P_{12} ……
P_{76} = P 1♂ x $_2$♀ ………P_7 ♂ x $_6$ ♀, ♂ = Male parent, ♀ = Female parent

DISCUSSION

The high success obtained in the hybridization and germination percentage of the F_1 seeds indicated that all the parental cultivars were cross compatible. The germination percentage, which was relevant in the determination of F_1 viability and fertility, showed that the F_1 were highly viable with the highest mean viability of 70%. This is also suggestive of the absent of any chromosomal or physiological aberration in their genomes. This situation is similar to the possession of a balanced lethal system which showed existence of fully functional egg cells. Morphologically, hybrids are placed in relation to their parents, with most crosses intermediate, albeit closer to the maternal parent. Maternal effects have substantial impacts on the hybrids fitness. However, maternal effects occur when maternal phenotype influences the offspring's phenotypes independent of the offspring genotypes (Corinna *et al*., 2007).

The metric characters of the parental cultivars were significantly different from each other, showing that the land races were more genetically diverse. Thus the land races could be explored in the development of high yielding hybrids. The highest mean plant height at flowering of 26.05 and 24.75 cm were recorded for hybrids P_{14} and P_{43}, respectively. The final plant height of the crosses ranged from 23.36 cm (P_{53}) to 34.25 cm (P_{42}). Plant height at flowering and final plant height were relevant in terms of the canopy geometry and level above the ground. If it is too closed to the ground, the leaves which constitute the economic part of the plant, which of course, is of primary interest to the farmers could be dirtied by the spattering of rain drops, splashing soils and dirt on the leaves and also damaged by low crawling pests.

The number of branches per plant (both primary and secondary branches) ranged from 3.60 (P_7) to 29.13 (P_3) in the parental cultivars and 14.70 (P_{61}) to 55.50 (P_{34}) in the crosses.

The means number of leaves per plant varied from 21.70 to 108.65 from the parental cultivars, with the highest mean recorded for P_3. The hybrids had the mean leaves per plant ranged from 50.00 exhibited by P_{47}, P_{35}, P_{45} and P_{64} to 88.66 leaves possessed by P_{43}. Yield measurements as presented by fresh shoots yield (g) showed that the land races had values ranging from 20.50 g (P_7) to 113.13 g (P_3), whereas from the hybrids, fresh shoots yield of 88.00 g was obtained from P_{43} as the highest mean value. Here, there is yield advantage of the land races planted by stem cuttings over the hybrids raised by seeds as earlier reported by Grubben (1977). The numbers of branches per plant were relevant in terms of their contributions to bearing the total number of leaves per plant and consequently, the overall shoots yield and these are important criteria of interest to farmers and breeders because they constitute great economic aspect of the plant and for improvement of yield components (Nya and Eka, 2007). This is in lines with earlier findings by Ariyo (1987).

Number of days to 50% flowering ranged from 21 days to 29 days among the hybrids. Hybrids with the least number of days, to flowering (P_{13}, P_{73} and P_{75}) with 21 days were early yielders as compared to their late yielding counterparts (P_{21} and P_{24}) with 29 days, followed by P_{23}, P_{25}, P_{41} and P_{72} with 28 days each. This is of relevant important to both the farmers and the breeders. The early yielders could be used in breeding program twice or more within a year in this South Eastern ecology and the farmers would be able to embark on three or more cropping cycle within a year especially when irrigation and other management factors like fertilizers are employed, thereby enhancing their standard of living. Water availability is important environmental parameters in *Talinum triangulare* production (Taisma and Terrara, 2003).

The percentage heterosis as indicated in Table 2 showed a form of heterotic pattern at play in *Talinum triangulare*. They proposed heterotic pattern for mid-parent heterosis in fresh shoots yield with parental combinations (P_{12} and its reciprocal, P_{26} and its reciprocal and P_{27} and its reciprocal). And indeed, they also showed better-parent heterotic pattern in this parameter with P_{35} and its reciprocal. The existence of these heterotic patterns indicated that there is heterosis within *Talinum triangulare* germplasm most especially among the above parental cultivars.

The establishment of heterotic patterns in *Talinum* germplasm would plays a prominent role in the selection of land races for hybrids production. This is in lines with the findings of Hallaur and Mirander (1988), their analysis of diallel crosses of maize provides preliminary data about the heterotic relationships among the parents. In general, heterosis is discussed as an expression of the genetic diversity among cultivars, when it is positive or some of their components are significant for all traits, it means that the parental cultivars are genetically diverse (Moll *et al*., 1962).

The positive heterosis exhibited by these Hybrids (P_{14} and P_{43}) for plant height indicated that the parental cultivars involved in these cross combinations could be used in the development of superior

F_1 hybrids. All other crosses with negative heterosis for both plant heights per plant and at flowering indicated the tendency of the hybrids to go dwarfism, which is a favourable phenomenon when dealing with loses due to lodging, which has been one single effect of climate change in sub-Saharan countries with attendant frequent storms and flooding. This is in lines with similar findings by Ajibade (2000). Heterosis of metric traits such as number of branches per plant, numbers leaves per plant, leaf area and fresh shoots yield have been found to be positive in most of the crosses. Two crosses showed positive heterosis over both Mid-parent and Better-parent for shoots yield and five crosses had positive heterotic values for number of leaves per plant. Selections within these crosses with positive heterosis would be useful in breeding for high yielding hybrids, which will lead to improvement in yield and other metric characters.

CONCLUSION

On the basis of the result obtained from this study, we conclude that the best parental combinations for use in generating superior hybrids of *Talinum triangulare* in South Eastern Agro-ecological zone of Nigeria are P_{43} and its reciprocal, P_{47}, P_{35}, P_{45} and P_{64}. This study showed that there is heterosis or heterotic patterns in *Talinum* germplasm. We acknowledged that heterosis are often modified by interactions between genotypes and the environment in which it is cultivated, but their effect varies widely with sites or locations differing in seasonal water supply and other management factors. We indicated that it is more meaningful to characterised hybrid lines as showing heterosis for metric traits at a specific location and under certain environmental conditions. Further more, this study demonstrates the yield advantage of the land races planted by stem cuttings over the hybrids raised by seeds. The progeny testing described in this research, not only ensures the establishment of heterotic patterns among the parental crosses but also engender much more genetic gain from selections.

ACKNOWLEDGMENTS

The authors are grateful to the Akwa Ibom state Ministry of Agriculture and Natural Resources for the mandate and other logistics to embark on the study. The first author is grateful to the Federal Ministry of Education, Abuja, Nigeria, for awarding the educational scholarships.

REFERENCES

Ajibade, S.R., 2000. Pedigree selection in Cowpea. Nig. J. Bot., 13 (1): 29-33.

Ariyo, O.J., 1987. Plant character correlation and path analysis of pod yield in Okra. Euphtica, 36 (2): 677-686.

Ariyo, O.J., 1989. Variation and heritability of fifteen characters in Okra. J. Trop. Agric. (Trinidad), 67 (3): 215-216.

Ashton, T., 1949. The use of heterosis in the production of agricultural and horticultural crops. Commonwealth bur. Plant Breed. Genet., pp: 30.

Chapman, S., M. Cooper, D. Butler and R. Henzell, 2000. Genotype by environment interactions affecting grain sorghum. I. Characteristics that confound interpretation of hybrid yield. Aust. J. Agric. Res., 51 (2): 197-207.

Corinna, R., M. Shane and J. Schmitt, 2007. Maternal effects of drought stress and inbreeding in Impatiens capensis *Balsaminaceae*. Am. J. Bot., 94 (12): 1984-1991.

Denton, L., 1997. Exploiting the diversity of fruits and vegetables for improved nutrition. Proceedings of 15th Annual Conference of the Horticultural Society of Nigeria, 8-11: 26-29.

Dowker, B.D., 1990. Onion Breeding. In: Onions and Allied Crops, Vol. 1. Baca Raton, FL: CRC Press, Inc. Ref. (Text in En) (En Abst) (SB339.O5R3), pp: 215-232.

Duvick, D.N., 1997. Heterosis: Feeding People and Protecting Natural Resources. In: Genetics and Exploitation of Heterosis in Crops. Coors, J.G. and S. Pandey (Eds.). American Society of Agronomy, inc. Madison, Wisconsin. USA., pp: 19-29.

Falconer, D.S. and T.F. Mackey, 1996. Introduction to Quantitative Genetics. Longman, Essex, England.

Gill, L.S., 1988. Taxonomy of Flowering Plants. Published by Africana-FEP Ltd. Ibadan, Nigeria, pp: 178-193.

Gimelfarb, A., 1986. Offspring-parent genotypic regression: How linear is it? Biometrics, 42 (1): 67-71.

Grubben, G.J.H., 1977. Tropical Vegetables and Their Genetics Resources. Tindall, H.D. and J.T. Williams (Eds.). International Board of Plant Genetics Resources. FAO, Rome. pp: 18-20.

Hallaur, A.R. and J.B. Mirander, 1988. Quantitative genetics in Maize breeding. Iowa State Univ., Ames.

Hutchinson, J. and J.M. Dalziel, 1994. Flora of West Tropical Africa. 2nd Edn. Vol. 1, Part 1. White Friars Press, London.

Little, T.M. and F.J. Hills, 1972. Statistical Methods in Agriculture and Research. Agricultural Extension University of California, pp: 67-159.

Moll, R.H., W. Salhuana and H. Robinson, 1962. Heterosis and genetic diversity in variety crosses of Maize. Crop Sci., 2 (3): 197-198.

Nwofia, G.E. and E. Ene-Obong, 2001. Crossability relationship and heterosis in intra and interspecific hybrids of capsicum. J. Sustainable Agric. Environ., 3 (2): 57-63.

Nya, E.J. and M.J. Eka, 2007. Genetic variability and heritability studies of desirable metric characters in *Talinum triangulare* land races in South Eastern Nigeria. J. Agron., 6 (3): 459-463.

Okafor, J.C., H. Okolo and M. Ejiofor, 1997. Strategies for Enhancing Potential of Edible Woody Forest Species of South Eastern Nigeria. In: The Biodiversity of African Plants, Vander Maesen *et al*. (Eds.). The Netherlands, pp: 684-695.

Opabode, J.T. and C.O. Adebooye, 2005. Application of biotechnology for the improvement of Nigerian indigenous leaf vegetables. Afr. J. Biotechnol., 4 (3): 138-142.

Riday, H. and E.C. Brummer, 2002. Forage yield in Alfalfa. Crop Sci., 42 (3): 716-723.

Steel, R.G.D. and J.D.H. Torries, 1980. Principles and Procedures of Statistics. With Special Reference to Biological Science. McGraw-Hill book Co. Inc. New York.

Taisma, M.A. and A. Terrara, 2003. Drought under natural conditions affect leaf properties induces CAM in Talinum triangulare. Intercien, 28 (5): 292-297.

Tindall, H.D., 1983. Vegetables in the Tropics. The Macmillian Press Ltd. UK., pp: 102-106.

Yi Zhang, Z., N. Zhongfu, Y. Yingyin and S. Qixin, 2007. Gibberellins and heterosis of plant height in Wheat (*Triticum aestivum* L.). BMC. Genet., 8 (40): 1471-2156.