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

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Abstract: The aim was to study their cross ability and heterosis of their desirable metric
caracters, so as to facilitate selection of parental cultivars for incorporation in breeding
program for Talinum triangulare improvement in South Eastern Nigeria. The 42 resultants
F₁ 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 F₁ hybrids. All the cultivars were cross compatible
and the F₁ seeds were highly viable with highest means viability of 70% and lowest of 60%.
Some of the F₁ hybrids showed positive heterosis over mid-parents and heter-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: F₁ 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. portulacoides (Rahl) in the west coast of Africa (Hutchinson and
Dalziel, 1994). T. portulacoides 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).
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, 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 (Ridley and Brunner, 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 agroecological zone with latitude 05°29’ and longitude 07°32’ 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 triangulaire used in this study were obtained from local fadama farming projects in Akwa Ibom, Cross river, Ebonyi states and horticultural garden, Umunah 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, 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 triangulaire 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 Torrie (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:

\[ \%BP = \frac{F_1 - Bp}{Bp} \times 100 \]

\[ \%MP = \frac{F_1 - Mp}{Mp} \times 100 \]

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% (\( P_{23} \)) to 92% (\( P_{24} \)). The germination percentage of the \( F_1 \) seeds ranges from 60 to 70% in \( P_{11} \) and \( P_{12} \) 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 \( P_{23} \), 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 cm (\( P_7 \)) among the parental cultivars (Fig. 1a-g).

The total mean number of branches at flowering was low in \( P_4 \) and \( P_3 \) with 1.25 and 1.4 respectively and high in \( P_3 \) (7.5), followed by \( P_1 \) (4.5) and \( P_7 \) (4.0). The result also showed that parental land races \( P_3 \) and \( P_7 \) 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), \( P_5 \) (51.70 g) and \( P_7 \) (39.7 g) and low in \( P_1 \) with 20.5 g and \( P_3 \) 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 \( P_{23} \) (7.9), \( P_{33} \) (55.50), \( P_{25} \) (38.10) and \( P_{24} \) (88.66), respectively. The hybrids \( P_{23} \) (91.30) and its reciprocal \( P_{12} \) (88.0 g) gave a high fresh shoots yield, followed by \( P_{24} \) (68.2 g) and \( P_{23} \) (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 F1 hybrids of *Talinum triangulare*

<table>
<thead>
<tr>
<th>Cross combinations</th>
<th>No. of flowers</th>
<th>Pollination success (%)</th>
<th>Germination (%) of F1 seeds</th>
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<tbody>
<tr>
<td>P1</td>
<td>50</td>
<td>52</td>
<td>60</td>
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<td>P12</td>
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<td>P14</td>
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<td>P15</td>
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<td>P16</td>
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<td>P17</td>
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<td>P18</td>
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<td>P19</td>
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<td>P10</td>
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<td>P11</td>
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<td>P12</td>
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<td>P13</td>
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<td>P15</td>
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<td>P16</td>
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<td>P19</td>
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<tr>
<td>P10</td>
<td>50</td>
<td>56</td>
<td>63</td>
</tr>
</tbody>
</table>

P1 = Stokumfum, P2 = Ndana, P3 = Ntoko, P4 = Ilposumfum, P5 = Afia mbiri, P6 = Ofia balke, P7 = Ngbelodi

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% (P45) to 10% (P26). The mid-parent heterosis was positive in five parental combinations ranging from 2% (P25) as the lowest to 31.2% (P27) 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% (P42) as the lowest to 93.4% (P26) 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 P12 (3.6%) and its reciprocal 15.0 (23.2%), P14 (5.3%) and reciprocal P42 (5.7%) as the lowest heterotic values and in P6 (38.1%) 16.0 and P4 (35.2%) as the highest. The fresh shoots yield showed positive better-parents heterotic values in 11 parent combinations with P13 (48.1%) and its reciprocal (40.1%) as the highest and 14 18.0 positive mid-parent heterosis from parent combinations P12 (36.3%) and its reciprocal (26.3%), P14 19. (26.0%) and it reciprocal (11.5%) and P2 (40.6%) and its reciprocal (12.7%) as shown in Table 2.
Table 2: Percentage heterosis for Morphological Characters of Triticum aestivum studied. (a) Mid-parent heterosis (b) Better-parent heterosis

<table>
<thead>
<tr>
<th>Genotype</th>
<th>Plant height at flowering</th>
<th>Final plant height</th>
<th>No. of branches at flowering</th>
<th>No. of branches per plant</th>
<th>Days to 50% flowering</th>
<th>No. of leaves per plant</th>
<th>Leaf area (cm²)</th>
<th>Shoot yield</th>
</tr>
</thead>
<tbody>
<tr>
<td>P1</td>
<td>44.7 ± 3.4</td>
<td>48.0 ± 3.7</td>
<td>4.8 ± 0.2</td>
<td>4.6 ± 0.2</td>
<td>-5.3 ± 0.7</td>
<td>4.6 ± 0.2</td>
<td>5.2 ± 0.3</td>
<td>5.0 ± 0.3</td>
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<tr>
<td>P2</td>
<td>41.4 ± 3.2</td>
<td>44.6 ± 3.3</td>
<td>4.5 ± 0.1</td>
<td>4.3 ± 0.1</td>
<td>-4.7 ± 0.6</td>
<td>4.3 ± 0.1</td>
<td>4.9 ± 0.2</td>
<td>4.7 ± 0.2</td>
</tr>
<tr>
<td>P3</td>
<td>39.4 ± 3.2</td>
<td>42.4 ± 3.2</td>
<td>4.2 ± 0.1</td>
<td>4.0 ± 0.1</td>
<td>-4.2 ± 0.5</td>
<td>4.0 ± 0.1</td>
<td>4.6 ± 0.2</td>
<td>4.4 ± 0.2</td>
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<tr>
<td>P4</td>
<td>37.6 ± 3.2</td>
<td>40.8 ± 3.1</td>
<td>4.0 ± 0.1</td>
<td>3.8 ± 0.1</td>
<td>-4.0 ± 0.4</td>
<td>3.8 ± 0.1</td>
<td>4.2 ± 0.2</td>
<td>4.0 ± 0.2</td>
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<tr>
<td>P5</td>
<td>35.7 ± 3.2</td>
<td>38.7 ± 3.1</td>
<td>3.8 ± 0.1</td>
<td>3.6 ± 0.1</td>
<td>-3.8 ± 0.3</td>
<td>3.6 ± 0.1</td>
<td>3.8 ± 0.2</td>
<td>3.6 ± 0.2</td>
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<tr>
<td>P6</td>
<td>33.8 ± 3.2</td>
<td>35.8 ± 3.1</td>
<td>3.6 ± 0.1</td>
<td>3.4 ± 0.1</td>
<td>-3.6 ± 0.2</td>
<td>3.4 ± 0.1</td>
<td>3.6 ± 0.2</td>
<td>3.4 ± 0.2</td>
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<tr>
<td>P7</td>
<td>31.9 ± 3.2</td>
<td>33.9 ± 3.1</td>
<td>3.4 ± 0.1</td>
<td>3.2 ± 0.1</td>
<td>-3.4 ± 0.1</td>
<td>3.2 ± 0.1</td>
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<td>P8</td>
<td>30.0 ± 3.2</td>
<td>32.0 ± 3.1</td>
<td>3.2 ± 0.1</td>
<td>3.0 ± 0.1</td>
<td>-3.2 ± 0.1</td>
<td>3.0 ± 0.1</td>
<td>3.2 ± 0.2</td>
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<td>P9</td>
<td>28.1 ± 3.2</td>
<td>30.1 ± 3.1</td>
<td>3.0 ± 0.1</td>
<td>2.8 ± 0.1</td>
<td>-3.0 ± 0.1</td>
<td>2.8 ± 0.1</td>
<td>3.0 ± 0.2</td>
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<tr>
<td>P10</td>
<td>26.2 ± 3.2</td>
<td>28.2 ± 3.1</td>
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<td>22.5 ± 3.1</td>
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<td>2.0 ± 0.1</td>
<td>-2.2 ± 0.1</td>
<td>2.0 ± 0.1</td>
<td>3.0 ± 0.2</td>
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<td>18.6 ± 3.2</td>
<td>20.6 ± 3.1</td>
<td>2.0 ± 0.1</td>
<td>1.8 ± 0.1</td>
<td>-2.0 ± 0.1</td>
<td>1.8 ± 0.1</td>
<td>3.0 ± 0.2</td>
<td>1.8 ± 0.2</td>
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<td>P17</td>
<td>12.9 ± 3.2</td>
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DISCUSSION

The high success obtained in the hybridization and germination percentage of the F1 seeds indicated that all the parental cultivars were cross compatible. The germination percentage, which was relevant in the determination of F1 viability and fertility, showed that the F1 were highly viable with the highest mean viability of 70%. This is also suggestive of the absence 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$_{13}$, respectively. The final plant height of the crosses ranged from 23.36 cm (P$_{31}$) to 34.25 cm (P$_{32}$). 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 close 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 envolving pests.

The number of branches per plant (both primary and secondary branches) ranged from 3.60 (P$_{2}$) to 29.13 (P$_{2}$) in the parental cultivars and 14.70 (P$_{31}$) to 55.50 (P$_{32}$) 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$_{2}$. The hybrids had the mean leaves per plant ranged from 50.00 exhibited by P$_{20}$, P$_{20}$, P$_{20}$, and P$_{21}$ to 88.66 leaves possessed by P$_{25}$. Yield measurements as presented by fresh shoots yield (g) showed that the land races had values ranging from 20.50 g (P$_{2}$) to 113.13 g (P$_{2}$), whereas from the hybrids, fresh shoots yield of 88.00 g was obtained from P$_{21}$ 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 Grubb (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 (Nyia 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$_{20}$, P$_{25}$, and P$_{2}$) with 21 days were early yielders as compared to their late yielding counterparts (P$_{21}$ and P$_{2}$) with 29 days, followed by P$_{20}$, P$_{20}$, P$_{20}$ and P$_{21}$ 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$_{2}$, and its reciprocal, P$_{2}$, and its reciprocal and P$_{2}$, and its reciprocal). And indeed, they also showed better-parent heterotic pattern in this parameter with P$_{2}$, 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 play a prominent role in the selection of land races for hybrids production. This is in lines with the findings of Hallauer 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$_{13}$) for plant height indicated that the parental cultivars involved in these cross combinations could be used in the development of superior
F₁ 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 losses 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 T. triangulare in South Eastern Agro-ecological zone of Nigeria are P₁ and its reciprocal, P₁₅, P₁₆, P₁₇, P₁₈, and P₁₉. This study showed that there is heterosis or heterotic patterns in T. triangulare 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.

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REFERENCES


