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Production and Genetic Evaluation of Tomato Hybrids using the Diallel Genetic Design

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ABSTRACT. *Tomato (Lycopersicon esculentum Mill.) F1 hybrids were produced at the Regional Agricultural Research and Development Centre, Bandarawela, using the Diallel genetic design, in order to select superior hybrids depending on the genetic analysis of their performance with reference to yield and fruit quality characters. Six tomato varieties namely, Marglobe, Bianz, Roma, Katugastota Wilt Resistant (KWR), Castal Rock (PT 254) and T 146 (AVRDC variety) were selected as parents in order to combine important characters such as yield, fruit quality and disease resistance. A 6 × 6 full Diallel crossing programme was carried out to produce the F1 hybrids, which were evaluated together with their parents for yield and yield related characters such as fruit weight, number of fruits per plant, days to maturity, resistance to wilt, as well as fruit quality characters such as number of locules, pericarp thickness, Brix, acidity, peel colour, shape and hardness. The result indicated that in all yield and yield related characters, heterobeltiosis was shown. Significant GCA and SCA values were obtained for all characters. Hayman's analysis of variance indicated significant additive genetic variation as well as dominance (except for fruit weight). Possible epistatic effects were also observed for all characters except for days to maturity. Overdominance was not observed in any of the characters indicating that heterobeltiosis was due to dispersion of genes in the parents. Although these results indicated that superior hybrids could be selected for yield and yield related characters, the significant additive genetic variance and the absence of overdominance indicate that equally good or even better inbred lines could be obtained from these hybrids in future improvement programmes. Considering yield and related characters. T146 × KWR was selected as the best hybrid. It also showed complete resistance to wilt. The hybrid T-146 × Marglobe gave the largest fruits while T-146 × Bianz and T-146 × PT-254 were the earliest to mature.*

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INTRODUCTION

Tomato is one of the major vegetable crops grown in Sri Lanka, especially in the Badulla, Kandy and Matale districts. In order to increase the income of tomato farmers, it is essential to improve both total yield, yield related characters such as number of fruits per plant, fruit weight, and days to maturity, as well as fruit quality characters and resistance to wilt, which is a major disease that threatens tomato cultivation in this country. In order to select superior products of breeding programmes, it is necessary to understand the genetic basis of the performances of these products. This can be achieved by carrying out breeding programmes using one of many genetic designs available to the breeder. One such design which is very popular in breeding hybrids is the Diallel (Perera *et al.*, 1993; Ranatunga *et al.*, 1990; Patil and Bojappa, 1988; Tripathy and Misra, 1987; Wilson *et al.*, 1978 and Baker, 1978). The Diallel analysis is a systematic method of evaluating and selecting hybrids based on heterosis, and/or parents on combining ability. Das *et al.* (1988) showed highly significant GCA and SCA effects in their Diallel experiments for yield characters in tomato. Moreover, the development of disease resistant varieties has been an important feature in many tomato breeding programmes around the world (Tigchelan, 1986; Opena, 1993).

The objectives of this experiment were to use the Diallel design to produce F1 hybrids using foreign and local parental germplasm and to evaluate their performance for yield and other characters of importance in comparison to their parents and to select the best hybrid/s as a new variety/varieties.

MATERIALS AND METHODS

Six tomato varieties were used as parents (Table 1) in a 6 × 6 Diallel crossing design to produce 30 F1 hybrids. The variety KWR was used for its resistance to bacterial wilt, T-146 for yield and fruit colour, Marglobe for fruit quality, Roma for thickness of pericarp, Bianz for fruit quality and yield and PT 254 for fruit quality and high yielding ability.

The 30 F1 hybrids (including their reciprocals) and the 6 parents were grown in the nursery and transplanted in the field as 25-day-old seedlings in a randomized complete block design with 4 replicates. Each plot measured 4.0 m × 0.8 m with a spacing of 80 cm × 50 cm. Fertilizer application and other cultural practices were carried out according to the recommendations of the Department of Agriculture.

Table 1. Characters of parental varieties.

Variety	Time of flower	Average yield (t/ha)	Fruit characters		
			Shape	Colour	Pericarp thickness
Marglobe (A)	Medium	20.0	SF	OR	Medium
Bianz (B)	Late	50.0	HR	OR	Thick
Roma (C)	Medium	25.0	PS	OR	Thick
KWR (D)	Medium	25.9	R	OR	Thin
PT-254 (E)	Medium	51.0	R	RE	Thick
T-146 (F)	Medium	34.9	SF	OR	Thin

SF - Slightly flat HR - High, round, PS - Plum shaped
RO - Round OR - Orange RE - Red

Hayman's analysis of variance (1954a, 1954b) modified by Morley Jones (1965) was used in the analysis of data. It provides information on additive genetic variation, dominance and residual dominance effects as well as general combining ability (GCA) and specific combining ability (SCA). This will enable breeders to decide on the final outcome of their breeding programmes.

RESULTS AND DISCUSSION

Analysis of variance showed significant GCA and SCA effects for all the characters (Table 2).

Days to maturity

Table 3 shows the mean values for days to maturity. The variety Roma was the earliest to mature (79 days). Four hybrids showed significant heterobeltiosis, the best being T-146 × Bianz and T-146 × PT 254 which matured in 75 days.

Table 2. **Mean squares from the combining ability analysis of variance for four characters.**

	Maturity	Fruit/plant	Fruit weight (g)	Yield (t/ha)
GCA	6.51*	149.80 ns	311.39**	83.67 **
SCA	4.87 ns	205.33**	103.55**	76.71**

* - Significant at p = 0.05
** - Significant at p = 0.01
ns - not significant

Table 3. **Mean values for days to maturity (number of days) test for heterobeltiosis.**

Cross	Better parent	Hybrid	Heterobeltiosis
T-146 × Bianz (FB)	81.5	75.0	*
T-146 × PT-254 (FE)	80.0	75.0	*
T-146 × KWR (FD)	83.3	76.0	*
PT-254 × Roma (FC)	79.0	76.5	*

* - Significant at P = 0.05

Partitioning of variance into its components by Hayman's analysis indicated significant additive genetic variance among the parents and mean dominance effects in hybrids showing heterosis (Table 7).

Number of fruits per plant

Among the parent varieties, Bianz had the largest number of fruits per plant (35.88). Three hybrids showed heterobeltiosis, with the best being T-146 × KWR (62.28) (Table 4).

Table 4. Mean values for number of fruits per plant. Test for heterobeltiosis.

Cross	Better parent	Hybrid	Heterobeltiosis
T-146 × KWR (FD)	17.25	62.28	*
PT-254 × KWR (ED)	21.88	50.25	*
PT-254 × Roma (FC)	19.75	35.88	*

* - Significant at P = 0.05

Hayman's analysis of variance (Table 7) showed highly significant additive as well as dominance effects. Other non-additive variation including epistasis was also significant.

Table 5. Mean values for fruit weight (g). Test for heterobeltiosis.

Cross	Better parent	Hybrid	Heterobeltiosis
T-146 × Marglobe (FA)	17.25	62.28	*
PT-254 × Marglobe (EA)	21.88	50.25	*

* - Significant at P = 0.05

Fruit weight (g)

Marglobe had the highest mean fruit weight of 66.06 g among the parental varieties (Table 5). Two hybrids showed significant heterobeltiosis, with T-146 × Marglobe showing the highest mean fruit weight value of 79.35 g.

Hayman's analysis of variance showed significant additive genetic variance (Table 7). Both the mean dominance effect as well as other non-additive gene effects were not significant.

Fruit yield (t/ha)

Bianz had the highest yield among the parents of 35.46 t/ha. Three hybrids showed heterobeltiosis, with T-146 × KWR being the best with 44.54 t/ha compared to its better parent which had a yield of only 17.65 t/ha (Table 6).

Table 6. Mean values for fruit yield (t/ha). Test for heterobeltiosis.

Cross	Better parent	Hybrid	Heterobeltiosis
T-146 × KWR (FD)	17.65	44.54	*
PT-254 × KWR (ED)	17.65	40.21	*
T-146 × Roma (FC)	15.18	36.09	*

* - Significant at P = 0.05 ns - not significant at P =0.05

Hayman's analysis of variance (Table 7) showed significant additive, dominance and other non-additive gene effects such as epistasis.

Table 7. Genetic parameters controlling days to maturity (C1), Number of fruits per plant (C2), Fruit weight (C3), Fruit yield (C4).

Genetic parameters	C1	C2	C3	C4
Additive gene effects (a)	*	*	*	*
Mean dominance effects (b1)	*	*	ns	*
Additional dominance (b2)	ns	*	ns	*
Residual dominance (b3)	ns	*	ns	*

* - significant at P = 0.05 ns - not significant

Fruit quality characters

Several important fruit quality characters were examined and evaluated as shown in Table 8.

Table 8. Fruit quality characters of some parents and hybrids.

No. of Locules	Pericarp thickness (cm)	Acidity % Citric acid
AD (9)	CC (0.5)	AD (1.2)
ED (14)	EE (0.5)	AC (1.2)
EB (11)	AB (0.5)	CE (1.2)
BB (8)	BC (0.5)	DF (0.2)
	CD (0.5)	
	CE (0.5)	
	DF (0.5)	
	BF (0.5)	
	CF (0.5)	

The hybrids E × D(14), and E × B(11) had the largest number of locules indicating the possibility of obtaining large number of seeds from these. Amongst the parents, BB had 8 locules.

Several hybrids had thick pericarps of 0.5 cm each. Two parent types CC and EE too showed the same values. Thick pericarps are useful in transporting fruits to distant places as well as to prevent postharvest losses and to provide resistance to insect and pathogen attacks.

Several hybrids, AD, CA, EC, AF, EA, and ED showed high acid content in terms of the % citric acid content (1.2%), while DF had the lowest (0.2%).

The peel colour varied from orange-red to red, while the shapes varied from oblong to round.

Resistance to wilt

Seedlings of parents and hybrids were inoculated under laboratory conditions to test for resistance to wilt. All hybrids with KWR as a parent, as well as KWR showed a higher percentage of resistance to wilt (> 40%) compared to all other parents and hybrids. Under field conditions, all hybrids with KWR as a parent, as well as KWR showed total resistance to wilt, whereas all other parents and hybrid combinations had a low percentage of wilted plants (- 10%).

Covariance - Variance analysis (Wr/Vr)

The Wr/Vr graph provided information on the type of dominance present (Mather and Jinks, 1982). Partial dominance was indicated for fruit weight and yield, while complete dominance was shown for number of fruits per plant (Figure 1, 2 and 3).

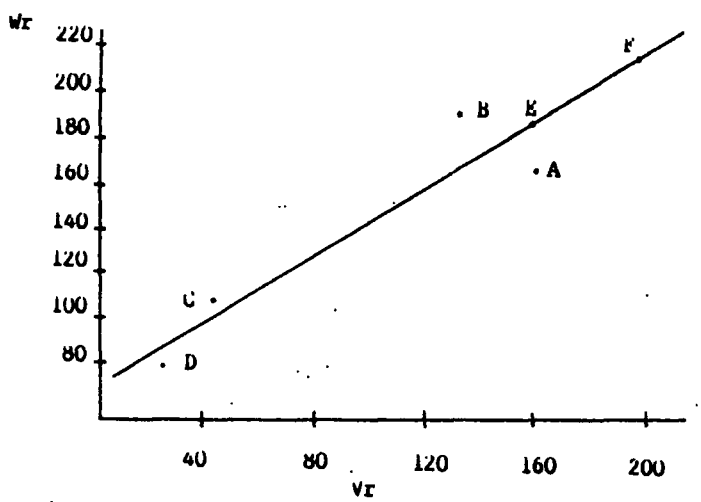

Figure 1. Wr/Vr graph for fruit weight.

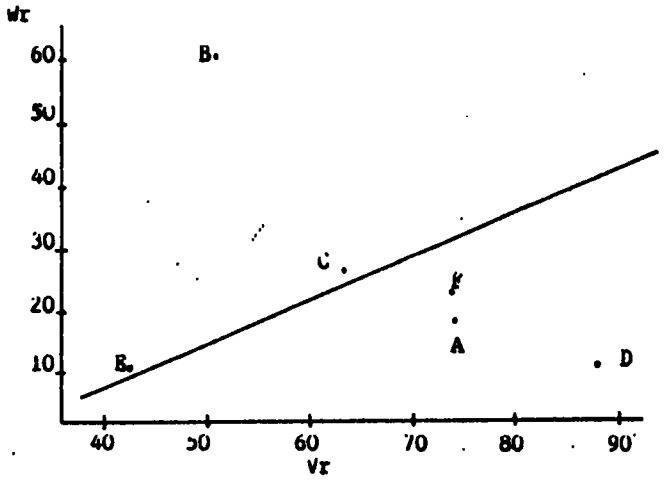

Figure 2. **Wr/Vr graph for fruit yield.**

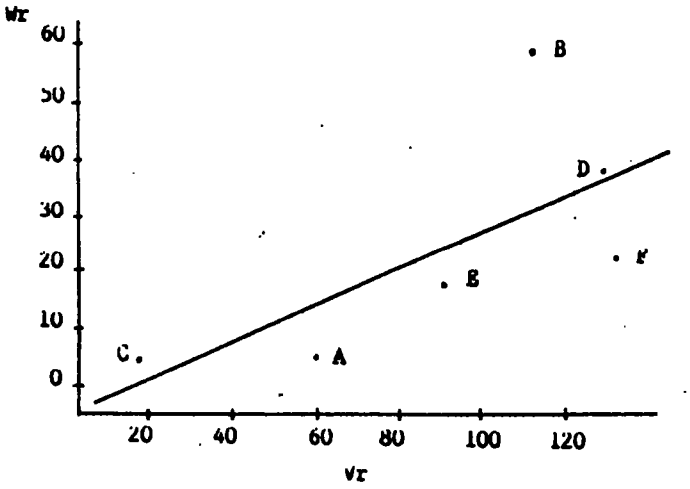

Figure 3. **Wr/Vr graph for fruits per plant.**

CONCLUSIONS

Heterobeltiosis was shown in yield and all yield related characters. The parent T-146 had the highest GCA for all characters. Hayman's analysis of variance showed significant additive genetic variance as well as dominance. Overdominance was not observed in any of the characters, indicating that heterobeltiosis was due to dispersion of genes in the parents. Therefore, although superior hybrids were identified in this programme, it will be possible to obtain equally good or even better inbred lines from these hybrids. All hybrids with KWR as a parent showed total resistance to wilt under field conditions. The hybrid T-146 × KWR gave the highest yield with the highest number of fruits per plant, while the hybrid T-146 × Marglobe had the largest fruits. The hybrids T-146 × Bianz and T-146 × PT-254 were the earliest to mature.

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