

Full Length Research Paper

Development and comparative studies of double cross tomato hybrids

Abdul Munim Farooq¹, Idrees Ahmad Nasir¹, Bushra Tabassum¹, Muhammad Tariq¹, Zahida Qamar¹, Mohsin Ahmad Khan¹, Nadeem Ahmad¹, M. Saleem Haider^{2*}, Waheed Anwar², Muhammad Arshad Javed³ and Tayyab Husnain¹

¹National Centre of Excellence in Molecular Biology, University of the Punjab, Lahore, Pakistan.

²Institute of Agricultural Sciences, University of the Punjab, Lahore, Pakistan.

³Faculty of Bioscience and Bioengineering, University Technology, 81310 Skudai, Johor, Malaysia.

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In this present study, six F1 hybrids (Maya, Roma, Rio Grande, Emotion F1 Hybrid, Tomato 55 and Western Hybrid) were grown and their 15 crosses were evaluated. Out of 15 combination of crosses, 10 were recorded as successful viable hybrids, that is, Maya x Roma, Maya x Rio Grande, Maya x Western Hybrid, Roma x Rio Grande, Roma x Western Hybrid, Rio Grande x Tomato 55, Rio Grande x Western Hybrid, Emotion F1 Hybrid x Tomato 55, Emotion F1 hybrid x Western hybrid, Western Hybrid x Tomato 55. In F1 hybrids, average plant height, average flowers per cluster, average number of fruits per cluster, average weight of fruits, average days to harvest and 100 seed weight were recorded maximum in western hybrid, while average number of fruits per plant and average fruit yield per plant were recorded maximum in emotion F1 hybrid. In double cross hybrids, average flowers per cluster, average number of fruits per cluster and average fruit yield per plant were recorded maximum in emotion F1 hybrid x western hybrid. Average fruits weight and 100 seed weight were recorded maximum in emotion F1 hybrid x tomato 55, while average plant height, average number of fruits and average days to harvest were recorded maximum in western hybrid x tomato 55, Maya X Roma and Rio Grande X Western hybrid, respectively. Overall, a general trend was found that all F1 plants within the same variety were similar while plants within the same double cross hybrid showed segregation and distinct characteristics were noted. This study showed that there are greater chances of improvement through double cross hybrid production. The adopted pattern is an ideal way of exploiting variability which usually arises during the hybridization of two parental lines.

Key words: F1 hybrids, double cross hybrids, hybrids variability.

INTRODUCTION

Tomato is an important vegetable of Pakistan and all over the world. Tomato (*Lycopersicon esculentum*) belongs to the family solanaceae and classified in the genus *Lycopersicon* (Miller and Tanksley, 1990). The center of diversity for tomato is located in Western South America, and the cherry tomato *L. esculentum* var. *cerasiforme* is considered as the most likely ancestor of cultivated tomatoes. In 2002 to 2003 total area under this crop in Pakistan was 30957 h with a production of 306290 tons,

(Anonymous, 2003). In tomato, interspecific crosses have been used frequently and many useful traits such as disease resistance, drought tolerant and high yielding have been incorporated from *L. pimpinellifolium* to *L. esculentum*, because of their cross compatibility (Rick and Chetelat, 1995). Tomatoes are self-pollinating with perfect flowers. Although, genetic sterility is available in tomato, hand emasculation and hand pollination are preferred for making hybrids. Seed number per pollination is high, tomato hybrids can exhibit heterosis therefore, and yield increase in absence of stress is small or even non-existent. The unique utility and attraction of hybrid tomatoes is that they allow breeders to assemble,

*Corresponding author. E-mail: haider65us@yahoo.com.

in one cultivar, complementary genes for disease resistance as well as for traits affecting product quality such as shelf life. Breeders of hybrid tomatoes do not need to place all desirable resistance genes in one inbred cultivars, which accentuates problems with linkage drag; instead they can hybridize two complementary inbred lines to produce a hybrid with the desired full set of resistance genes. Tomato hybrids also exhibit increased yield stability, perhaps because they have a better balance of genes for disease resistance (Janick, 1994). With the increasing need of consumers for both quality and diversity of tomato products, there is a need to collect, exploit and evaluate unknown tomato germplasm extensively (Agong and Schittenhelm, 1993; Agong et al., 1997). However, most of the tomato germplasm are largely undocumented and have unknown morphological, agronomic and biochemical attributes. Tomato is continuously introduced and grown in all ecological zones where arable agriculture is practicable. This tendency has fuelled the extensive cultivation of various tomato cultivars with unclear documentation (Agong and Schittenhelm, 1993).

MATERIALS AND METHODS

Production of double cross hybrids

Seeds of six imported Tomato F1 hybrid (Maya, Roma, Rio Grande, Emotion F1 Hybrid, Tomato 55 and Western Hybrid) were purchased from the Sunny Seed Company, Egerton Road Lahore. Their nursery was grown in control conditions and plants were shifted after one month of germination to floriculture hybrid seed production tunnel. Each treatment was subjected to single plot comprising of eight rows of 10 feet. Plant to plant distance was 60 cm while row-to-row distance was 70 cm. The crosses were made in diallel fashion.

Emasculation

Crossing began about 50 to 60 days after the transplantation of nursery to the tunnel. Flower buds which were to be opened after 2 to 3 days were chosen to emasculate. Undesirable flower buds and flowers were removed from the cluster. Selected buds were forcibly opened by using sharp-pointed forceps. The anther was opened carefully and removed out of the bud, leaving the calyx, corolla and gynoecium (pistil).

A few sepals of emasculated flower were cut using scissors to differentiate the hybrid fruits from selfed fruits at the time of harvest. Then the emasculated flowers were tagged (labeled the tag with lead pencil showing female parent name, date and time of emasculatation) and the flowers were covered with butter paper bag. Then emasculated flowers were hand pollinated after two days.

Pollination

Stigma was exposed to facilitate pollination after removing the paper butter bags. Pollination was done by touching the stigma with the tip of the index finger, which was exposed to mature anthers of male plants or by direct exposure of stigma to the mature anthers. The name of the male parent from which the anther was brought

was also noted on tag.

Harvesting

Successful pollinations were visible within one week by the enlargement of the fruit size and their cut sepals. Tomato fruits ripped about 40 to 50 days after pollination. Only fully ripped fruits were harvested.

Seed extraction

Seed extraction was done manually. Crossed fruits were harvested in polyethylene bags. The fruits were crushed and put the bags and fermented for one day at 30°C to separate the gel mass (pulp) embedding the seeds. The fermented mass was put in an open plastic container and the container was filled up with water and the seeds were stirred to allow the pieces of flesh and skin sticking on the seeds to float. The container was inclined and the floating refuse was gently removed, making sure that the seeds remained at the bottom. The seeds were washed several times by adding fresh water to the container each time until all the flesh and gel were completely removed.

Seed drying

The washed seeds were placed in an open air under shade to dry for 3 to 4 day. The seeds were stirred 2 to 3 times daily so that seeds can dry uniformly. The seed clumps were also loosen daily to keep them separate.

Evaluation of double cross hybrids

Nursery sowing for evaluation

Nursery of following six F1 hybrids and 10 double cross hybrids were sown in controlled conditions.

T ₁	Maya
T ₂	Roma
T ₃	Rio Grande
T ₄	Emotion F1 Hybrid
T ₅	Tomato 55
T ₆	Western Hybrid
T ₇	Maya x Roma
T ₈	Maya x Rio Grande
T ₉	Maya x Western Hybrid
T ₁₀	Roma x Rio Grande
T ₁₁	Roma x Western Hybrid
T ₁₂	Rio Grande x Tomato 55
T ₁₃	Rio Grande x Western Hybrid
T ₁₄	Emotion F1 hybrid x Tomato 55
T ₁₅	Emotion F1 hybrid x Western Hybrid
T ₁₆	Western Hybrid x Tomato 55

Green house evaluation

The seedlings at the age of 4 weeks were shifted to green house. Each double cross hybrids and parental F1 hybrids were transplanted in five rows. Plant to plant distance was 50 cm while row-to-row distance was 70 cm. Data were recorded on the following parameters.

1) Average plant height

- 2) Average flowers per cluster
- 3) Average number of fruits per cluster
- 4) Average fruit weight. (g)
- 5) Average number of fruits per plant
- 6) Fruit yield per plant (kg)
- 7) Days to harvest
- 8) 100 seed weight (mg).

Average plant height

Average plant height was measured in cm using meter rod. The height was measured from the base of plant to the tip of the plant. For each treatment 5 randomly selected plants were used.

Average flowers per cluster

Numbers of flowers per cluster were counted on randomly selected 5 plants.

For each plant three flowers clusters were selected, one from the top of the plant, one from the middle of the plant and one from the bottom of the plant and the mean were used as average flowers per clusters of the genotype.

Average number of fruits per cluster

Number of fruits per cluster was counted on randomly selected 5 plants. For each plant three fruit clusters were selected, one from the top of the plant, one from the middle of the plant and one from the bottom of the plant and its mean used as flowers per clusters of the genotypes.

Average fruit weight

There were 4 to 6 pickings so after each picking, thirty tomatoes were randomly selected and weighed in grams. Finally the average was calculated.

Average number of fruits per plant

Number of fruits per plant was counted from randomly selected five plants from each plot. The small sized fruits usually at the tip of cluster were not counted. There were 4 to 6 pickings so the plants were selected, marked and then noted data from the same selected plants.

Fruit yield per plant

Fruit yield was measured in kg. All ripened fruits were harvested from randomly selected 5 plants; weighed and their average was calculated.

Days to first harvest

The interval between sowing to the first harvest was noted for each cross in comparison with their parents.

100 Seed weight

The extracted and dried seeds were counted and 100 seeds were weighed in mg from each plot.

RESULTS

Production and evaluation of double cross hybrids

Six F1 hybrids (Maya, Roma, Rio Grande, Emotion F1 hybrid, Tomato 55, Western hybrid) were grown in centre for excellence in molecular biology (CEMB) hybrid seed production tunnel. Hybrids were manually emasculated and subsequently pollinated at appropriate time in all possible 15 combinations, out of these ten were recorded as successful viable hybrids that is, Maya x Roma, Maya x Rio Grande, Maya x western hybrid, Roma x Rio Grande, Roma x western hybrid, Rio Grande x Tomato 55, Rio Grande x western hybrid, Emotion F1 hybrid x Tomato 55, Emotion F1 hybrid x Western hybrid, Western Hybrid x Tomato 55. After attaining maturity fruits were harvested and seed were extracted.

The seeds of F1 and double cross hybrids were grown as nursery and eventually transplanted in the tunnel. Average plant height, flowers per cluster, number of fruits per cluster, average fruit weight (g), number of fruits per plant, fruit yield per plant (kg), days to harvest, 100 seed weight (mg) were the characteristics considered for comparison and performance of genotypes.

Average plant height

Plant height was recorded from base of the plant to the tip of the plant for F1 hybrids and double cross hybrids. In F1 hybrids maximum average plant height was recorded for Western Hybrid (275 cm) and minimum average plant height was that of Maya (106 cm). However, plant height was found almost uniform within the genotypes, in contrast variation was found among genotypes. In double cross hybrids average maximum plant height was recorded for Western Hybrid x Tomato 55 (248 cm) and minimum plant height was that of Maya x Roma (100.4 cm). Variation in plant height was recorded within as well as among successful crosses (Table 1).

Average flowers per cluster

In F1 hybrids maximum average flowers per cluster was recorded for Western Hybrid (10.4) and minimum average flowers per cluster was that of Roma (6). However, flowers per cluster were found uniform within the genotypes, in contrast variation was found among genotypes. In double cross hybrids average flowers per cluster was recorded for Emotion F1 hybrid x Western hybrid (10.6) and minimum flowers per cluster was that of Maya x Rio Grande (4.6). Variation was recorded within as well as among successful crosses (Table 1).

Average number of fruits per cluster

In F1 hybrids maximum average number of fruits per

Table 1. Average of the characters \pm standard error of the treatments grown in green house.

S/N	Variety name	Plant height (cm)	Flowers per cluster	No. of fruits per cluster	Fruit weight (g)	No. of fruits per plant	Fruit yield per plant (kg)	Days to harvest	100 seed wt (mg)
1	MA	106 \pm 3.68	7.4 \pm 0.24	6.2 \pm 0.20	86.6 \pm 1.72	55 \pm 2.02	4.9 \pm 0.16	103 \pm 2.83	293 \pm 1.82
2	RO	109 \pm 4.08	6 \pm 0.32	6 \pm 0.32	89.2 \pm 2.35	50.8 \pm 2.31	4.72 \pm 0.16	89.4 \pm 2.84	289 \pm 1.79
3	RG	120 \pm 4.92	7.6 \pm 0.40	7 \pm 0.32	94.8 \pm 1.66	71 \pm 2.66	6.76 \pm 0.18	93.4 \pm 1.54	284 \pm 2.01
4	EM	266 \pm 2.89	7.8 \pm 0.37	7.6 \pm 0.24	104 \pm 2.01	78.6 \pm 2.82	8.58 \pm 0.11	101 \pm 2.73	271 \pm 1.87
5	T55	269 \pm 4.85	9.8 \pm 0.37	8.6 \pm 0.24	119 \pm 1.52	62.4 \pm 2.29	7.64 \pm 0.16	117 \pm 2.25	301 \pm 2.27
6	WH	275 \pm 2.66	10.4 \pm 0.51	8.6 \pm 0.40	121 \pm 3.36	76.4 \pm 2.01	8.9 \pm 0.15	123 \pm 2.80	318 \pm 2.63
7	MA x RO	100.4 \pm 4.54	9.4 \pm 0.86	9.2 \pm 0.86	89 \pm 3.36	80.4 \pm 2.38	7.4 \pm 0.38	123 \pm 1.57	298 \pm 2.14
8	MA x RG	87.8 \pm 4.54	4.6 \pm 0.24	3.2 \pm 0.37	78.2 \pm 4.35	50 \pm 1.58	3.7 \pm 0.76	133 \pm 2.48	288 \pm 2.71
9	MA x WH	129 \pm 8.06	5.8 \pm 0.37	5.4 \pm 0.68	81.8 \pm 5.16	54 \pm 2.28	4.16 \pm 0.76	126 \pm 2.68	290 \pm 2.01
10	RO x RG	141 \pm 9.54	7.4 \pm 0.51	4.2 \pm 0.20	73.4 \pm 5.72	51.8 \pm 3.02	3.26 \pm 0.42	128 \pm 1.02	276 \pm 1.82
11	RO x WH	155 \pm 7.48	7.8 \pm 0.58	7.4 \pm 0.24	72 \pm 3.85	52.2 \pm 3.26	4.06 \pm 0.64	119 \pm 2.56	280 \pm 1.57
12	RG x T55	222 \pm 7.22	8.6 \pm 0.51	7.4 \pm 0.51	106 \pm 3.17	67.8 \pm 4.68	7.38 \pm 0.35	104 \pm 1.43	256 \pm 1.72
13	RG x WH	201 \pm 6.90	6.6 \pm 0.60	6 \pm 0.63	105 \pm 5.33	64 \pm 4.92	6.48 \pm 0.49	123 \pm 1.88	274 \pm 1.38
14	EM x T55	236 \pm 6.61	7.6 \pm 0.51	5.8 \pm 0.66	109 \pm 6.04	59.8 \pm 3.89	6.1 \pm 0.48	135 \pm 1.84	314 \pm 1.57
15	EM x WH	218 \pm 4.37	10.6 \pm 0.51	8.2 \pm 0.37	111 \pm 5.03	63.6 \pm 2.73	7.76 \pm 0.55	120 \pm 2.97	299 \pm 2.40
16	WH x T55	248 \pm 5.15	8.8 \pm 0.58	7.8 \pm 0.73	92.8 \pm 3.81	61.2 \pm 2.96	5.7 \pm 0.24	100 \pm 2.35	300 \pm 2.20

MA=Maya, RO=Roma, RG=Rio Grande, EM=Emotion F1 Hybrid, T55=Tomato 55, WH=Western Hybrid, MA x RO=Maya x Roma, MA x RG=Maya x Rio Grande, MA x WH= Maya x western hybrid, RO x RG=Roma x Rio Grande, RO x WH= Roma x western hybrid, RG x T55= Rio Grande x Tomato 55, RG x WH=Rio Grande x western hybrid, EM x T55=Emotion F1 hybrid x Tomato 55, EM x WH= Emotion F1 hybrid x Western hybrid, WH x T55=Western Hybrid x Tomato 55.

cluster was recorded for Western Hybrid (8.6) and minimum average number of fruits per cluster was that of Roma (6). However, numbers of flowers per cluster were found uniform within the genotypes, in contrast variation was found among genotypes. In double cross hybrids average number of fruits per cluster was recorded for Emotion F1 hybrid x Western hybrid (8.2) and minimum number of fruits per cluster was that of Maya x Rio Grande (3.2) (Table 1).

Average fruit weight

In F1 hybrids a maximum average fruit weight was recorded for Western Hybrid (121 g) and minimum average fruits weight was that of Maya (86.6 g). However, fruits weight was found uniform within the genotypes, in contrast variation was found among genotypes. In double cross hybrids average fruits weight was recorded for Emotion F1 hybrid x Tomato 55 (109 g) and minimum fruits weight was that of Maya x Rio Grande (78 g) (Table 1).

Average number of fruits per plant

In F1 hybrids maximum average number of fruits per plant was recorded for Emotion F1 hybrid (78.6) and minimum average number of fruits per plant was that of

Maya (55). However, number of fruits per plant was found uniform within the genotypes, in contrast variation was found among genotypes. In double cross hybrids average number of fruits per plant was recorded for Maya x Roma (80.4) and minimum number of fruits per plant was that of Maya x Rio Grande (50) (Table 1).

Fruit yield per plant

In F1 hybrids maximum average fruit yield per plant was recorded for Emotion F1 hybrid (8.58 kg) and minimum average fruit yield per plant was that of Maya (4.9 kg). However, fruit yield per plant was found uniform within the genotypes, in contrast variation was found among genotypes. In double cross hybrids average fruit yield per plant was recorded for Emotion F1 hybrid X Western Hybrid (7.76 kg) and minimum fruit yield per plant was that of Roma x Rio Grande (3.26 kg) (Table 1). Fruit yield per plant is our main goal so we also noted data on individual plants of superior three double cross hybrids and found that maximum fruit yield per plant is found in a plant of Emotion F1 Hybrid X Western Hybrid (9.6 kg) (Table 2).

Days to first harvest

In F1 hybrids maximum average days to harvest was

Table 2. Average fruit yield per plant \pm standard error, minimum and maximum yield of each treatment.

S/N	Variety name	Fruit yield per plant (kg)	Inferior plant yield (kg)	Highest yield per plant (kg)
1	MA	4.9 \pm 0.16	4.6	5.5
2	RO	4.72 \pm 0.16	4.4	5.3
3	RG	6.76 \pm 0.18	6.3	7.4
4	EM	8.58 \pm 0.11	8.4	9
5	T55	7.64 \pm 0.16	7.2	8
6	WH	8.9 \pm 0.15	8.4	9.2
7	MA x RO	7.4 \pm 0.38	6.5	8.4
8	MA x RG	3.7 \pm 0.76	2.2	6
9	MA x WH	4.16 \pm 0.76	2.4	6.4
10	RO x RG	3.26 \pm 0.42	2.3	4.3
11	RO x WH	4.06 \pm 0.64	2.5	6.4
12	RG x T55	7.38 \pm 0.35	6.5	8.3
13	RG x WH	6.48 \pm 0.49	5.2	7.6
14	EM x T55	6.1 \pm 0.48	4.8	7.3
15	EM x WH	7.76 \pm 0.55	6.5	9.6
16	WH x T55	5.7 \pm 0.24	5	6.2

MA=Maya, RO=Roma, RG=Rio Grande, EM=Emotion F1 Hybrid, T55=Tomato 55, WH=Western Hybrid, MA x RO= Maya x Roma, MA x RG= Maya x Rio Grande, MA x WH= Maya x western hybrid, RO x RG= Roma x Rio Grande, RO x WH=Roma x western hybrid, RG x T55=Rio Grande x Tomato 55, RG x WH=Rio Grande x western hybrid, EM x T55=Emotion F1 hybrid x Tomato 55, EM x WH=Emotion F1 hybrid x Western hybrid, WH x T55=Western Hybrid x Tomato 55.

recorded for Western Hybrid (123) and minimum average days to harvest was that of Roma (89). However, days to harvest was found uniform within the genotypes, in contrast variation was found among genotypes. In double cross hybrids average days to harvest was recorded for Rio Grande X Western Hybrid (135) and minimum days to harvest was that of Western Hybrid x Tomato 55 (100) (Table 1).

100 seed weight

In F1 hybrids maximum 100 seed weight was recorded for Western Hybrid (318 mg) and minimum 100 seed weight of Roma (271 mg). In double cross hybrids 100 seed weight was recorded for Emotion F1 hybrid X Tomato 55 (314 mg) and minimum days to harvest was that of Rio Grande x Tomato 55 (256 mg) (Table 1).

DISCUSSION

One of the objectives of the present study was to generate double cross hybrids by crossing F1 hybrids to combine superior genes, as well as to get the better segregates. Hybrid cultivars generally showed advantages of high yield over pure line cultivars as strongly favored by Troyer (1999) in case of corn hybrids. Ten out of fifteen different types of double crosses were found properly set. Seedlings were transplanted at the age of 4 weeks (best for transplanting) which are in agreement with Ibrahim and Dadari (2002) who opined

that 4 weeks old seedling usually performed well under *in vivo* conditions. To evaluate the performance of double cross hybrids in comparison with their parents we considered different yield related parameters. Ibrahim and Dadari (2002) studied such parameters for the evaluation of genotypes. Makesh (2003a, b) observed same traits for heterosis and heritability studies in tomato. Generally double cross hybrids are inferior to F1 hybrids in all yield related parameters, never the less there are certain genotypes among the double cross hybrids which are outstanding in their mean value of yield related traits. A promising individual is Emotion F1 Hybrid X Western Hybrid embarged on complementary gene action. These results are in line with that of Yunbi et al. (1998) who studied intraspecific hybrids, interspecific hybrids and F2 populations in rice and found improved characters.

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