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RESEARCH ARTICLE

Estimation of combining ability of single and double cross hybrids of tomato for yield and yield related characters

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Abstract

This study was conducted to assessment of combining ability of single and double cross hybrids (*Solanum lycoperson* Mill) of tomatoes from 2018 to 2019 in the farmers' fields of village Tarar, Rawalakot, AJK. This trial was set up in RCBD with 3 replicates. Twelve tomato hybrids were obtained by a 4×4 diallel fashion in 1st year and were evaluated for plant attributes i.e., number of branches per plant, number of cluster per plant, number of locules per fruit, plant height, fruit drop, number of flowers per cluster, pericarp thickness, number of fruits per cluster, single fruit weight, fruit diameter and fruit yield per plant in the second year. Among the parents Sahel and Dinar has good GCA for fruits per plant, single fruit weight and yield per plant and could be used in hybridization for yield improvement. While crosses Sahel × Dinar, Sandal × Dinar and Sandel × Sahel had better SCA for single fruit weight and yield per plant and need further evaluation for yield stability at multilocations.

Key words: Tomato, combining ability, single and double cross hybrids, yield

Introduction

Tomato (*Solanum lycopersicon* Mill.) which belongs to the family solanaceae is the most essential vegetable crop, having chromosomes number 2n=24. Southern Mexico is considered to be the center origin of tomato. It is the second ranked after potato in the world. Tomatoes are eaten regularly and cooked with meats, vegetables and pulses. During 2017-18 total world production of tomatoes was 170.8 million tons. Tomatoes in Pakistan occupy area of 0.04 million hectares with an annual production of yield is 414,645 tonnes (MNFSR, 2018).The capability of a genotype to transfer its superior performance to its crosses is called combining ability. Its value depends on ability of genotype to produce best hybrids with other inbred. It also benefits in assortment of superior parents for hybridization and identification of hybrids. It helps to design a breeding program for such characters (Aisyah *et al.*, 2016). The main problems in tomato growing in Pakistan and Azad Kashmir are low productivity of local cultivars, scarcity of quality seeds of high yielding varieties. To overcome these problems and to meet the national demand it is necessary to extensively collect the local cultivars, characterization and evaluation of existing tomato genotypes and design different breeding programs for development of new improved varieties and indigenous hybrids with high yield, disease resistant and wider adoption.

However, a large number of local land races having a huge genetic diversity are undocumented having unknown morphological and agronomic traits (Fahmida and Ahmed 2007). The characterization will help in the identification of varieties and their future utilization for varietal improvement using conventional techniques of selection and hybridization. Hence, the objectives of the present investigation to estimate the combining ability of single and double cross hybrids of tomato for yield and yield related characters developed form easily available the local varieties.

Materials and methods

The experiment was intended to estimate the combining ability of single and double cross hybrids of tomato for yield and yield related characters. In this experiment F_1 parents of tomato i.e. Salar, Sandel, Sahel and Dinar were procured as single cross hybrids. During the first year seeds of parents were sown in trays during March, 2018 in incubator at 25˚C. After germination of seeds trays were placed in plastic tunnel so that required temperature can be provided. After emergence of 4-5 true leaves 35 days old seedlings were transplanted in green house. During first year of the experiment, parents were crossed in 4 × 4 diallel fashion, using every possible combination to produce a double cross. In this experiment, a total of four parents were crossed to create twelve double crosses (Table 1). The seeds were collected from double-crossed tomatoes and re-sown with parents to collect data for next year. During 2nd year 16 genotypes seeds were sown in the trays and kept in the incubator at 25˚C for one week. After seed germination, the trays were placed in a plastic tunnel to provide the desired temperature. After emergence of 4-5 true leaves 35 days old seedlings were shifted in the experimental field during April, 2019. Each seedling was removed carefully from its chamber and the roots were loosening very gently. Seedlings were planted deeply, only the top most leaves were kept above ground. The soil was firmly tamped with hands and then watered.

Table 1: List of double crosses produced in the experiment

Sr. No.	Crosses	Sr. No.	Crosses	Sr. No.	Crosses
1	Salar × Sandel	5	Salar × Sahel	9	Salar × Dinar
2	Sandel × Salar	6	Sandel × Sahel	10	Sandel × Dinar
3	Sahel × Salar	7	Sahel × Sandel	11	Sahel × Dinar
4	Dinar × Salar	8	Dinar × Sandel	12	Dinar × Sahel

Collection of data

Data were recorded from 5 randomly selected plants and the mean values of the parameters were calculated likr number of clusters per plant, plant height (cm), number of flowers per cluster, number of branches per plant, number of fruits per cluster, number of locules per fruit, fruit diameter (mm), single fruit weight and fruit yield per plant (kg).

Statistical analysis

Means were computed and (ANOVA) was conducted by computer software MSTATC (Steel et al., 1997). Data regarding to parents and F_1 crosses of the 4×4 diallel fashion set were subjected to analysis. Assessments of variance for specific combining ability (SCA) and general combining ability (GCA) and their effects were estimated as the procedure given by Griffing (1956).

Results and discussion

Estimations of specific combining ability (SCA) and general combining ability (GCA) effects of four parents and their twelve crosses for all nine traits are existing in (Table 2) and (Table 3) for various traits investigated in the current study and accordingly the outcomes are presented character wise in the following heads.

Plant height

Data regarding plant height revealed that highest significant positive general combining ability (GCA) effect was exhibited by Dinar (3.22) indicated its good general combiner (Table 2). On the other hand, only one parent, Sandel (-4.77) was selected as poor general combiner because of its significant negative general combining ability (GCA) effect. On the other hand two parents, Salar (0.52) and Sahel (1.03) were chosen as average general combiners because of its nonsignificant positive value of GCA effect. Two crosses out of twelve cross combinations, showed significant positive effects which can be regarded as a good specific combiners (Table 3). On the other hand two cross combinations viz., Sandel × Sahel (10.30) and Sandel × Dinar (3.24) observed significant positive SCA effects. The only one cross combinations viz., Salar × Sahel (1.91) observed to have non-significant positive values for SCA effect. While, two crosses, viz., Sandel × Salar (-1.49) and Salar × Dinar (-1.92), because of its nonsignificant negative SCA effect was assigned as average cross combination. These results are similar to outcomes of Kumar et al. (2013) for general combining ability (GCA) effects and with Gautam et al., (2016) for specific combining ability (SCA) studies.

Number of branches per plant

For number of branches per plant, (Table 2) two parents viz., Salar (0.31) and Sandel (0.33) showed significant positive effects of GCA, which showed its good general combiner. Whereas, two parents, *viz*., Dinar (-0.61) and Sahel (-0.03) were found to be average general combiners because of their non-significant negative general combining ability (GCA) effects. Of all cross combinations, only one cross, *viz*., Sandel ×Salar (0.42) showed significant positive values which showed, it was promising good specific cross combinations (Table 3). While, four cross combination, *viz*., Salar × Dinar (-0.44), Sandel × Dinar (-0.39), Salar × Sahel (-0.32) and Sandel × Sahel (-0.26) revealed significant negative SCA effect which showed poor specific combining ability. Similar results were also conveyed by Vekariya *et al.,* (2019) and Angadi *et al.*, (2012).

Number of clusters per plant

The hybrid Salar showed highest significantly positive general combining ability (GCA) effect and was marked as the best general combiner for number of cluster per plant (Table 2) followed by Sahel, which was also a good combiner for this trait. Among hybrids, Sahel × Dinar (0.97) exhibited the highly significant positive specific combining ability (SCA) effect but it was rated as good specific cross combination. Cross Salar × Dinar (-0.19) showed the negative and non-significant specific combining ability followed by Salar × Sahel (-0.08) were assigned as average specific cross combination.

Number of flowers per cluster

Two parents, Dinar (0.21) and Sahel (0.50) showed highly significant positive (GCA) effects for number of flower per cluster. Dinar (0.21) and Sahel (0.50) were observed to be good general combiner for number of flowers per cluster (Table 2).

Only the cross combination Sandel × Dinar (0.39) showed the highly significant positive (SCA) effects which represented that it was promising good specific cross combinations. While two cross combination viz., Salar × Sahel (0.08) and Sandel × Sahel (0.12) showed the non-significant positive specific combining ability (SCA) which indicate average specfic combiner (Table 3). On the other hand three cross combination *viz*., Sahel × Dinar (-0.67), Sandel × Salar (-0.39) and Salar × Dinar (-0.21) which revealed significant negative (SCA) effect, which were indicated as poor cross combination. Similar results for SCA reported by Kumar and Gowda (2016).

Number of fruits cluster

For the number of fruits per cluster parents Dinar (0.69), Sahel (0.56) and Salar (0.24) demonstrated significant positive values for (GCA) effects, were indicated as good general combiners. While, only one parent, *viz*., Sandel (-1.49) found as poor general combiner because of their significant negative general combining ability (GCA) effects. Out of the twelve cross combinations, only one cross, *viz*., Sahel× Dinar (1.71) was found as good specific cross combination because of its significant positive specific combining ability effects. Sandel × Salar (-0.42) and Sandel × Sahel (-0.78) was the only cross combination which exhibited significant negative specific combining ability (SCA) effect, which indicated as poor cross combination (Table 3). The remaining three crosses, viz., Sandel × Dinar (-0.09), Salar × Sahel (-0.05) and Salar × Dinar -0.03) were selected as average cross combinations because of their non-significant negative specific combining ability (SCA) effects for trait under study. Similar result for SCA reported by Kumar and Gowda (2016), and for GCA with the results of Kumar *et al*., (2013) and Kumar and Gowda (2016).

Fruit diameter (mm)

The significant highest positive GCA effect was noticed for Salar (2.49) (Table 2) followed by Sahel (2.41) which were noted as good general combiners. While Sandel (-3.31) and Dinar (-1.59) were poor general combiner as it showed significantly maximum negative general combining ability (GCA) effect. Cross Sandel × Sahel revealed significantly maximum positive specific combining ability (SCA) effect (5.92) followed by Sandel × Dinar (5.85). These crosses were indicated as good specific combiner for fruit diameter (mm). Whereas, two cross combination viz., Sahel × Dinar (-6.61) and Sandel ×Salar (-6.17) were exhibited significant negative specific combining ability effect, which indicated as poor cross combination. Only one cross combination Salar × Dinar (0.104) showed non-significant positive value which indicated average specific combiner. The remaining only one cross, *viz*., Salar × Sahel (-0.75) was selected as average cross combinations because of their non-significant negative specific combining ability (SCA) effects for fruit diameter.

Single fruit weight (g)

Three parents, *viz*., Dinar (2.63), Sahel (1.81) and Sandel (0.85) showed the significantly positive GCA effects for single fruit weight (Table 3), and thus, they were observed as the good general combiners. Salar was found as the poor general combiner because it showed significantly negative general combining ability (GCA) effects (-3.31). Cross Sahel × Dinar showed the significantly maximum positive specific combining ability (SCA) effect (6.44) closely followed by Sandel × Dinar (5.34), Sandel × Sahel (3.81) and Sandel × Salar (0.90). These four crosses were observed as good specific combiner for single fruit weight (g). Whereas, the cross Salar × Sahel (-5.63) represented significantly negative specific combining ability (SCA) effects, and thus, it was marked as the poor specific cross combination.

Number of locules per fruit

Three parents, *viz*., Salar (0.18), Sahel (0.13) and Dinar (0.09) showed significantly positive GCA effects for number of locules per fruit (Table 2), and thus, they were observed as the good general combiners. On the other hand Sandel (-0.40) was found as the poorest general combiner because of significant negative general combining ability (GCA) effect. Out of the twelve cross combinations, only one cross, *viz*., Sahel× Dinar (0.09) was found as good specific cross combiner because of its significant positive specific combining ability (SCA) effects. Whereas, two cross combination viz., Sandel ×Salar (-0.14) and Salar × Sahel (-0.10) were exhibited significant negative specific combining ability (SCA) effect, which indicated as poor cross combination. Only one cross combinations Salar × Dinar (0.00) showed non-significant positive value which indicated average specific combiner. The remaining only two cross, *viz*., Sandel × Sahel (-0.03) and Sandel × Dinar (-0.01) were indicated as average cross combiner because of their non-significant negative SCA effects for number of locules per fruit.

Total fruit yield per plant (kg)

Generally there will be 7-11 harvests in a crop life span for fruits in Tomato. The yield per hectare varies greatly according to variety and season. On an average, the yield varies from 20-25 t/ha. Hybrid varieties may yield upto 50-60 t/ha. In the present investigation the assessments of general combining ability (GCA) for total fruit yield per plant revealed that only two parents, viz., Sahel (0.54) and Dinar (0.44) were good general combiner because of its significant positive GCA effect. On the other hand, two parents, Salar (-0.21) and Sandel (-0.77) were selected as poor general combiner because of its significant negative GCA effect for total fruit yield per plant. These results are similar with Mahendrakar (2004) and Premalakshmi *et al*., (2006). Out of twelve cross combinations, three crosses, *viz*., Sahel× Dinar (0.54), Sandel × Dinar (0.51) and Sandel × Sahel (0.50) revealed significant positive specific combining ability (SCA) effects, indicated as good specific combiner for total yield per plant. While two cross combinations showed significant negative, While, only two cross combinations, *viz*., Salar × Sahel (-0.22) and Salar × Dinar (-0.53) were selected as poor combiners because of their significant negative specific combining ability (SCA) effects for this character (Table 2). The only one cross combination, Sandel × Salar (-0.08) was found as average cross combiner because of its non-significant negative SCA effect for this character (Table 3). Similar results were revealed by Kumar *et al.*, (2013), Shankar *et al.*, (2013) and Agarwal *et al.*, (2014) for GCA and SCA.

In general in Pakisthan double-cross hybrids are little explored in the tomato segment, possibly due to higher production costs and greater unevenness of its fruits. Nonetheless, heterosis, as well as the incorporation of genes responsible for disease resistance, precocity, fruit quality, and yield in the new genotypes, may surpass these disadvantages.

In conclusion from the present investigation it can be concluded that based on the GCA analysis Sahel was known as best combiner for fruits per cluster, fruit diameter, single fruit weight and yield per plant and dinar was known as good combiner for plant height, fruits per cluster, single fruit weight and fruit yield per plant. Specific Combining Ability revealed that cross combination *viz*., Sandel × Sahel for single fruit weight and fruit yield, Sandel × Dinar for single fruit weight and yield per plant and for single fruit weight and fruit yield per plant. The results suggest that varieties Sahel and Dinar could be used to enhance tomato yield by hybrid production. Moreover, crosses Salar × Sandel, Sandel × Sahel and Sahel × Dinar could be further evaluated for yield stability at different locations.

Table 2: General Combining Ability of the parents of tomato

Parents	Plant height (cm)	Number of branches per plant	Number of cluster per plant	Number of flower per cluster	Fruit per cluster	Fruit diameter (mm)	Number of locules per fruit	Single fruit weight	Fruit yield per plant (g)
Sandel	-4.7^{**}	0.3^{**}	-0.9^{**}	-0.6^{**}	-1.4^{**}	-3.3^{**}	-0.3^{**}	0.8^{**}	-0.7^{**}
Salar	0.5^{ns}	0.3^{**}	0.6^{**}	-0.0^{ns}	0.2^{**}	2.4^{**}	0.1^{**}	-5.2^{**}	-0.2^{**}
Sahel	1.0^{ns}	-0.0^{ns}	0.3^{**}	0.5^{**}	0.5^{**}	2.4^{**}	0.1^{**}	1.8^{**}	0.5^{**}
Dinar	3.2^{**}	-0.6^{**}	-0.0^{ns}	0.2^{**}	0.6^{**}	-1.5^{**}	0.0^{**}	2.6^{**}	0.4^{**}
S.E. $\pm$	0.5	0.0	0.0	0.0	0.0	0.2	0.0	0.0	0.0

Table 3: Specific Combining Ability of 4×4 diallel fashion of tomato

Crosses	Plant height (cm)	Number of branches per plant	Number of cluster per plant	Number of flower per cluster	Fruit per cluster	Fruit diameter (mm)	Number of locules per fruit	Single fruit weight	Fruit yield per plant (g)
Sandel ×Salar	-1.5	0.4^{**}	0.2*	-0.3^{**}	-0.4^{**}	-6.1^{**}	-0.1^{**}	0.9^{**}	0.0
Sandel×Sahel	10.3^{**}	-0.2^{**}	0.1	0.0	-0.7^{**}	5.9^{**}	0.0	3.8^{**}	0.4^{**}
Sandel×Dinar	3.2^{**}	-0.3^{**}	-0.5^{**}	0.3^{**}	0.0	5.8^{**}	0.0	5.2^{**}	0.5^{**}
Salar × Sahel	1.9	-0.3^{**}	0.0	0.0	0.0	-0.7	-0.1^{**}	-5.6^{**}	-0.2^{**}
Salar × Dinar	-1.9	-0.4^{**}	-0.1	-0.2^{**}	0.0	0.1	0.0	-2.1^{**}	-0.5^{**}
Sahel× Dinar	-1.1	0.3^{**}	0.9^{**}	-0.6^{**}	1.7^{**}	-6.6^{**}	0.0	6.4^{**}	0.5^{**}
S.E. $\pm$	1.4	0.1	0.1	0.0	0.0	0.5	0.0	0.2	0.0

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