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COMBINING ABILITY STUDIES IN TOMATO (*SOLANUM LYCOPERSICUM* L.) FOR QUALITY PARAMETERS.

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ABSTRACT

Ten parental lines were crossed in line x tester fashion comprising 5 lines and 5 testers at Horticulture Research Scheme (vegetable), Vasantrao Naik Marathwada Krishi Vidyapeeth Parbhani, Maharashtra, India to estimate combining ability in tomato for fruit quality traits. F_1 and parents were grown in randomized block design with two replications during Kharif 2023-2024 and Rabi 2023-2024. All the fruit quality characters like Total soluble solids (TSS), Ascorbic acid, Lycopene and Acidity of the fruit were governed by non-additive gene action. Estimation of general combining ability (GCA) for quality parameters showed that line PBNT-20 had the highest GCA for TSS, tester PBNT-2 had highest GCA for ascorbic acid, line Arka Saurabh had highest GCA for lycopene and line Dhanashree had highest GCA for acidity. Cross combination Arka Saurabh × PBNT-2 exhibit significant specific combining ability (SCA) for TSS, Arka Saurabh × PBNT-5 exhibit significant specific combining ability (SCA) for ascorbic acid, cross combinations Dhanashree × PBNT-1 and PBNT-10 × PBNT-5 exhibit significant specific combining ability (SCA) for lycopene and Arka Saurabh × PBNT-12 exhibit significant specific combining ability (SCA) for acidity.

***Key words*:** Tomato, general combining ability, specific combining ability, line x tester, quality parameters.

Introduction

Tomato (*Lycopersicon esculentum* Miller, 2n = 2x = 24) renamed by A. Child (1990) and I.E. Peralta and D.M. Spooner (2006) as *Solanum lycopersicum* is one of the most important vegetable crops grown throughout the world. The leading tomato growing countries in the world are the USA, several European countries, Japan and China. China is the major producer of tomato followed by US, Turkey, India and Italy. The most likely ancestor of tomato is the wild cherry tomato formerly *Lycopersicon esculentum* var. *cerasiforme*. The word "tomato" may refer to the plant *Solanum lycopersicum*. The word "tomato" may actually originate from the Nahautl (Aztecan) word "tomatl" meaning "the swelling fruit" Originally, tomato was named after the food family to which it belongs to the Solanaceae. While it is botanically a fruit, it is considered a vegetable for culinary purposes.

The postharvest losses of vegetable and fruits in the developing countries account for almost 50% of the total production. In India loses up to 40% of produce occur because of excessive fruit softening. In case of tomato experiences high post-harvest losses due its natural perishability, storage conditions, precarious transportation and inadequate packaging. Tomato is rich in minerals, vitamins, antioxidants and organic acids so universally treated as "Protected food". The importance of nutrition value in tomato indicates there is need to formulate breeding programme and to develop TSS, ascorbic acid, lycopene and acidity rich cultivars with high quality of fruits as well as yield.

In any sound breeding programme, the proper choice of parents based on their combining ability is an indispensable. Knowledge of magnitude of general combining ability (GCA) in parents and specific combining ability (SCA) in F_1 crosses is essential for crop improvement programme (Sprague and Tatum, 1942). GCA reveals the role of additive gene action while SCA reveals the extant of non-additive gene action. Information about GCA effects in necessary while choosing best

Table 1: Analysis of variance for general and specific combining ability in parent and F_1s for character studied in tomato.

Source of variation	D.F.	S	TSS	AAC	Ly	A (%)
			1	2	3	4
Replic-ations	1	S_1	0.05	3.37	0.56	0.00
		S_2	0.08	0.30	5.86	0.00
Crosses	24	S_1	0.22**	16.40**	15.59**	0.01**
		S_2	0.23**	17.56**	9.75**	0.01**
Lines	4	S_1	0.52	1.36	17.49	0.012
		S_2	0.51	2.34	8.53	0.011
Testers	4	S_1	0.11	39.16	3.27	0.006
		S_2	0.10	39.54	0.93	0.007
Line × Tester	16	S_1	0.18**	14.46**	18.19**	0.004**
		S_2	0.20**	15.87**	12.26**	0.005*
Error	24	S_1	0.03	1.14	0.61	0.00
		S_2	0.02	0.73	1.03	0.001

S: Season; **TSS:** Total soluble solids (%); **ACC:** Ascorbic acid content (mg/100g); **Ly:** Lycopene (mg/100g); **A:** Acidity (%)

combiner parents and SCA effects information reveals best cross combination for further discernment. Thus, combining ability studies are very useful indicating the parent combination for the best progeny with probably high productivity and other selected novel characters.

GCA is the performance of a line as combination of merely crossing with other lines, whereas SCA is the performance of a hybrid line resulted from the cross with other line (Singh and Chaudhary, 1977). Combining ability is a measurement of plant genotype ability in crossing to produce superior plants. Combining ability which is obtained from a cross between two parental lines can provide information regarding cross combinations for better heredity. Knowledge of gene action helps in the choice of appropriate breeding procedure for the genetic improvement of various quantitative characters. In plant breeding, gene action is usually measured in terms of components of genetic variance or combining ability variances and effects.

Material and Methods

The present investigation was undertaken at Horticulture Research Scheme (Vegetable), Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani (M.S.). The crossing programme undertaken in kharif 2022-2023, while hybrids along with the parents and checks were evaluated during *Kharif* seasons of 2023-2024 and rabi 2023-2024. Parbhani is situated at an elevation of 413 meters above mean sea level at latitude of 19.27° North and longitude of 76.480 East.

The experimental material comprised five genetically divers lines (Arka Meghali, Arka Saurabh, Dhanashree, PBNT-10 & PBNT-20) and five testers (PBNT-1, PBNT-2, PBNT-4, PBNT-5 & PBNT-12) along with their 25 F_1 hybrids developed by crossing them in a line x tester mating design (Kempthorne, 1957). All the 35 genotypes (10 parents and 25 F_1 hybrids) were evaluated; the seedlings were transplanted in in a randomized block design with two replications at the spacing of 60 cm between rows and 50 cm between plants. Recommended cultural practices and plant protection measures were

Table 2: General combining ability (GCA) effect of the 10 parents quality parameters.

Genotypes	TSS			ACC			Lycopene (mg/100g)			Acidity (%)		
Lines	**S-1**	**S-2**	**Pooled**	**S-1**	**S-2**	**Pooled**	**S-1**	**S-2**	**Pooled**	**S-1**	**S-2**	**Pooled**
Arka Meghali	-0.04	-0.04	-0.04	0.03	-0.4	-0.19	-1.39**	-1.09**	-1.24**	-0.001	00	00
Arka Saurabh	0.16**	0.14**	0.15**	-0.17	-0.6	-0.38	2.17**	1.26**	1.71**	-0.001	-0.008	-0.004
Dhanashree	-0.35**	-0.34**	-0.35**	0.59	0.47	0.53*	-0.53*	0.16	-0.18	0.05**	0.056**	0.055**
PBNT-10	-0.02	-0.01	-0.02	-0.04	0.43	0.2	-0.32	-0.69*	-0.50*	-0.01*	-0.014	-0.013
PBNT-20	0.25**	0.25**	0.25**	-0.41	0.1	-0.16	0.07	0.36	0.22	-0.04**	-0.03**	-0.037**
SEgj	**0.07**	**0.06**	**0.05**	**0.43**	**0.43**	**0.31**	**0.33**	**0.46**	**0.29**	**0.007**	**0.01**	**0.009**
C.D. 5%	**0.1**	**0.09**	**0.07**	**0.63**	**0.63**	**0.43**	**0.49**	**0.67**	**0.41**	**0.01**	**0.02**	**0.01**
C.D. 1%	**0.14**	**0.12**	**0.09**	**0.86**	**0.85**	**0.58**	**0.66**	**0.9**	**0.54**	**0.014**	**0.03**	**0.02**
Testers												
PBNT-1	-0.15**	-0.14**	-0.14**	2.11**	2.08**	2.10**	0.36	0.19	0.28	0.03**	0.03**	0.03**
PBNT-2	-0.06	-0.05	-0.05	2.14**	2.11**	2.12**	-0.84**	-0.54	-0.69*	0.02**	0.018	0.02**
PBNT-4	0.11*	0.11*	0.11**	-1.15**	-0.92**	-1.03**	0.36	0.05	0.21	-0.03**	-0.04**	-0.035**
PBNT-5	0.09	0.07	0.08*	-1.05**	-1.00**	-1.02**	0.47	0.16	0.32	-0.01*	-0.01	-0.01
PBNT-12	0.004	0.01	0.007	-2.06**	-2.28**	-2.17**	-0.36	0.13	-0.11	0.001	-0.002	00
SEgj	**0.07**	**0.06**	**0.05**	**0.43**	**0.43**	**0.31**	**0.33**	**0.46**	**0.29**	**0.007**	**0.01**	**0.009**
C.D. 5%	**0.1**	**0.09**	**0.07**	**0.63**	**0.63**	**0.43**	**0.49**	**0.67**	**0.41**	**0.01**	**0.02**	**0.01**
C.D. 1%	**0.14**	**0.12**	**0.09**	**0.86**	**0.85**	**0.58**	**0.66**	**0.9**	**0.54**	**0.014**	**0.03**	**0.02**

* Significant at 5% level; ** Significant at 1% level **S:** Season; **TSS:** Total soluble solids (%); **ACC:** Ascorbic acid content (mg/100g)

Table 3: General combining ability (GCA) effect of the 10 parents quality parameters.

Genotypes	TSS			ACC			Lycopene (mg/100g)			Acidity (%)		
	S-1	S-2	Pooled	S-1	S-2	Pooled	S-1	S-2	Pooled	S-1	S-2	Pooled
Arka Meghali × PBNT-1	0.36 **	0.36 **	0.36 **	-4.99 **	-4.96**	-4.97 **	-2.71 **	-1.34	-2.03 **	-0.043 **	-0.046	-0.045 **
Arka Meghali × PBNT-2	-0.23	-0.23 *	-0.23 **	1.42 *	1.94 **	1.68 **	1.33 *	0.23	0.78	0.033 **	0.036	0.034 *
Arka Meghali × PBNT-4	-0.20	-0.20	-0.20 *	4.54 **	4.81 **	4.67 **	3.42 **	2.93 **	3.17 **	0.026 *	0.030	0.028
Arka Meghali × PBNT-5	-0.01	0.004	-0.01	-0.93	-1.48 *	-1.20 *	-0.24	-0.73	-0.49	-0.015	-0.016	-0.016
Arka Meghali × PBNT-12	0.08	0.08	0.08	-0.04	-0.32	-0.18	-1.79 **	-1.08	-1.44 **	0.001	-0.004	-0.002
Arka Saurabh × PBNT-1	0.14	0.16	0.15	0.75	1.28	1.01 *	0.99	1.56 *	1.28 **	-0.043 **	-0.048 *	-0.046 **
Arka Saurabh × PBNT-2	0.56 **	0.58 **	0.57 **	-4.78 **	-4.75 **	-4.76 **	2.20 **	2.32 **	2.26 **	-0.077 **	-0.076 **	-0.077 **
Arka Saurabh × PBNT-4	0.13	0.15	0.14	-1.44 *	-2.16 **	-1.80 **	-2.36 **	-2.66 **	-2.51 **	-0.004	-0.002	-0.003
Arka Saurabh × PBNT-5	-0.49 **	-0.58 **	-0.54 **	4.76 **	5.22 **	4.99 **	-2.66 **	-2.96 **	-2.81 **	0.045 **	0.042	0.043 **
Arka Saurabh × PBNT-12	-0.32 **	-0.30 **	-0.31 **	0.70	0.42	0.56	1.83 **	1.73 *	1.78 **	0.081 **	0.084 **	0.082 **
Dhanashree × PBNT-1	-0.04	-0.04	-0.04	1.02	1.24	1.13 *	3.79 **	2.75 **	3.27 **	0.033 **	0.028	0.030 *
Dhanashree × PBNT-2	-0.22	-0.22 *	-0.22 **	1.13	1.36	1.24 *	-1.58 **	-1.08	-1.33 **	0.059 **	0.060 *	0.059 **
Dhanashree × PBNT-4	0.21	0.20	0.20 *	-1.18	-1.21	-1.19 *	3.47 **	2.57 **	3.02 **	-0.048 **	-0.046	-0.047 **
Dhanashree × PBNT-5	-0.07	-0.05	-0.06	-0.98	-0.80	-0.89	-3.20 **	-2.09 **	-2.64 **	0.001	-0.002	-0.001
Dhanashree × PBNT-12	0.12	0.11	0.11	0.00	-0.59	-0.29	-2.48 **	-2.17 **	-2.32 **	-0.043 **	-0.040	-0.042 **
PBNT-10 × PBNT-1	-0.26 *	-0.26 *	-0.26 **	1.56 *	1.19	1.37 **	-0.96	-1.23	-1.10 *	0.058 **	0.078 **	0.068 **
PBNT-10 × PBNT-2	-0.16	-0.16	-0.16 *	1.41	1.04	1.22 *	0.16	-0.28	-0.06	-0.006	-0.010	-0.008
PBNT-10 × PBNT-4	-0.04	-0.04	-0.04	-1.03	-0.66	-0.84	-1.05	-0.88	-0.97 *	0.022	0.014	0.018
PBNT-10 × PBNT-5	0.22	0.24 *	0.23 **	-1.64 *	-1.08	-1.36 **	3.19 **	3.36 **	3.27 **	-0.034 **	-0.042	-0.038 *
PBNT-10 × PBNT-12	0.23	0.22 *	0.22 **	-0.30	-0.48	-0.39	-1.33 *	-0.96	-1.15 *	-0.038 **	-0.040	-0.039 **
PBNT-20 × PBNT-1	-0.21	-0.22 *	-0.21 **	1.66 *	1.25	1.46 **	-1.11 *	-1.74 *	-1.42 **	-0.003	-0.012	-0.008
PBNT-20 × PBNT-2	0.04	0.03	0.04	0.82	0.41	0.62	-2.11 **	-1.19	-1.65 **	-0.007	-0.010	-0.009
PBNT-20 × PBNT-4	-0.10	-0.11	-0.10	-0.90	-0.78	-0.84	-3.47 **	-1.96 *	-2.71 **	0.006	0.004	0.005
PBNT-20 × PBNT-5	0.36 **	0.39 **	0.38 **	-1.22	-1.86 *	-1.54 **	2.91 **	2.42 **	2.67 **	0.005	0.018	0.011
PBNT-20 × PBNT-12	-0.10	-0.11	-0.10	-0.36	0.97	0.31	3.77 **	2.48 **	3.13 **	0.001	0.000	0.000
SE	**0.11**	**0.09**	**0.08**	**0.68**	**0.68**	**0.48**	**0.53**	**0.72**	**0.45**	**0.011**	**0.023**	**0.014**
C.D. 5%	**0.23**	**0.20**	**0.16**	**1.41**	**1.41**	**0.97**	**1.09**	**1.49**	**0.91**	**0.022**	**0.047**	**0.029**
C.D. 1%	**0.32**	**0.28**	**0.21**	**1.91**	**1.91**	**1.30**	**1.48**	**2.02**	**1.21**	**0.030**	**0.063**	**0.039**

* Significant at 5% level; ** Significant at 1% level **S:** Season; **TSS:** Total soluble solids (%); **ACC:** Ascorbic acid content (mg/100g)

followed. The observations were recorded for quality traits i.e. TSS, ascorbic acid, lycopene & acidity. Data were compiled for analysis of variance for all these traits using method suggested by Panse and Sukhatme (1967).

Result and Discussion

The analysis of variance for combining ability (Table 1) showed the existence of significant variation for four characters, indicating a wide range of variability among the genotypes. Highly significant variation due to GCA as well as SCA indicated the importance of additive as well as non-additive type of gene action of inheritance for all the traits.

Effect of GCA

Nature and magnitude of combining ability effects provide guideline in identifying the better parents and their utilization. The summery of the GCA effects of the parents (Table 2) revealed that among the 10 parents, in S_1, and S_2, line PBNT-20 (0.25, 0.25), line Arka Saurabh (0.16, 0.14) and tester PBNT-4 (0.11, 0.11) and in pooled season, line PBNT-20 (0.25), line Arka Saurabh (0.15), tester PBNT-4 (0.11) and line PBNT-10 (0.08) were manifested highly significant positive GCA effect for TSS. Among the 10 parents, in S_1, and S_2, tester PBNT-2 (2.14, 2.11), tester PBNT-1 (2.11, 2.08) and in pooled season, tester PBNT-2 (2.12), tester PBNT-1 (2.10) and line Dhanashree (0.53) were manifested highly significant positive GCA effect for ascorbic acid. Among the 10 parents, in S_1, S_2 and pooled seasons, line Arka Saurabh (2.17, 1.26, 1.71) was manifested highly significant positive GCA effect for lycopene and among the 10 parents, in S_1 and pooled seasons, line Dhanashree (0.05, 0.055), tester PBNT-1 (0.03, 0.03), tester PBNT-2 (0.02, 0.02) and in S_2, line Dhanashree (0.056) and tester PBNT-1 (0.03) were manifested highly significant positive GCA effect.

Effect of SCA

The magnitude of SCA effects having a vital importance in selecting the cross combinations with higher probability of obtaining desirable transgressive segregants. The summery of the SCA effects of the crosses (Table 3) revealed that for TSS, In S_1 out of 25 crosses, 03 crosses exhibited highly significant positive SCA effects. Maximum positive SCA effect was noticed in the cross Arka Saurabh × PBNT-2 (0.56) which was on par with the cross Arka Meghali × PBNT-1 (0.36). And in S_2 and pooled season, out of 25 crosses, 05 and 06 crosses exhibited highly significant positive SCA effects, respectively. Maximum positive SCA effect was noticed in the cross Arka Saurabh × PBNT-2 (0.58, 0.57) which was on par with the cross PBNT-20 × PBNT-5 (0.39, 0.38), respectively. For ascorbic acid, In S_1, S_2 and pooled season, out of 25 crosses, 05, 03 and 09 crosses exhibited highly significant positive SCA effects, respectively. Maximum positive SCA effect was noticed in the cross Arka Saurabh × PBNT-5 (4.76, 5.22, 4.99) which was on par with the cross Arka Meghali × PBNT-4 (4.54, 4.81, 4.67), respectively. For lycopene, In S_1 out of 25 crosses, 09 crosses exhibited highly significant positive SCA effects. Maximum positive SCA effect was noticed in the cross Dhanashree × PBNT-1 (3.79) which was on par with the cross PBNT-20 × PBNT-12 (3.77). And in S_2 out of 25 crosses, 09 crosses exhibited highly significant positive SCA effects. Maximum positive SCA effect was noticed in the cross PBNT-10 × PBNT-5 (3.36) which was on par with the cross Arka Meghali × PBNT-4 (2.93). In pooled season, 09 crosses exhibited highly significant positive SCA effects. Maximum positive SCA effects were noticed in the cross Dhanashree × PBNT-1 (3.27) which was on par with the cross Arka Meghali × PBNT-4 (3.17) and for acidity, In S_1 out of 25 crosses, 07 crosses exhibited highly significant positive SCA effects. Maximum positive SCA effect was noticed in the cross Arka Saurabh × PBNT-12 (0.081) which was on par with the cross Dhanashree × PBNT-2 (0.059). And in S_2 and pooled season, out of 25 crosses, 03 and 06 crosses exhibited highly significant positive SCA effects, respectively. Maximum positive SCA effect was noticed in the cross Arka Saurabh × PBNT-12 (0.084, 0.082) which was on par with the cross PBNT-10 × PBNT-1 (0.078, 0.068), respectively.

Conclusion

Parent PBNT-20 showed maximum GCA for different characters and proved to be best general combiner. Hybrid Dhanashree × PBNT-1 was found to be best hybrid combination showing high specific combining ability for lycopene (3.27). Thus, these hybrids proved as potential hybrids that could be considered for commercial exploitation of hybrid vigour for lycopene.

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