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Studies on *per se* performance and combining ability in tomato under Coimbatore condition

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ABSTRACT : A study on diallel crossing involving nine parents, were taken up and crosses were effected in all possible combinations. Thus, a total of 72 F_1 crosses and their nine parents were evaluated for various quantitative and qualitative characters. *Per se* performance of the parents for different traits revealed that among nine parents involved, P_5 showed superiority for yield per plant. P_6 was superior for single fruit weight and P_2 for days to fifty per cent flowering and P_2 and P_3 showed highest plant height. In case of hybrids tested the cross $P_3 \times P_6$ was superior for plant height, days to fifty per cent flowering and yield per plant. The combinations $P_6 \times P_4$ and $P_6 \times P_8$ exhibited highest single fruit weight. The magnitude of GCA variances for all the characters studied were higher than their corresponding SCA variances in all 72 crosses, suggesting that all the 18 traits studied were controlled by additive gene action. Analyzing the GCA effects of parents for various traits revealed that P_2, P_3 and P_5 were the best general combiners for almost all the traits. The parent P_1, followed by parent P_3 had higher *per se* with higher GCA effects for most of the economic traits studied. Hence, the parents P_1 and P_3 could be exploited in further breeding programmes for over all tomato crop improvement. The next best choice would be P_4 when the breeders aim is primarily to increase the fruit yield and quality characters. The hybrid cross $P_2 \times P_3$ exhibited more number of fruiting clusters per plant and highest single fruit weight was noticed in $P_1 \times P_4$ and $P_1 \times P_5$. Highest yield per plant was recorded in $P_2 \times P_3$.

KEY WORDS : Performance, Combining ability, Tomato

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Tomato occupies the largest area among the vegetable crops in the world, next to potato and sweet potato. It is considered as "poor man's apple" because of its attractive colour, appearance, very high nutritive value and comparatively low price. It is a good source of vitamin A (320 IU 100 g^{-1}), vitamin C (31 mg 100 g^{-1}), and minerals (680 mg 100 g^{-1}). Tomato is one of the most economically important popular vegetables in Asia. It tops the list of industrial crops because of its outstanding processing qualities. It is mainly used as a food ingredient. The fruits are consumed as raw, cooked or processed forms as juice, ketchup, sauce, paste, puree etc. In India, research on this precious crop has moved progressively since independence. India is the second largest producer of vegetables next to China, sharing nearly 12 per cent of total world output. Though the area under tomato is increasing steadily in this country, the productivity is quite low as compared to world statistics. The bottle necks in tomato production are low yielding varieties/hybrids with poor post harvest qualities and lack of resistant varieties and hybrids for biotic and abiotic stresses.

RESEARCH METHODS

Investigations were carried out in tomato (*Lycopersicon esculentum* Mill.) to develop potential

F_1 hybrids with high yield, quality parameters and good post harvest shelf-life. A study on diallel crossing involving nine parents, *viz.*, PKM 1 (P_1), CLN 2123 A (P_2), Hisar N_2 (P_3), LCR 1 (P_4), LE 812 (P_5), Swarna Lalima (P_6), Utkal Kumari (P_7), Dharmapuri local (P_8) and Arka Ahuti (P_9) were taken up and crosses were effected in all possible combinations. Thus, a total of 72 F_1 crosses and their nine parents were evaluated in Horticultural College and Research Institute, Coimbatore. The experiment was laid out in Randomized Block Design with three replication. Five randomly selected plants from each plot were utilized for recording the observations. Observations were recorded for quantitative and qualitative traits in tomato. The analyses of variance was done. Estimation of general and specific combining ability was done as per the procedures outlined by Griffing (1956).

Statistical analysis :

The obtained data was analyzed by statistical significant at $P<0.05$ level, S.E. and C.D. at 5 per cent level by the procedure given by (Panse and Sukhatme, 1994).

RESEARCH FINDINGS AND DISCUSSION

The hybrids with high yield and early with their growth habit are preferred to meet out the market compactions. A desirable genotype is one which produces more flowers in the early phase of crop growth would be as ideal in early hybrid for their vegetative characters as presented in Table 1. In the present study the parents *viz.*, P_2 (29.00), P_3 (45.50), P_4 (36.50) and P_6 (45.20) recorded earlier flowering. These parents also showed their potentiality in expressing this trait in their respective hybrids. Among the hybrids, $P_3 \times P_6$ (30.10), $P_2 \times P_4$ (32.00), $P_3 \times P_2$ (32.50) and $P_2 \times P_3$ (33.10) recorded early flowering. These early flowering hybrids could have a greater period of reproductive phase and resulted in a relatively high yield. Supporting evidences in their aspects were available from results of Sujatha *et al.* (2014). Among parents, plant height were more in P_2 (88.20) and P_4 (72.50). In hybrids $P_3 \times P_6$ (30.10), $P_3 \times P_4$ (34.30) and $P_3 \times P_2$ (32.50) were taller in the both environments. Hybrids with indeterminate nature were normally tall. These hybrids could be effectively utilized for getting sequential flower clusters and prolonged growing period which will reflect in higher production efficiency under protected cultivation. Such informations on variation in plant height are available from the studies of Mahendrakar *et al.* (2006 and 2005) and Mahendrakar (2004). Number of fruiting clusters per plant is one of the major yield contributing components in tomato. Among nine parents, P_1 (12.75) recorded more number of fruiting cluster per plant followed by P_2 (9.70) and P_5 (12.50). In hybrids $P_3 \times P_2$ (15.30), $P_5 \times P_1$ (14.20), $P_9 \times P_8$ (13.65), $P_1 \times P_5$ (13.50) and $P_9 \times P_5$ (12.75) exhibited higher values for this trait. Hybrids exhibited superiorness for this trait, this shows that the parents have a potential role for inheritance of this character. Supporting evidences for increase in number of fruiting clusters can be obtained from Panda *et al.* (2014); Shobha and Arumugam (1991) and Rai *et al.* (2005). Fruit setting percentage is an economically valuable trait that too in a crop like tomato. This has a direct influence on the yield of the crop. The flower cluster number and position and the prevailing climatic condition dictates the fruit setting per cent. Similar results on good fruit setting percentage on hybrids were reported by Rai *et al.* (2005). The parents, P_1 (77.50), P_2 (68.00), P_3 (72.50) and P_4 (65.00) had more fruit setting percentage. While the hybrids, $P_6 \times P_7$ (76.50), $P_3 \times P_1$ (76.10) and $P_2 \times P_6$ (75.20) registered highest fruit setting percentage. Single fruit weight is yet another important component that contributing directly to the yield. In case of hybrids, the following crosses *viz.*, $P_6 \times P_4$ (118.3), $P_1 \times P_6$ (93.50) and $P_3 \times P_6$ (86.30) registered the higher values. The single average fruit weight of all the hybrids was higher than the inferior parent and the results are in concurrence with the earlier finding of Marik (2005). Yield is a complex character and is dependent on its component traits and their inheritance. Any change in these component traits would reflect on total yield. The parents, P_5 (2.45 kg) and P_6 (2.20 kg) recorded high values in yield per plant. Based on their *per se* performance, the hybrids $P_3 \times P_6$ (3.57), $P_3 \times P_2$ (3.23), $P_2 \times P_3$ (3.12) and $P_5 \times P_1$ (2.82) have been adjudged as the best F_1 cross combinations. The increased yield of first generation hybrids obtained in the present study correlated the findings of Sumathi *et al.* (2006).

Analysis of variance :

The study clearly revealed that variances due to GCA and SCA were significant for all the characters, as suggested by Griffing (1956), indicating the presence of both additive and dominant gene action.

The variance due to reciprocal effects was also

Table 1 : *Per se* performance of tomato parents and hybrids

Parents / Hybrids	Days to 50 per cent flowering	Plant height (cm)	Branches per plant	No. of fruiting clusters per plant	Pollen germination (%)	Fruit setting percentage	Number of locules per fruit	Firmness (kg/cm^2)	Single fruit weight (g)	Yield per plant (kg)
P_1	57.00	54.10	10.50	12.75	45.50	77.50	6.00	0.36	33.80	1.70
P_2	29.00	88.20	10.00	9.70	36.00	68.00	2.50	0.41	46.50	1.80
P_3	45.50	79.20	12.25	9.00	42.50	72.50	3.00	0.40	59.30	1.90
P_4	36.50	72.50	10.25	6.50	42.00	65.00	3.50	0.35	90.50	1.90
P_5	53.50	55.60	11.20	12.50	62.50	57.00	3.00	0.42	45.20	2.45
P_6	45.20	60.50	10.30	6.20	53.20	63.50	3.50	0.43	110.0	2.20
P_7	48.50	65.30	10.30	8.30	51.20	60.50	3.00	0.41	65.50	1.80
P_8	47.25	65.20	9.50	7.25	18.50	52.00	4.50	0.43	67.20	1.60
P_9	53.20	52.60	10.25	9.50	49.50	73.00	7.00	0.44	47.30	1.70
P_1 x P_2	45.70	72.50	11.50	11.50	53.00	72.50	5.50	0.38	43.20	2.15
P_1 x P_3	35.30	68.30	12.25	11.20	47.20	70.00	6.00	0.35	49.30	2.32
P_1 x P_4	38.50	62.80	10.05	8.20	44.50	68.30	7.50	0.36	89.20	1.97
P_1 x P_5	35.50	68.10	12.25	13.50	63.80	62.10	4.00	0.41	62.50	2.89
P_1 x P_6	39.50	60.70	11.25	8.50	45.00	71.50	5.50	0.40	93.50	1.96
P_1 x P_7	40.50	60.15	10.35	10.52	37.00	62.50	6.50	0.38	72.35	2.30
P_1 x P_8	48.50	62.00	10.70	9.80	22.50	58.25	4.50	0.41	58.20	2.12
P_1 x P_9	49.50	58.25	10.30	12.50	43.90	70.25	3.00	0.42	43.50	2.18
P_2 x P_1	35.10	68.70	11.40	11.55	59.50	68.20	5.50	0.36	49.75	2.32
P_2 x P_3	33.10	93.25	12.75	12.50	43.50	65.25	4.50	0.42	67.50	3.12
P_2 x P_4	32.00	75.20	10.50	8.70	46.00	69.50	6.00	0.38	87.30	2.21
P_2 x P_5	37.00	68.10	10.20	11.20	52.50	62.50	4.00	0.41	72.20	2.42
P_2 x P_6	36.50	72.80	10.60	8.30	32.00	75.20	5.00	0.40	79.35	2.38
P_2 x P_7	39.50	60.30	10.50	10.20	52.90	61.25	5.00	0.40	82.51	2.10
P_2 x P_8	40.20	72.50	9.75	9.70	36.20	57.51	4.50	0.43	76.50	1.98
P_2 x P_9	36.00	68.55	10.25	11.20	47.30	72.10	3.00	0.41	52.25	1.87
P_3x P_1	34.50	65.20	11.50	10.20	45.30	76.10	4.50	0.34	58.35	2.17
P_3x P_2	32.50	95.35	13.25	15.30	42.30	69.70	4.00	0.42	53.50	3.23
P_3x P_4	34.30	98.20	12.20	9.50	40.70	70.30	4.50	0.39	83.50	3.01
P_3x P_5	38.00	73.70	12.15	11.25	55.20	55.25	4.00	0.40	63.50	2.40
P_3x P_6	30.10	100.25	13.50	12.20	47.50	64.52	6.00	0.43	86.30	3.57
P_3x P_7	47.50	63.70	11.95	8.20	42.50	70.00	4.50	0.39	73.50	1.82
P_3x P_8	49.50	75.80	12.15	9.20	46.30	62.55	3.50	0.40	69.30	1.97
P_3x P_9	50.20	60.35	11.50	10.25	49.50	70.50	4.50	0.41	64.35	2.14
P_4 x P_1	38.50	59.30	10.50	8.20	47.20	72.50	6.50	0.35	82.50	2.23
P_4 x P_2	35.20	70.10	10.90	9.50	43.20	63.50	5.00	0.38	63.25	2.46
P_4 x P_3	38.75	69.30	9.30	9.20	40.30	74.51	4.00	0.39	72.55	2.18
P_4 x P_5	39.50	78.50	11.20	9.50	64.50	54.30	4.50	0.37	69.20	2.32
P_4 x P_6	43.30	65.30	10.25	7.80	43.50	62.50	5.00	0.41	75.35	2.41
P_4 x P_7	46.20	71.50	11.70	7.30	52.30	66.00	4.50	0.37	81.35	2.12
P_4 x P_8	45.75	63.70	10.00	8.20	47.50	68.25	4.00	0.37	79.35	1.90
P_4 x P_9	38.70	60.35	10.25	10.25	26.40	69.50	4.00	0.39	67.50	2.13
P_5 x P_1	36.25	62.35	11.95	14.20	43.50	63.50	5.00	0.42	47.35	2.82
P_5 x P_2	39.50	72.60	11.50	11.25	46.50	65.80	5.50	0.40	49.35	2.58
P_5 x P_3	52.50	66.70	11.70	10.60	42.50	71.50	4.00	0.39	76.55	2.38
P_5 x P_4	47.50	65.40	12.10	11.20	64.50	45.00	4.50	0.41	72.35	2.27

Table 1 contd…

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P_5 x P_6	43.30	68.70	12.35	12.70	59.30	68.15	4.00	0.41	68.30	2.80
P_5 x P_7	49.70	68.80	11.35	10.30	63.50	72.50	5.00	0.42	57.35	2.33
P_5 x P_8	51.60	70.10	11.20	12.20	27.30	63.15	5.00	0.42	69.35	2.40
P_5 x P_9	55.70	60.85	10.90	10.75	35.00	68.35	4.50	0.42	49.35	2.25
P_6 x P_1	43.70	68.10	11.25	8.80	37.50	71.50	4.00	0.40	72.50	2.32
P_6 x P_2	37.50	73.10	10.15	9.30	46.70	64.50	4.50	0.41	77.35	2.42
P_6 x P_3	40.20	68.60	11.10	10.25	32.40	68.50	4.00	0.41	70.35	2.32
P_6 x P_4	48.30	63.20	10.25	6.30	47.30	71.35	4.50	0.40	118.3	1.97
P_6 x P_5	37.25	57.25	11.30	8.55	68.20	68.55	4.00	0.40	80.35	2.59
P_6 x P_7	39.75	69.45	12.15	7.50	44.50	76.50	4.50	0.40	79.35	2.20
P_6 x P_8	45.70	74.50	10.65	7.85	36.50	52.55	4.00	0.42	83.50	2.25
P_6 x P_9	50.25	58.45	11.70	6.80	48.50	65.35	3.50	0.41	87.35	1.98
P_7 x P_1	49.20	52.20	10.40	9.30	51.25	61.00	5.50	0.38	68.50	2.25
P_7 x P_2	38.50	68.75	10.15	10.20	52.00	62.50	4.00	0.40	73.50	2.72
P_7 x P_3	39.40	75.20	12.50	9.75	38.70	71.50	4.50	0.40	72.50	2.17
P_7 x P_4	42.50	68.55	10.30	9.25	39.80	62.50	3.50	0.39	76.50	2.51
P_7 x P_5	50.25	62.00	11.55	9.60	72.10	64.20	4.00	0.41	65.35	2.31
P_7 x P_6	47.30	60.70	12.70	7.50	58.70	59.55	3.50	0.42	82.50	2.21
P_7 x P_8	39.50	60.20	10.60	8.35	68.50	63.25	3.50	0.41	79.50	1.90
P_7 x P_9	34.50	49.70	12.30	9.85	50.00	69.30	3.00	0.45	69.50	2.75
P_8 x P_1	43.55	72.10	10.00	9.72	27.00	59.30	4.50	0.40	63.30	2.10
P_8 x P_2	39.35	72.50	10.30	8.25	34.50	56.50	4.50	0.40	72.51	2.35
P_8 x P_3	42.25	73.15	9.95	9.53	47.80	75.20	4.00	0.39	62.55	2.30
P_8 x P_4	39.70	70.40	10.20	10.30	36.50	69.50	5.00	0.40	75.10	2.13
P_8 x P_5	34.75	60.10	11.50	11.28	29.50	57.50	3.00	0.43	60.20	2.73
P_8 x P_6	39.20	59.10	11.20	8.30	32.00	68.30	4.50	0.42	70.12	2.40
P_8 x P_7	40.05	64.70	9.75	8.35	38.50	65.50	3.00	0.42	79.50	1.92
P_8 x P_9	35.50	59.30	12.30	10.35	19.20	64.80	2.50	0.46	63.50	2.65
P_9 x P_1	51.20	63.15	11.50	11.25	39.20	73.10	3.50	0.39	47.35	2.21
P_9 x P_2	35.00	78.30	10.10	9.85	42.50	61.50	4.50	0.40	53.50	2.30
P_9 x P_3	37.25	78.70	11.35	8.95	45.20	68.35	4.50	0.40	65.35	2.12
P_9 x P_4	38.70	65.10	11.20	9.50	41.30	71.55	4.00	0.40	78.12	2.02
P_9 x P_5	39.45	60.15	12.30	12.75	66.50	68.50	3.50	0.44	52.15	2.57
P_9 x P_6	40.70	65.70	11.25	11.35	47.20	62.50	4.00	0.42	73.50	2.42
P_9 x P_7	42.50	61.80	12.70	9.65	32.10	75.00	2.50	0.45	63.50	2.37
P_9 x P_8	45.70	68.70	12.50	13.65	28.50	68.50	3.00	0.44	55.35	2.63
Mean of parents	46.18	65.91	10.51	9.08	44.54	65.44	4.00	0.40	62.81	1.89
Mean of hybrids	41.24	68.07	11.22	10.01	45.05	66.29	4.38	0.40	69.51	2.34
Grand mean	41.79	67.83	11.14	9.90	44.99	66.20	4.34	0.40	68.77	2.29
S.E. ±	1.04	1.11	0.83	0.50	1.14	2.18	0.22	0.02	1.73	0.06
C.D. (P=0.05)	2.06	2.19	1.63	0.98	2.26	4.31	0.43	0.05	3.42	0.11

significant for all the characters studied. The reciprocal variation might be due to cytoplasmic inheritance and interaction between cytoplasmic and nuclear genes.

General combining ability effects :

The *per se* performance and GCA effects were related to each other. As evaluation based on mean and GCA effects separately did not show parallelism, it is, therefore, necessary to consider both *per se* and GCA effects together for further isolation of desirable parental genotypes.

The parents P_1 (1.48), P_7(1.75), P_8 (1.28) and P_9 (1.94) were the best parents with desirable mean and GCA for days to 50 per cent flowering (Table 2a and b). These parents have recorded low mean with negative GCA effects. Thus, these four parents could be effectively utilized in hybridization programme to produce early flowering hybrids. These results of current investigation were in agreement with Marik (2005) who has also reported favourable GCA effects for earliness.

The parents P_2 (1.48), P_3 (8.02) and P_4 (1.11) were the tallest among the nine parents and these parents recorded high GCA for the trait plant height, suggesting that the parental per se might be an indicator of GCA effects and these parents could be used as a donor in hybridization programme for improving this trait. Positive GCA effects for plant height, two parents *viz.*, P_1 (-4.88) and P_9 (-4.18) were dwarf structured and they also had negative GCA effects for plant height.

The number of fruiting clusters was higher in the parents P_1(0.90), P_3(0.43), P_5 (1.53) and P_9 (0.54) and these parents had positive and significant GCA effects which reflected in the crosses involving these parents showed an increase in the number of fruiting clusters

Table 2a : General combining ability effects of tomato parents

Parents	Days to 50 per cent flowering	Plant height	No. of branches per plant	No. of fruiting clusters per plant	Pollen germination	Fruit setting percentage	Number of locules per fruit	Firmness
P_1	1.48**	-4.88**	-0.13	0.90**	-0.64**	2.45**	0.97**	-0.02**
P_2	-5.65**	4.18**	-0.37**	0.54**	-0.40*	-0.42	0.16**	-0.00**
P_3	-1.44**	8.02**	0.75**	0.43**	-1.00**	3.18**	0.05	-0.01**
P_4	-1.77**	1.11**	-0.48**	-1.24**	-0.02	-0.14	0.44**	-0.02**
P_5	2.36**	-3.01**	0.41**	1.53**	9.42**	-3.71**	-0.03	0.01**
P_6	0.04	-0.03	0.1	-1.33**	1.30**	0.36	0.02	0.01**
P_7	1.75**	-1.99**	0.06	-0.88**	4.83**	-0.42	-0.28**	0.00**
P_8	1.28**	0.76**	-0.48**	-0.49**	-10.81**	-4.28**	-0.45**	0.01**
P_9	1.94**	-4.18**	0.14	0.54**	-2.70**	2.98**	-0.87**	0.02**
S.E. ± (gi)	0.027	0.030	0.017	0.006	0.032	0.118	0.001	0.0001
S.E (gi-gj)	0.060	0.068	0.038	0.014	0.073	0.265	0.003	0.0002

Table 2b : General combining ability effects of tomato parents

Parents	TSS	Acidity	Ascorbic acid	Lycopene	Chlorophyll stability index	Single fruit weight	Yield per plant
P_1	-0.36**	0.03**	-0.94**	0.48**	1.44**	-9.38**	-0.08**
P_2	0.11**	0.03**	2.32**	-0.71**	-2.15**	-5.07**	0.06**
P_3	-0.31**	0.02**	4.15**	-0.53**	2.62**	-1.68**	0.10**
P_4	-0.17**	0.01*	1.49**	-0.76**	1.11**	11.92**	-0.09**
P_5	-0.11**	-0.02**	-2.20**	-0.02	0.74	-7.34**	0.21**
P_6	-0.28**	0.01**	-0.49*	-0.08	-0.86*	15.56**	0.08**
P_7	0.12**	-0.00	-0.02	-0.06	-0.62	3.91**	-0.09**
P_8	0.51**	-0.02**	-1.97**	0.66**	1.75**	0.80**	-0.13**
P_9	0.50**	-0.05**	-2.33**	1.02**	-4.02**	-8.73**	-0.07**
S.E. ± (gi)	0.001	0.0001	0.043	0.004	0.158	0.074	0.001
S.E. ± (gi-gj)	0.002	0.0002	0.096	0.009	0.356	0.167	0.002

* and ** indicate significance of value at P=0.05 and P=0.01, respectively

Table 3 : Specific combining ability effects of tomato hybrids

Hybrids	Days to 50 per cent flowering	Plant height	No. of branches per plant	No. of fruiting clusters per plant	Pollen germination	Fruit setting percentage	Number of locules per fruit	Firmness
P_1 x P_2	2.77**	-5.75**	0.81*	0.19	12.30**	2.13*	0.03	-0.01**
P_1 x P_3	-6.94**	-4.75**	0.11	-0.54*	2.89**	1.23	-0.10	-0.03**
P_1 x P_4	-3.01**	-1.60**	-0.25	-1.36**	1.52**	1.89	1.26**	0.00
P_1 x P_5	-9.76**	2.42**	0.68	1.52**	-0.12	-2.14*	-0.77**	0.02**
P_1 x P_6	-1.71**	2.44**	0.14	-0.83**	-4.40**	2.50*	-0.58**	0.01*
P_1 x P_7	-0.18	-0.44	-0.69	-0.01	-5.06**	-6.48**	0.98**	0.00
P_1 x P_8	1.47**	4.30**	-0.17	-0.56*	-8.80**	-5.59**	-0.35**	0.01**
P_1 x P_9	5.13**	6.39**	-0.24	0.54*	-0.11	0.05	-1.19**	0.00
P_2 x P_3	-1.91**	7.28**	1.48**	3.03**	-0.69	-1.48	-0.30**	0.03**
P_2 x P_4	-0.78	-4.49**	0.41	-0.10	0.03	0.86	0.56**	0.00
P_2 x P_5	-0.26	-7.87**	-0.33	-0.74**	-4.51**	2.08*	0.28**	0.00
P_2 x P_6	0.82	1.93**	-0.49	-0.31	-6.54**	3.71**	0.23*	0.00
P_2 x P_7	1.10*	-4.53**	-0.5	0.64**	3.03**	-3.49**	0.28**	-0.01
P_2 x P_8	2.35**	0.69	-0.26	-0.98**	1.57**	-4.50**	0.45**	0.00
P_2 x P_9	-2.59**	-0.22	-0.73	-0.45*	3.01**	-1.96*	0.12	-0.02**
P_3x P_4	-2.06**	6.21**	-0.44	0.25	-3.48**	3.17**	-0.58**	0.01**
P_3x P_5	2.54**	-2.18**	-0.38	-0.94**	-4.57**	-2.29*	-0.35**	-0.01**
P_3x P_6	-5.24**	5.59**	0.31	2.21**	-5.34**	-3.22**	0.59**	0.01**
P_3x P_7	1.34**	-3.28**	0.27	-0.48*	-8.22**	1.79	0.40**	0.00
P_3x P_8	4.24**	-1.17*	-0.36	-0.49*	13.86**	3.78**	-0.19	-0.02**
P_3x P_9	1.43**	-4.01**	-0.6	-1.27**	6.05**	-2.93**	0.98**	-0.01*
P_4x P_5	1.12*	1.79**	0.58	0.16	10.11**	-12.70**	-0.24*	0.00
P_4x P_6	5.74**	-3.70**	-0.51	-0.29	-0.87	0.51	-0.05	0.02**
P_4x P_7	2.57**	1.14*	0.28	0.50*	-3.75**	-1.39	-0.49**	0.00
P_4x P_8	1.42**	-1.69**	-0.07	1.07**	7.84**	7.09**	0.17	-0.01**
P_4x P_9	-3.27**	-1.07*	-0.07	0.68**	-8.43**	1.49	0.09	-0.01*
P_5x P_6	-3.92**	-0.85	0.18	0.52*	8.04**	5.50**	-0.33**	-0.02**
P_5x P_7	4.07**	5.14**	-0.16	-0.61**	8.56**	6.28**	0.48**	0.00
P_5x P_8	-2.26**	4.99**	0.28	0.79**	-15.21**	2.11*	0.15	0.00
P_5x P_9	1.48**	1.81**	-0.09	-0.22	-0.97	2.96**	0.56**	0.00
P_6x P_7	-0.06	1.23*	1.13**	-0.2	0.48	1.89	-0.08	-0.01
P_6x P_8	-0.66	-1.29*	0.17	-0.02	-1.23*	-1.86	0.34**	-0.01**
P_6x P_9	1.70**	0.95	0.1	-0.04	4.26**	-5.61**	0.26**	-0.02**
P_7x P_8	-5.05**	-3.18**	-0.54	-0.19	14.49**	2.87**	-0.35**	0.00
P_7x P_9	-6.99**	1.51**	1.17**	0.19	-6.08**	3.39**	-0.44**	0.03**
P_8x P_9	-4.41**	0.55	1.61**	2.05**	-7.64**	1.75	-0.27**	0.02**
SE (sij)	0.218	0.246	0.137	0.049	0.262	0.956	0.01	0.0001
SE (sij-skl)	0.422	0.476	0.266	0.096	0.508	1.853	0.019	0.0002

* and ** indicates significance of values at P=0.05 and P=0.01, respectively

Table 3 contd…

Table 3 contd…

P_1 x P_2	0.10	0.02*	-1.51*	0.37*	3.36**	-7.84**	-0.03
P_1 x P_3	0.02	0.01	0.04	0.24	-0.44	-3.88**	-0.06*
P_1 x P_4	-0.12	0.05**	-1.39*	0.71**	-2.28*	14.54**	-0.02
P_1 x P_5	-0.05	0.02	-0.48	-0.33	-1.06	2.87**	0.44**
P_1 x P_6	-0.01	-0.02**	0.35	0.31	2.94*	8.05**	-0.14**
P_1 x P_7	0.33**	-0.02*	4.46**	-0.10	0.00	7.13**	0.16**
P_1 x P_8	-0.43**	-0.02*	1.88**	-0.50**	-0.67	0.56	0.03
P_1 x P_9	-0.16	-0.07**	-0.43	-1.07**	0.75	-5.23**	0.06*
P_2 x P_3	-0.08	0.01	1.53*	0.85**	-2.31*	-1.51	0.73**
P_2 x P_4	0.28**	0.01	3.67**	0.15	2.48*	-0.34	0.08**
P_2 x P_5	-0.03	-0.05**	1.67**	-0.52**	-1.07	4.41**	-0.05*
P_2 x P_6	0.14	-0.03**	-0.25	-0.38*	1.18	-0.91	-0.02
P_2 x P_7	0.24**	0.01	-2.40**	-0.34	2.84*	10.40**	0.15**
P_2 x P_8	-0.65**	0.00	-2.00**	0.46*	0.17	10.01**	-0.05*
P_2 x P_9	-0.28**	-0.01	-1.47*	-0.05	-0.12	-2.09**	-0.19**
P_3x P_4	0.45**	-0.06**	-2.12**	0.07	-0.47	-0.98	0.29**
P_3x P_5	-0.36**	-0.07**	-0.08	-0.85**	3.08**	10.27**	-0.21**
P_3x P_6	-0.19*	0.03**	-1.99**	0.20	2.76*	-4.33**	0.48**
P_3x P_7	0.16	0.03**	-2.22**	0.66**	-2.18	2.00*	-0.31**
P_3x P_8	-0.11	0.02*	4.72**	0.21	1.75	-1.96*	-0.13**
P_3x P_9	-0.21*	0.05**	-1.58**	-0.38*	-0.21	6.49**	-0.19**
P_4x P_5	0.38**	0.01	-0.81	0.84**	1.02	-2.58**	-0.12**
P_4x P_6	0.30**	0.02**	-1.81**	-1.11**	1.04	0.57	-0.09**
P_4x P_7	-0.86**	-0.05**	-1.42*	0.16	2.53*	-5.68**	0.20**
P_4x P_8	-0.37**	0.03**	-0.62	0.13	1.91	-4.27**	-0.06*
P_4x P_9	-0.48**	0.01	2.07**	0.37*	-5.38**	0.85	-0.06*
P_5x P_6	-0.01	0.02*	0.76	-0.24	2.29*	-2.67**	0.12**
P_5x P_7	-0.29**	0.06**	-0.11	0.25	-2.85*	-4.00**	-0.09**
P_5x P_8	0.57**	-0.01	0.69	0.15	-2.22	2.54**	0.19**
P_5x P_9	0.21*	0.01	0.23	0.31	3.01**	-1.96*	-0.02
P_6x P_7	0.00	-0.01	2.51**	0.45*	-5.30**	-7.32**	-0.07**
P_6x P_8	0.37**	0.00	-1.67**	0.10	-3.62**	-8.32**	0.08**
P_6x P_9	-0.37**	0.01	5.12**	0.27	-1.10	4.82**	-0.10**
P_7x P_8	-0.04	0.02**	1.30*	-0.81**	1.57	6.02**	-0.16**
P_7x P_9	0.10	-0.02*	0.23	0.25	2.87*	2.55**	0.43**
P_8x P_9	0.09	-0.01	-1.25*	0.23	0.94	-1.41	0.54**
SE (sij)	0.008	0.0001	0.347	0.034	1.286	0.601	0.001
SE (sij-skl)	0.015	0.0002	0.673	0.066	2.493	1.166	0.002

* and ** indicates significance of values at P=0.05 and P=0.01, respectively

per plant. Similar findings on increase in fruiting clusters were also reported by Marik (2005).

The parents P_1 (2.45) and P_9 (2.98) were adjudged as the best for the trait fruit setting percentage. Among them the parent P_4 did not show high mean value but showed highly significant positive GCA effects. This indicated that the parent P_4 had a more active set of dominant genes. Hence, the parent P_1 and P_9 could be employed in hybridization programme to improve the trait fruit setting percentage. The parents, P_7, P_8 and P_9 registered high mean values and high GCA effects. Hence, these parents can be used as the good combiners. Among parents P_5 had high mean value for this trait firmness it had a low GCA indicating lack of interaction among the dominant genes.

The parents P_4 (11.92), P_6 (15.56), P_7 (3.91) and P_8 (0.80) the excelled in their *per se* for character trait single fruit weight and these parents had higher GCA effects.

The yield per plant is an important character in tomato. Here the mean value for this trait was higher in the following parents P_3, P_5, P_6 and these parents also had positive and high significant GCA effects as best combiners for fruit yield. Similar findings were reported by Mahendrakar *et al.* (2006).

Specific combining ability :

In the present study the inheritance of this days to 50 per cent flowering was governed by additive gene action as revealed by the predominance of GCA variance over SCA variance presented in Table 3. Whereas, involvement of both additive and dominance gene action, the hybrids *viz.*, $P_1 \times P_5$, $P_7 \times P_9$, $P_1 \times P_3$, $P_3 \times P_6$ and $P_8 \times P_9$, were the top performing ones based on sca effects. The performance of these hybrids were the outcomes of high × low, high × high, high × low, low × low, high × high GCA effects of their respect parents. The superior performing hybrids for fruit setting percentage based on SCA effects were $P_2 \times P_3$, $P_8 \times P_9$, $P_3 \times P_6$ and $P_4 \times P_8$. These hybrids were the outcome of high × high, low × low, high × low and low × low GCA effects of their respective parents. The *per se* status of these hybrids was found to be high for all the hybrids except $P_4 \times P_8$. This indicated the predominance of additive × additive, additive × dominance and dominance × dominance types of gene interactions. Even though the prevalence of all the types of gene interactions were envisaged the predominance of additive type of gene action was noticed. In single fruit weight high GCA variance when compared to SCA variance revealed that additive gene action was predominant. The hybrids *viz.*, $P_2 \times P_7$, $P_2 \times P_8$, $P_1 \times P_4$, $P_1 \times P_5$ and $P_3 \times P_5$ were found to be superior ones based on their sca effects. The *per se* performance of these hybrids were found to be high in all the hybrids except for $P_1 \times P_5$. This indicated the presence of additive × additive, dominance × additive and additive × dominance types of gene actions. The additive type of gene action was more prevalent. The best performing hybrids based on SCA effects were $P_2 \times P_3$, $P_8 \times P_9$, $P_1 \times P_5$, $P_7 \times P_9$ and $P_3 \times P_4$ for yield per plant. These hybrids were the outcome of low × low, high × low, low × low and high × low GCA effects of their respective parents. The mean status of these hybrids was found to be high for all the hybrids except $P_7 \times P_9$. This indicated the presence of additive type of gene action was, however, more prevalent (Pradheep, 2004).

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