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Evaluation of the Performance of Parental Lines and Their F1 Hybrids for Yield and Attributing Traits in Tomato (*Solanum lycopersicum* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The present investigation was carried out to obtain information based on *per se* performances of parents and their combinations for genetic improvement in tomatoes. Ten promising genotypes were crossed in a dial manner (excluding reciprocals). Half diallel set of 45 F_1's in tomato was evaluated in Randomized Complete Block Design (RBD) with three replications for eighteen yield and yield attributing traits during *Rabi* 2020-21 (Y_1) and 2021-22 (Y_2) at the Main Experimental Station (MES), Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Ayodhya (U.P.) India. The study evidently showed highly significant differences being observed for most of the traits under study. Based on *per se* performance, parent P_3 (3.27 kg) exhibited the highest yield per plant followed by P_6 (3.20 kg). The *per se* performance of crosses *i.e.* P_3XP_4 (3.33kg), followed by P_2 x P_9 (2.17 kg) produced

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significantly higher yield per plant than the general mean and P_2 X P_3 (24.97), followed by P_1 X P_2 (26.18) was found to be early as observed from character of days to 50% flowering. These hybrids may be exploited as a new variety after selection and subjected to multi-locational trials for their release for cultivation on a commercial scale.

Keywords: Evaluated; traits; hybrid; commercial.

1. INTRODUCTION

"Tomato (*Solanum lycopersicum* L., 2n=24) belonging to family Solanaceae is one of the most important vegetables, widely grown worldwide for supply to the fresh market and for processing. Tomato is grown worldwide for its edible fruits, with antioxidants benefit. The crop is native to Central and South America. The total area covered under tomato cultivation is 8.52 Mha with production of 21.03 MT" [1]. "Tomato is considered a healthy food because of its nutritional awareness among people. In recent years, researchers are interested and focused on the identification of bioactive components in food that affects health, and may also reduce the risk of some diseases. The high nutritional value and potential health benefits of tomato have drawn an increased interest towards tomato-based products among consumers. Hence major emphasis is being given to improve the quality of produce along with higher production. Due to carotenoids, lycopene and β-carotene [2] tomato has high nutritional value". "The development of high yielding varieties requires detailed knowledge of the genetic variability present in the germplasm of the crop, the association among yield components, input requirements and cultural practices. The development of new tomato cultivars is intended to improve productivity, quality and adaptation to different production conditions. Sometimes, this is difficult to achieve due to reduced availability of genetic resources. It is a herbaceous, annual to perennial, and sexually propagated plant, mostly grown as annual plant. The plants have taproot system and two types of growth habit, determinate and indeterminate. In determinate types, plants are dwarf, where growth is restricted with the appearance of terminal flower, while in indeterminate plants, growth is continued and there is less initiation of flower and fruits on the stem, the lateral buds always exist to continue vegetative growth. The tomato flower is normally perfect; there are four to eight flowers in each compound inflorescence. There is a light protective anther cone surrounding the stigma leading to self-pollination. Tremendous improvement has been made in various aspects by exploitation of tomato being most important to growers, consumers and to the processing industry, there is a pressing need to increase its productivity to fulfil the increasing demand. Although, a lot of genetic studies have been done in tomato and as a consequence a large number of varieties/hybrids have been developed. However, there is still lack of adequate information for a very strong improvement programme to increase area and quality specific varieties. Development of hybrids with extreme earliness, quality, uniformity and adaptability to adverse conditions, is easily possible in tomato because it is a self-pollinated crop" [3].

2. MATERIALS AND METHODS

The present investigation was carried out at the Main Experimental Station, Department of Vegetable Science, Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar (Kumarganj), Ayodhya (UP), India, during *Rabi*, 2021-22 (Y_1) and 2022–23 (Y_2). "The experimental farm falls under a humid subtropical climate and is located between 24.47° and 26.54°N latitude and 81.84° and 83.58°E longitude at an altitude of 98 m above mean sea level" [4].

The experimental materials comprised ten promising varieties of tomato which were selected on the basis of genetic variability from the germplasm stock maintained in the Department of Vegetable Science. The selected parental lines *i.e*., were NDT-4, NDT-5, NDT Sel-3, NDT-P-1, NDTSel-1, 2012/TOLCVRes-1, NDTSel-2, 2019/TOLCVRes-2, 2019/TOLCV Res -4, 2019/TOLCV Res -6, crossed in all possible cross combinations (excluding reciprocals) during *Rabi* season of 2020-2021 to get 45 F_1 s for the study of the mean performance of parental line and their resultant F_1.

The experiments were grown in a Randomized Block Design (RBD) with three replications to evaluate the performance of the 45 F_1 hybrids and their 10 parental lines of tomato. The crop was sown in single row spaced at 60 cm apart with a plant-to-plant spacing of 50 cm.

Observations were recorded for eighteen economic and quality traits, days to 50% flowering, days to first fruit harvest, plant height (cm), primary branches per plant, average fruit weight (g), pericarp thickness (mm), locules per fruit, fruits per cluster, polar diameter (cm), equatorial diameter(cm), marketable fruit yield per plant (kg), total soluble solids (%), titratable acidity (%), ascorbic acid content (mg/100g), reducing sugar (mg/100g), non-reducing sugar (mg/100g), total sugar (mg/100g), total fruit yield per plant (kg), fruits per plant *viz.*. *Per se* performance was evaluated for parents and hybrids following the method suggested by Panse and Sukhatme [5] for analysis of variance on 17 quantitative and qualitative characters in tomato.

3. RESULTS AND DISCUSSION

"Selection of suitable parents and proper breeding methodology are basic steps for the improvement of yield and attributing traits. The selection of parents having high *per se* performance would be of merit in producing better hybrids and hence the parents selected for the crossing program were evaluated based on their *per se* performances. The most important trait fruit yield per plant and other quality traits results for pooled data are discussed below" [4]. A perusal of Table 1 revealed that days to 50% flowering ranged from 28.71 to 41.47 for parents and F_1 hybrids with an overall mean of 35.50. Among the parents, P_6 (33.05) and P_{10} (33.28) exhibited minimum days to 50% flowering while P_8 (41.44) took maximum days to 50% flowering. Out of 45 crosses, hybrids that exhibited maximum days to 50% flowering were P_3x P_4 (41.47) followed by P_4 x P_8 (41.29) while cross P_1x P_3 (28.71) took minimum days to 50% flowering. Days to first fruit harvest ranged from 67.70 to 91.24 for parents and F_1 hybrids with an overall mean of 84.11. Among the parents, P_6 (76.13) and P_9 (81.78) exhibited minimum days to first fruit harvest while P_4 (90.81) took maximum Days to first fruit harvest Out of 45 crosses, hybrids that exhibited maximum days to first fruit harvest was P_4 x P_5 (91.24) followed by P_5 x P_9 (91.05) while P_2 x P_6 (72.63) cross took minimum days to first fruit harvest. Similar findings was reported by Pattnaik *et al*., [6]; Panthee *et al*., [7].

Plant height ranged from 70.10 to 142.86 for parents and F_1 hybrids with an overall mean of 109.47. P_{10} (78.08) and P_9 (80.19) exhibited minimum plant height among the parents, while P_6 (132.46) took maximum plant height. Out of 45 crosses, hybrids that exhibited maximum plant height were P_1 X P_3 (142.86) followed by P_1 X P_4 (139.83) while crossing P_2 X P_9 (70.10), took minimum plant height. Primary branches per plant ranged from 4.28 to 7.00 for parents and F_1 hybrids with an overall mean of 5.56. Among the parents, P_{10} (4.39) and P_9 (4.42) exhibited minimum primary branches per plant while P_6 (6.97) took maximum primary branches per plant. Out of 45 crosses, hybrids that exhibited maximum primary branches per plant were P_1X P_7 (7.00) followed by P_6 X P_7 (6.97) while cross P_2 x P_{10} (4.28) took minimum primary branches per plant. Fruits per plant ranged from 23.94 to 35.79 for parents and F_1 hybrids with an overall mean of 28.36. Among the parents, P_9 (23.99) P_2 (24.24) exhibited minimum fruits per plant while P_6 (34.13) took maximum fruits per plant. Out of 45 crosses, hybrids that exhibited maximum fruits per plant were P_1 X P_3 (35.79) followed by P_5 X P_7 (32.30) while P_8 X P_9 (23.94) cross took minimum fruits per plant.

Average fruit weight (g) ranged 63.94 from to 92.34 for parents and F_1 hybrids with an overall mean of 78.63. Among the parents, P_1 (61.94) and P_2 (70.77) exhibited minimum average fruit weight (g) while P_3 (84.54) took maximum average fruit weight (g). Out of 45 crosses, hybrids that exhibited maximum average fruit weight (g) were P_1 X P_3 (92.34) followed by P_1 X P_4 (89.85) while P_6 X P_9 (64.44) cross took minimum average fruit weight (g). Pericarp thickness (mm) ranged from 4.14 to 5.34 for parents and F_1 hybrids with an overall mean of 4.67 among the parents P_1 (4.22) and P_2 (4.22) exhibited minimum pericarp thickness (mm) while P_6 (5.34) took maximum pericarp thickness (mm). Out of 45 crosses, hybrids that exhibited maximum pericarp thickness (mm) were P_4 X P_7 (5.17) followed by P_1 X P_3 (5.12) while cross P_1 X P_6 (4.14) took minimum pericarp thickness (mm). Locules per fruit ranged from 3.83 to 5.21 for parents and F_1 hybrids with an overall mean of 4.51. Among the parents P_8 (4.00) and P_9 (4.12) exhibited minimum locules per fruit while P_6 (4.77), took maximum locules per fruit. Out of 45 crosses, hybrids that exhibited maximum locules per fruit were P_1 X P_3 (5.21) followed by P_1 X P_8 (5.16) while cross P_2 X P_6 (3.83) took minimum locules per fruit. Similar findings were reported by Singh *et al.,* [8].

Fruit per cluster ranged from 3.39 to 4.73 for parents and F_1 hybrids with an overall mean of 3.98. Among the parents, P_9 (3.69) and P_1 (3.78)

exhibited minimum fruit per cluster, while P_6 (4.5) took maximum fruit per cluster. Out of 45 crosses, hybrids that exhibited maximum fruit per cluster were P_4 X P_6 (4.73) followed by P_4 X P_5 (4.71) while P_2 X P_3 (3.39) cross took minimum fruit per clusters. Polar diameter (cm) ranged from 4.51 to 6.27 for parents and F_1 hybrids with an overall mean of 5.56. Among the parents P_1 (4.51) and P_5 (5.08) exhibited minimum polar diameter (cm) while P_6 (6.27) took maximum polar diameter (cm). Out of 45 crosses, hybrids that exhibited maximum polar diameter (cm) were P_1 X P_3 (6.25) followed by P_5 X P_7 (6.13) while cross P_2 X P_8 (4.85) took minimum polar diameter (cm). Equatorial diameter (cm) ranged from 7.96 to 9.58 for parents and F_1 hybrids with an overall mean of 8.91. Among the parents P_1 (7.96) and P_7 (8.81) exhibited minimum equatorial diameter (cm) while P_{10} (9.28) took maximum equatorial diameter (cm). Out of 45 crosses, hybrids that exhibited maximum equatorial diameter (cm) were P_5 X P_7 (9.58) followed by P_1 X P_6 (9.39) while cross P_3 X P_8 (8.02) took minimum equatorial diameter (cm). Similar findings were suggested by Mohamed *et al.*, [9] and Mishra *et al.,* [10].

Marketable fruit yield per plant (kg) ranged from 1.6 to 2.93 for parents and F_1 hybrids with an overall mean of 2.25. Among the parents, P_9 (1.6) and P_8 (1.890) exhibited minimum marketable fruit yield per plant (kg) while P_6 (2.93) took maximum marketable fruit yield per plant (kg). Out of 45 crosses, hybrids P_3 X P_7 (82.89) that exhibited maximum marketable fruit yield per plant (kg) were P_3 X P_7 (2.89) followed by P_3 X P_4 (2.71) while cross P_2 X P_9 (1.78) took minimum marketable fruit yield per plant (kg) Total soluble solids (%) ranged from 3.4 to 4.74 for parents and F_1 hybrids with an overall mean of 4.03. Among the parents P_9 (3.62) and P_7 (3.69) exhibited minimum total soluble solids (%) while P_2 (4.74) took maximum total soluble solids (%). Out of 45 crosses, hybrids that exhibited maximum total soluble solids (%) were P_1 X P_{10} (4.71) followed by P_1 X P_9 (4.67) while cross P_6 X P_9 (3.4) took minimum total soluble solids (%). Titratable acidity (%) ranged from 0.36 to 0.46 for parents and F_1 hybrids with an overall mean of 0.41. Among the parents P_1 (0.36) and P_2 (0.39) exhibited minimum titratable acidity (%) while P_3 (0.45) took maximum titratable acidity (%). Out of 45 crosses, hybrids that exhibited maximum titratable acidity (%) were P_1XP_3 (0.46) followed by P_1XP_8 (0.45) while cross P_4XP_{10} (0.36) took minimum titratable acidity (%). Ascorbic acid content (mg/100g) ranged from 19.37 to 21.67 for parents and F_1 hybrids with an overall mean of 20.36 among the parents P_1 (19.37) and P_3 (19.91) exhibited minimum ascorbic acid content (mg/100g) while P_9 (21.67). Took maximum ascorbic acid content (mg/100g). Out of 45 crosses, hybrids that exhibited maximum ascorbic acid content (mg/100g) were P_6 X P_7 (21.51) followed by P_1 X P_3 (21.28) while cross P_7 X P_{10} (19.63) took minimum ascorbic acid content (mg/100g). Similar findings were suggested by Muhammad *et al.,* [11].

Reducing Sugar (mg/100g) ranged from 1.17 to 1.53 for parents and F_1 hybrids with an overall mean of 1.41 among the parent P_{10} (1.17) and P_1 (1.26) exhibited minimum Reducing Sugar (mg/100g) while P_4 (1.5) took maximum reducing Sugar (mg/100g). Out of 45 crosses, hybrids that exhibited maximum reducing Sugar (mg/100g) were P_4 X P_5 (1.53) followed by P_1 X P_3 (1.52) while P_2 X P_{10} (1.3) cross took minimum reducing Sugar (mg/100g). Non reducing Sugar (mg/100g) ranged from 1.8 to 2.72 for parents and F_1 hybrids with an overall mean of 2.48. Among the parents P_8 (1.97) and P_1 (1.98) exhibited minimum non reducing Sugar (mg/100g) while P_7 (2.66) took maximum non reducing Sugar (mg/100g). Out of 45 crosses, hybrids that exhibited maximum non reducing Sugar (mg/100g) were P_1 X P_8 (2.72) followed by P_3 X P_7 (2.67) while cross P_8 X P_9 (1.8) took minimum non reducing Sugar (mg/100g).

Total sugar (mg/100g) ranged from 3.15 to 4.17 for parents and F_1 hybrids with an overall mean of 3.89. Among the parents P_1 (3.15) and P_8 (3.37) exhibited minimum total sugar (mg/100g) while P_6 (4.15) took maximum total sugar (mg/100g). Out of 45 crosses, hybrids that exhibited maximum total sugar (mg/100g) were P_1 X P_8 (4.17) followed by P_1 X P_9 (4.08) while cross P_8 X P_9 (3.31) took minimum total sugar (mg/100g). Total fruit yield per plant (kg) ranged from 1.9 to 3.33 for parents and F_1 hybrids with an overall mean of 2.7. Among the parents P_9 (1.9) and P_1 (2.13) exhibited minimum Total fruit yield per plant (kg) while P_3 (3.27) took maximum total fruit yield per plant (kg). Out of 45 crosses, hybrids that exhibited maximum total fruit yield per plant (kg) were P_3 X P_4 (3.33) followed by P_1 X P_3 (3.21) while cross P_2 X P_9 (2.17) took minimum total fruit yield per plant (kg). Similar finding suggested by Gautuam *et al*. and Ibrahim *et al.,* [12,13].

Table 1. Mean performance, general mean, range, coefficient of variation and critical difference for Eighteen characters of diallel set of 45 F_1's and their 10 parents in tomato for eighteen different parameters during overseason pooled

Sr. No.	Genotypes	Days to 50% flowering	Days to first fruit harvest	Plant height (cm)	Primary branches per plant	Fruits per plant	Average fruit weight (g)	Pericarp thickness (mm)	Locules per fruit	Fruits per cluster
		Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
1.	P_1	36.33	84.33	122.1	5.84	24.43	63.94	4.22	4.37	3.78
2.	P_2	38.08	86.75	81.5	4.83	24.24	70.77	4.22	4.5	4.03
3.	P_3	35.9	87.74	94	5.14	24.68	84.54	4.32	4.41	4.02
4.	P_4	34.44	90.81	96.56	4.98	30.82	74.59	4.51	4.75	4.32
5.	P_5	33.45	85.71	103.62	5.53	26.55	79.69	4.46	4.6	4.37
6.	P_6	33.05	76.13	132.46	6.97	34.13	83.79	5.34	4.77	4.5
7.	P_7	36.65	87.21	118.1	5.97	31.81	72.26	4.76	4.39	4.05
8.	P_8	41.44	87.6	96.44	5.41	28.29	82.98	4.57	4	3.89
9.	P_9	34.93	81.78	80.19	4.42	23.99	74.67	4.81	4.12	3.69
10.	P_{10}	33.28	88.36	78.08	4.39	28.17	81.83	4.3	4.51	3.96
1.	P_1XP_2	32.16	75.71	132.35	5.72	29.25	79.11	4.95	4.71	4.07
2.	P_1XP_3	28.71	67.7	142.86	6.34	35.79	92.34	5.12	5.21	4.51
3.	P_1XP_4	32.02	78.82	139.83	5.9	30.98	89.85	4.99	4.95	4.4
4.	P_1XP_5	34.84	80.03	135.89	5.88	30.75	88.36	4.69	4.82	4.14
5.	P_1XP_6	37.09	79.85	131.44	6.44	29.42	85.16	4.14	4.79	3.72
6.	P_1XP_7	39.5	78.82	130.43	7	28.73	83.17	4.68	5.07	4
7.	P_1XP_8	37.71	80.67	117.49	6.26	28.87	79.3	4.71	5.16	4.38
8.	P_1XP_9	30.88	78.53	118.22	5.51	30.84	88.86	4.45	4.99	4.16
9.	P_1XP_{10}	32.18	76.91	118.49	5.39	29.92	85.82	4.2	4.94	4.28
10.	P_2XP_3	32.21	88.44	71.93	4.68	25	68.25	4.5	4.42	3.39
11.	P_2XP_4	32.75	89.48	85.19	4.79	31.16	78.85	4.93	4.37	3.63
12.	P_2XP_5	38.31	77.27	113.67	4.99	29.37	74.34	4.94	3.9	3.93
13.	P_2XP_6	32.62	72.63	119.04	4.77	25.3	70.18	4.93	3.83	3.67
14.	P_2XP_7	32.62	83.43	111.73	4.78	25.51	71.1	4.96	4.31	3.9
15.	P_2XP_8	40.13	90.09	96.05	4.74	27.74	70.75	4.66	4.84	3.9
16.	P_2XP_9	38.63	77.89	70.1	4.49	31.93	78.53	4.36	4.94	3.94
17.	P_2XP_{10}	35.27	75.39	71.86	4.28	30.59	85.21	4.25	4.47	4.03
18.	P_3XP_4	41.47	90.03	109.26	6.17	27.33	77.54	4.41	3.95	3.98
19.	P_3XP_5	36.56	90.59	112.63	6.01	26.24	76.81	4.82	3.91	4.03
20.	P_3XP_6	31.93	79.82	126.66	6.6	24.48	66.5	4.8	4.36	4.27
21.	P_3XP_7	32.76	76.57	128.11	6.82	27.47	69.15	4.78	4.84	4.2
22.	P_3XP_8	38.47	90.34	112.12	6.01	26.94	82.01	4.46	4.93	4.15
23.	P_3XP_9	38.35	86.71	102.52	5.51	27.78	87.01	4.93	4.51	3.79
24.	P_3XP_{10}	34.28	84.19	100.56	5.2	32.12	83.69	4.95	4.44	3.91
25.	P_4XP_5	34.5	91.24	105.55	5.22	27.51	81.86	4.93	4.36	4.71
26.	P_4XP_6	31.43	83.74	124.38	5.66	26.45	87.02	4.99	4.05	4.73
27.	P_4XP_7	36.2	82.6	123.04	5.85	26.67	80.25	5.17	4.54	4.19

Sr. No.	Genotypes	Days to 50% flowering	Days to first fruit harvest	Plant height (cm)	Primary branches per plant	Fruits per plant	Average fruit weight (g)	Pericarp thickness (mm)	Locules per fruit	Fruits per cluster
		Pooled	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**
28.	**P_4XP_8**	41.29	89.64	99.63	5.35	31.84	73.05	5.08	4.03	3.62
29.	**P_4XP_9**	38.12	89.67	87.61	4.67	30.18	84.91	4.64	4.06	3.69
30.	**P_4XP_{10}**	33.11	84.77	85.99	4.49	26.2	84.64	4.37	4.51	3.9
31.	**P_5XP_6**	33.48	90.23	124.98	6.78	27.21	76.21	4.62	4.57	4.03
32.	**P_5XP_7**	33.33	81.1	131.67	6.85	32.3	86.81	4.49	4.95	3.98
33.	**P_5XP_8**	38.42	82.77	121.81	5.98	31.47	85.84	4.23	4.99	4.04
34.	**P_5XP_9**	35.57	91.05	107.3	5.51	25.06	73.09	4.32	4.54	3.68
35.	**P_5XP_{10}**	32.34	81.36	121.82	6.16	29.5	79.39	4.9	4.87	3.99
36	**P_6XP_7**	33.43	86.91	131.95	6.97	30.34	73.85	5.08	4.33	4.24
37.	**P_6XP_8**	36.65	90.66	122.96	5.86	26.12	70.07	5	4.41	3.45
38.	**P_6XP_9**	37.72	89.75	117.81	5.02	24.55	64.44	4.69	3.98	3.48
39.	**P_6XP_{10}**	38.2	87.64	115.49	5.28	27.77	66.88	4.86	3.99	3.67
40.	**P_7XP_8**	34.06	83.81	121.95	6.47	31.71	78.67	4.38	4.85	4.27
41.	**P_7XP_9**	35.67	84.26	119.55	6.1	28.14	81.72	4.52	4.86	3.77
42.	**P_7XP_{10}**	40.51	89.47	117.91	6.3	28.54	79.44	4.95	3.91	3.87
43.	**P_8XP_9**	39.22	87.49	79.15	4.62	25.27	78.23	4.45	4.48	3.5
44.	**P_8XP_{10}**	34.48	82.48	78.47	4.42	23.94	77.1	4.59	4.45	3.56
45.	**P_9XP_{10}**	35.61	88.99	80.35	4.54	28.25	80.47	4.56	4.36	3.56
	Mean	**35.5**	**84.11**	**109.47**	**5.56**	**28.36**	**78.63**	**4.67**	**4.51**	**3.98**
	C.V.	10.73	9.65	11.97	11.03	12.68	11.61	9.42	10.1	12.95
	S.E.±M	1.55	3.31	5.35	0.25	1.47	3.73	0.18	0.19	0.21
	C.D. 5%	4.33	9.22	14.89	0.7	4.09	10.38	0.5	0.52	0.59
Range	**Lowest**	28.71	67.7	70.1	4.28	23.94	63.94	4.14	3.83	**3.39**
	highest	41.47	91.24	142.86	7	35.79	92.34	5.34	5.21	**4.73**

Table 2. Mean performance, general mean, range, coefficient of variation and critical difference for Eighteen characters of diallel set of 45 F2's and their 10 parents in tomato for eighteen different parameters during overseason pooled

Sr. No.	Genotypes	Polar diameter (cm)	Equitorial diameter (cm)	Marketable fruit yield per plant (kg)	Total soluble solids (%)	Titratable acidity (%)	Ascorbic acid content (mg/100g)	Reducing Sugar (mg/100g)	Non-Reducing Sugar (mg/100g)	Total sugar (mg/100g)	Total fruit yield per plant (kg)
		Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled	Pooled
1.	P_1	4.51	7.96	2.08	4.11	0.36	19.37	1.26	1.98	3.15	2.13
2.	P_2	5.65	9.02	2.31	4.74	0.39	20.15	1.38	2.45	3.83	2.71
3.	P_3	5.59	9.13	2.85	3.90	0.45	19.91	1.35	2.53	3.88	3.27
4.	P_4	5.91	9.08	2.22	4.02	0.43	20.00	1.50	2.50	3.99	2.75
5.	P_5	5.08	9.36	2.02	4.33	0.40	20.53	1.37	2.50	3.86	2.47
6.	P_6	6.27	9.39	2.93	3.87	0.44	21.23	1.50	2.65	4.15	3.20
7.	P_7	6.04	8.81	2.49	3.69	0.42	20.09	1.49	2.66	4.15	3.03
8.	P_8	5.77	8.96	1.89	3.83	0.39	20.59	1.41	1.97	3.37	2.27
9.	P_9	5.37	9.24	1.60	3.62	0.40	21.67	1.35	2.58	3.93	1.90
10.	P_{10}	5.99	9.28	2.13	3.94	0.40	20.72	1.17	2.54	3.70	2.56
1.	P_1XP_2	5.47	8.79	2.38	4.31	0.40	20.31	1.41	2.28	3.69	2.64
2.	P_1XP_3	6.25	9.26	2.70	4.51	0.46	21.28	1.52	2.65	4.17	3.21
3.	P_1XP_4	5.90	8.81	2.63	4.55	0.43	20.80	1.42	2.55	3.97	3.13
4.	P_1XP_5	5.95	9.22	2.46	4.50	0.43	20.61	1.45	2.55	4.00	3.03
5.	P_1XP_6	5.90	9.39	2.11	4.20	0.40	20.63	1.41	2.44	3.85	2.55
6.	P_1XP_7	5.87	9.22	2.11	4.48	0.43	20.30	1.39	2.49	3.88	2.48
7.	P_1XP_8	5.88	9.22	2.44	4.46	0.45	20.37	1.45	2.72	4.17	3.00
8.	P_1XP_9	5.78	8.79	2.62	4.67	0.41	21.13	1.45	2.63	4.08	3.00
9.	P_1XP_{10}	5.98	8.83	2.54	4.71	0.41	21.21	1.39	2.49	3.87	2.63
10.	P_2XP_3	5.66	8.54	2.35	4.43	0.42	19.87	1.38	2.50	3.89	3.03
11.	P_2XP_4	5.16	8.53	2.21	3.97	0.43	19.72	1.42	2.52	3.95	2.72
12.	P_2XP_5	4.99	8.97	1.93	4.25	0.41	19.64	1.38	2.56	3.95	2.28
13.	P_2XP_6	5.59	9.02	1.85	4.09	0.38	20.16	1.36	2.40	3.75	2.23
14.	P_2XP_7	4.96	8.89	2.13	3.96	0.36	20.18	1.38	2.57	3.95	2.67
15.	P_2XP_8	4.85	8.84	2.09	4.09	0.38	19.95	1.43	2.41	3.84	2.31
16.	P_2XP_9	5.60	8.96	1.78	3.92	0.36	20.12	1.43	2.27	3.70	2.17
17.	P_2XP_{10}	5.50	9.19	2.34	4.16	0.42	19.84	1.30	2.53	3.83	2.70
18.	P_3XP_4	5.26	9.21	2.71	3.63	0.42	19.86	1.50	2.55	4.05	3.33
19.	P_3XP_5	5.21	8.55	2.35	3.89	0.39	19.81	1.36	2.48	3.83	2.77
20.	P_3XP_6	5.79	8.36	2.69	3.93	0.41	20.47	1.36	2.45	3.81	3.08
21.	P_3XP_7	5.38	8.13	2.89	3.78	0.42	20.58	1.42	2.67	4.08	2.86
22.	P_3XP_8	5.52	8.02	2.26	3.65	0.42	19.85	1.46	2.56	4.02	2.48
23.	P_3XP_9	5.94	9.01	2.17	3.41	0.44	20.02	1.37	2.51	3.88	2.74
24.	$P3XP_{10}$	5.83	8.82	2.27	3.48	0.44	19.97	1.41	2.61	4.02	2.85
25	P_4XP_5	5.16	8.7	2.21	4.35	0.40	19.98	1.53	2.38	3.89	3.00

Sr. No.	Genotypes	Polar diameter (cm)	Equitorial diameter (cm)	Marketable fruit yield per plant (kg)	Total soluble solids (%)	Titratable acidity (%)	Ascorbic acid content (mg/100g)	Reducing Sugar (mg/100g)	Non-Reducing Sugar (mg/100g)	Total sugar (mg/100g)	Total fruit yield per plant (kg)
		Pooled	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**	**Pooled**
26	**P_4XP_6**	5.09	8.12	2.24	4.05	0.38	20.08	1.47	2.41	3.88	3.03
27	**P_4XP_7**	5.65	8.68	2.13	3.65	0.38	20.25	1.41	2.50	3.91	2.66
28	**P_4XP_8**	4.85	8.95	2.27	3.60	0.39	21.01	1.32	2.61	3.93	2.74
29	**P4XP9**	5.09	8.43	2.08	3.57	0.38	19.95	1.36	2.44	3.80	2.79
30	**P_4XP_{10}**	5.06	8.55	2.22	3.89	0.36	19.85	1.37	2.34	3.71	2.82
31.	**P_5XP_6**	5.99	9.38	2.01	4.00	0.41	19.89	1.42	2.60	4.01	2.56
32.	**P_5XP_7**	6.13	9.58	2.22	4.34	0.43	20.83	1.40	2.61	4.01	3.11
33.	**P_5XP_8**	5.97	9.35	2.14	4.64	0.45	20.73	1.46	2.57	4.02	2.82
34.	**P_5XP_9**	5.71	9.09	1.87	4.05	0.41	19.96	1.46	2.39	3.85	2.04
35.	**P_5XP_{10}**	6.05	9.21	2.39	4.14	0.40	20.58	1.48	2.53	4.01	2.58
36.	**P_6XP_7**	5.67	9.19	2.38	4.52	0.40	21.51	1.48	2.51	3.98	2.96
37.	**P_6XP_8**	5.64	8.99	2.22	4.07	0.41	20.41	1.47	2.37	3.85	2.61
38.	**P_6XP_9**	5.14	9.21	2.14	3.40	0.39	20.77	1.46	2.35	3.81	2.72
39.	**P_6XP_{10}**	5.20	9.27	2.12	3.43	0.43	20.33	1.39	2.50	3.89	2.90
40.	**P_7XP_8**	5.63	8.58	2.33	3.71	0.40	20.31	1.41	2.63	4.05	2.96
41.	**P_7XP_9**	5.39	8.25	2.24	3.70	0.41	20.00	1.44	2.62	4.06	2.47
42.	**P_7XP_{10}**	5.00	8.27	2.05	3.70	0.38	19.63	1.37	2.65	4.03	2.22
43.	**P_8XP_9**	5.88	9.30	2.03	4.09	0.42	21.26	1.51	1.80	3.31	2.6
44.	**P_8XP_{10}**	5.35	9.20	2.08	4.00	0.40	20.87	1.45	2.41	3.87	2.34
45.	**P_9XP_{10}**	5.88	9.21	1.80	3.59	0.42	20.47	1.31	2.56	3.87	2.19
	Mean	**5.56**	**8.91**	**2.25**	**4.03**	**0.41**	**20.36**	**1.41**	**2.48**	**3.89**	**2.70**
	C.V.	10.15	6.91	16.65	10.86	9.89	5.00	7.03	9.09	6.77	15.44
	S.E.±M	0.23	0.25	0.15	0.18	0.02	0.42	0.04	0.09	0.11	0.17
	C.D. 5%	0.64	0.70	0.43	0.50	0.05	1.16	0.11	0.26	0.30	0.47
Range	**Lowest**	**4.51**	**7.96**	**1.60**	**3.40**	**0.36**	**19.37**	**1.17**	**1.80**	**3.15**	**1.90**
	highest	**6.27**	**9.58**	**2.93**	**4.74**	**0.46**	**21.67**	**1.53**	**2.72**	**4.17**	**3.33**

4. CONCLUSION

Based on performance, parent P_3 (3.27 kg) exhibited the highest yield per plant followed by P_6 (3.20 kg). The *per se* performance of crosses *i.e.* P_3 X P_4 (3.33kg), followed by P_2 x P_9 (2.17 kg) produced significantly higher yield per plant than the general mean. These hybrids may be exploited as a new variety after selection and subjected to multi-locational trials for their release as cultivation on a commercial scale.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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