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Evaluation of parents and hybrids for yield and yield contributing traits in tomato (*Solanum lycopersicum* L.) for *per se* performance

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Abstract
A field experiment was conducted on 21 hybrids resulted from crossing seven lines of tomato with three testers in line x tester mating design and evaluated for fifteen yield and yield contributing traits during early *Summer*, 2019 in Randomized Block Design with three replications at College of Horticulture, Sri KondaLaxman Telangana State Horticultural University, Telangana. The experiment revealed that hybrid EC 620452 x Money Maker performed best for characters *viz*., plant height, days to last harvest, fruit length, average fruit weight, fruit yield per plant, TSS and lycopene content, when compared to all other hybrids. Besides, other hybrid EC 620441 x AVTO 1219 also showed best performance for characters *viz*., number of flowers per cluster, days to last harvest, number of marketable fruits per plant, fruit length, fruit width and lycopene content. The superior performing hybrids may be released for commercial cultivation after multilocational evaluation for yield exploitation.

Keywords: Hybrids, parents, mean performance, tomato, yield and yield traits

Introduction
Tomato (*Solanum lycopersicum* L.) is one of the most important vegetable crops belongs to the family Solanaceae and chromosome number 2n=2x=24. Tomato is a perennial plant but commonly cultivated as an annual (Rick, 1978), and ranks second to potato in many countries. Tomato has acquired the status of world's most popular vegetable crop due to its wider adaptability to various agro climatic conditions (Gupta *et al*., 2015) [7]. The leading tomato growing countries in the world are China, India, United States of America, Egypt and Turkey. In India, tomato occupies an area of 0.8 million hectares with a production of 22.34 million metric tonnes and productivity of 26 metric tonnes per hectare (NHB Database, 2017-18) [11]. In Telangana, tomato cultivated in an area of 0.06 million hectares with a production of 1.1 million tonnes and productivity of 21 tonnes per hectare. (NHB Database, 2017-18) [11].
Tomato is considered as protective food crop because of having rich source of minerals, vitamins and organic acids. On an average it contains 900 IU of vitamin A and 23 mg of vitamin C per 100g of fruit pulp. Tomatoes are important source of lycopene, ascorbic acid and Beta carotene valued for their colour, flavour and antioxidant properties. Tomato is potential vegetable crop and has a plenty of scope in India for its improvement because of having varied agro climatic conditions. New cultivars have been developed to meet the diverse needs and their suitability to different agro climatic conditions. But there is huge gap between national average yield of India when compared with average yield of Telangana. The low yield is due to non availability of high yielding varieties and lack of quality seed. To increase productivity of this crop, there is a need for development of hybrids and varieties with improvement in yield and quality.
Improving the productivity through traditional plant breeding methods means, it is sustainable, affordable and eco-friendly. Generally, diverse parents are expected to give high hybrid vigour and it is also often possible to combine desired alleles in regular fashion without waiting for longer term as in case of development of an open pollinated cultivars. The hybrids show better breeding value as compared to parents from which they are made. Higher yield and better fruit quality are universally desired. Keeping the above in view, the present investigation was carried out to

Materials and Methods
The experimental material consists of seven genotypes of tomato *viz*., Pusa Ruby, EC 620441, EC 914100, EC 914093, EC 914090, EC 620481 and EC 620452 as lines and were crossed

with three testers (AVTO 1219, AVTO 1314 obtained from World Vegetable Center, Taiwan and one high yielding genotype, Money Maker from Yates, New Zealand) in line x tester mating design to obtain twenty one cross combinations. The 21 hybrids along with parents and three standard checks (Arka Rakshak, Arka Vikas and PKM-1) were evaluated during early *Summer*, 2019 in Randomized Block Design with three replications, at PG students Research farm, Sri KondaLaxman Telangana State Horticultural University, Rajendrangar, Hyderabad-30. The mean performance of fifteen yield and yield related traits *viz*., plant height (cm), number of flowers per cluster, days to first flowering, number of marketable fruits per plant, fruit length (cm), fruit width (cm), average fruit weight (g), fruit yield/ plant (kg), ascorbic acid content (mg/100g), TSS (^{0}Brix), beta carotene(mg/100g) and lycopene content (mg/100g). The data was subjected to subject to stastical analysis (Panse and Sukhame, 1985).

Results and Discussion

The results revealed significant variation among genotypes for the characters.

Morpho-physiological characters

High vegetative vigour in the hybrids in terms of increased plant height is desirable. Plant height is considered desirable, because it leads to more number of fruits per plant and ultimately in increased productivity. The mean values of plant height were (Table.1a) ranged from 65.75 cm in EC 914090 to 102.91cm in EC 620441 in lines with an average of 81.12 cm. In testers (Table.1a), plant height ranged from 74.68 cm in AVTO 1314 to 112.14 cm in Money Maker with an average of 78.11 cm. Among hybrids, it ranged from 72.12 cm in EC 914090 x AVTO 1314 to 107.86 cm in EC 620441 x Money Maker with an average of 91.00 cm. In order to develop hybrid tomatoes possessing semi-dwarf to tall type, either both parents of hybrids should be dwarf possessing the same or different dwarfing gene(s) or one parent with dominant semi-dwarfing or tall gene (s) should be considered. High vegetative vigour in the hybrids in terms of increased plant height were recorded in the present investigation in EC 620441 x Money Maker (107.86cm), EC 620452 x Money Maker (104.13 cm), EC 620441 x AVTO 1219 (103.24 cm), EC 620452 x AVTO 1219 (99.40 cm), EC 914100 x Money Maker (96.74 cm), which recorded significantly superior plant height over hybrid check Arka Rakshak (71.16 cm). The results are well agreed to some earlier reports of Tiwari and Lal (2004) [32], Singh *et al*. (2005) [26], Harer *et al*. (2006) [8], Chattopadhyay and Paul (2012) [4], Ravindra Kumar *et al*. (2013), Narasimhamurthy *et al*. (2013) [10], Sunil *et al*. (2013) [30] and Sujeetkumar and Ramanjinigowda (2016) [29], Arun Kumar *et al*. (2016) [1], Dharva *et al*. (2018) [5], Nidhish *et al*. (2018) [12] and Pramod *et al*. (2018) [15].

The mean values of number of flowers per cluster (Table.1a) in lines were ranged from 3.56 in Pusa Ruby to 6.23 in EC 914093 with an average of 4.81. In testers, it varied from 4.2 in Money Maker to 5.26 in AVTO1314 with average mean of 4.58. Among hybrids, this character was ranged from 4.2 in Pusa Ruby × AVTO1314 to 6.6 inEC914090 × Money Maker with an average of 4.84 (Table. 1b). The hybrids *viz.*, EC 914093 x Money Maker (6.2), EC 914100 X AVTO1314 (6.26), EC 914090 x Money Maker (6.4) and EC 631410 x Money Maker (5.9) were significantly at par with the hybrid EC 914090 x Money Maker (6.6), which were superior over standard checks Arka Raksshak, Arka Vikas and PKM-1. The results are in close conformity with the findings of Gul *et al.* (2010) [6], Shankar *et al*. (2014) [27], Vilas *et al*. (2015) [34], Sahu *et al.* (2016) [24] and Triveni *et al.* (2017) [35].

The days of first flowering (Table.1a) was ranged from 35.4 days in EC 914093 to 38.8 days in 620452, with an average of 37.1 days among the lines. The five lines *viz.*, EC 620408, EC 620494, EC 654289, EC 631407 and EC 631410 were significantly on par with the line EC 620639. In testers, the average means was30.33 days and it was varied from 35.4 days in EC 914093 to 36.2 days in EC 62081. Among crosses, it was ranged (Table.1b) from 29 days in EC 914100 × AVTO 1314, EC 914100 x Money Maker and 33.53 days in Pusa Ruby x AVTO 1314 with an average of 31.16 days to first flowering. The hybrids *viz.*, EC 620441x AVTO Money Maker (31.33 days), EC 914100 x AVTO 1219 (31.33 days), EC 620452 x Money Maker (31.66 days), EC 620452 x AVTO 1219 (31.86 days),Pusa Ruby x AVTO 1219 (32.13 days), Pusa Rubyx Money Maker (32.26 days), EC 620452 x AVTO 1314 (32.26 days), Pusa Ruby x AVTO 1314 (33.53 days) were at par with the early flowering hybrids EC 914100 × AVTO 1314 and EC 914100 x Money Maker (29 days) and produced late flowering over the check Arka Rakshak (31.8 days). The results are in agreement with the results of Arun Kumar *et al.* (2016) [1], Triveni *et al.* (2017) [35], Dharva *et al.* (2018) [5] and Pramod *et al.* (2018) [15].

Among lines, days to 50% flowering (Table.1a) was ranged from 36.16 days in Pusa Ruby to 38.86 days in EC 620452 in lines with an average of 37.45 days. In testers, it was ranged from 36.4 days in AVTO 1314 to 32.06 days in AVTO 1219 with an average mean of 30.88 days. Among hybrids, this character (Table.1b) was ranged from 35.6 in EC 914093 × AVTO 1219, EC 914090 x Money Maker to 39.06 in EC 620441 × AVTO 1219 with an average of 37.22 days to 50 % flowering. The hybrids *viz.*, EC 914100 x Money Maker (35.43 days), EC 914093 x AVTO 1314 (35.73 days), Pusa Ruby x AVTO 1219 (36.5 days), EC 914100 x AVTO 1314and EC 620481 x AVTO 1314 (36.66 days), EC 914100 x AVTO 1219 (36.83 days), Pusa Ruby x AVTO 1314 (37.3 days), EC 914090 x AVTO 1219 (37.60 days), EC 914093 x AVTO 1314 (37.13 days), EC 620481x Money Maker (37.63 days), EC 620441 x AVTO 1314 (37.83 days), Pusa Ruby x Money Maker(37.93 days), EC 620452 x AVTO 1219 (38 days), EC 914093 x Money Maker (38.1 days), EC 620481 x AVTO 1219 (38.4 days), EC 620452 x Money Maker (38.23 days), EC 620441 x Money Maker (38.26 days), EC 620452 x AVTO 1314 (39 days), EC 620441 x AVTO 1314 (39.06 days) were recorded significant and take more number of days to complete for days to 50% flowering. These results are in agreement with the previous findings of Saidaiah *et al*., 2010, 2012 [18, 23], Raghu *et al*., 2012 [18], Ravindrakumar *et al*. (2013), Sunil *et al*. (2013) [30], Arun Kumar *et al*. (2016) [1], Rajasekhar reddy *et al*., 2017, Triveni *et al.* (2017) [35], Pidigam *et al*., 2019 [22] and Srivatsava *et al*., 2019.

Days to first harvest (Table.1a) in lines, ranged from 69.60 days in EC 914093 to 72.26 days in EC 914090, with an average of 70.59 days. In testers, it varied from 70.26 days in Money Maker to 74.86 days in AVTO 1219 with an average of 72.64 days. Among the hybrids, days to first harvest (Table.1b) was ranged from 69.5 days in EC 620441 x Money Maker and EC 914093 x AVTO 1314 to 72.26 days in Pusa Ruby ×AVTO 1314, with an average of 70.16 days. Among 21 hybrids, one hybrid, EC 620441 x AVTO 1314 (68.73 days) significantly superior for early harvest over best check Arka Rakshak (69.4 days). Eight hybrids (Table 4.3) *viz.*, EC 620441 ×Money Maker and EC 914093 x AVTO 1314 (69.5 days), EC 914093 x AVTO 1219 (69.6 days), EC 914090 x

Money Maker (69.16 days), EC 620452 x Money Maker (69.83), EC 914093 x Money Maker (70.2), Pusa Ruby x Money Maker (70.3) and EC 914100 x AVTO 1219 (70.26) were significantly superior for early harvest when compared to check Arka Vikas (70.63 days). The results are in close conformity with the findings Arun Kumar *et al.* (2016) [1], Triveni *et al.* (2017) [35], Dharva *et al.* (2018) [5].

The mean values for days to last harvest (Table.1a) in lines ranged from 106.73 days in EC 620441 to 121.53 days in EC 620452 with an average of 113.04 days. Higher mean value for days to last harvest was recorded in EC 914093 (114.86 days), Pusa Ruby (113.46 days), EC 620452 (112.86 days), EC 620481 (111.26 days) and EC 914093 (110.6 days). Among testers, it varied from 94.9 days in AVTO 1314 to 109.13 days in Money Maker with an average of 101.78 days. Among hybrids (Table.1b), it was ranged from 109.26 days in EC 914100 × Money Maker to 125.53 days in EC 620441 x AVTO 1219 with an average of 116.46 days. All crosses will harvest earlier than the best check Arka Rakshak (126.53 days). The results are in close conformity with the findings of Triveni *et al.* (2017) [35].

Yield attributes and yield

The number of marketable fruits per plant (Table.1a) was ranged from 18.2 in EC 914100 to 38.33 in EC 620441 with an average mean of 28.36 in lines. Among lines EC 620481 (36.26) was significantly at par with the higher value, EC 620452(32.00). In testers, it was varied from 26.26 in AVTO 1219 to 49.26 in Money Maker with an average of 35.70. Among hybrids (Table.1b), this character was ranged from 22 in EC 914100 × AVTO 1314 to 48.2 in Pusa Ruby x Money Maker with an average of 33.41. Five hybrids *viz.*, Pusa Ruby x AVTO 1219 (41.73), EC 620441 x AVTO 1314 (42.33), EC 620481 x Money Maker (45.26), EC 620441 x Money Maker (45.46) and EC 620441 x AVTO 1219 (46.46) showed significantly superior number of marketable fruits per plant compared to best check Arka Rakshak (41.53).These results are in agreement with the previous findings of Triveni *et al.* (2017) [35].

Fruit length (Table.1a) among the lines it was ranged from 3.08 cm in Pusa Ruby to 7.19 cm in EC 914090 with an average mean of 5.20 cm. Higher value for fruit length was recorded in EC 904093 (6.62 cm) and EC 914100 (6.18 cm). Among testers, it varied from 3.16 cm in Money Maker to 5.12 cm in AVTO 1219 with an average mean of 4.27 cm. Among hybrids (Table.1b), it was ranged from 3.49 cm in EC 620441 x Money Maker to 6.68 cm in Pusa Ruby x AVTO 1314 with an average of 5.11 cm. Six hybrids *viz.*, EC 914090 x AVTO 1314 (5.53cm), EC 620481 x Money Maker (6.14 cm), EC 620481 x AVTO 1314and EC 914100 x AVTO 1219 (6.15cm),EC 620481 x AVTO 1219 (6.19cm) and Pusa Ruby x AVTO 1314 (6.68 cm) showed significantly superior fruit length compared to best check Arka Rakshak (5.51cm). The results are in close conformity with the findings of Gul *et al.* (2010) [6] and Sunil *et al.* (2013) [30], Sahu *et al.* (2016) [24], Triveni *et al.* (2017) [35], Dharva *et al.* (2018) [5] and Pramod *et al.* (2018) [16].

Among lines, fruit width (Table.1c) was ranged from 3.64 cm in EC Pusa Ruby to 7.55 cm in EC 914090 with an average mean of 5.55 cm. In testers, the average mean was 4.79 cm and it ranged from 4.14 cm in Money Maker to 5.22 cm in AVTO 1314. Among hybrids, fruit width (Table 4.5) varied from 4.17 cm in EC 620481 x Money Maker to 6.75 cm in Pusa Ruby x AVTO 1314 with an average mean of 5.29 cm. The hybrids (Table.1d) *i.e.*, EC 620481 x Money Maker (4.17 cm), EC 620452 x Money Maker(4.22 cm), EC 620441 x Money Maker(4.24 cm), EC 620452 x AVTO 1314(4.62 cm),EC 620452 x AVTO 1219 (4.70 cm), EC 914090 xAVTO 1314(4.81cm), EC 914090 xAVTO 1219 (4.87cm), EC 914093 x Money Maker(4.91 cm), EC 914100 x Money Maker(5.14 cm), EC 620481 xAVTO 1314(5.22 cm), EC 914093 xAVTO 1219(5.24 cm), Pusa Ruby xMoney Maker(5.25 cm), EC 914093xAVTO 1314 (5.28 cm),EC 620441 x AVTO 1219(5.32 cm), EC 914090 x Money Maker(5.38 cm),EC 914100 x AVTO 1219 (5.41 cm), Pusa Ruby x AVTO 1219 (5.53 cm), EC 914100 x AVTO 1314 (5.61 cm), EC 620441 x AVTO 1314 (5.63 cm), EC 620481 xAVTO 1219 (5.86 cm) and Pusa Ruby x AVTO 1314 (6.75 cm) were showed significantly higher fruit width compared to best check Arka Rakshak (4.13 cm). Similar results was also reported by Gul *et al.* (2010) [6] and Sunil *et al.* (2013) [30], Sahu *et al.* (2016) [24], Triveni *et al.* (2017) [35], Dharva *et al.* (2018) [5] and Pramod *et al.* (2018) [15].

Among lines, average fruit weight (Table.1c) was varied from 54 g in EC 620441 to 92.2g in EC 914100 with an average of 67.5 g. Among testers, it ranged from 32.8g in Money Maker to 71.06 g in AVTO 1219 with an average of 55.07 g. Among hybrids (Table.1d), it was ranged from EC 620441 x Money Maker (56 g) to Pusa Ruby x AVTO 1314 (100.8 g) with an average of 75.98g. Sixteen hybrids *viz.*, EC 620452 x AVTO 1314 (60.66g), EC 620452 x AVTO 1219 (62.13g), EC 914090 x AVTO 1314 (71.86g),EC 620441 x AVTO 1219 (72.66g), EC 914090 x AVTO 1219 (73g),EC 620481 x Money Maker (73.66g), EC 620481 x AVTO 1314 (73.86g), Pusa Ruby x Money Maker (75.8g), EC 914093xAVTO 1314 (77.86g), EC 620481 xAVTO 1219 (80.2g), EC 620481 xAVTO 1219 (81.46g), EC 914100 x AVTO 1314 (86.86g), Pusa Ruby x AVTO 1219(89.2 g), EC 620441 x AVTO 1314(92.4g), EC 914100 x AVTO 1219 (93g) and Pusa Ruby x AVTO 1314 (100.8g) recorded higher fruit weight compared to best check Arka Rakshak (60.93 g). The results are in agreement with the previous findings ofGul *et al.* (2010) [6], Ravindrakumar *et al.* (2013), Sujeet and Ramanjinigowda (2016), Triveni *et al.* (2017) [35], SavitaTamta and Singh (2017) [25], Dharva *et al.* (2018) [5] and Nidhish *et al.* (2018) [13].

The fruit yield per plant (Table.1c) in lines was ranged from 1.42 Kg in EC 914090 to 2.48 Kg in EC 620441 with an average mean of 1.76 Kg. Among testers, it ranged from 1.76 Kg in AVTO 1314 to 2.4 Kg in Money Maker with an average mean 2.4 Kg. Among hybrids, this character was ranged from 2.08 Kg in EC 914093 × AVTO 1314 to 3.25 Kg in EC 620452 × Money Maker with an average mean 2.56 Kg. The mean values of hybrids for fruit yield per plant are presented in Table 4.5. Six hybrids *viz.*, Pusa Ruby x AVTO 1314 (2.67Kg), EC 620441 x Money Maker (3.05Kg), Pusa Ruby x AVTO 1219 (3.14 Kg), EC 620441 x AVTO 1314 (3.15 Kg),Pusa Ruby x Money Maker (3.19 Kg)and EC 620452 x Money Maker(3.25 Kg) were recorded significant and superior fruit yield per plant over best check Arka Rakshak (2.49 Kg). The present results getting a support from Saidaiah *et al*., 2010, 2012 [18, 23], Raghu *et al*., 2012 [18], Ravindrakumar*et al*. (2013), Sunil *et al*. (2013) [30], Basavaraj *et al*. (2016) [2], Sujeet Kumar and Ramanjinigowda (2016), Arun Kumar *et al*. (2016) [1], Rajasekhar reddy *et al*., 2017, Triveni *et al.* (2017) [35], Dharva *et al.* (2018) [5] and Pramod *et al.* (2018) [16], Pidigam *et al*., 2019 [22] and Srivatsava *et al*., 2019.

Table 1a: Mean performance of lines and testers for plant height (cm), number of flowers per cluster, days to first flowering, days to 50% flowering, days to first harvest, days to last harvest, number of marketable fruits per plant and fruit length (cm)

Treatments	Plant height (cm)	Number of flowers per cluster	Days to first flowering	Days to 50% flowering	Daysto first harvest	Days to last harvest	Number of marketable fruits per plant	Fruit length (cm)
Lines								
Pusa Ruby	82.31	3.56	36.9	36.16	13	113.46	32.73	3.08
EC 620441	102.91	4	37.8	37.2	68.33	106.73	38.33	3.55
EC 914100	85.53	4.96	37.8	38.4	70.9	114.86	18.2	6.18
EC 914093	66.53	6.23	35.4	36.93	69.6	121.53	19.23	6.62
EC 914090	65.75	5.16	36.8	37.33	72.26	110.6	18.8	7.19
EC 620481	74.51	3.76	36.2	37.3	70.66	111.26	36.26	5.07
EC 620452	90.28	4.4	38.8	38.86	70.56	112.86	35	4.74
Line means	81.12	4.81	37.1	37.45	70.59	113.04	28.36	5.20
Testers								
AVTO 1219	103.98	4.3	32.06	38.26	74.86	101.33	26.26	5.12
AVTO 1314	74.68	5.26	30.26	36.4	72.8	94.9	31.6	4.55
MoneyMaker	112.14	4.2	30.33	37.96	70.26	109.13	49.26	3.16
Testers mean	78.11	4.58	30.88	37.54	72.64	101.78	3570	4.27
Parental mean	79.61	4.69	33.99	37.49	67.14	107.41	32.03	4.73

Harvest, number of marketable fruits per plant and fruit length (cm)

Table 1b: Mean performance of crosses for plant height (cm), number of flowers per cluster, days to first flowering, days to 50% flowering, days to first harvest, days to last harvest, number of marketable fruits per plant and fruit length (cm)

Treatments	Plant height(cm)	Number of flowers per cluster	Days to first flowering	Days to 50% flowering	Daysto first harvest	Days to last harvest	Number of marketable fruits per plant	Fruit length(cm)
Crosses								
Pusa Ruby x AVTO 1219	96.05	4.3	32.13	36.5	70.73	117.73	41.73	3.79
Pusa Ruby x AVTO 1314	81.64	4.2	33.53	37.3	72.46	121.93	38.8	6.68
Pusa Ruby x Money Maker	96.44	4.4	32.26	37.93	70.03	122.86	48.2	4.22
EC620441 x AVTO1219	103.24	4.6	30.86	39.06	70.66	125.53	46.46	5.20
EC620441 x AVTO1314	91.22	4.33	31.6	37.83	68.73	122.53	42.33	5.19
EC 620441 x Money Maker	107.86	4.23	31.33	38.26	69.5	117.2	45.46	3.49
EC914100 x AVTO1219	92.49	5.26	31.33	36.86	70.26	109.46	20.53	6.15
EC914100 x AVTO1314	81.62	6.26	29	36.66	70.86	112.6	22	5.15
EC914100 x Money Maker	96.74	5.9	29	35.43	69.43	109.26	23.86	5.38
EC914093 x AVTO1219	82.29	4.33	31	35.6	69.6	112.86	23.06	5.53
EC914093 x AVTO1314	77.52	4.1	31.06	37.13	69.5	114.13	23.8	5.43
EC914093 x MoneyMaker	84.93	6.2	30.86	38.1	70.2	111.46	24.8	5.17
EC914090 x AVTO1219	83.94	4.6	30.46	37.6	71.73	111.33	22.06	5.17
EC914090 x AVTO1314	72.12	6.4	31	35.73	69.16	110.6	22.13	4.54
EC914090 x MoneyMaker	88.16	6.6	30.53	35.6	70.66	109.33	23.53	5.14
EC620481 x AVTO1219	89.82	5.6	31.06	38.4	71.13	118.13	37.56	6.19
EC620481 x AVTO1314	78.38	5.2	30.93	36.66	72.26	120.33	39.23	6.15
EC620481 x MoneyMaker	95.36	5.3	30.8	37.63	71	120.53	45.26	6.14
EC620452 x AVTO1219	99.40	5.3	31.86	38	71.56	121.8	40.23	4.40
EC620452 x AVTO1314	84.44	5.3	32.26	39	71.56	122	40.4	4.47
EC620452 x MoneyMaker	104.13	4.4	31.66	38.23	69.86	125.13	41.46	4.23
Crosses mean	91.00	4.84	31.16	37.22	70.16	116.46	33.41	5.11
Checks								
Arka Rakshak	71.16	5.36	31.8	39.1	69.4	126.53	41.53	5.51
Arka Vikas	91.31	4.26	32.66	36.26	70.63	117.93	35.13	3.63
PKM-1	71.84	3.96	31.53	36.7	69	111.13	31.86	3.25
Checks means	78.10	4.52	31.99	37.35	69.67	118.53	36.17	4.13
S.E (d)	1.23	0.16	0.61	0.72	0.78	1.22	0.97	0.07
CD (0.05%)	2.49	0.33	1.23	1.46	1.59	2.47	1.96	0.15
CD (0.01%)	3.33	0.44	1.65	1.96	2.13	3.30	2.63	0.20

Table 1c: Mean performance of lines and teters for fruit width (cm), average fruit weight (g), fruit per plant (kg), ascorbic acid content (mg/100g), TSS (^{0}Brix), beta-carotene (mg/100g) and lycopene content (mg/100g)

Treatments	Fruit width (cm)	Average fruit weight (g)	Fruit yield per plant (kg)	Ascorbic acid (mg/100g)	TSS(^{0}Brix)	Beta-carotene (mg/100g)	Lycopene (mg/100g)
Lines							
Pusa Ruby	3.64	34.33	1.56	25.14	4.12	1.88	4.75
EC-620441	4.13	54	2.48	20.22	4.62	1.95	2.87
EC-914100	6.27	92.2	1.41	23.63	3.96	1.68	5.19
EC-914093	6.90	74.46	1.53	22.56	4.02	1.67	4.05

EC-914090	7.55	82.6	1.42	22.65	4.10	1.31	2.39
EC-620481	5.76	74.8	1.89	19.38	4.25	1.67	2.39
EC-620452	4.63	60.46	2.09	17.97	3.46	1.51	4.03
Lines means	5.55	67.55	1.76	21.65	4.07	1.66	3.66
Testers							
AVTO 1219	5.01	71.06	2.28	17.20	3.98	1.95	4.01
AVTO 1314	5.22	61.36	1.76	24.84	4.52	1.86	5.05
MoneyMaker	4.14	32.8	2.4	27.45	4.48	2.52	4.19
Testers Mean	4.79	5 5.07	2.14	23.16	4.32	2.11	4.41

Table 1d: Mean performance of crosses for fruit width (cm), average fruit weight (g), fruit per plant (kg), ascorbic acid content (mg/100g), TSS (^{0}Brix), beta carotene (mg/100g) and lycopene content (mg/100g)

Treatments	Fruit width (cm)	Average fruit weight (g)	Fruit yield per plant (kg)	Ascorbic acid (mg/100g)	TSS (^{0}Brix)	Beta-carotene (mg/100g)	Lycopene (mg/100g)
Crosses							
Pusa Ruby x AVTO 1219	5.53	89.2	3.14	20.89	4.12	2.11	4.28
Pusa Ruby xAVTO 1314	6.75	100.8	2.67	23.03	4.14	2.17	4.74
Pusa Ruby xMoney Maker	5.25	75.8	3.19	25.07	4.02	2.28	4.40
EC 620441 x AVTO1219	5.32	72.66	2.48	19.12	4.35	2.08	3.37
EC620441 x AVTO1314	5.63	92.4	3.15	21.78	4.31	2.01	3.87
EC 620441 x Money Maker	4.24	56	3.09	25.39	4.36	2.26	3.48
EC914100 x AVTO1219	5.41	93	2.06	21.05	4.3	1.93	4.59
EC914100 x AVTO1314	5.61	86.86	2.09	24.73	4.19	1.88	5.08
EC914100 x Money Maker	5.14	78.4	2.39	26.10	4.05	2.19	4.65
EC914093 x AVTO1219	5.24	80.2	2.18	24.04	4.18	1.84	4.01
EC914093 x AVTO1314	5.28	77.86	2.08	25.12	4.44	1.84	4.52
EC914093 x Money Maker	4.91	42.66	2.40	25.71	4.52	2.17	4.10
EC914090 x AVTO1219	4.87	73	2.23	22.79	4.14	1.72	3.41
EC914090 x AVTO1314	4.81	71.86	2.14	23.46	4.25	1.51	4.69
EC914090 x Money Maker	5.38	49.13	3.18	24.82	4.2	1.98	3.29
EC620481 x AVTO1219	5.86	81.46	2.18	19.92	4.32	1.94	3.22
EC620481 x AVTO1314	5.22	73.86	2.39	20.21	4.22	1.84	4.92
EC620481 x Money Maker	4.17	73.66	2.79	24.55	4.54	2.16	3.27
EC620452 x AVTO1219	4.70	62.13	2.34	19.54	4.19	1.74	4.04
EC620452 x AVTO1314	4.62	60.66	2.20	22.26	4.22	1.66	4.49
EC620452 x Money Maker	4.22	56.93	3.25	22.82	4.51	2.12	4.09
Crosses mean	5.29	75.98	2.56	23.54	4.23	1.99	4.16
Checks							
Arka Rakshak	4.13	60.93	2.49	25.59	4.18	2.06	4.81
Arka Vikas	4.19	49.93	1.76	27.41	4.32	1.57	4.05
PKM-1	4.07	44.6	1.51	25.86	4.39	1.68	3.10
Checks means	4.13	51.82	1.92	26.28	4.29	1.77	3.98
S.E (d)	0.05	0.90	0.04	0.43	0.04	0.07	0.04
CD (0.05%)	0.11	1.83	0.09	0.87	0.09	0.14	0.09
CD (0.01%)	0.15	2.45	0.12	1.17	0.12	0.19	0.12

Quality characters

Ascorbic acid content (Table.1c) in lines was ranged from 17.97 mg/100g in EC 620452 to 25.14 mg/100g in Pusa Ruby with a mean 26.28 mg/100g. Among testers, it varied from 17.20 mg/100g in AVTO 1219 to 27.45 mg/100g in Money Maker, with an average mean of 23.16 mg/100g. The mean values of hybrids for ascorbic acid are presented in Table.1d. Among hybrids, this character was varied from 19.12 mg/100g in EC 620441 × AVTO 1219 to 26.10 mg/100g in EC 914100 × Money Maker with a mean 23.54 mg/100g. Only two hybrids with 25.71 mg/100g in EC 914093 × Money Maker and 26.10 mg/100g in EC 914100 × Money Maker registered higher ascorbic acid content compared to Arka Rakshak (25.59mg/100g). The hybrids *viz.*, Pusa Ruby x Money Maker (25.07 mg/100g), EC 914093 x AVTO 1314 (25.12 mg/100g) and EC 914093 x Money Maker (25.71 mg/100g) were at par, significant and superior with EC 914100 × Money Maker (26.10 mg/100g).The results is in agreement the results of Shankar *et al*. (2014) [27], Basavaraj *et al*. (2016) [2] and Pramod *et al.* (2018) [16].

Total soluble solids (Table.1c) in lines were ranged from 3.46 in EC 620452 to 4.62 in EC 620441with average of 4.07. Among the testers, it varied from 3.68 in AVTO 1219 to 4.52 in AVTO 1314 with an average mean of 4.32. The mean values of hybrids for TSS were presented in Table.1d. Among hybrids, it was ranged from 4.05 in EC 914100 x Money Maker to 4.54 in EC 620481 x Money Maker, with an average mean of 4.23. Among 21 hybrids, fifteen hybrids showed significantly superior TSS (°Brix) compared to best check Arka Rakshak (4.18). Present findings are in accordance with the reports of Shankar *et al*. (2014) [27], Basavaraj *et al*. (2016) [2] and Triveni *et al.* (2017) [35].

Beta carotene content (Table.1c) in lines was ranged from 1.31 mg/100g in EC 914090 to 1.95 mg/100g in EC 620441 with a mean 1.66 mg/100g. Among testers, it varied from 1.86 mg/100g in AVTO 1314 to 2.52 mg/100g in Money Maker with an average mean of 2.11 mg/100g (Table.1d). Among hybrids, it was ranged from 1.51 mg/100g in EC 914090 × AVTO 1314 to 2.28 mg/100g in Pusa Ruby × Money Maker, with average mean of 1.99 mg/100g. Nine hybrids ranged from 2.11 in Pusa Ruby x AVTO 1219 to 2.28 inPusa Ruby x

Money Maker were showed significant and superior values for beta carotene compared best check Arka Rakshak (2.06).

Lycopene content (Table. 1c) in lines was ranged from 2.39 mg/100g in EC 914090 and EC 620481 to 5.19 mg/100g in EC 914100 with a mean of 3.66 mg/100g. Among testers, it varied from 4.01 mg/100g in AVTO 1219 to 5.05 mg/100g in AVTO 1314 with an average mean of 4.41 mg/100g. Among hybrids (Table 4.5), it was ranged from 3.22 mg/100g in EC 620481 x AVTO 1219 to 5.08 mg/100g in EC 914100 x AVTO 1314 with average mean of 4.16 mg/100g. Two hybrids *viz.*, EC 620481 x AVTO 1314 (4.92) and EC 620481 x AVTO 1219 (5.08) were showed significant and superior values for lycopene over best check Arka Rakshak (4.81). The present results are getting support from the findings of Bhatt *et al.* (2004) [3], Kumar *et al.* (2013a) [9], Shankar *et al*. (2014) [27], Kumar *et al.* (2013b), Arun Kumar *et al.* (2016) [1] and Basavaraj *et al*. (2016) [2]. From the present findings, it can be summarized that based on mean worth, top six hybrids for fruit yield per plant were *viz.*, EC 620452 x Money Maker (3.25 kg), Pusa Ruby x Money Maker (3.19 kg), EC 914090 x Money Maker (3.18 kg), EC 620441 x AVTO 1314 (3.15 kg), Pusa Ruby x AVTO 1219 (3.14 kg) and EC 620481 x Money Maker (2.79 kg). Hence, these should be utilized for future breeding programmes for desirable trait improvement.

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