

## Evaluation of F1 Hybrids along with Parents for Yield and Related Characteristics in Tomato (*Solanum lycopersicum* Child)

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### ABSTRACT

Eight diverse homozygous tomato parental lines were crossed in half diallel fashion, to develop twenty-eight hybrids. These 28 F<sub>1</sub> hybrids and their parents were evaluated at Department of Vegetable Science, C.H.F., CAU, Pasighat, A.P. during 2014-2015. A wide range of variation was observed for fruit yield and related constituents. The high PCV, GCV, ECV, heritability (broad sense), and genetic advance over percentage of mean were recorded for fruit yield per plant. DVRT-1 × CHFT-50 was found earliest flowering in 50.67 days and earliest harvest in 70.00 days. Earliest flowering concurrent with early fruit set that are expressed in all hybrids under studied. The highest fruit yield was established in DVRT-2 × CHFT-77 (9.13 kg), followed by DVRT-2 × H-86 (6.86 kg) and CHFT-60 × CHFT-71 (5.92 kg). Among the hybrids, the fruit weight was correlated with fruit yield. Cross, H-86 × CHFT-50 was given high yield along with quality characters. The hybrid DVRT-2 × CHFT-77, H-86 × CHFT-50 and CHFT-60 × CHFT-71 were found best regarding fruit yield, quality traits and earliness. Therefore, the current study showed that hybrid breeding approaches strengthening to improve yield, earliness together with qualities.

### Keywords

Tomato, Hybrids, Fruit yield, Quality, Range, PCV, GCV.

### Article Info

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### Introduction

Now a day, population and demand both are escalating day by day. The major challenges in agriculture research are the ways and means of achieving food and nutritional security (Swaminathan and Bhavani, 2013). Production of enough quantity and quality of vegetables holds the key to overcome the situation. Tomato (*Solanum lycopersicum* Child, 2n=2x=24) is one of the most popular and commercially cultivated annual

herbaceous vegetable, grown in tropical and subtropical regions worldwide (Rao *et al.*, 2007). It is estimated that the total tomato area and production in India were 0.76 million hectares and 18.39 million tonnes, respectively (Anonymous, 2015). It is rich in medicinal value having antiseptic, antioxidant and anticancerous properties. Tomato being predominantly bisexual self-pollinated crop, does not suffer much from inbreeding

depression and has the advantage of producing a large number of seed per fruit, facilitating hybrid breeding through reasonably low cost of hybrid seed production. For proper evaluation of genetic resources is essential to understand the genetic variability and heritability. Due to increasing popularity of F<sub>1</sub> hybrids in tomato, it is need to obtain such hybrids that have excellent qualities and yield together with resistance to biotic and abiotic stresses. The F<sub>1</sub> hybrids and their parents for yield related traits were also evaluated by Chattopadhyay *et al.*, (2013); Jindal *et al.*, (2015); Panthee *et al.*, (2015); Lekshmi and Celine (2015) and Pandey *et al.*, (2016). The major objectives are (1) to study the genetic variability, heritability and genetic advance for yield and yield components and (2) to develop parents and hybrids having high yield along with earliness and quality traits.

## Materials and Methods

The experiment was conducted at Vegetable Experimental Farm, College of Horticulture and Forestry, Central Agricultural University, Pasighat, East Siang, Arunachal Pradesh, India. The experimental materials for the present study comprised of eight elite diverse and homozygous pure lines/varieties of tomato parental lines namely DVRT-1, DVRT-2, H-86, CHFT-50, CHFT-60, CHFT-71, CHFT-77 and CHFT-79 were crossed in all possible combinations in half diallel technique excluding reciprocals  $[n(n-1)/2]$  during *Rabi*, 2013-2014. The parents and hybrids were evaluated in the successive year (2014-15) for sixteen quantity and quality traits i.e., days to first flowering (DFF), days to 50% flowering (DF), days to 50% fruit set (DFS), days to first harvest (DFH), number of primary branches per plant (NPB), number of locules per fruit (NLF), pericarp thickness (PT), plant height (PH), fruit length (FL), fruit girth (FG), fruit weight (FW), number of

fruits per plant (NFP), fruit yield per plant (FYP), total soluble solids (TSS), lycopene content (LC) and  $\beta$ -carotene content (BC). Observations were recorded on five randomly selected plants from each hybrid in each replication. The recorded observations were averaged to get mean values. Analysis of variance for Randomized Block Design was carried out according to following procedure as suggested by Gomez and Gomez (1983). The genotypic and phenotypic coefficients of variation were estimated by Burton (1952). Heritability in broad sense was computed according to Allard (1960). Genetic advance and genetic advance as per cent of mean was calculated using the method of Johnson *et al.*, (1955).

## Results and Discussion

The mean square differences due to parents vs. hybrids were found to be significant for seven characters (Table 1). Analysis of variance due to treatments and hybrids revealed significant differences for all the characters, suggested great variability in the source of variations for almost all the characters under studied. These results are in accordance with Pedapati *et al.*, (2014) except for yield and some yield related traits. Mean performance of 8 parental lines and 28 F<sub>1</sub> hybrids for all the traits (Tables 2, 3 and 4) revealed a wide range of mean values, which indicated that the parental lines involved in this study were genetically diverse and had good breeding value, which confirmed the predictions of analysis of variance.

The estimates of genotypic coefficient of variation (Table 1) was the highest for  $\beta$ -carotene (46.25), followed by lycopene content (45.37) and fruit yield per plant (44.82), whereas the lowest GCV was found for days to first harvest (4.64), followed days to first flowering (6.91) and days to 50% fruit set (7.19). The results were in concurrence

with Ahmad *et al.*, (2016). The highest phenotypic coefficient of variation was recorded for fruit yield per plant (47.13), followed by  $\beta$ -carotene (46.51), and lycopene content (45.59), whereas the lowest PCV was recorded for days to first harvest (8.40), T.S.S. (8.96) and days to 50% fruit set (10.78). The values of PCV were higher than GCV obtained for all traits under studied (Table 1). Prajapati *et al.*, (2015) also reported the higher PCV value than GCV for most of the characters. The highest and lowest ECV were found for fruit yield per plant (14.57) and lycopene content (4.52), respectively. Genotypic coefficient of variation shows the extent of genetic variability in a population, was high for all the characters.

The highest heritability and genetic advance over percentage of mean were recorded on lycopene content (99.02 and 93.01%),  $\beta$ -carotene (98.88 and 94.74%) and fruit yield per plant (90.45 and 87.82%). However, the lowest heritability was that of days to first harvest (30.51%) with an expected genetic advance over percentage of mean of 5.28% (Table 1). High heritability also reported by Meeena and Bahadur (2014) and Yadav *et al.*, (2016). Most of the characters have high heritability estimates that they will be affected by environmental condition.

The range for days to first flowering was from 46.00 to 55.33 days with a mean value of 50.46 days in parents. In case of hybrids, average mean value was 50.46 days through a range of 43.67 to 68.00 days. The results were in confirmation with Singh *et al.*, (2014). Parent DVRT-1 showed earliest 50% flowering and fruit set with 53.00 and 56.67 days, respectively. The best F<sub>1</sub> hybrid for early flowering and fruit set was DVRT-1 x CHFT-50 (50.67 and 54.67 days), which was followed by CHFT-77 x H-86 (51.33 and 55.33 days) and CHFT-60 x CHFT-71 (52.33 and 56.67 days). Similar results were also

obtained by Islaam *et al.*, (2014) and Lekshmi and Celine (2015). The promising F<sub>1</sub> hybrid for early harvest was DVRT-1 x CHFT-50 (70.00 days), which was parity with CHFT-77 x CHFT-71 (71.67 days) and CHFT-77 x H-86 (72.67 days). These kinds of results are also reported by Chernet *et al.*, (2014).

Among the parents, the primary branches per plant varied from 7.07 to 9.33 with a mean value of 8.18. However, for the hybrids, it was in the range of 8.20 to 13.33 with a mean value of 9.58. Parent CHF-60 recorded maximum number of primary branches per plant (9.33), which was statistically at par with DVRT-2 (8.80), CHFT-77 (8.67), DVRT-1(8.33), H-86 (8.13) and CHFT-79 (7.87). The above results are in accordance with Shankar *et al.*, (2013) and Yadav *et al.*, (2013). The maximum number of locules per fruit was recorded for DVRT-2 x CHFT-77 (6.33) followed by DVRT-1 x CHFT-77 (4.73) and CHFT-79 x H-86 (4.53). High magnitude of number of locules per fruit has been reported by Pandey *et al.*, (2016). Among the parental lines, maximum pericarp thickness recorded for CHFT-79 (0.51 cm). However, thickest pericarp was recorded for hybrids DVRT-2 x H-86 (0.70 cm), which was statistically at par with DVRT-2 x CHFT-77 (0.68 cm), CHFT-79 x CHFT-71 (0.67 cm) and CHFT-77 x CHFT-79 (0.63 cm). Chattopadhyay *et al.*, (2013) and Jindal *et al.*, (2015) also reported the similar findings. Out of 28 hybrids, maximum plant height was recorded for CHFT-60 x CHFT-50 (119.87 cm) followed by CHFT-60 x CHFT-71 (117.45 cm), DVRT-2 x CHFT-79 (112.20 cm), DVRT-2 x CHFT-60 (108.93 cm) and H-86 x CHFT-50 (108.12 cm). Similar observation was also made by Farooq *et al.*, (2012) and Jindal *et al.*, (2015). Longest fruits were recorded in the parent CHFT-50 (5.16 cm). In the hybrids, DVRT-2 x CHFT-77 (5.55 cm) showed maximum fruit length fruit girth and fruit weight.

**Table.1** Analysis of variance (mean squares), PCV, GCV, ECV,  $h^2$  (broad sense), GA and GA as % of mean for sixteen characters of tomato

Characters	Replications	Treatments	Parents	Hybrids	Parent vs. Hybrids	Error	PCV	GCV	ECV	$h^2$ (broad sense)	GA	GA as % of mean
<b>DF</b>	0.36	64.01**	29.71	75.00**	7.29	26.78	12.28	6.91	10.16	31.67	4.08	8.02
<b>DF</b>	44.18	81.14**	98.80**	79.34**	5.97	26.62	11.62	7.40	8.96	40.57	5.59	9.71
<b>DFS</b>	10.12	84.72**	102.95**	82.75**	10.17	24.91	10.78	7.19	8.04	44.45	6.13	9.87
<b>DFH</b>	8.79	70.33**	25.43	84.48**	2.54	30.35	8.40	4.64	7.01	0.31	4.15	5.28
<b>NPB</b>	0.47	5.60**	1.78	5.45**	36.46**	1.11	17.42	13.20	11.37	57.4	1.91	20.60
<b>NLF</b>	0.05	1.35**	1.97**	1.24**	0.01	0.15	19.34	16.42	10.23	72.04	1.10	28.71
<b>PT</b>	0.00	0.02**	0.00	0.02**	0.15**	0.00	16.03	12.96	9.42	65.42	0.11	21.59
<b>PH</b>	152.90	948.66**	494.76**	765.56**	9069.71**	78.94	22.75	20.17	10.52	78.6	31.09	36.84
<b>FL</b>	0.35	0.56**	0.84**	0.51**	0.07	0.22	12.89	7.54	10.45	34.25	0.41	9.10
<b>FG</b>	0.40	0.97**	0.63**	1.07**	0.42	0.27	12.65	8.60	9.27	46.24	0.67	12.06
<b>FW</b>	60.24	2612.57**	961.33**	3117.01**	551.62	149.71	35.32	32.48	13.87	84.58	54.28	61.53
<b>NFP</b>	139.95	515.31**	16.60	578.25**	2307.03**	59.63	27.25	23.09	14.46	71.8	21.51	40.31
<b>FYP</b>	0.42	8.97**	1.90**	10.27**	23.62**	0.31	47.13	44.82	14.57	90.45	3.33	87.82
<b>TSS</b>	0.01	0.26**	0.10*	0.31**	0.00	0.04	8.96	7.33	5.15	66.94	0.46	12.36
<b>LC</b>	0.16	42.54**	19.54**	49.60**	12.99**	0.14	45.59	45.37	4.52	99.02	7.71	93.01
<b>BC</b>	0.00	2.15**	2.21**	2.06**	4.30**	0.01	46.51	46.25	4.91	98.88	1.73	94.74

\*, \*\* Significant at 5 and 1 per cent probability level, respectively. PCV- Phenotypic Coefficient of Variation, GCV- Genotypic Coefficient of Variation, ECV- Environmental Coefficient of Variation,  $h^2$  - Heritability, GA- Genetic Advance (5%)

**Table.2** Range, mean values, top 3 parents and 5 best hybrids for yield and its attributing traits

Particulars		Days to first flowering	Days to 50% flowering	Days to 50% fruit set	Days to first harvest	Number of primary branches per plant
Range value	Parents	46.00 to 55.33	53.00 to 71.33	56.67 to 76.00	74.00 to 82.67	7.07 to 9.33
	Hybrids	43.67 to 68.00	50.67 to 74.67	54.67 to 79.33	70.00 to 97.00	8.20 to 13.33
Mean value	Parents	50.46	58.04	62.67	78.33	8.18
	Hybrids	50.46	57.48	61.93	78.70	9.58
Top three F <sub>1</sub> parents with their mean value		DVRT-1 (46.00)	DVRT-1 (53.00)	DVRT-1 (56.67)	DVRT-1 (74.00)	CHFT-60 (9.33)
		DVRT-2 (46.33)	DVRT-2 (53.33)	DVRT-2 (58.00)	DVRT-2 (76.00)	DVRT-2 (8.80)
		CHFT-71 (49.67)	CHFT-71 (56.00)	CHFT-71 (61.00)	CHFT-79 (76.00)	CHFT-77 (8.67)
Top five F <sub>1</sub> hybrids with their mean value		DVRT-1 x CHFT-50 (43.67)	DVRT-1 x CHFT-50 (50.67)	DVRT-1 x CHFT-50 (54.67)	DVRT-1 x CHFT-50 (70.00)	DVRT-2 x CHFT-60 (13.33)
		DVRT-1 x CHFT-60 (44.67)	CHFT-77 x H-86 (51.33)	CHFT-77 x H-86 (55.33)	CHFT-77 x CHFT-71 (71.67)	DVRT-2 x CHFT-77 (12.27)
		CHFT-77 x CHFT-71 (45.67)	CHFT-60 x CHFT-71 (52.33)	CHFT-60 x CHFT-71 (56.67)	CHFT-77 x H-86 (72.67)	CHFT-77 x CHFT-60 (12.20)
		CHFT-60 x CHFT-71 (46.00)	CHFT-77 x CHFT-79 (53.33 days)	CHFT-77 x CHFT-79 (58.00 days)	CHFT-60 x CHFT-79 (74.67 days)	DVRT-2 x CHFT-79 (11.73)
		CHFT-77 x CHFT-79 (47.33)	CHFT-77 x CHFT-71 (53.67 days).	DVRT-1 x CHFT-77 (58.33 days).	CHFT-60 x CHFT-71 (74.67 days)	H-86 x CHFT-50 (10.87)
C.V. (%)		10.16	8.96	8.04	7.01	11.37
S.E.m ±		2.99	2.98	2.88	3.19	0.61

**Table.3** Range, mean values, top 3 parents and 5 best hybrids for yield and its attributing traits

Particulars		Number of locules per fruit	Pericarp thickness	Plant height	Fruit length	Fruit girth
Range value	Parents	2.33 to 5.13	0.43 to 0.51	46.83 to 87.73	3.70 to 5.16	4.81 to 6.11
	Hybrids	2.93 to 6.33	0.42 to 0.70	64.97 to 119.87	3.90 to 5.55	4.89 to 8.03
Mean value	Parents	3.83	0.46	67.24	4.44	5.48
	Hybrids	3.85	0.55	89.28	4.50	5.63
Top three parents with their mean value		CHFT-77 (5.13)	CHFT-79 (0.51)	CHFT-60 (87.73)	CHFT-50 (5.16)	H-86 (6.11)
		DVRT-2 (4.40)	H-86 (0.49)	CHFT-71 (76.33)	H-86 (5.07)	CHFT-77 (5.91)
		DVRT-1 (4.20)	CHFT-71 (0.47)	CHFT-79 (76.07)	CHFT-79 (4.67)	DVRT-2 (5.83)
Top five F <sub>1</sub> hybrids with their mean value		DVRT-2 x CHFT-77 (6.33)	DVRT-2 x H-86 (0.70)	CHFT-60 x CHFT-50 (119.87)	DVRT-2 x CHFT-77 (5.55)	DVRT-2 x CHFT-77 (8.03)
		DVRT-1 x CHFT-77 (4.73)	DVRT-2 x CHFT-77 (0.68)	CHFT-60 x CHFT-71 (117.45)	DVRT-2 x H-86 (5.33)	DVRT-2 x H-86 (6.61)
		CHFT-79 x H-86 (4.53)	CHFT-79 x CHFT-71 (0.67)	DVRT-2 x CHFT-79 (112.20)	CHFT-79 x H-86 (5.29)	CHFT-79 x H-86 (6.32)
		DVRT-1 x H-86 (4.27)	CHFT-77 x CHFT-79 (0.63 cm)	DVRT-2 x CHFT-60 (108.93 cm)	DVRT-2 x CHFT-71 (4.89 cm)	CHFT-77 x CHFT-79 (6.04)
		DVRT-1 x CHFT-50 (4.20)	CHFT-60 x CHFT-71 (0.61)	H-86 x CHFT-50 (108.12)	CHFT-79 x CHFT-71 (4.84)	DVRT-2 x CHFT-71 (5.92)
C.V. (%)		10.23	9.43	10.53	10.46	9.28
S.E.m ±		0.23	0.03	5.13	0.27	0.30

**Table.4** Range, mean values, top 3 parents and 5 best hybrids for yield and its attributing traits

Particulars		Fruit weight	Number of fruits per plant	Fruit yield per plant	Total soluble solids (%)	Lycopene content (mg/100g)	β-carotene content (mg/100g)
Range value	Parents	51.08 to 105.37	41.40 to 48.20	1.58 to 3.94	3.44 to 3.99	4.28 to 11.40	0.91 to 3.25
	Hybrids	54.59 to 209.67	30.88 to 92.83	1.19 to 9.13	3.15 to 4.47	2.46 to 21.36	0.67 to 3.62
Mean value	Parents	83.98	44.73	2.92	3.69	7.64	2.20
	Hybrids	89.42	55.84	4.04	3.70	8.47	1.72
Top three parents with their mean value		H-86 (105.37)	CHFT-71 (48.20)	H-86 (3.94)	CHFT-60 (3.99)	CHFT-79 (11.40)	H-86 (3.25)
		CHFT-77 (99.67)	CHFT-60 (47.80)	CHFT-71(3.71)	CHFT-71 (3.81)	H-86 (9.40)	CHFT-50 (2.91)
		CHFT-71 (96.37)	DVRT-2 (45.53)	CHFT-77 (3.56)	CHFT-79 (3.77)	CHFT-50 (9.12)	CHFT-71 (2.82)
Top five F <sub>1</sub> hybrids with their mean value		DVRT-2 x CHFT-77 (209.67)	CHFT-60 x CHFT-50 (92.83)	DVRT-2 x CHFT-77 (9.13)	DVRT-2 x CHFT-60 (4.47)	CHFT-79 x CHFT-50 (21.36)	DVRT-2 x CHFT-50 (3.62)
		DVRT-2 x H-86 (164.94)	CHFT-60 x CHFT-71 (82.70)	DVRT-2 x H-86 (6.86)	DVRT-1 x CHFT-71 (4.39)	DVRT-1 x CHFT-50 (15.13)	CHFT-79 x CHFT-50 (2.95)
		CHFT-79 x H-86 (124.39)	H-86 x CHFT-71 (79.27)	CHFT-79 x H-86 (6.47)	CHFT-79 x CHFT-50 (4.31)	DVRT-2 x CHFT-71 (14.61)	DVRT-1 x CHFT-50 (2.92)
		DVRT-2 x CHFT-71 (101.33)	CHFT-79 x CHFT-50 (72.55)	CHFT-60 x CHFT-71 (5.92)	DVRT-2 x CHFT-79 (4.07)	DVRT-1 x CHFT-60 (13.50)	CHFT-71 x CHFT-50 (2.80)
		DVRT-2 x CHFT-79 (101.14)	H-86 x CHFT-50 (72.27)	H-86 x CHFT-71 (5.80)	H-86 x CHFT-71 (3.97)	DVRT-2 x H-86 (10.82)	H-86 x CHFT-50 (2.70)
C.V. (%)		13.87	14.47	14.57	5.15	4.52	4.91
S.E.m ±		7.06	4.46	0.32	0.11	0.22	0.05

Results are in agreement with Singh *et al.*, (2014) and Lekshmi and Celine (2015). The highest number of fruit per plant observed in CHFT-60 x CHFT-50 (92.83), which was statistically at par with CHFT-60 x CHFT-71(82.70). The fruit yield per plant ranged from 1.58 to 3.94 kg for parents and 1.19 to 9.13 kg in F<sub>1</sub> hybrids. Among the parental lines, the highest fruit yield per plant was recorded in H-86 (3.94 kg). The best hybrid regarding fruit yield performance was DVRT-2 x CHFT-77 (9.13 kg), followed by DVRT-2 x H-86 (6.86 kg) and CHFT-79 x H-86 (6.47 kg). Results of increased number of fruits per plant and yield are in concurrence with the findings of Farooq *et al.*, (2012); Shankar *et al.*, (2013); Islaam *et al.*, (2014) and Dagade, *et al.*, (2015).

Among the parental lines, highest total soluble solid was recorded for CHFT-60 (3.99 %). Out of F<sub>1</sub> hybrids, highest total soluble solid was observed for DVRT-2 x CHFT-60 (4.47 %), which was statistically at par with DVRT-1 x CHFT-71 (4.39 %) and CHFT-79 x CHFT-50 (4.31 %). Chattopadhyay *et al.*, (2013) and Chernet *et al.*, (2014) also reported the similar findings. The lycopene content among the parents ranged from 4.28 to 11.40 mg/100g and among hybrids, it was between 2.46 to 21.36 mg/100g. Out of 28 hybrids, highest lycopene content was recorded for CHFT-70 x CHFT-50 (21.36 mg/100g) followed by DVRT-1 x CHFT-50 (15.13 mg/100g) and DVRT-2 x CHFT-71 (14.61 mg/100g). The findings are in accordance with Panthee *et al.*, (2015). The  $\beta$ -carotene content ranged from 0.91 to 3.25 mg/100g and 0.67 to 3.62 mg/100g in parents and F<sub>1</sub> hybrids, respectively. The highest  $\beta$ -carotene content found in hybrids DVRT-2 x CHFT-50 (3.62 mg/100g) followed by CHFT-79 x CHFT-50 (2.95 mg/100g) and DVRT-1 x CHFT-50 (2.92 mg/100g). Similar findings were also made by Jindal *et al.*, (2015) and Lekshmi and Celine (2015).

High estimates of heritability and genetic advance as per cent over mean were noticed for most of the traits indicates that their inheritance and phenotypic selection for their improvement could be achieved by simple breeding methods. From the above findings, it is concluded that parents DVRT-1 and CHFT-60 for earliness; DVRT-2 and H-86 for fruits yield; CHFT-50 for lycopene and  $\beta$ -carotene content, were found superior among all the parents. These could be used in as one of the parent to produce high yielding and better quality hybrids, as well as in varietal improvement programmes. Hybrid DVRT-2 x CHFT-77, showed best for high yield and CHFT-60 x CHFT-71 for high yield and earliness. Average yield, earliness and quality traits observed in hybrid H-86 x CHFT-50. CHFT-79 x CHFT-50 showed high yield, TSS and lycopene content. For high lycopene and  $\beta$ -carotene, DVRT-1 x CHFT-50 found superior. These crosses may be exploited as commercial hybrids, after testing with few more in multilocation trial to confirm their potentiality stability over different agro-climatic situations. Therefore, it is suggested that hybrid breeding approaches might be more rewarding because hybrids advocate increased yield and other related traits in comparison with parents.

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