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Evaluation of tomato lines and hybrids for fruit morphological and processing traits

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Abstract
A field experiment with 120 tomato hybrids generated from sixteen tomato lines using a half-diallel mating design was conducted over two seasons. We assessed these tomato hybrids for their suitability in processing. We considered 22 yield and processing traits for assessing the suitability of hybrids for processing. Among the hybrids, the maximum TSS (5.32 °Brix) was found in IIHR-2957 x CLN3916D. The experiment revealed that the hybrid IIHR-2833 x IIHR-2955 (2.17) and IIHR-2784 x IIHR-2833 (2.20) had a minimum locule number. The hybrids IIHR-2784 x IIHR-2955 (32.50) and IIHR-2955 x Arka Ashish (39.24) had minimum number of seeds per fruit. The hybrids IIHR-2327-1 x Arka Ashish (101.83) had maximum number of fruits per plant and IIHR-2327-1 X IIHR-2955 (8.18 kg) had high yield per plant. The maximum shelf life to the extent of 44.5 days was shown by IIHR-2847 x IIHR-Sel.19. IIHR-Sel.57 X CLN3916D (14.5%) had high dry matter content and Arka Ashish x CLN3916C (9223 mPa) had high viscosity. Overall, we identified as many as 11 hybrids for most of the processing traits studied. These promising hybrids can be used for developing tomato lines suitable for processing which can be used in hybridization programs.

Keywords: Hybrid, parents, mean performance yield, processing quality

Introduction
Tomato (*Solanum lycopersicum*) is one of the important crops used to make a variety of processed products, including juice, ketchup, sauce, diced tomato, puree and paste. Tomato adds nutrients, color and flavor to the diet. In addition, tomato is referred to as a "functional food" (Ranieri *et al*., 2004) [12] as it is a valuable source of antioxidants or chemo-protective substances. Tomato has a particularly high concentration of lycopene, ascorbic acid, phenolics, flavonoids, and vitamin E, which together make up the tomato antioxidant potential (Kaur *et al*., 2004) [8]. A beneficial effect of tomato consumption in preventing some chronic diseases such as cancer and cardiovascular diseases has been reported (Trout, 1991) [18]. Apart from the nutritional and antioxidant vitamin contents, sugars and organic acids, which form a substantial fraction of tomato dry matter, are relevant more to taste attributes than to the nutritional value of tomato (Raffo *et al*., 2002) [11]. Quality and flavour of the processed products depend on chemical components like reducing sugar, acidity, ascorbic acid, lycopene, ß-carotene, T.S.S and total sugar which has been reported to vary greatly with variety (Balasubramanian T, 1984) [5]. High total soluble solids (4–8° Brix), acidity not less than 0.4%, p^H less than 4.5, consistent red color, smooth surface, wrinkle-free, small core, firm flesh and uniform ripening are all desirable characteristics for a tomato cultivar to be used for processing (Adsule *et al*., 1980, Tiwari *et al*., 2002) [1, 19].

Nearly 80 per cent of fresh tomatoes are processed into various products in the majority of developed countries. Tomatoes are grown on 0.81 mha in India, with a production of 20.57 MT and an average productivity of 22.7 t/ha (Anon, 2022) [2]. Only 2.2% of India's total production is now processed; the rest is sold as fresh vegetable (Takeoka *et al*., 2001) [14]. Tomato quality depends on many factors, including cultivar, growing environment and on and off vine ripening. The morphological and bio-chemical characteristics of tomato also affect the quality of processed products. Therefore, good quality tomato should be processed for the best products. High yield coupled with good processing qualities are the prerequisites for the general acceptance of the hybrid by the farmers. However, very little attempt has been made so far in India to assess the morphological and bio-chemical properties of tomato hybrids developed by both public and private sectors in recent times from the point of view of processing. The present study was undertaken to assess the processing qualities of tomato hybrids which would be acceptable by the processing industries.

Materials and Methods

A total of 120 tomato hybrids and their parents were evaluated in the field in an augmented block design (ABD). This experiment was undertaken during the summer of 2021 (April - August) and Kharif of 2021 (September-December) at the Indian Institute of Horticultural Research (IIHR), Hessaraghatta, Bangalore (Karnataka) an experimental plot (Block-8), division of vegetable crops. The experimental site is 930 meters above mean sea level (MSL) 130° N latitude and 77.37° E longitude. The experimental area was divided into three blocks in such a way that beds in each block were treated as single rows. These 120 hybrids developed following the half diallel mating design along with the 16 parental lines and four checks (Arka Vishesh, Arka Apeksha, Arka Rakshak and Arka Samrat) were used in the experiment.

The observations were recorded over two seasons (summer and Rabi seasons during 2021) and pooled. The 22 quantitative and processing traits *viz*., days to 50 per cent flowering, days to first fruit ripening, number of fruits per cluster, fruit length (cm), fruit width (cm), Pericarp thickness (mm, Digital slide calipers), number of locules per fruit, number of seeds per fruit, size of the core in fruit cross section (mm), peduncle scar size (mm), TSS (°Brix, Hand refractometer), firmness (kg/ cm^2), number of fruits per plant, average fruit weight (g), yield per plant (kg), pulp recovery (%), moisture (%), p^H (digital p^H meter), titrable acidity (%, in terms of citric acid), dry matter (%), viscosity (mPa, lab matrix viscometer) and shelf life (days) were recorded. The observation was taken on five randomly selected plants from each hybrid, parents and checks. Analysis was performed on the collected data for each trait using Indostat services, Hyderabad.

Results and Discussion

The mean performance of sixteen parents for twenty-two quantitative and processing traits is presented in Table 1. The mean performance of the parents plays a crucial role in crop improvement, based on which better parents are selected for hybridization. The parents such as Pusa Early Dwarf (22.50) and Arka Ashish (24.50) were found to be early bearers. The Pusa Early Dwarf (5.00) and IIHR-2847 (5.00) had maximum number of fruits per cluster. The parents such as IIHR-Sel.22 (2.33) and IIHR-2784 (2.33) were found to have less number of locules per fruit, IIHR-2833 had maximum pericarp thickness (8.92 mm) and p^H (4.33). IIHR-2957 had maximum TSS (5.23). IIHR-2327-1 had maximum fruit width (6.13 cm), peduncle scar size (15.12 mm), average fruit weight (132.17 g), number of fruits per plant (100.50) and yield per plant (6.49 kg). The parents such as IIHR-2847 (34.73) and IIHR-2834 (42.11) were found to have less number of seeds per fruit. IIHR-Sel.41-1 had maximum fruit length (6.68 cm) and moisture content (98.46%). IIHR-2784 had maximum firmness (7.53 kg/ cm^2) and shelf life (35.50). IIHR-Sel.19 had maximum size of the core in fruit cross section (37.50 mm). The variety Arka Ashish had highest pulp recovery (96.12%). Titrable acidity (0.55%) was found to be maximum in IIHR-Sel.57. Maximum dry matter (6.94%) was found in IIHR-Sel.22 and maximum viscosity (1108.85mPa) was observed in IIHR-2327-1. Similar results on yield and yield components in tomato were observed by Umesh *et al*. (2021) [20] and Pooja *et al*. (2021) [10] in tomato.

The mean performance of 120 hybrids for 22 quantitative and qualitative traits is presented in Table 2. Among 120 Hybrids PED X Arka Ashish (20.5 days), PED x CLN3916C (21 days) were early bearers. The cross combination IIHR-2784 X IIHR-Sel.41–1 (3.17) had maximum number of fruits per cluster. The hybrid IIHR-Sel.41-1 X CLN3916D (222.17g) had maximum average fruit weight. Whereas the hybrids IIHR-2955 x IIHR-2834 (53.33g)) had minimum average fruit weight. IIHR-2784 X IIHR-Sel.22 (7.25 kg/cm^2) had maximum fruit firmness and IIHR-2847 x CLN3916C (86.5 mm) had highest fruit size of core in cross section of fruit. The cross combinations IIHR-2327-1 x IIHR-2821(18.03 mm) had maximum peduncle scar size, IIHR-2784 x IIHR-2955 (32.50), IIHR-2955 x Arka Ashish (39.24) had minimum number of seeds per fruit, IIHR-2327-1 x Arka Ashish (101.83) had maximum number of fruits per plant, IIHR-2327-1 X IIHR-2955 (8.18 kg) had high yield per plant and IIHR-2847 x IIHR-Sel.19 (44.5 days) had maximum shelf life. The cross combinations IIHR-2821 X CLN3916D (99.12%) had highest pulp recovery, PED X Arka Ashish (99.84%) had high moisture, IIHR-Sel.57 X CLN3916D (14.5%) had high dry matter content and Ashish x CLN3916C (9223 mPa) had high viscosity. Hence these hybrids were found to be the best performers for respective traits. These results were in accordance with those reported by Singh *et al*. (2005) [13], Joshi *et al*. (2006) [7] and Asati *et al*. (2007) [4].

A wide range (4.00 cm to 7.78 cm) of variation was recorded among the different hybrids with respect to their mean fruit length. The hybrid IIHR-Sel.41-1 X IIHR-2833 (7.78 cm) had maximum fruit length followed by IIHR-Sel.19 x IIHR-2955 (7.16 cm). Whereas the hybrids IIHR-2957 x PED (4.00 cm) and IIHR-2957 x CLN3916D (4.15 cm) had minimum fruit length. Hybrids with high fruit length and pear shape are desired for processing as the fruit contains more pulp as reported by Tiwari, 1996. Like fruit width, the maximum fruit width was observed in IIHR-Sel.19 x IIHR-2327-1 (6.93 cm), whereas minimum in IIHR-2327-1 x IIHR-2821 (4.08 cm).

The number of locules in fruit is an important trait for choosing hybrids for processing. To ensure that the fruit has the proper shape and has a high concentration of solids and ascorbic acid, there should be a minimum of two to three locules (Thamburaj, 1998) [16]. In the present study, a slight variation in locule number of different hybrids was observed, the hybrid IIHR-2833 x IIHR-2955 (2.17) and IIHR-2784 x IIHR-2833 (2.20) had minimum and the hybrid IIHR-Sel.19 x IIHR-2327-1 (5.33) had maximum number of locules per fruit. The number of locules is typically lesser in pear or oblong-shaped types (higher fruit length) (Thakur and Kaushal, 1995 [15]; Chakraborty *et al*., 2007) [6].

The pericarp thickness showed a large variance. Among the hybrids, IIHR-2327-1 x IIHR-2833 (10.72 mm) had the maximum pericarp thickness, while IIHR-Sel.41–1 X PED (3.92 mm) had the minimum pericarp thickness. This result is in accordance with the findings of Thakur and Kaushal, 1995 [15]. High total soluble solids (TSS) is the main quality component for nutritional and processing purposes (Kumari *et al*., 1998). Among the hybrids, the maximum total soluble solids content (5.32 °Brix) was found in IIHR-2957 x CLN3916D followed by IIHR-2833 X IIHR- 2821(5.22 °Brix) and IIHR-2327-1 x IIHR-2834 (5.20 °Brix). Overall, the TSS ranged from 4.05 °Brix to 5.32 °Brix with a mean of 4.89 ° Brix.

Titratable acidity and p^H are two important qualities for processing tomatoes (Anthon *et al*., 2011) [3]. Citric acid is the most prevalent acid in tomatoes and the main contributor to

the total titratable acidity (Paulson and Stevens, 1974) [9]. The acidity of the fruit is also important as a contributor to the flavour of the tomato products. The minimum acidity requirement for processing tomatoes should be 0.40% as the processed product from low acid tomato may be affected by *Bacillus coagulans* (Thamburaj, 1998) [16]. The mean acid content of hybrids ranged from 0.16 to 0.54 per cent. The maximum fruit acidity was recorded in IIHR-2847 x IIHR-2327-1 (0.54%) followed by Arka Ashish x CLN3916C (0.52%). The p^H of tomatoes is determined primarily by the acid content of the fruit. The minimum p^H (3.64) of the fruit was recorded in IIHR-Sel.41-1 X CLN3916C and the maximum (4.79) was shown by IIHR-Sel.41–1 X IIHR-2821 (4.79). Superior parent lines and hybrid cross combinations with respect of growth, yield and quality traits in tomato is presented in Table 3.

Table 1: Per se performance of parents for growth, yield and quality parameters in tomato for pooled season

S. No.	Parents	Days to 50 percent flowering	Days to first fruit ripening	Number of fruits per cluster	Fruit length (cm)	Fruit width (cm)	Pericarp thickness (mm)	Number of locules per fruit	TSS	Firmness (kg/cm^2)	Size of the core in fruit cross section (mm)	Peduncle scar size (mm)
1	IIHR- 2821	28.00	69.50	3.83	5.00	5.45	6.97	2.67	4.95	4.98	27.55	7.30
2	IIHR- 2957	27.50	67.00	4.33	3.91	5.49	6.00	4.50	5.23	4.28	25.33	14.27
3	Arka Ashish	24.50	63.00	4.67	6.12	4.82	6.68	2.50	4.77	5.50	21.92	8.27
4	CLN3916C	27.00	68.50	4.50	5.30	5.15	5.90	3.33	4.95	5.33	24.22	6.88
5	IIHR-Sel.57	29.50	76.00	4.00	5.07	5.32	6.80	3.67	4.67	6.43	30.17	9.60
6	IIHR- 2847	28.50	76.00	5.00	4.35	5.30	5.62	3.33	5.07	4.85	24.83	8.03
7	PED	22.50	59.00	5.00	4.65	4.47	4.85	3.67	5.03	3.98	22.80	6.18
8	IIHR-Sel.22	25.50	67.50	3.67	5.48	4.52	4.90	2.33	4.87	5.40	22.67	8.95
9	IIHR- 2784	29.00	77.50	4.17	5.45	5.10	5.80	2.33	4.77	7.53	28.08	6.23
10	IIHR- 2833	26.00	68.50	4.00	6.00	5.38	8.92	2.83	4.80	5.15	26.47	12.88
11	IIHR-Sel.19	26.00	68.00	3.67	5.40	4.37	6.82	3.50	5.02	6.97	37.50	10.45
12	IIHR-Sel.41-1	28.50	71.50	3.83	6.68	5.65	7.17	3.33	4.75	7.10	29.38	9.05
13	CLN3916D	26.00	68.00	4.33	5.63	5.65	6.52	2.67	4.97	6.27	23.33	10.52
14	IIHR- 2834	26.50	70.00	4.00	5.47	4.62	6.72	2.83	4.77	6.45	17.90	8.07
15	IIHR- 2955	25.00	67.00	4.00	5.03	4.47	4.73	2.67	4.93	4.93	24.83	9.97
16	IIHR- 2327-1	28.50	76.50	4.50	4.98	6.13	5.22	5.17	5.05	4.30	30.58	15.12
17	Arka Vishesh (Check -1)	29.67	69.83	4.44	5.40	5.32	6.80	3.17	5.02	5.92	20.71	7.96
18	Arka Apeksha (Check -2)	28.00	76.00	4.39	4.83	5.79	9.87	3.54	5.02	6.93	28.41	10.06
19	Arka Samrat (Check -3)	27.00	68.67	4.44	4.69	4.97	7.51	4.17	5.03	6.61	25.83	14.92
20	Arka Rakshak (Check -4)	26.00	69.00	4.44	5.58	5.26	8.06	3.39	4.90	6.75	24.89	7.60
	C.D. (5%)	1.37	1.56	0.30	0.24	0.19	0.52	0.39	0.14	0.32	2.44	0.54
	S.E.	0.56	0.64	0.12	0.10	0.08	0.21	0.16	0.06	0.13	1.00	0.22
	C.V (%)	1.75	0.73	2.41	1.38	1.13	2.46	3.81	0.88	1.82	2.79	1.62

Table 2: Per se performance of parents for growth, yield and quality parameters in tomato for pooled season

S. No.	Parents	Number of seeds per fruit	Average fruit weight (g)	Number of fruits per plant	Yield per plant (kg)	shelf life (days)	Pulp recovery (%)	p^H	Titrable acidity (%)	Moisture (%)	Dry matter (%)	Viscosity (mPa)
1	IIHR- 2821	79.61	73.17	60.00	4.53	26.50	72.90	4.24	0.37	97.81	2.19	1639.00
2	IIHR- 2957	93.41	100.17	53.03	3.98	31.50	87.27	4.27	0.41	96.95	3.06	2293.50
3	Arka Ashish	48.28	91.00	60.28	4.64	25.50	96.12	4.20	0.35	97.29	2.71	8945.50
4	CLN3916C	87.00	86.33	50.53	4.26	27.50	93.27	4.20	0.33	94.96	5.04	5012.15
5	IIHR-Sel.57	73.11	101.50	31.08	3.80	21.50	93.88	4.13	0.55	96.88	3.12	2280.00
6	IIHR- 2847	34.73	72.17	64.55	4.93	26.00	90.99	4.22	0.40	94.04	5.96	2112.25
7	PED	59.11	60.17	83.77	4.09	12.50	92.36	4.13	0.31	98.38	1.62	2403.75
8	IIHR-Sel.22	58.41	88.00	57.00	5.05	10.50	82.51	4.30	0.32	93.06	6.94	1293.90
9	IIHR- 2784	47.06	86.17	45.76	3.95	35.50	93.28	3.82	0.40	96.00	4.00	1215.50
10	IIHR- 2833	82.51	99.67	46.78	4.47	32.00	80.99	4.33	0.34	98.09	1.91	3316.00
11	IIHR-Sel.19	55.44	105.33	35.83	4.14	25.50	78.26	4.28	0.39	94.42	5.58	2515.00
12	IIHR-Sel.41-1	48.96	121.00	30.44	4.70	21.00	91.19	4.23	0.41	98.46	1.54	1179.50
13	CLN3916D	122.33	92.50	45.00	3.74	32.00	85.88	4.25	0.46	95.18	4.82	7999.00
14	IIHR- 2834	42.11	90.17	44.88	3.83	24.00	77.77	4.26	0.40	96.02	3.98	9586.00
15	IIHR- 2955	48.50	74.50	83.50	5.34	19.50	77.24	4.32	0.42	97.28	2.72	2168.50
16	IIHR- 2327-1	73.61	132.17	100.50	6.49	25.50	72.05	4.31	0.37	97.33	2.67	1108.85
17	Arka Vishesh (Check -1)	53.24	101.78	94.47	10.23	23.67	82.13	4.27	0.47	95.00	4.60	5855.83
18	Arka Apeksha (Check -2)	83.61	90.78	97.14	9.67	25.33	82.43	4.20	0.42	94.84	4.55	8674.17
19	Arka Samrat (Check -3)	117.50	117.78	107.59	11.67	35.67	92.07	4.26	0.38	96.35	3.36	7650.50
20	Arka Rakshak (Check -4)	82.33	102.83	99.83	10.70	37.33	80.44	4.30	0.36	95.06	4.47	8773.50
	C.D. (5%)	12.13	3.38	7.89	0.17	2.15	2.87	0.20	0.03	1.29	1.01	182.01
	S.E.	4.96	1.38	3.23	0.07	0.88	1.17	0.08	0.01	0.53	0.41	74.38
	C.V (%)	5.10	0.99	4.04	0.97	2.50	0.98	1.51	2.76	0.43	8.02	1.48

Table 3: Per se performance of hybrids for growth, yield and quality parameters in tomato for pooled season

S. No.	Hybrids	Days to 50 percent flowering	Days to first fruit ripening	Number of fruits per cluster	Fruit length (cm)	Fruit width (cm)	Pericarp thickness (mm)	Number of locules per fruit	TSS	Firmness (kg/cm^2)	Size of the core in fruit cross section (mm)	Peduncle scar size (mm)
1	IIHR-2821 X CLN3916C	24.00	65.50	4.00	5.18	4.90	5.35	3.33	4.68	5.37	23.83	6.02
2	IIHR-2821 X Arka Ashish	25.00	65.00	3.67	5.68	4.85	8.62	3.00	4.42	4.77	24.25	7.77
3	IIHR-Sel.41–1 X IIHR-Sel.22	24.50	68.50	3.67	6.33	4.82	6.08	3.33	4.68	6.22	27.00	13.42
4	IIHR-Sel.41-1 X CLN3916D	26.00	66.0s0	3.67	6.93	6.42	7.22	4.50	4.88	6.70	41.65	10.30
5	IIHR-2847 x CLN3916D	24.00	64.00	4.50	5.42	5.55	8.63	2.67	5.20	5.78	22.83	14.92
6	IIHR-2847 x IIHR-Sel.22	25.00	68.00	3.67	6.39	4.98	5.77	2.67	4.67	4.37	30.13	9.72
7	IIHR-2784 X IIHR-2955	23.50	68.00	4.33	6.30	5.23	5.62	2.67	4.83	5.42	20.30	15.63
8	IIHR-2784 X CLN3916C	25.50	69.50	3.83	6.97	5.67	8.40	2.67	5.07	7.13	25.42	12.28
9	IIHR-2834 X PED	23.00	62.50	4.67	4.52	5.28	6.60	2.67	5.00	4.65	22.17	5.03
10	IIHR-2957 x IIHR-Sel.57	24.00	63.00	3.50	5.28	4.45	4.72	3.33	5.02	5.28	30.42	5.40
11	IIHR-2327-1 x IIHR-2957	26.00	67.50	4.17	4.48	5.57	5.18	3.67	4.93	5.53	26.50	15.58
12	IIHR-23271-1 x PED	23.00	64.00	4.17	4.77	5.38	5.20	2.67	4.80	4.22	22.83	5.93
13	IIHR-2957 x IIHR-2834	25.00	66.00	4.00	4.47	5.33	6.00	3.33	4.98	5.47	24.17	6.30
14	IIHR-Sel.41-1 X CLN3916C	26.50	65.50	3.50	7.00	6.02	5.52	3.33	4.50	6.88	33.67	15.30
15	IIHR-2327-1 x CLN3916C	24.50	67.50	3.83	6.31	6.11	5.18	3.33	5.01	4.50	30.22	6.08
16	IIHR-2327-1 x IIHR-Sel.22	23.50	66.00	4.00	5.58	5.45	5.77	3.50	5.03	6.05	30.97	6.92
17	IIHR-Sel.41-1 X IIHR-2957	23.50	65.50	4.00	5.20	5.10	5.75	3.33	4.97	5.80	25.67	5.55
18	IIHR-Sel.41-1 X IIHR-2833	25.00	68.00	3.67	7.78	5.35	7.57	2.67	4.90	5.90	29.80	12.58
19	IIHR-2834 X IIHR-Sel.57	25.00	75.50	4.00	6.45	6.40	8.47	3.67	5.00	6.33	30.17	15.03
20	IIHR-2834 X CLN3916D	25.00	66.00	3.67	5.20	4.60	7.43	3.00	4.93	5.42	24.17	10.00
	C.D. (5%)	1.37	1.56	0.30	0.24	0.19	0.52	0.39	0.14	0.32	2.44	0.54
	S.E.	0.56	0.64	0.12	0.10	0.08	0.21	0.16	0.06	0.13	1.00	0.22
	C.V (%)	1.75	0.73	2.41	1.38	1.13	2.46	3.81	0.88	1.82	2.79	1.62

Table 4: Per se performance of hybrids for growth, yield and quality parameters in tomato for pooled season

S. No.	Hybrids	Number of seeds per fruit	Average fruit weight (g)	Number of fruits per plant	Yield per plant (kg)	Shelf life (days)	Pulp recovery (%)	p^H	Titrable acidity (%)	Moisture (%)	Dry matter (%)	Viscosity (mPa)
1	IIHR-2821 X CLN3916C	81.75	111.00	37.00	3.31	37.00	97.52	3.70	0.47	95.82	4.18	2997.50
2	IIHR-2821 X Arka Ashish	54.66	80.67	42.00	4.41	41.50	98.23	3.87	0.47	96.13	3.87	2137.00
3	IIHR-Sel.41–1 X IIHR-Sel.22	47.86	116.00	46.34	4.42	12.00	97.90	3.65	0.34	95.82	4.18	1285.00
4	IIHR-Sel.41-1 X CLN3916D	93.68	222.17	41.94	7.00	24.50	95.63	3.83	0.33	95.03	4.98	1498.00
5	IIHR-2847 x CLN3916D	52.95	99.50	36.24	5.53	34.00	95.40	3.84	0.50	94.94	5.06	3659.50
6	IIHR-2847 x IIHR-Sel.22	55.44	104.83	66.44	5.65	29.50	98.09	3.89	0.46	96.01	3.99	1496.50
7	IIHR-2784 X IIHR-2955	32.50	122.83	39.91	4.88	32.00	97.81	3.85	0.36	96.36	3.64	2080.00
8	IIHR-2784 X	56.91	130.50	41.41	5.41	34.50	97.57	3.85	0.34	95.93	4.07	8882.50

	CLN3916C											
9	IIHR-2834 X PED	71.44	82.83	77.00	5.52	16.50	88.23	3.81	0.34	96.48	3.52	1898.50
10	IIHR-2957 x IIHR-Sel.57	65.41	108.17	39.41	5.18	39.50	97.54	4.03	0.34	95.22	4.78	1847.00
11	IIHR-2327-1 x IIHR-2957	83.46	122.00	45.79	5.32	40.00	97.16	3.81	0.37	95.06	4.95	1291.00
12	IIHR-23271-1 x PED	59.11	108.33	53.63	6.31	22.00	94.45	3.70	0.50	94.56	5.44	3730.50
13	IIHR-2957 x IIHR-2834	115.58	117.67	40.96	3.80	35.50	96.11	3.85	0.33	93.48	6.52	3172.50
14	IIHR-Sel.41-1 X CLN3916C	48.39	146.50	46.94	5.81	22.50	97.49	3.64	0.35	94.93	5.07	1935.00
15	IIHR-2327-1 x CLN3916C	85.61	199.00	33.58	5.71	12.50	96.30	4.20	0.24	86.50	13.51	4141.50
16	IIHR-2327-1 x IIHR-Sel.22	68.96	173.00	46.13	5.31	13.50	97.17	3.98	0.45	92.35	7.65	1068.50
17	IIHR-Sel.41-1 X IIHR-2957	63.74	155.17	59.46	7.09	28.50	97.73	4.19	0.29	88.29	11.71	6887.50
18	IIHR-Sel.41-1 X IIHR-2833	96.89	131.00	50.24	5.52	13.00	97.11	4.14	0.26	93.60	6.41	1102.00
19	IIHR-2834 X IIHR-Sel.57	59.74	131.50	31.24	4.04	26.00	97.74	4.08	0.31	88.83	11.17	4683.50
20	IIHR-2834 X CLN3916D	55.08	93.50	47.50	4.71	12.50	95.74	4.23	0.23	93.90	6.10	8015.50
	C.D. (5%)	12.13	3.38	7.89	0.17	2.15	2.87	0.20	0.03	1.29	1.01	182.01
	S.E.	4.96	1.38	3.23	0.07	0.88	1.17	0.08	0.01	0.53	0.41	74.38
	C.V (%)	5.10	0.99	4.04	0.97	2.50	0.98	1.51	2.76	0.43	8.02	1.48

Table 5: Per se performance of hybrids for growth, yield and quality parameters in tomato for pooled season

S. No.	Hybrids	Days to 50 percent flowering	Days to first fruit ripening	Number of fruits per cluster	Fruit length (cm)	Fruit width (cm)	Pericarp thickness (mm)	Number of locules per fruit	TSS	Firmness (kg/cm^2)	Fruit size of core cross section (mm)	Peduncle scar size (mm)
21	IIHR-Sel.57 X CLN3916D	23.00	65.50	3.67	5.02	5.35	5.90	5.00	4.22	5.28	27.42	10.08
22	PED x CLN3916C	21.00	60.00	4.33	5.47	5.87	8.10	5.00	4.97	4.97	40.33	14.13
23	IIHR-2327-1 X CLN3916D	23.50	66.00	4.00	5.00	5.47	5.25	3.33	4.92	5.45	28.38	15.93
24	IIHR-2327-1 X IIHR-2955	28.00	75.00	4.33	5.05	6.05	8.23	3.33	5.08	6.08	29.58	13.13
25	IIHR-2834 X CLN3916C	24.50	66.00	4.33	5.22	4.65	6.77	2.67	4.97	5.45	22.00	6.58
26	IIHR-2834 X IIHR-Sel.22	28.50	70.00	3.67	5.43	4.62	7.93	2.50	4.97	5.40	20.08	5.47
27	IIHR-2957 x CLN3916C	25.00	63.00	3.67	4.25	5.52	6.18	4.50	4.83	5.68	23.33	14.87
28	IIHR-2957 X Arka Ashish	23.50	63.50	4.33	4.60	5.02	5.82	3.50	4.22	5.60	23.33	9.68
29	IIHR-2784 x CLN3916D	26.00	70.00	4.00	5.97	5.60	7.57	2.67	5.00	6.40	20.08	10.30
30	IIHR-2784 X IIHR-Sel.22	27.50	71.00	3.67	6.25	5.07	8.37	3.67	4.85	7.25	25.17	8.30
31	IIHR-2847 x IIHR-2957	24.50	65.50	4.00	5.53	4.50	7.47	3.50	5.02	5.25	33.83	12.13
32	IIHR-2847 x IIHR-2821	23.00	66.50	4.50	4.62	5.15	5.90	2.83	5.13	6.05	29.33	10.17
33	IIHR-2957 x PED	23.50	61.00	4.67	4.00	4.47	4.80	3.33	4.45	3.78	27.33	8.15
34	IIHR-2957X IIHR-Sel.22	23.00	64.50	3.67	5.02	5.43	5.40	2.67	5.03	5.98	29.00	15.90
35	IIHR-2957 x IIHR-2955	24.00	64.50	4.33	4.67	5.13	6.02	3.50	4.78	5.48	29.97	14.97
36	IIHR-2957 x CLN3916D	22.50	63.50	4.00	4.15	5.68	5.97	4.50	5.32	6.38	35.33	10.60
37	IIHR-2847 X Arka Ashish	22.50	65.00	4.50	5.08	4.99	8.18	3.00	5.17	5.15	26.00	8.93
38	IIHR-2847 x CLN3916C	23.00	65.00	3.67	4.60	5.88	6.00	3.33	4.93	6.00	86.50	12.20
39	IIHR-2833 X IIHR-2834	25.00	68.00	3.67	6.03	4.65	6.53	3.00	4.78	5.73	19.85	10.12
40	IIHR-2833 X IIHR-2821	23.50	64.50	3.67	5.15	5.08	8.67	3.33	5.22	5.65	28.47	10.05
	C.D. (5%)	1.37	1.56	0.30	0.24	0.19	0.52	0.39	0.14	0.32	2.44	0.54
	S.E.	0.56	0.64	0.12	0.10	0.08	0.21	0.16	0.06	0.13	1.00	0.22
	C.V (%)	1.75	0.73	2.41	1.38	1.13	2.46	3.81	0.88	1.82	2.79	1.62

Table 6: Per se performance of hybrids for growth, yield and quality parameters in tomato for pooled season

S. No.	Hybrids	Number of seeds per fruit	Average fruit weight (g)	Number of fruits per plant	Yield per plant (kg)	shelf life (days)	Pulp recovery (%)	p^H	Titrable acidity (%)	Moisture (%)	Dry matter (%)	Viscosity (mPa)
21	IIHR-Sel.57 X CLN3916D	80.61	98.00	33.93	3.59	29.50	96.91	4.09	0.32	85.50	14.50	7930.00
22	PED x CLN3916C	54.63	111.33	44.39	4.96	16.00	97.41	4.39	0.30	99.43	0.58	3608.50
23	IIHR-2327-1 X CLN3916D	78.91	110.17	49.56	6.19	37.00	95.72	4.04	0.33	94.64	5.36	2227.50
24	IIHR-2327-1 X IIHR-2955	131.41	149.67	54.79	8.18	14.00	97.06	4.22	0.31	94.96	5.04	1321.50
25	IIHR-2834 X CLN3916C	66.24	110.50	52.91	6.01	24.50	93.43	4.23	0.41	98.55	1.45	6432.00
26	IIHR-2834 X IIHR-Sel.22	56.61	90.00	52.44	6.45	20.50	97.46	4.12	0.27	96.93	3.07	1088.00
27	IIHR-2957 x CLN3916C	103.11	91.33	57.24	6.07	42.00	97.67	4.18	0.35	98.59	1.41	8984.00
28	IIHR-2957 X Arka Ashish	61.94	97.17	92.24	7.74	38.00	96.27	4.06	0.23	94.90	5.10	2310.50
29	IIHR-2784 x CLN3916D	82.63	119.50	51.11	5.98	41.00	91.64	4.12	0.31	95.15	4.85	3336.50
30	IIHR-2784 X IIHR-Sel.22	39.33	135.17	62.24	6.13	30.50	86.40	4.12	0.25	86.30	13.70	1020.00
31	IIHR-2847 x IIHR-2957	120.78	96.00	64.96	5.79	29.50	97.27	4.09	0.40	92.55	7.45	348.50
32	IIHR-2847 x IIHR-2821	61.39	79.00	76.91	7.65	27.00	97.36	4.05	0.38	93.97	6.03	1195.00
33	IIHR-2957 x PED	84.06	70.00	64.24	4.12	14.00	94.46	4.09	0.47	94.70	5.30	1297.00
34	IIHR-2957X IIHR-Sel.22	66.58	105.67	65.41	5.85	37.50	98.10	4.17	0.20	96.14	3.86	1719.50
35	IIHR-2957 x IIHR-2955	63.94	80.67	59.91	5.05	35.50	97.38	4.25	0.31	94.84	5.16	3053.50
36	IIHR-2957 x CLN3916D	97.89	106.67	56.17	4.31	38.00	97.82	4.28	0.24	94.08	5.92	5264.50
37	IIHR-2847 X Arka Ashish	48.56	106.00	40.83	4.12	35.50	97.04	4.22	0.28	95.33	4.67	5143.50
38	IIHR-2847 x CLN3916C	52.18	156.17	55.28	7.28	35.50	94.36	4.23	0.35	94.18	5.82	4653.00
39	IIHR-2833 X IIHR-2834	58.41	104.50	91.78	7.34	12.50	96.23	4.21	0.27	95.86	4.14	5196.00
40	IIHR-2833 X IIHR-2821	68.41	103.67	66.44	5.53	34.00	97.37	4.29	0.18	95.78	4.22	2883.50
	C.D. (5%)	12.13	3.38	7.89	0.17	2.15	2.87	0.20	0.03	1.29	1.01	182.01
	S.E.	4.96	1.38	3.23	0.07	0.88	1.17	0.08	0.01	0.53	0.41	74.38
	C.V (%)	5.10	0.99	4.04	0.97	2.50	0.98	1.51	2.76	0.43	8.02	1.48

Table 7: Per se performance of hybrids for growth, yield and quality parameters in tomato for pooled season

S. No.	Hybrids	Days to 50 percent flowering	Days to first fruit ripening	Number of fruits per cluster	Fruit length (cm)	Fruit width (cm)	Pericarp thickness (mm)	Number of locules per fruit	TSS	Firmness (kg/cm^2)	Fruit size of core cross section (mm)	Peduncle scar size (mm)
41	IIHR-2833 X CLN3916C	23.00	65.50	3.50	5.37	5.02	6.72	3.33	4.72	6.12	24.33	14.83
42	IIHR-2833 X CLN3916D	23.50	64.50	3.50	5.20	4.86	8.37	2.67	4.85	6.37	24.00	9.85
43	IIHR-2833 X Arka Ashish	24.00	65.50	4.00	5.10	4.24	6.92	3.50	4.05	6.13	16.75	9.08
44	IIHR-2833 x PED	23.00	60.50	4.33	4.43	5.07	7.12	3.67	4.80	4.85	25.60	10.10
45	IIHR-2847 X PED	22.50	60.00	4.00	4.15	4.65	5.62	3.33	5.18	4.35	19.95	6.98
46	IIHR-2847 x IIHR-Sel.57	24.50	69.50	3.67	6.30	6.45	6.85	4.50	5.00	6.38	35.83	14.92
47	IIHR-2847 X IIHR-2834	24.50	68.00	3.67	5.37	4.87	7.95	3.17	4.95	5.92	24.80	9.85
48	IIHR-2847 X IIHR-2955	25.00	67.00	4.00	5.11	4.94	7.17	3.67	4.96	5.85	31.17	8.83
49	IIHR-Sel.19 x IIHR-2833	25.00	65.00	3.67	4.71	4.80	6.22	3.33	4.73	6.23	25.17	13.70
50	IIHR-Sel.19 x IIHR-2327-1	26.00	69.00	3.67	6.50	6.93	4.72	5.33	5.00	6.65	49.75	10.42
51	IIHR-2821 x IIHR-Sel.57	24.50	66.50	4.00	6.08	6.30	5.78	3.67	4.87	5.30	33.27	15.92
52	IIHR-2821 x IIHR-2957	24.50	64.50	4.00	4.78	5.55	6.43	3.67	4.95	4.53	27.72	12.70

53	PED X CLN3916D	22.00	60.50	4.00	4.65	5.15	6.88	3.67	4.38	4.23	23.85	13.03
54	PED X IIHR-Sel.22	21.50	60.00	4.17	4.35	5.85	5.55	5.00	4.55	4.23	28.02	10.10
55	IIHR-2327-1 x IIHR-2833	24.00	66.50	4.33	5.03	6.00	10.72	3.50	5.07	5.27	35.20	13.35
56	IIHR-2327-1 x IIHR-2834	24.00	67.50	4.33	5.28	6.12	8.95	2.67	5.20	6.20	30.13	15.02
57	IIHR-2955 x CLN3916C	24.00	65.50	4.17	5.23	6.11	5.98	3.00	4.87	5.25	22.97	14.95
58	IIHR-2955 X IIHR-Sel.22	23.50	66.00	4.00	5.98	4.75	7.03	2.83	4.65	6.05	20.62	10.07
59	IIHR-2327-1 x IIHR-2821	27.00	70.00	4.00	5.35	6.43	7.00	4.67	4.90	5.25	37.10	18.03
60	IIHR-2327-1 x IIHR-Sel.57	25.00	66.00	4.00	5.42	5.55	6.00	2.83	5.08	5.97	30.50	12.13
	C.D. (5%)	1.37	1.56	0.30	0.24	0.19	0.52	0.39	0.14	0.32	2.44	0.54
	S.E.	0.56	0.64	0.12	0.10	0.08	0.21	0.16	0.06	0.13	1.00	0.22
	C.V (%)	1.75	0.73	2.41	1.38	1.13	2.46	3.81	0.88	1.82	2.79	1.62

Table 8: Per se performance of hybrids for growth, yield and quality parameters in tomato for pooled season

S. No.	Hybrids	Number of seeds per fruit	Average fruit weight (g)	Number of fruits per plant	Yield per plant (kg)	Shelf life (days)	Pulp recovery (%)	p^H	Titrable acidity (%)	Moisture (%)	Dry matter (%)	Viscosity (mPa)
41	IIHR-2833 X CLN3916C	93.11	85.33	45.13	3.96	36.00	98.72	4.30	0.25	96.20	3.80	7756.50
42	IIHR-2833 X CLN3916D	98.78	58.67	47.50	4.15	35.50	93.92	4.26	0.24	97.45	2.55	3637.00
43	IIHR-2833 X Arka Ashish	52.74	60.50	65.50	4.75	32.00	95.05	4.18	0.28	96.01	3.99	2143.00
44	IIHR-2833 x PED	131.06	67.00	71.61	5.13	15.50	97.79	4.20	0.31	99.30	0.70	2288.50
45	IIHR-2847 X PED	89.58	86.83	65.00	4.92	15.50	96.40	4.24	0.23	98.52	1.48	3675.50
46	IIHR-2847 x IIHR-Sel.57	95.51	142.50	49.33	4.87	16.50	92.32	4.17	0.27	95.98	4.02	5005.50
47	IIHR-2847 X IIHR-2834	67.08	127.67	80.50	7.41	13.50	93.44	4.33	0.30	96.04	3.97	1112.50
48	IIHR-2847 X IIHR-2955	70.50	104.83	71.11	7.22	20.50	98.32	4.15	0.21	96.57	3.43	3609.50
49	IIHR-Sel.19 x IIHR-2833	120.50	60.83	56.91	5.05	33.50	97.18	4.23	0.18	95.24	4.76	982.00
50	IIHR-Sel.19 x IIHR-2327-1	91.74	221.00	30.61	4.98	32.00	78.67	4.22	0.17	99.68	0.32	2773.00
51	IIHR-2821 x IIHR-Sel.57	100.94	151.83	54.46	4.13	38.00	93.87	4.13	0.21	96.69	3.31	5212.50
52	IIHR-2821 x IIHR-2957	104.61	58.67	64.24	6.07	38.50	96.15	4.10	0.27	96.59	3.41	8419.00
53	PED X CLN3916D	119.96	98.33	56.78	3.67	37.50	97.47	4.14	0.34	96.34	3.66	3915.00
54	PED X IIHR-Sel.22	139.41	100.50	58.61	4.66	13.50	97.22	4.09	0.24	98.50	1.50	3609.50
55	IIHR-2327-1 x IIHR-2833	130.63	144.67	77.74	8.03	25.50	96.17	4.13	0.32	97.45	2.55	788.75
56	IIHR-2327-1 x IIHR-2834	113.00	151.67	62.33	5.69	15.50	93.57	4.17	0.30	96.59	3.41	3834.50
57	IIHR-2955 x CLN3916C	60.29	102.50	99.67	8.16	24.50	91.31	4.18	0.18	95.43	4.57	3667.50
58	IIHR-2955 X IIHR-Sel.22	97.11	97.50	95.91	7.12	24.00	95.49	4.18	0.16	97.94	2.06	3470.50
59	IIHR-2327-1 x IIHR-2821	139.83	180.00	53.83	6.29	26.50	96.28	4.15	0.18	95.13	4.87	1603.00
60	IIHR-2327-1 x IIHR-Sel.57	52.74	139.50	81.29	7.24	35.50	94.46	4.14	0.29	96.51	3.49	5573.00
	C.D. (5%)	12.13	3.38	7.89	0.17	2.15	2.87	0.20	0.03	1.29	1.01	182.01
	S.E.	4.96	1.38	3.23	0.07	0.88	1.17	0.08	0.01	0.53	0.41	74.38
	C.V (%)	5.10	0.99	4.04	0.97	2.50	0.98	1.51	2.76	0.43	8.02	1.48

Table 9: Per se performance of hybrids for growth, yield and quality parameters in tomato for pooled season

S. No.	Hybrids	Days to 50 percent flowering	Days to first fruit ripening	Number of fruits per cluster	Fruit length (cm)	Fruit width (cm)	Pericarp thickness (mm)	Number of locules per fruit	TSS	Firmness (kg/cm^2)	Fruit size of core cross section (mm)	Peduncle scar size (mm)
61	CLN3916C X CLN3916D	24.50	64.50	3.67	5.10	4.92	8.87	3.50	4.85	6.25	29.00	6.23
62	IIHR-SEL.19 X IIHR-2957	23.50	63.00	3.67	4.48	5.02	8.00	3.00	5.07	4.87	25.50	15.92
63	IIHR-2821 X PED	23.00	62.50	4.50	4.69	5.63	6.40	3.50	4.62	3.55	29.60	8.00
64	IIHR-2821 X IIHR-2955	24.00	67.00	4.50	5.47	5.40	7.90	2.33	4.93	5.13	30.38	13.63
65	PED X Arka Ashish	20.50	59.00	4.50	4.43	4.50	5.57	3.67	4.45	4.80	31.85	10.12
66	IIHR-2327-1 x Arka Ashish	23.50	65.00	4.00	5.08	5.08	8.43	2.67	5.00	5.42	28.10	12.22
67	Ashish x CLN3916D	24.00	64.50	3.83	5.10	5.33	6.98	2.67	4.87	6.03	26.10	15.02
68	Ashish x CLN3916C	23.00	64.00	4.00	5.75	4.88	5.93	2.33	4.84	4.93	21.50	12.97
69	IIHR-2784 x IIHR-2821	25.50	71.50	4.00	5.42	5.40	7.10	2.67	5.02	5.80	24.27	10.05
70	IIHR-2955 x Arka Ashish	24.00	65.50	4.50	5.17	4.22	5.73	3.33	4.70	5.62	17.30	5.67
71	IIHR-Sel.19 x IIHR-2821	24.00	63.50	3.67	5.07	5.47	7.60	4.00	5.05	5.07	30.03	12.97
72	IIHR-Sel.19 x CLN3916C	24.50	68.00	3.67	6.05	6.18	5.80	3.67	4.90	5.92	30.72	10.22
73	IIHR-2834 X Arka Ashish	24.50	66.00	4.33	5.47	4.88	9.10	2.83	4.60	5.75	25.62	10.18
74	IIHR-2955 x PED	21.50	63.50	5.00	4.78	5.18	7.08	4.50	5.02	4.25	29.08	15.18
75	IIHR-2847 x IIHR-2833	24.00	65.50	3.67	4.85	4.18	5.32	2.33	5.00	5.33	24.87	10.02
76	IIHR-2847 x IIHR-2327-1	25.00	68.50	3.67	5.02	6.37	8.25	3.33	5.07	5.40	34.17	13.05
77	IIHR-Sel.19 x IIHR-2955	24.50	71.50	4.00	7.16	6.22	7.10	4.50	5.00	6.15	40.00	12.68
78	IIHR-Sel.19 x PED	21.50	64.50	4.00	5.57	5.12	5.95	3.50	4.95	5.05	29.50	12.25
79	IIHR-Sel.41–1 x Arka Ashish	24.00	66.00	3.67	6.50	5.10	7.10	2.67	4.75	6.18	25.50	10.38
80	IIHR-Sel.41 -1 x IIHR-2327-1	25.00	69.50	3.67	5.64	5.92	5.97	3.50	5.00	6.45	29.50	12.92
	C.D. (5%)	1.37	1.56	0.30	0.24	0.19	0.52	0.39	0.14	0.32	2.44	0.54
	S.E.	0.56	0.64	0.12	0.10	0.08	0.21	0.16	0.06	0.13	1.00	0.22
	C.V (%)	1.75	0.73	2.41	1.38	1.13	2.46	3.81	0.88	1.82	2.79	1.62

Table 10: Per se performance of hybrids for growth, yield and quality parameters in tomato for pooled season

S. No.	Hybrids	Number of seeds per fruit	Average fruit weight (g)	Number of fruits per plant	Yield per plant (kg)	shelf life (days)	Pulp recovery (%)	p^H	Titrable acidity (%)	Moisture (%)	Dry matter (%)	Viscosity (mPa)
61	CLN3916C X CLN3916D	67.00	89.83	41.79	3.21	23.50	97.60	4.16	0.28	95.87	4.13	4338.50
62	IIHR-SEL.19 X IIHR-2957	68.11	98.33	63.58	5.15	38.50	97.13	4.16	0.33	94.68	5.32	1068.50
63	IIHR-2821 X PED	104.28	79.17	38.11	3.36	24.50	94.00	4.04	0.37	98.24	1.76	1151.50
64	IIHR-2821 X IIHR-2955	152.29	123.00	92.00	6.59	22.00	95.13	4.17	0.35	98.00	2.00	3917.50
65	PED X Arka Ashish	50.91	82.67	45.17	4.31	13.50	87.23	4.15	0.25	99.84	0.16	6047.00
66	IIHR-2327-1 x Arka Ashish	51.74	128.83	101.83	8.02	25.50	97.12	4.12	0.19	98.51	1.50	7994.00
67	Ashish x CLN3916D	84.96	139.50	69.61	5.21	37.50	97.84	4.16	0.26	95.58	4.42	1997.00
68	Ashish x CLN3916C	66.61	93.50	64.28	6.20	39.50	94.24	4.25	0.52	96.78	3.22	9223.50
69	IIHR-2784 x IIHR-2821	45.61	122.50	38.50	3.68	22.50	97.21	4.19	0.43	96.66	3.34	2418.50
70	IIHR-2955 x Arka Ashish	39.24	102.17	100.50	6.10	37.50	96.92	4.14	0.19	96.30	3.70	9032.00
71	IIHR-Sel.19 x IIHR-2821	60.94	99.00	57.94	5.54	27.50	91.72	4.28	0.35	96.16	3.84	1075.00
72	IIHR-Sel.19 x CLN3916C	80.61	120.17	51.63	4.25	28.50	95.02	4.15	0.28	96.23	3.77	8353.50
73	IIHR-2834 X Arka Ashish	49.41	119.00	85.13	7.07	34.00	96.58	4.13	0.29	97.73	2.27	6179.50
74	IIHR-2955 x PED	150.08	94.17	78.50	4.25	24.00	96.05	4.13	0.28	95.40	4.60	1524.00
75	IIHR-2847 x IIHR-2833	50.61	113.17	79.83	6.27	37.00	95.70	4.18	0.32	96.31	3.69	1446.50
76	IIHR-2847 x IIHR-2327-1	93.24	165.50	56.11	5.07	35.50	94.79	4.31	0.54	97.66	2.34	1480.50
77	IIHR-Sel.19 x IIHR-2955	89.08	169.17	53.78	4.36	27.00	97.18	4.17	0.21	97.65	2.35	2099.00
78	IIHR-Sel.19 x PED	160.46	92.83	54.63	4.23	27.00	97.88	4.24	0.28	99.17	0.83	1282.00
79	IIHR-Sel.41–1 x Arka Ashish	51.79	81.00	51.33	4.20	24.50	97.65	4.16	0.27	96.17	3.83	8444.00
80	IIHR-Sel.41 -1 x IIHR-2327-1	129.00	125.33	54.28	5.41	20.00	94.88	4.33	0.18	96.69	3.31	1576.50
	C.D. (5%)	12.13	3.38	7.89	0.17	2.15	2.87	0.20	0.03	1.29	1.01	182.01
	S.E.	4.96	1.38	3.23	0.07	0.88	1.17	0.08	0.01	0.53	0.41	74.38
	C.V (%)	5.10	0.99	4.04	0.97	2.50	0.98	1.51	2.76	0.43	8.02	1.48

Table 11: Per se performance of hybrids for growth, yield and quality parameters in tomato for pooled season

S. No.	Hybrids	Days to 50 percent flowering	Days to first fruit ripening	Number of fruits per cluster	Fruit length (cm)	Fruit width (cm)	Pericarp thickness (mm)	Number of locules per fruit	TSS	Firmness (kg/cm^2)	Fruit size of core cross section (mm)	Peduncle scar size (mm)
81	IIHR-2784 x IIHR-2833	25.00	68.00	3.67	6.05	5.78	5.97	2.20	4.80	4.55	25.63	6.93
82	IIHR-2784 x IIHR-2847	25.00	69.00	3.50	5.67	5.25	7.00	2.67	5.03	4.63	30.00	9.95
83	IIHR-Sel.57 x CLN3916C	23.50	67.00	3.67	6.70	5.80	9.03	3.00	5.15	6.45	30.77	14.92
84	IIHR-2784 X IIHR-Sel.19	25.50	69.00	3.67	6.57	5.52	7.98	2.33	5.17	6.95	23.77	10.02
85	IIHR-2833 x IIHR-2955	25.50	67.00	3.67	4.45	4.08	5.59	2.17	4.77	4.68	24.17	5.53
86	IIHR-Sel.19 x IIHR-2834	27.00	67.00	4.00	5.68	5.60	7.05	2.67	4.93	5.53	27.70	12.13
87	IIHR-2784 x IIHR-2834	27.50	71.50	3.67	6.33	5.75	9.02	2.33	4.87	6.00	29.20	11.38
88	IIHR-2784 x IIHR-2327-1	26.50	71.00	3.67	5.67	5.60	7.00	3.00	4.97	6.28	30.98	13.67
89	IIHR-2955 X IIHR-Sel.57	23.50	66.50	4.00	6.12	5.13	6.07	3.17	5.00	5.45	25.17	10.15
90	IIHR-2955 x IIHR-2834	24.00	64.50	4.50	4.80	4.30	4.07	2.50	4.95	5.27	21.50	9.12
91	IIHR-Sel.19 x Arka Ashish	23.50	66.00	4.17	6.13	5.15	5.23	2.67	4.87	5.50	25.72	10.27
92	IIHR-Sel.19 X IIHR-Sel.57	26.50	70.00	3.50	5.03	5.20	7.10	3.50	4.95	5.40	24.77	14.00
93	IIHR-Sel.22 x CLN3916D	23.00	66.50	4.00	6.03	5.27	8.03	2.67	4.97	5.98	25.27	12.85
94	Arka Ashish x Sel.22	22.00	65.00	4.00	6.12	4.50	7.23	2.33	4.75	5.90	19.97	10.27
95	IIHR-Sel.57 x Arka Ashish	23.00	65.00	4.17	5.95	4.50	5.10	2.67	4.95	4.53	25.58	10.10
96	IIHR-Sel.57 x IIHR-Sel.22	22.00	66.00	3.50	6.18	5.08	5.97	4.00	4.98	5.38	33.83	14.32
97	IIHR-2784 X IIHR-Sel.41–1	25.00	76.00	3.17	7.02	5.22	6.07	2.83	4.98	7.22	30.13	5.18
98	IIHR-2784 x IIHR-2957	25.00	69.00	3.67	5.15	6.11	8.00	3.67	4.67	5.43	29.98	14.88
99	IIHR-2847 x IIHR-Sel.41–1	25.50	69.50	4.00	5.97	5.93	5.97	2.83	5.07	5.95	33.83	12.95
100	IIHR-2847 x IIHR-Sel.19	24.00	70.00	3.83	6.20	5.22	6.47	3.17	5.10	5.73	27.30	9.38
	C.D. (5%)	1.37	1.56	0.30	0.24	0.19	0.52	0.39	0.14	0.32	2.44	0.54
	S.E.	0.56	0.64	0.12	0.10	0.08	0.21	0.16	0.06	0.13	1.00	0.22
	C.V (%)	1.75	0.73	2.41	1.38	1.13	2.46	3.81	0.88	1.82	2.79	1.62

Table 12: Per se performance of hybrids for growth, yield and quality parameters in tomato for pooled season

S. No.	Hybrids	Number of seeds per fruit	Average fruit weight (g)	Number of fruits per plant	Yield per plant (kg)	Shelf life (days)	Pulp recovery (%)	p^H	Titrable acidity (%)	Moisture (%)	Dry matter (%)	Viscosity (mPa)
81	IIHR-2784 x IIHR-2833	58.61	108.83	74.41	6.13	34.00	97.23	4.25	0.41	99.40	0.60	2413.50
82	IIHR-2784 x IIHR-2847	49.46	107.83	85.74	7.62	14.00	84.35	4.30	0.28	95.07	4.93	2087.00
83	IIHR-Sel.57 x CLN3916C	85.91	153.83	40.06	3.59	31.50	92.60	4.17	0.54	93.67	6.33	8075.00
84	IIHR-2784 X IIHR-Sel.19	45.77	115.17	50.00	4.71	22.00	97.60	4.25	0.30	96.86	3.14	1865.50
85	IIHR-2833 x IIHR-2955	49.28	85.33	65.61	4.46	25.00	94.89	4.06	0.37	95.69	4.32	2715.90
86	IIHR-Sel.19 x IIHR-2834	81.58	109.83	60.11	4.89	30.00	92.04	4.38	0.29	96.63	3.37	1204.00
87	IIHR-2784 x IIHR-2834	61.44	111.50	64.67	6.79	34.00	94.90	4.27	0.35	97.62	2.38	2925.00
88	IIHR-2784 x IIHR-2327-1	74.41	137.00	54.61	4.92	13.50	90.92	4.26	0.29	95.65	4.35	1078.50
89	IIHR-2955 X IIHR-Sel.57	99.00	89.83	43.50	3.71	29.50	95.04	4.35	0.25	97.89	2.12	2473.50
90	IIHR-2955 x IIHR-2834	70.11	53.33	74.50	4.95	32.50	97.65	4.28	0.41	99.42	0.58	2392.50
91	IIHR-Sel.19 x Arka Ashish	66.92	96.17	63.78	5.47	34.50	97.30	4.35	0.34	98.04	1.96	1443.50
92	IIHR-Sel.19 X IIHR-Sel.57	63.91	86.67	62.94	5.51	34.50	98.41	4.29	0.36	97.14	2.86	7706.00
93	IIHR-Sel.22 x CLN3916D	60.79	85.83	51.78	4.32	12.50	84.05	4.33	0.30	95.64	4.36	1357.50
94	Arka Ashish x Sel.22	55.50	97.00	51.33	4.42	35.50	97.91	4.38	0.28	99.25	0.75	7055.00
95	IIHR-Sel.57 x Arka Ashish	67.25	91.33	73.00	5.40	27.00	93.01	4.11	0.31	99.23	0.77	5956.50
96	IIHR-Sel.57 x IIHR-Sel.22	105.28	91.17	71.11	5.42	13.00	96.17	4.27	0.36	98.20	1.81	5038.50
97	IIHR-2784 X IIHR-Sel.41–1	55.61	90.33	69.83	6.50	29.00	94.59	4.16	0.41	98.86	1.14	1022.00
98	IIHR-2784 x IIHR-2957	62.58	125.50	63.17	5.91	35.50	97.54	4.21	0.31	98.21	1.79	1882.50
99	IIHR-2847 x IIHR-Sel.41–1	95.24	125.33	45.83	3.25	31.50	97.56	4.33	0.41	95.80	4.20	7028.50
100	IIHR-2847 x IIHR-Sel.19	51.94	112.33	55.00	4.08	44.50	83.58	4.79	0.43	95.92	4.08	4515.00
	C.D. (5%)	12.13	3.38	7.89	0.17	2.15	2.87	0.20	0.03	1.29	1.01	182.01
	S.E.	4.96	1.38	3.23	0.07	0.88	1.17	0.08	0.01	0.53	0.41	74.38
	C.V (%)	5.10	0.99	4.04	0.97	2.50	0.98	1.51	2.76	0.43	8.02	1.48

Table 13: Per se performance of hybrids for growth, yield and quality parameters in tomato for pooled season

S. No.	Hybrids	Days to 50 percent flowering	Days to first fruit ripening	Number of fruits per cluster	Fruit length (cm)	Fruit width (cm)	Pericarp thickness (mm)	Number of locules per fruit	TSS	Firmness (kg/cm^2)	Fruit size of core cross section (mm)	Peduncle scar size (mm)
101	Sel.19 x CLN3916D	24.00	67.00	3.67	4.92	5.10	7.02	2.67	5.00	5.28	25.08	5.08
102	IIHR-Sel.19 x IIHR-Sel.22	24.00	68.00	3.50	7.11	5.55	9.87	2.83	4.95	5.47	29.88	10.23
103	IIHR-Sel.41–1 x IIHR-2834	24.50	67.50	4.00	5.35	5.07	5.97	3.33	4.92	6.23	25.90	12.63
104	IIHR-Sel.41–1 x IIHR-2955	25.00	68.00	3.67	5.93	5.18	5.72	3.83	4.84	5.43	28.08	9.32
105	IIHR-Sel.57 x PED	21.00	61.50	3.83	4.57	5.41	8.93	4.33	5.05	4.62	29.30	6.15
106	IIHR-2821 X CLN3916D	26.00	66.50	4.00	4.28	4.97	5.17	3.00	4.88	6.03	23.83	5.30
107	IIHR-Sel.41-1x IIHR-Sel.19	24.00	69.00	3.50	6.98	5.83	5.07	3.33	4.73	5.30	24.87	6.08
108	CLN3916C x IIHR-Sel.22	22.50	63.00	3.67	5.12	4.70	4.10	3.33	4.82	5.32	21.13	4.18
109	IIHR-2833 x IIHR-Sel.22	24.00	67.50	4.33	6.20	4.77	5.98	2.33	5.03	4.92	19.93	11.83
110	IIHR-2833 x IIHR-Sel-57	23.50	67.50	3.83	5.05	4.93	5.98	2.67	5.07	5.53	26.47	10.07
111	IIHR-2784 x PED	23.50	64.50	4.00	6.08	4.77	5.08	3.33	4.90	4.90	19.97	5.05
112	IIHR-2784 x IIHR-SEL.57	25.50	76.00	3.50	6.43	4.97	8.08	3.17	5.05	5.42	24.73	12.77
113	IIHR-Sel.41–1 X IIHR-2821	24.50	68.00	3.50	6.10	5.48	6.13	3.50	4.30	4.68	35.05	10.23
114	IIHR-Sel.41–1 X PED	22.50	63.00	4.00	5.17	5.42	3.92	3.67	4.47	4.50	35.13	9.97
115	IIHR-2821 x IIHR-Sel.22	23.50	66.50	4.00	5.18	5.26	5.75	2.67	4.93	5.38	30.38	5.47
116	IIHR-2833 X IIHR-2957	25.50	66.00	4.33	4.68	5.25	6.52	3.67	5.07	4.87	27.80	11.65
117	IIHR-2821 X IIHR-2834	25.50	67.50	4.00	4.55	5.23	5.72	2.83	5.02	5.97	26.67	8.00
118	IIHR-2784 X Arka Ashish	24.00	67.50	4.17	5.88	4.95	6.25	3.00	5.00	5.48	27.22	7.07
119	IIHR-2955 x CLN3916D	24.00	66.50	4.17	5.03	5.17	10.13	3.00	4.93	6.95	29.72	10.13
120	IIHR-Sel.41-1x IIHR-Sel.57	24.00	67.00	4.00	7.12	5.65	5.08	4.50	4.92	5.10	35.72	14.85
	C.D. (5%)	1.37	1.56	0.30	0.24	0.19	0.52	0.39	0.14	0.32	2.44	0.54
	S.E.	0.56	0.64	0.12	0.10	0.08	0.21	0.16	0.06	0.13	1.00	0.22
	C.V (%)	1.75	0.73	2.41	1.38	1.13	2.46	3.81	0.88	1.82	2.79	1.62

Table 14: Per se performance of hybrids for growth, yield and quality parameters in tomato for pooled season

S. No.	Hybrids	Number of seeds per fruit	Average fruit weight (g)	Number of fruits per plant	Yield per plant (kg)	shelf life (days)	Pulp recovery (%)	p^H	Titrable acidity (%)	Moisture (%)	Dry matter (%)	Viscosity (mPa)
101	Sel.19 x CLN3916D	49.24	118.50	41.00	4.52	41.00	93.06	4.34	0.36	95.18	4.82	8728.00
102	IIHR-Sel.19 x IIHR-Sel.22	61.74	135.83	54.67	4.92	11.00	97.97	4.32	0.26	97.03	2.97	1013.50
103	IIHR-Sel.41–1 x IIHR-2834	62.00	115.67	44.33	5.52	26.50	95.75	4.48	0.29	93.99	6.01	4720.50
104	IIHR-Sel.41–1 x IIHR-2955	58.15	110.17	56.50	7.10	24.50	93.89	4.26	0.28	94.20	5.80	8213.00
105	IIHR-Sel.57 x PED	46.33	105.83	69.83	6.83	24.00	94.92	4.46	0.17	96.71	3.29	1598.00
106	IIHR-2821 X CLN3916D	54.13	76.67	54.00	3.92	35.00	99.12	4.22	0.17	96.66	3.34	3080.00
107	IIHR-Sel.41-1x IIHR-Sel.19	47.11	143.33	53.33	5.08	16.50	97.68	4.36	0.31	98.43	1.57	1174.50
108	CLN3916C x IIHR-Sel.22	90.39	73.67	63.33	4.32	17.50	94.44	4.21	0.48	96.21	3.79	8066.50
109	IIHR-2833 x IIHR-Sel.22	93.24	68.17	75.83	4.88	25.00	96.41	4.36	0.36	96.00	4.00	1690.50
110	IIHR-2833 x IIHR-Sel-57	73.85	111.33	42.83	3.38	25.50	98.52	4.56	0.42	94.69	5.31	4766.50
111	IIHR-2784 x PED	72.91	99.83	44.83	4.18	19.50	97.73	4.28	0.41	94.35	5.65	1136.00
112	IIHR-2784 x IIHR-SEL.57	69.89	137.00	35.89	2.38	26.50	98.20	4.37	0.31	94.90	5.10	985.50
113	IIHR-Sel.41–1 X IIHR-2821	59.24	99.50	58.94	5.47	24.00	86.05	4.79	0.34	95.68	4.32	1459.00
114	IIHR-Sel.41–1 X PED	50.24	121.50	68.17	5.05	28.00	94.65	4.56	0.29	99.15	0.85	1186.50
115	IIHR-2821 x IIHR-Sel.22	61.08	110.17	65.00	5.70	12.00	82.66	4.53	0.26	94.92	5.08	7591.00
116	IIHR-2833 X IIHR-2957	86.76	80.33	41.83	3.46	28.50	94.64	4.18	0.38	98.29	1.71	1863.50
117	IIHR-2821 X IIHR-2834	59.08	86.67	56.17	2.97	31.50	95.17	4.23	0.34	97.65	2.35	4080.00
118	IIHR-2784 X Arka Ashish	46.41	87.83	94.50	5.74	30.00	97.32	4.18	0.40	96.80	3.20	3746.00
119	IIHR-2955 x CLN3916D	92.61	110.17	65.67	6.31	28.50	95.91	4.34	0.32	98.33	1.67	4678.50
120	IIHR-Sel.41-1x IIHR-Sel.57	41.68	111.33	64.67	5.85	11.50	86.51	4.19	0.31	96.63	3.37	1822.00
	C.D. (5%)	12.13	3.38	7.89	0.17	2.15	2.87	0.20	0.03	1.29	1.01	182.01
	S.E.	4.96	1.38	3.23	0.07	0.88	1.17	0.08	0.01	0.53	0.41	74.38
	C.V (%)	5.10	0.99	4.04	0.97	2.50	0.98	1.51	2.76	0.43	8.02	1.48

Table 15: Superior parent and hybrid combinations in respect of growth, yield and quality traits in tomato

S. No.	Trait	Best parent	Best hybrid
1	Days to 50% flowering	PED	PED x Arka Ashish
2	Days to first fruit ripening	PED	PED x Arka Ashish
3	Pericarp thickness (mm)	IIHR-2833	IIHR-2327-1 x IIHR-2833
4	Number of locules per fruit	IIHR-Sel.22	IIHR-2833 x IIHR-2955
5	TSS (°Brix)	IIHR-2957	IIHR-2957 x CLN3916D
6	Fruit Firmness (kg/cm^2)	IIHR-Sel.41-1	IIHR-2784 x IIHR-Sel.22
7	Number of seeds per fruit	IIHR-2847	IIHR-2784 x IIHR-2955
8	Number of fruits per plant	IIHR-2327-1	IIHR-2327-1 x Arka Ashish
9	Yield per plant (kg)	IIHR-2327-1	IIHR-2327-1 x IIHR-2955
10	Shelf life (days)	CLN3916D	IIHR-2847 x IIHR-Sel.19
11	Pulp recovery (%)	Arka Ashish	IIHR-2821 x CLN3916D
12	Dry matter (%)	IIHR-Sel.22	IIHR-Sel.57 x CLN3916D
13	Viscosity (mPa)	IIHR-2834	Arka Ashish x CLN3916C

Conclusion

According to the results of the current study, it can be concluded that the parents PED, Arka Ashish, IIHR-2327-1, IIHR-Sel.41-1, IIHR-2833, IIHR-2957, IIHR-2784, IIHR-Sel.19, IIHR-Sel.57 and IIHR-Sel. 22 performed better for most of the traits and thus, these tomato lines can be considered as best parents. A total of 16 tomato lines were evaluated for processing traits and all the lines recorded TSS more than 4.9 °Brix.

Among 120 hybrids, IIHR-2957 x CLN3916D, IIHR-2327-1 x IIHR-2955, IIHR-2847 x IIHR-Sel.19, IIHR-2955 x Arka Ashish and Arka Ashish x CLN3916C were found to be better hybrids for TSS, yield, shelf life, number of seeds and titrable acidity traits studied. None of the hybrids outperformed checks in terms of fruit yield. As many as 11 cross combinations recorded TSS more than 5.3 °Brix. The cross combination IIHR 2957x CLN3916D recorded a TSS of 5.32 °Brix. Therefore, these cross combinations can be used in future breeding programmes aimed at improving desirable traits.

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