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Identification of promising germplasm lines for fruit biochemical, morpho-physiological and yield traits governing shelf life in tomato (*Solanum lycopersicum* L.)

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Abstract
An investigation was undertaken with an objective to evaluate tomato germplasm lines in two consecutive seasons for fruit biochemical, morpho-physiological and yield attributing traits related to extended shelf life in thirty tomato germplasm lines. The results revealed mean performance for all the studied traits were lower in summer compared to those recorded in *Kharif* indicating the influence of environment on all the characters. Red ball recorded higher values for pH, pulp content and shelf life which can be used as high shelf life donor parent in hybridisation with high yielding variety for development of high yielding with high shelf life hybrid and variety. Pod land pink had higher TSS and lycopene content along with acceptability for remaining fruit characters which can be useful for processing industry. AR-23 and AR-5 manifested highest ascorbic acid content and yield per plant respectively. These can be used as sources of vitamin-C and high yielding ability in hybridization.

Keywords: ascorbic acid, fruit firmness, germplasm, shelf life, TSS,

Introduction
Tomato [(*Solanum lycopersicum* L.), (2n = 2 × = 24)] is one of the world's most important self-pollinated, day neutral vegetable crops. Nutritionally, it is considered as 'protective food' and it is a significant dietary source of antioxidants like lycopene, β-carotene, ascorbic acid, folic acid, phenolic acids and flavonoids. Its nutritional importance is enlarged with antioxidant, blood purification and intestinal antiseptic properties of lycopene and anticancerous properties (Chakraborty *et al*., 2007) [3].

Tomato fruit is highly perishable and experiences more postharvest losses because of its natural perishability, precarious transportation and storage conditions and inadequate packaging. In India, losses of up to 22 to 33 per cent of tomato produce occur because of excessive fruit softening. In Karnataka, total postharvest losses accounted for about 19 per cent accompanying 9.43 per cent at field level, 4 to 5 per cent at the market level and about 5 per cent at the retail level (Gajanana *et al*., 2006) [5].

Several postharvest packaging methods and treatments are available like modified atmosphere packaging and treatment with vinegar, chlorine and origanum oil *etc*., and the advanced technique of antisense RNA technology is efficient in extending the shelf life, but these technologies are laborious, unfeasible in a farmer's field and need social acceptance (Yogendraand Gowda, 2013). Therefore, genetic enhancement of major fruit quality characteristics seems to be the best option and also one of the safest ways to improve shelf life. Fruit shelf life is a ripening associated trait affected by many fruit bio-chemical morpho-physiological and yield characters. Assessment of genetic variation and degree of transmission of desirable characters is helpful for planning a sound breeding programme. In this regard, it is necessary to evaluate variability for fruit biochemical, morpho-physiological and yield attributing traits.

There is a saying that "A ton of fruits and vegetables saved is equivalent to two tons produced" with this justified focus and keeping all the above considerations, the present study was planned and executed with an objectives to evaluate tomato germplasm lines for extended shelf life.

Material and Methods

The present investigation was carried out by conducting the field and lab experiments during summer and *Kharif* 2016 at the Department of Genetics and Plant Breeding, University of Agricultural and Horticultural Sciences, Navile, Shivamogga, Karnataka.

The experimental material for this study consisted of thirty germplasm lines collected from College of Horticulture, Arabhavi, Karnataka. Germplasm lines were planted in two separate contiguous blocks in Randomized Complete Block Design with two replications by following all the recommended package of practices.

Data were recorded on five randomly selected plants for five fruit biochemical (TSS, pH, lycopene content, Ascorbic acid and Titrable acidity), eight fruit morpho-physiological (shelf life, pericarp thickness, firmness, pulp percent, locule number, diameter, length and weight) and five yield characters (Plant height, Number of branches, Number of fruit clusters, Number of fruits/cluster and Yield/plant).Shelf life was measured in five tomato fruits harvested at the breaker stage and fruits were stored at 25±1°C and keeping quality in days were taken at weekly intervals. The recorded data was analyzed with the program WINDOSTAT software.

Results and Discussion

Mean performance of tomato germplasm lines for fruit biochemical, morpho-physiological and yield attributing traits

Mean performance of thirty tomato germplasm lines for fruit biochemical, morpho-physiological and yield attributing traits over summer and *Kharif* 2016 presented in Table 1,2 and 3. Mean values for all the studied traits were lower in summer compared to those recorded in *Kharif* indicating the influence of environment on all the characters. During summer, the temperature was high which triggered fast metabolic rate in the plant. This resulted in the relatively earlier completion of life cycle accompanied by low mean performance for all the studied traits compared to *Kharif*. The pooled mean performance of tomato germplasm lines for fruit biochemical, morpho-physiological and yield attributing traits over two seasons is presented in Table 4.

Table 1: Mean performance of Tomato germplasm lines for fruit biochemical traits during summer and *Kharif* 2016

Sl. No.	Germplasm lines	TSS (%)		pH		Lycopene (mg/100g)		Ascorbic acid (mg/100g)		Titratable acidity (%)	
		Kharif	Summer	*Kharif*	Summer	*Kharif*	Summer	*Kharif*	Summer	*Kharif*	Summer
1	Black prince	4.05	3.95	3.74	3.45	2.72	2.34	89.29	84.27	0.70	0.50
2	AR-8	2.10	2.25	4.17	4.05	2.34	1.55	89.29	84.40	0.85	0.70
3	Pod land pink	4.80	4.50	4.20	4.00	3.88	3.11	107.14	98.40	0.70	0.55
4	AR-56	4.75	4.20	4.55	4.35	2.41	2.29	96.43	90.80	0.55	0.40
5	AR-28	3.30	3.00	3.81	3.60	2.64	2.56	92.86	88.95	0.85	0.65
6	P2L-0091	2.25	2.10	4.21	4.15	2.62	2.38	107.14	97.20	0.90	0.75
7	L-04780	1.15	1.25	3.94	3.75	0.52	0.39	64.29	59.80	1.00	0.85
8	AR-34	2.85	2.45	4.74	4.55	2.87	2.73	82.14	78.85	1.25	1.05
9	Patriot	1.70	1.50	4.47	4.25	2.62	2.55	78.57	75.85	1.20	1.00
10	TLB-133	1.25	1.20	4.10	4.05	2.35	2.07	60.71	57.40	1.05	0.95
11	PKM-1	3.25	3.10	3.68	3.55	3.01	2.74	92.86	88.35	1.10	0.90
12	L-00398	1.65	1.50	4.18	4.10	2.41	2.27	96.43	91.85	1.75	1.55
13	AR-47	1.15	1.10	3.78	3.15	2.50	2.36	64.29	60.30	1.10	0.90
14	AR-4	1.95	1.80	3.68	3.15	2.23	1.97	96.43	90.75	1.00	0.80
15	AR-90	3.25	3.10	3.55	3.27	2.28	2.11	82.14	76.80	1.10	0.90

Cont'd. Table 1: Mean performance of Tomato germplasm lines for fruit biochemical traits during summer and *Kharif* 2016)

Sl. No.	Germplasm lines	TSS (%)		pH		Lycopene (mg/100g)		Ascorbic acid (mg/100g)		Titratable acidity (%)	
		Kharif	Summer	*Kharif*	Summer	*Kharif*	Summer	*Kharif*	Summer	*Kharif*	Summer
16	L-04787	1.45	1.30	4.36	4.15	2.84	2.70	89.29	89.45	1.05	0.90
17	Bonybest	1.15	1.15	4.87	4.55	2.43	2.40	96.43	90.65	1.25	1.05
18	AR-19	0.45	0.60	4.27	4.15	2.53	2.32	67.86	71.15	1.20	1.00
19	AR-30	2.75	2.70	4.29	4.10	2.85	2.70	82.14	77.05	1.30	1.05
20	AR-5	2.65	2.60	3.95	3.75	2.67	2.46	75.00	70.85	2.35	2.10
21	AR-7	3.30	3.30	4.69	4.50	2.32	2.15	78.57	76.30	1.35	1.10
22	AR-29	1.05	1.25	4.10	4.00	2.31	2.07	89.29	84.55	1.35	1.10
23	AR-17	1.00	1.10	3.66	3.45	2.87	2.75	103.57	97.15	2.65	2.25
24	TLB-20	2.15	2.20	3.77	3.55	2.56	2.46	71.43	74.45	0.55	0.40
25	L-03686	1.85	1.60	3.56	3.45	2.66	2.47	114.29	107.00	0.75	0.55
26	P-4	2.95	2.75	4.05	3.85	2.65	2.47	96.43	91.00	1.10	0.80
27	TLB-130	0.45	0.65	4.21	4.00	2.46	2.26	75.00	69.30	1.50	1.35
28	AR-23	3.15	3.05	3.86	3.75	2.82	2.68	142.86	127.90	0.80	0.60
29	L-00191	3.15	3.15	4.55	4.25	2.35	2.19	57.14	54.95	1.30	1.10
30	Red ball	3.05	3.00	5.31	5.21	2.74	2.74	10.67	10.57	0.60	0.57
Mean		2.33	2.24	4.13	3.92	2.54	2.33	84.62	80.12	1.14	0.95

Table 2: Mean performance of Tomato germplasm lines for fruit morpho-physiological traits during summer and *Kharif* 2016

Sl. No.	Germplasm lines	Fruit length (cm)		Fruit diameter (cm)		Fruit weight (g)		Fruit firmness (kg/cm^2)		Pericarp thickness (mm)		Pulp content (%)		Locule number		Shelf life (Days)	
		Kharif	Summer	*Kharif*	Summer	*Kharif*	Summer	*Kharif*	Summer	*Kharif*	Summer	*Kharif*	Summer	*Kharif*	Summer	*Kharif*	Summer
1	Black prince	21.74	18.65	22.82	17.60	3.45	3.35	3.49	3.18	1.85	1.60	55.61	41.00	2.25	2.05	23.00	16.30
2	AR-8	27.59	22.75	28.22	23.95	16.42	12.90	5.14	4.90	3.33	3.14	56.42	44.70	2.15	2.15	18.75	12.75
3	Pod land pink	33.78	28.80	28.78	24.85	17.25	14.80	5.87	5.69	2.70	2.39	57.51	47.45	3.25	3.05	12.75	8.75
4	AR-56	20.77	18.65	19.73	16.50	6.11	5.20	5.31	5.18	3.09	2.96	49.57	47.30	2.05	2.15	22.50	15.20
5	AR-28	27.48	24.95	30.95	26.70	14.23	6.80	4.90	4.69	2.67	2.43	49.73	45.20	3.10	3.10	25.25	17.60
6	P2L-0091	21.91	20.25	25.11	21.85	6.27	4.50	4.37	4.30	1.45	1.32	58.11	51.85	2.15	2.15	25.00	19.50
7	L-04780	27.83	24.40	30.51	26.45	13.59	11.35	6.42	6.22	3.17	3.12	51.74	47.25	3.10	3.05	26.75	21.25
8	AR-34	45.36	41.75	43.31	35.05	46.73	41.80	4.22	3.97	4.58	4.46	79.74	73.05	3.05	3.10	11.75	9.25
9	Patriot	33.34	31.65	43.85	41.05	51.92	45.45	3.49	3.33	2.42	2.49	83.54	76.85	8.17	8.20	31.75	25.30
10	TLB-133	37.91	32.85	35.14	32.60	20.61	18.70	4.17	4.00	3.30	3.21	67.57	59.90	3.10	3.10	35.00	26.55
11	PKM-1	29.60	26.60	46.37	41.75	31.29	26.45	3.90	3.69	2.70	2.58	64.04	57.25	5.05	5.05	25.00	30.35
12	L-00398	43.95	41.05	34.70	31.80	19.44	16.90	2.41	2.58	3.18	3.24	63.34	56.05	2.20	2.05	29.00	24.00
13	AR-47	33.15	31.05	34.78	31.80	17.33	15.35	4.50	4.28	2.61	2.48	80.10	72.60	2.15	2.10	24.50	22.50
14	AR-4	28.35	25.05	33.17	28.75	12.18	10.50	4.50	4.28	1.55	1.45	59.07	55.45	3.10	3.10	23.25	17.05
15	AR-90	11.52	10.05	21.04	25.05	19.30	17.65	1.62	1.38	1.42	1.44	50.82	44.50	2.20	2.05	12.00	13.00
16	L-04787	33.05	30.45	22.60	20.35	5.44	7.30	3.66	3.49	2.49	2.17	66.84	58.70	2.25	2.15	25.75	24.10
17	Bonybest	27.55	24.85	31.04	28.70	13.85	11.35	3.19	3.04	3.75	3.62	72.13	67.10	2.30	2.15	26.75	23.50
18	AR-19	30.02	29.15	35.60	32.50	14.50	12.35	4.61	4.61	2.69	2.66	77.59	58.80	3.30	3.20	23.00	20.00

Cont'd Table 2: Mean performance of Tomato germplasm lines for fruit morpho-physiological traits during summer and *Kharif* 2016)

Sl. No.	Germplasm lines	Fruit length (cm)		Fruit diameter (cm)		Fruit weight (g)		Fruit firmness (kg/cm^2)		Pericarp thickness (mm)		Pulp content (%)		Locule number		Shelf life (Days)	
		Kharif	Summer	*Kharif*	Summer	*Kharif*	Summer	*Kharif*	Summer	*Kharif*	Summer	*Kharif*	Summer	*Kharif*	Summer	*Kharif*	Summer
19	AR-30	26.94	25.40	31.82	27.90	18.52	15.00	4.65	4.65	2.69	2.47	70.83	68.85	3.35	3.20	16.50	13.45
20	AR-5	45.73	43.95	48.03	44.25	56.33	47.90	5.31	5.31	6.08	5.65	77.64	72.85	3.10	3.10	19.50	17.45
21	AR-7	26.22	23.85	28.63	29.00	3.20	2.70	4.15	4.15	1.69	1.30	35.62	29.40	2.30	2.05	25.75	23.90
22	AR-29	28.15	26.50	32.56	29.00	12.67	12.00	7.49	7.49	2.16	2.12	68.56	52.40	4.30	4.05	16.50	12.50
23	AR-17	28.36	27.00	48.50	42.85	37.38	34.45	3.06	3.06	2.11	2.00	72.49	68.00	8.05	8.05	27.25	22.00
24	TLB-20	26.62	25.00	33.38	31.45	33.37	30.45	4.68	4.68	3.09	2.90	74.14	70.40	3.05	3.30	17.00	15.50
25	L-03686	16.88	16.65	18.90	16.20	4.03	3.65	5.20	5.20	1.41	1.25	54.23	48.15	2.05	2.30	31.25	26.50
26	P-4	23.90	21.20	27.19	23.95	9.92	8.60	5.13	5.13	3.39	3.17	51.38	48.55	2.10	2.10	33.50	28.05
27	TLB-130	38.84	36.65	52.79	50.50	60.58	52.90	5.17	5.17	7.72	7.46	73.57	68.35	7.05	7.05	25.75	20.50
28	AR-23	24.19	22.45	26.39	25.40	11.06	9.55	5.76	5.76	2.37	2.15	54.78	45.90	3.10	3.05	29.00	26.50
29	L-00191	23.23	20.45	22.24	19.90	5.29	3.90	3.75	3.75	2.08	2.00	60.95	52.70	3.10	3.05	31.75	28.45
30	Red ball	42.51	42.51	51.30	51.31	51.92	50.42	3.85	3.65	6.88	6.53	81.13	80.68	3.05	3.10	35.80	33.05
Mean		29.92	27.54	33.22	30.19	21.55	18.81	4.47	4.36	3.09	2.93	64.47	57.60	3.27	3.24	24.30	20.43

Table 3: Mean performance of Tomato germplasm lines for yield and attributing traits during summer and *Kharif* 2016

Sl. No.	Germplasm lines	Plant height (cm)		Number of branches		Number of clusters		Number of fruit/cluster		Yield/plant (g)	
		Kharif	Summer	*Kharif*	Summer	*Kharif*	Summer	*Kharif*	Summer	*Kharif*	Summer
1	Black prince	89.43	82.45	13.48	10.73	6.90	6.66	3.28	2.54	154.40	145.68
2	AR-8	83.36	78.96	7.88	7.03	7.70	7.16	3.28	3.24	279.60	286.68
3	Pod land pink	73.63	71.53	5.48	4.93	12.30	12.06	3.28	2.84	608.00	598.48
4	AR-56	112.32	98.97	10.48	6.93	11.90	11.66	4.28	3.54	478.00	466.68
5	AR-28	81.25	80.90	11.08	10.23	10.90	10.66	2.28	3.04	460.00	446.40
6	P2L-0091	93.87	90.46	12.28	10.63	13.90	13.96	5.28	5.14	276.00	267.40
7	L-04780	72.77	70.96	8.08	7.93	9.90	9.96	2.28	2.24	289.40	276.40
8	AR-34	86.73	82.96	8.88	6.93	10.70	10.66	3.28	3.14	436.80	424.40
9	Patriot	42.60	40.46	7.08	6.33	11.10	10.95	3.28	3.24	343.00	334.46
10	TLB-133	65.54	65.56	7.08	6.60	7.70	7.66	3.28	3.54	342.80	337.00
11	PKM-1	47.94	46.51	6.86	5.70	10.10	9.66	2.28	2.54	250.40	236.40
12	L-00398	86.52	85.41	7.86	7.70	4.90	4.66	4.28	4.54	328.20	313.40
13	AR-47	75.95	72.41	7.46	6.70	11.10	10.96	3.28	2.44	175.00	167.40
14	AR-4	83.07	80.97	10.66	10.00	17.10	16.96	3.03	3.54	346.00	337.40
15	AR-90	75.20	73.41	11.26	10.30	20.10	19.96	2.03	2.34	224.80	217.40

Contd..Table 3: Mean performance of Tomato germplasm lines for yield and attributing traits during summer and *Kharif* 2016

Sl. No.	Germplasm lines	Plant height (cm)		Number of branches		Number of clusters		Number of fruit/cluster		Yield/plant (g)	
		Kharif	Summer	*Kharif*	Summer	*Kharif*	Summer	*Kharif*	Summer	*Kharif*	Summer
16	L-04787	58.65	56.41	8.86	8.30	7.10	6.06	2.03	3.27	171.15	167.46
17	Bonybest	98.20	90.41	9.66	9.30	11.70	11.26	2.00	3.17	583.35	567.40
18	AR-19	71.76	68.30	9.26	9.20	10.30	9.86	3.00	2.97	326.15	316.00
19	AR-30	104.92	100.41	8.26	8.16	10.30	10.06	3.00	3.17	251.55	246.10
20	AR-5	55.54	52.41	6.46	6.16	11.50	11.16	3.00	3.27	1568.15	1457.35
21	AR-7	66.94	66.41	8.66	8.16	11.30	11.06	2.00	2.07	135.35	125.35

22	AR-29	103.62	100.91	12.06	11.66	12.70	12.16	2.00	1.97	577.95	567.35
23	AR-17	109.58	101.70	12.06	11.56	11.70	11.26	2.00	1.87	399.35	399.35
24	TLB-20	53.02	50.48	7.06	6.06	6.70	6.66	2.00	1.97	231.95	226.95
25	L-03686	86.85	82.59	12.26	11.96	18.90	19.15	4.00	4.17	223.15	214.35
26	P-4	103.20	100.53	11.06	10.86	8.10	6.55	3.00	2.97	241.75	236.35
27	TLB-130	62.61	59.17	6.86	6.66	9.50	9.75	2.00	1.97	369.15	357.35
28	AR-23	86.33	84.58	9.46	9.26	8.90	9.15	2.00	2.17	307.75	297.41
29	L-00191	95.14	91.47	7.66	7.66	11.50	11.75	3.00	3.27	363.55	355.35
30	Red ball	92.20	72.20	5.20	5.00	7.10	5.75	3.15	3.30	550.40	529.55
Mean		79.81	75.86	9.05	8.31	10.87	10.60	2.96	3.04	418.85	398.09

Table 4: Pooled mean performance of Tomato germplasm lines for fruit biochemical, morpho-physiological and yield attributing traits during summer and *Kharif* 2016

Sl. No.	Germplasm lines	TSS	pH	LYC	ASA	TA	FL	FD	FW	FF	PT	PC	LN	SL	PHT	NOB	NOC	NOF/C	YPP
1	Black prince	4	3.6	2.53	86.78	0.6	20.19	20.21	3.4	3.33	1.72	48.3	2.15	19.65	85.94	12.11	6.78	2.91	150.04
2	AR-8	2.18	4.11	1.95	86.84	0.78	25.17	26.09	14.66	5.02	3.24	50.56	2.15	15.75	81.16	7.46	7.43	3.26	283.14
3	Pod land pink	4.65	4.1	3.49	102.77	0.63	31.29	26.82	16.02	5.78	2.54	52.48	3.15	10.75	72.58	5.21	12.18	3.06	603.24
4	AR-56	4.48	4.45	2.35	93.61	0.48	19.71	18.11	5.65	5.24	3.03	48.44	2.1	18.85	105.65	8.71	11.78	3.91	472.34
5	AR-28	3.15	3.71	2.6	90.9	0.75	26.22	28.82	10.51	4.79	2.55	47.47	3.1	21.43	81.07	10.66	10.78	2.66	453.2
6	P2L-0091	2.18	4.18	2.5	102.17	0.83	21.08	23.48	5.38	4.33	1.38	54.98	2.15	22.25	92.17	11.46	13.93	5.21	271.7
7	L-04780	1.2	3.84	0.45	62.04	0.93	26.12	28.48	12.47	6.32	3.15	49.49	3.08	24	71.87	8.01	9.93	2.26	282.9
8	AR-34	2.65	4.64	2.8	80.5	1.15	43.55	39.18	44.26	4.09	4.52	76.39	3.08	10.5	84.84	7.91	10.68	3.21	430.6
9	Patriot	1.6	4.36	2.58	77.21	1.1	32.5	42.45	48.69	3.41	2.45	80.2	8.18	28.53	41.53	6.71	11.03	3.26	338.73
10	TLB-133	1.23	4.08	2.21	59.06	1	35.38	33.87	19.66	4.08	3.26	63.74	3.1	30.78	65.55	6.84	7.68	3.41	339.9
11	PKM-1	3.18	3.62	2.87	90.6	1	28.1	44.06	28.87	3.79	2.64	60.65	5.05	27.68	47.23	6.28	9.88	2.41	243.4
12	L-00398	1.58	4.14	2.34	94.14	1.65	42.5	33.25	18.17	2.49	3.21	59.69	2.13	26.5	85.96	7.78	4.78	4.41	320.8
13	AR-47	1.13	3.46	2.43	62.29	1	32.1	33.29	16.34	4.39	2.54	76.35	2.13	23.5	74.18	7.08	11.03	2.86	171.2
14	AR-4	1.88	3.42	2.1	93.59	0.9	26.7	30.96	11.34	4.39	1.5	57.26	3.1	20.15	82.02	10.33	17.03	3.28	341.7
15	AR-90	3.18	3.41	2.19	79.47	1	10.79	23.04	18.48	1.5	1.43	47.66	2.13	12.5	74.31	10.78	20.03	2.18	221.1
16	L-04787	1.38	4.26	2.77	89.37	0.98	31.75	21.48	6.37	3.57	2.33	62.77	2.2	24.93	57.53	8.58	6.58	2.65	169.31
17	Bony best	1.15	4.71	2.42	93.54	1.15	26.2	29.87	12.6	3.11	3.69	69.62	2.23	25.13	94.31	9.48	11.48	2.58	575.38
18	AR-19	0.53	4.21	2.42	69.5	1.1	29.59	34.05	13.43	4.61	2.68	68.19	3.25	21.5	70.03	9.23	10.08	2.98	321.08
19	AR-30	2.73	4.2	2.78	79.6	1.18	26.17	29.86	16.76	4.65	2.58	69.84	3.28	14.98	102.67	8.21	10.18	3.08	248.83
20	AR-5	2.63	3.85	2.56	72.93	2.23	44.84	46.14	52.12	5.31	5.86	75.24	3.1	18.48	53.98	6.31	11.33	3.13	1512.75
21	AR-7	3.3	4.6	2.23	77.44	1.23	25.03	28.81	2.95	4.15	1.5	32.51	2.18	24.83	66.67	8.41	11.18	2.03	130.35
22	AR-29	1.15	4.05	2.19	86.92	1.23	27.32	30.78	12.34	7.49	2.14	60.48	4.18	14.5	102.27	11.86	12.43	1.98	572.65
23	AR-17	1.05	3.56	2.81	100.36	2.45	27.68	45.68	35.91	3.06	2.05	70.25	8.05	24.63	105.64	11.81	11.48	1.93	399.35

Cont'd Table 4: Mean performance of Tomato germplasm lines for fruit biochemical, morpho-physiological and yield attributing traits

Sl. No.	Germplasm lines	TSS	pH	LYC	ASA	TA	FL	FD	FW	FF	PT	PC	LN	SL	PHT	NOB	NOC	NOF/C	YPP
24	TLB-20	2.18	3.66	2.51	72.94	0.48	25.81	32.41	31.91	4.68	3	72.27	3.18	16.25	51.75	6.56	6.68	1.98	229.45
25	L-03686	1.73	3.51	2.57	110.64	0.65	16.77	17.55	3.84	5.2	1.33	51.19	2.18	28.88	84.72	12.11	19.03	4.08	218.75
26	P-4	2.85	3.95	2.56	93.71	0.95	22.55	25.57	9.26	5.13	3.28	49.97	2.1	30.78	101.87	10.96	7.33	2.98	239.05
27	TLB-130	0.55	4.11	2.36	72.15	1.43	37.75	51.64	56.74	5.17	7.59	70.96	7.05	23.13	60.89	6.76	9.63	1.98	363.25
28	AR-23	3.1	3.8	2.75	135.38	0.7	23.32	25.89	10.31	5.76	2.26	50.34	3.08	27.75	85.46	9.36	9.03	2.08	302.58
29	L-00191	3.15	4.4	2.27	56.05	1.2	21.84	21.07	4.6	3.75	2.04	56.82	3.08	30.1	93.31	7.66	11.63	3.13	359.45
30	Red ball	3.03	5.26	2.74	10.62	0.59	42.51	51.3	51.17	3.75	6.7	80.91	3.08	34.43	82.2	5.1	6.43	3.23	539.98
Mean		2.28	4.02	2.44	82.37	1.05	28.73	31.71	20.18	4.42	3.01	61.03	3.25	22.36	77.84	8.68	10.73	3	408.47
CV		6.55	4.07	8.9	10.68	15.92	8.07	13.42	13.23	3.01	6.32	15.58	3.53	18.57	3.53	7.4	2.99	9.53	7.74
S.Em. ±		0.1	0.08	0.11	4.54	0.08	1.14	2.08	1.27	0.07	0.09	4.74	1.37	2.04	1.37	0.33	0.16	0.14	15.63
CD 5%		0.21	0.23	0.3	12.76	0.24	3.2	5.86	3.56	0.19	0.26	13.33	3.85	5.73	3.85	0.92	0.46	0.4	43.91
CD 1%		0.28	0.3	0.4	16.9	0.31	4.24	7.76	4.71	0.25	0.34	17.65	5.11	7.59	5.11	1.21	0.6	0.53	58.16

TSS = TSS (%)
pH = pH
LYC = Lycopene (mg/100g)
ASA = Ascorbic acid (mg/100g)
TA = Titratable acidity (%)
FL = Fruit length (cm)
FD = Fruit diameter (cm)
FW = Fruit weight (g)
FF = Fruit firmness (kg/cm^2)
PT = Pericarp thickness (mm)
PC = Pulp content (%)
LN = Locule number
SL = Shelf life (Days)
PHT = Plant height (cm)
NOB = Number of branches
NOC = Number of clusters
NOF = Number of fruit/cluster
YPP = Yield/plant (g)

TSS (%)
Total soluble solids (TSS) is a refractometric index that indicates the proportion (%) of dissolved solids in a solution. It is the sum of sugars (sucrose and hexoses; 65 %), acids (citrate and malate; 13 %) and other minor components (phenols, amino acids, soluble pectins, ascorbic acid and minerals) in the tomato fruit pulp (Beckles, 2012) [1]. Among the thirty tomato germplasm lines, TSS ranged between 0.53 per cent (AR-19) to 4.65 per cent (Pod land pink) with a mean of 2.29 per cent. Present germplasm contains less TSS which is considered low for processing industries (Campos *et al*., 2006) [2].

PH
pH content ranged between 3.41 (AR-90) to 5.26 (Red ball) with mean of 4.02. pH below 4.5 is a desirable trait, because it halts the proliferation of microorganisms in the final product during industrial processing (Giordano *et al.,* 2000) [7]. Thus, pH values as low as possible (up to the point that it does not adversely affect the taste) should be bred into tomato cultivars for industrial use (Tigist *et al*., 2012) [16].

Lycopene content (mg / 100 g)
Lycopene is responsible for the red colour of tomatoes. It is a powerful antioxidant and efficacious free radical scavenger and its presence in the diet positively correlates with reduced cancer incidence (Mukesh Kumar *et al.,* 2007). In the present investigation lycopene content ranged between 0.45 mg / 100 g (L-04780) to 3.49 mg / 100 g (Pod land pink) with a mean of 2.44 mg / 100 g.

Ascorbic acid (mg / 100 g)
Ascorbic acid (Vitamin-C) is considered as an index of quality of fresh produce. In general tomato contains moderate amounts of ascorbic acid (20 mg / 100 g). Thus contribute to 40 per cent of the recommended dietary allowance for ascorbic acid. The ascorbic acid content ranged between 10.62 mg / 100 g (Red ball) to 135.38 mg / 100 g (AR-23) with a mean of 82.37 mg / 100 g.

Titratable acidity (%)
The Titratable acidity represents acidity of malic and citric acids which comprise about 15 per cent of the dry content of fresh tomatoes. In the present study titratable acidity ranged between 0.48 per cent (AR-56 and TLB-20) to 2.45 per cent (AR-17) with a mean of 1.04 per cent. A titratable acidity greater than 0.35 per cent used for processing (Garcia and Barret, 2006) [6].

Fruit length (cm)
Fruit length ranged between 10.79 cm (AR-90) to 44.84 cm (AR-5) with a mean of 28.73 cm.

Fruit diameter (cm)
Fruit diameter ranged between 17.55 cm (L-03686) to 51.64 cm (TLB-130) with a mean of 31.71 cm.

Fruit weight (g)
Fruit weight ranged between 2.95 g (AR-7) to 56.74 g (TLB-130) with a mean of 20.18 g. Domesticated tomatoes show a wide range of morphological diversity, whereas wild tomatoes produce small, round fruit (Passam *et al.,* 2007). Fruit size determines the consumer preference. Fruit size is less important for processing purpose, but it is important for table purpose. Small to medium-sized fruits with lower TSS and higher acid contents are suitable for processing into juice.

Fruit firmness (kg / cm^2)
It is one of the critical components of internal fruit quality both concerning commercialisation and assessment of organoleptic properties. It is the final index by which the consumer's perception and decision to purchase a given batch of tomatoes. In the present study fruit firmness ranged between 1.50 kg / cm^2 (AR-90) to 7.49 kg / cm^2 (AR-29) with a mean of 4.42 kg / cm^2.

Pericarp thickness (mm)
Pericarp includes the skin, peripheral pericarp, radial arms and columella. The pericarp thickness ranged between 1.33mm (L-03686) to 7.59mm (TLB-130) with a mean of 3.01mm. Pericarp thickness assumes prime importance among the parameters which condition fruit firmness. Tomato fruits with thicker pericarp would stand long-distance transport and keep well for longer days (Chakraborty *et al*., 2007) [3].

Pulp content (%)
The pulp content ranged from 32.51 per cent (AR-7) to 80.91 per cent (Red ball) with a mean of 61.03 per cent. Thicker pulp generally enhances the firmness and ultimately the shelf life of the tomato.

Locule number
Locules play an important role in governing fruit's quality. Number of locules in the fruit is very important for the selection of varieties for processing (Chakraborty *et al*., 2007) [3]. In the present investigation, locule number ranged between 2.10 (AR-56 and P-4) to 8.18 (Patriot) with a mean of 3.25. Locule number is negatively associated with fruit firmness. Hence, tomatoes with the fewer locules (four or less than four) are desirable, particularly for fresh market.

Shelf life (Days)
Shelf life is an important quality parameter which is measured as the average number of days taken by the fruits harvested at breaker stage to show first visible shrinkage on the fruit surface on the shelf. Shelf life ranged between 10.50 days (AR-34) to 34.43 days (Red ball) with a mean of 22.36 days. Cultivation of tomato varieties with longer shelf life can be transport to long distance markets and farmers can get a good price for their produce during the price crash periods in the local markets.

Plant height (cm)
Plant height is an important yield attributing trait which ranged from 41.53 cm (Patriot) to 105.65 cm (AR-56) with a mean of 77.84 cm.

Number of branches
The number of branches ranged between 5.10 (Red ball) to 12.11 (Black Prince and L-03686) with a mean of 8.68. Higher number of branches positively associated with yield per plant.

Number of clusters
Generally more number of clusters in the plant resulting in more number of fruits. The number of clusters ranged between 4.78 (L-00398) to 20.03 (AR-90) with a mean of 10.73.

Number of fruits per cluster

The number of fruits per cluster ranged from 1.93 (AR-17) to 5.21 (P2L-0091) with a mean of 3.00. It is advisable to maintain a range of 4-6 fruits per cluster to reduce the variation of average fruit weight.

Yield per plant (g)

The prime and ultimate objective of all breeding work is the release of a high yielding variety. In the present investigation, the yield per plant ranged between 130.35 g (AR-7) to 1512.75 g (AR-5) with a mean of 408.47 g.

Similar kind of results for all the above-discussed traits reported by the earlier works of Dar and Sharma (2011) [13], Joseph *et al.* (2014) [8], Meena *et al*. (2015) [15] and Rakesh *et al.* (2018) [18].

Conclusion

Mean values for all the studied traits were lower in summer compared to those recorded in *Kharif* indicating the influence of environment on all the traits. The germplasm lines which were recorded lowest and highest values for a specific character can be used as contrasting parents in hybridisation programme to study the inheritance and gene action governing the respective character. Red ball recorded higher values for pH, pulp content and shelf life which can be used as high shelf life donor parent in hybridisation with high yielding variety for development of high yielding with high shelf life hybrid and variety. Pod land pink had higher TSS and lycopene content along with acceptability for remaining fruit characters which can be useful for processing industry. AR-23 and AR-5 manifested highest ascorbic acid content and yield per plant respectively. These can be used as sources of vitamin-C and high yielding ability in hybridization.

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