Evaluation of growth characters of various genotypes of Tomato (*Solanum lycopersicum* L.) under different environment conditions

ABSTRACT

The current investigation aimed to analyze growth and growth related attributes involving fifty tomato genotypes including three control varieties under low tunnel, paddy straw and open field conditions. The trial was carried out in Randomized Block Design (RBD) with three replications over two years 2020-2021 and 2021-2022 Rabi season at Faculty of Agriculture, Vegetable farm, Guru Kashi University, Talwandi Sabo, Bathinda. The analysis of variance depicted significantly high amount of variability among different genotypes for all the parameters. The maximum data for plant height was recorded in the genotype S-115 (220.54cm) under low tunnel conditions.Maximum number of primary branches were recorded in S-115 (18.66). Days to first flowering was revealed in S-115 (33.21 days), days to first fruit set was observed in S-115 (72.56). Maximum value for days to first fruit harvest and last fruit harvest was observed in S-115 (102.56 days) and (177.24 days) respectively. The mean performances of genotypes depicted wide variations over various environments for all the parameters under research.

Keywords: Tomato genotypes, Growth parameters, Environments, Mean performance

1. INTRODUCTION

Tomato (*Solanum lycopersicum* L.) is known as the world's most significant and widely grown vegetable crop and it has been the subject of genetic study for more than a century (Gowda, 2013). Tomato require warm and dry climatic conditions but get acclimatize to varied climatic conditionns varying from temperate to tropical conditions (MoARD, 2009). However, it is adapted to a wide range of climatic conditions from temperate to hot and humid tropics. The plants can withstand wide range of temperatures and they grow well under temperature range of 20–27°C, whereas the plant tissues get damaged below 10 °C and above 38 °C (Naika *et al*., 2005). Extreme low and high temperature conditions eventually leads to poor fruit setting. Tomatoes prefer aerated soil because the roots are very sensitive to water-logging conditions. The optimum pH of soil is 6.0-7.0 (Hanson *et al*., 2001).

Tomato crop must be cultivated below 2000 meters above sea level. (Peralta and Spooner, 2007). According to reports, the tomato crop frequently experiences extremely high temperature in certain parts of the world which is extremely sensitive to tomato reproduction Adeniji *et al*. (2020). Extreme increase in temperature can lead to abortion of male gametophyte as well as causes reduced fruit set Acharya (2019). By 2100, according to research there would be increase in the atmospheric temperature which would dramatically impact the productivity of crop. Reddy and Kakani (2007); Stainforth *et al*, (2005). Hence, a thorough investigation of the reproductive behavior of tomato crops under the extreme environmental conditions is necessary Karapanos *et al* (2010). In order to meet the demands of the ever-growing population, it is important to bridge the productivity gap caused by the shrinkage of cultivable land and the unpredictable climatic conditions. It is only possible by the crop improvement programs of location-specific genotypes to develop an exceptional acclimatization ability to cultivate year-round Cox (2000). Tomato genotypes must be evaluated as this evaluation is paramount for selection of effective varieties in varied environmental conditions Taylor, (1986).

2. MATERIALS AND METHODS

.The research study evaluated the parameters of growth for various genotypes of Tomato (*Solanum lycopersicum* L.) under various environmental conditions during Rabi season of 2020-21 and 2021- 22. The trail for tomato research was laid out at the Faculty of Agriculture, Vegetable farm, Guru Kashi University, Talwandi Sabo, Bathinda The research study composed of 50 superior genotypes of Tomato (*Solanum lycopersicum* L.)

Table 1: List of genotypes used in the research:

Sr. No.	Genotypes	Sr. No.	Genotypes
1.	S-3	26.	S-37
2.	S-4	27.	S-38
3.	S-5	28.	S-39
4.	S-6	29.	S-44
5.	S-7	30.	S-46
6.	S-9	31.	S-47
7.	S-10	32.	S-49
8	S-11	33.	S-54
9.	S-12	34.	S-55
10.	S-13	35.	S-58
11.	S-14	36.	Marmade Pool
12.	S-15	37.	S-101
13.	S-17	38.	4-6 P_5

14.	S-18	39.	Selection 21 Round P L1
15.	S-19	40.	59 P/2 Round Large
16.	S-20	41.	WI-321
17.	S-21	42.	Israel Selection
18.	S-22	43.	Selection 39
19.	S-24	44.	S-115
20.	S-25	45.	WI-181 Round Deep Red
21.	S-26	46.	B_1
22.	S-30	47.	Deep Red Marmade P_9
23.	S-31	48.	Punjab Ratta
24.	S-32	49.	Punjab Upma
25.	S-36	50.	Punjab Sartaj

Research was analyzed for 3 varied environmental conditions:

1. Under the open field conditions
2. Use of paddy straw
3. Use of low tunnels

The experimental design of the experiment was Completely Randomized Block Design (CRBD) that comprised three replications and each replication had a plot size of 50 m^2 and 10 plants in one row were maintained. The statistical analysis was carried out for each observed character under study using MS-Excel and OP STAT Software.

4. RESULTS AND DISCUSSION

Plant height

The data from plant height recordings (Table 2) indicate that S-115 consistently displayed the highest plant height in both the first and second years across all three environments The highest plant height (220.54 cm) of S-115 was recorded in second years under low tunnel environment compared with check variety Punjab Ratta. It was followed by S-115 (218.33) in second years under Paddy straw conditions, out of three environments S-21 showed maximum height (209.89 cm) in first year under low tunnel.. This might be due to the fact that plants got favorable conditions and temperature to growth leading to good growth Gunadi and Sawanti (1988). Whereas, out of all environments the lowest plant height was recorded in genotype S-46 (141.78) in first year under open field conditions. The results are in consonance with the research findings of Kumar *et al*. (2001) who concluded that there is a wide range of variation among characters of plant height and number of fruits per plant. Ganesan (2001), Ganesan (2002) and Kanwar (2011) also delineated increased plant height under the protected tomato conditions due to right temperature, optimum CO_2 and optimal micro climate as compared to open field conditions. Also, optimal temperature inside

protected conditions lead to enhanced photosynthate accumulation which aids in increased plant height Pooja and Hakkim, (2017).

Table 2: Mean performance of tomato genotypes for Plant height (cm):

	Plant height					
	Low tunnel (E1)		Paddy(E2)		Open field (E3)	
Genotypes	1st year	2nd year	1st year	2nd year	1st year	2nd year
S-3	147.21	149.88	146.00	147.50	145.00	145.78
S-4	152.03	154.87	151.00	152.83	149.22	149.96
S-5	154.33	156.88	152.03	153.85	146.06	146.87
S-6	147.67	149.42	145.30	146.90	141.99	142.80
S-7	154.13	156.43	153.00	154.58	153.21	154.14
S-9	147.63	149.68	146.00	147.57	145.25	146.17
S-10	164.38	166.36	157.00	158.58	156.21	156.96
S-11	159.33	161.49	158.01	159.68	151.03	151.90
S-12	170.22	172.14	169.21	171.84	157.00	157.79
S-13	147.00	149.78	146.00	147.72	143.27	144.15
S-14	152.67	154.80	151.36	153.04	149.36	150.12
S-15	157.33	159.89	156.03	157.59	154.00	154.79
S-17	159.00	161.15	158.00	159.52	156.36	157.21
S-18	152.33	154.77	151.00	152.51	149.00	150.00
S-19	152.00	154.81	151.00	152.67	146.62	147.39
S-20	158.33	160.99	157.33	158.81	156.63	157.40
S-21	207.70	209.89	196.02	197.52	195.14	195.97
S-22	156.67	156.97	155.00	156.52	156.85	157.71
S-24	155.61	157.28	154.31	155.92	151.77	152.51
S-25	156.00	158.32	155.00	156.60	146.45	147.21
S-26	162.35	164.39	161.23	162.81	160.00	160.79
S-30	166.33	168.78	165.64	167.41	166.21	166.99
S-31	169.33	170.54	168.00	169.22	168.85	169.88
S-32	160.00	162.49	159.00	160.62	154.64	155.37
S-36	157.70	159.79	157.45	158.94	156.34	157.21
S-37	165.67	167.45	164.32	166.01	156.00	155.00
S-38	168.00	169.00	168.20	169.41	165.00	166.32
S-39	167.21	168.02	168.23	169.71	164.21	165.21
S-44	153.00	155.84	152.36	153.90	151.00	151.85
S-46	147.52	149.96	146.42	147.99	141.78	142.52
S-47	152.63	154.96	151.23	152.87	146.68	147.44
S-49	153.61	155.79	152.14	153.87	151.78	152.53

S-54	155.00	157.32	154.00	155.57	149.23	150.01
S-55	159.33	161.88	158.21	159.93	156.68	157.44
S-58	158.67	160.18	157.52	159.34	155.00	155.78
Marmade Pool	162.00	164.22	161.65	163.52	156.41	156.99
S-101	157.23	159.80	156.32	157.75	152.00	152.82
4-6 P_5	157.72	159.86	156.26	157.78	155.21	155.97
Selection 21 Round P L1	166.00	168.25	164.23	165.81	156.41	157.00
59 P/2 Round Large	167.00	169.09	166.43	168.02	155.00	156.21
WI-321	159.00	161.78	158.00	159.57	151.03	151.92
Israel Selection	161.68	163.25	160.67	162.01	155.00	155.80
Selection 39	162.45	164.77	161.67	162.95	155.21	156.32
S-115	217.63	220.54	216.67	218.33	212.00	212.85
WI-181 Round Deep Red	157.37	159.70	156.67	158.54	152.00	152.82
B_1	161.00	163.18	160.00	161.67	155.00	155.79
Deep Red Marmade P_9	155.67	157.77	153.96	155.63	152.00	152.86
Punjab Ratta	200.00	202.99	195.03	196.70	190.26	191.04
Punjab Upma	155.43	157.29	154.13	155.67	146.00	146.85
Punjab Sartaj	152.33	154.39	151.00	152.63	149.00	149.88
C.D.	7.25	8.02	5.63	6.84	8.01	7.48
SE(m)	2.00	2.48	2.00	1.89	2.87	2.24
SE(d)	2.83	2.12	2.83	1.96	2.99	2.17
C.V.	5.02	4.21	3.65	4.25	5.65	5.21

No. of primary branches

The different environments had significant influence on number of primary branches in various tomato genotypes. The maximum number of branches was observed in S-115 under all the three environments but the highest value of 18.66 branches was noted under low tunnel environment in second years followed by S-21 (17.83). The highest number of primary branches can be observed under protected conditions because the plants obtained the right amount of soil temperature and atmospheric conditions to grow. The results are in agreement with the research findings of Patil and Basod, (1972). The lowest number of primary branches was nearly 7 i.e., 7.4, 7.5, 7.6 which were recorded in S-4, S-5, S-18, S-19, S-9 under open field conditions in second years trial.

Table 3: Mean performance of tomato genotypes for No. of primary branches:

	No. of primary branches					
	Low tunnel (E1)		Paddy(E2)		Open field (E3)	
Genotypes	1st year	2nd year	1st year	2nd year	1st year	2nd year
S-3	10.33	11.00	9.33	10.22	8.20	8.66
S-4	9.67	10.67	8.67	9.24	7.60	7.88
S-5	9.67	11.33	8.67	9.20	7.70	7.88
S-6	11.00	12.33	10.00	11.10	9.00	9.43
S-7	10.67	11.52	9.67	10.48	8.48	8.88
S-9	9.33	10.81	8.33	9.49	7.50	7.66
S-10	12.33	12.56	11.33	12.30	10.10	10.32
S-11	10.67	11.90	9.67	10.51	8.49	9.21
S-12	14.00	16.00	13.00	14.09	11.00	11.10
S-13	9.33	11.19	8.33	9.40	7.90	7.66
S-14	10.33	11.75	9.33	10.36	8.20	8.66
S-15	10.67	11.81	9.67	10.53	8.80	9.05
S-17	10.00	12.06	9.67	10.48	8.52	9.08
S-18	9.00	10.85	8.33	9.28	7.50	7.66
S-19	9.33	11.06	8.33	9.45	7.40	7.66
S-20	11.00	12.90	10.00	11.18	9.00	9.39
S-21	16.67	17.84	15.67	15.80	14.67	14.88
S-22	11.00	12.30	10.00	11.24	11.00	11.10
S-24	10.33	12.04	9.33	10.56	9.00	9.39
S-25	10.33	11.82	9.33	10.42	8.33	8.65
S-26	10.33	11.88	9.33	10.52	8.00	8.43
S-30	11.67	12.15	10.67	11.60	9.00	9.10
S-31	11.67	12.84	10.67	12.10	9.67	9.88
S-32	11.00	12.20	10.00	11.19	9.00	9.26
S-36	10.67	12.07	9.67	10.42	8.21	8.57
S-37	11.67	12.23	10.67	11.58	9.00	9.32
S-38	11.00	13.17	14.67	14.22	9.00	9.35
S-39	14.00	15.89	13.00	14.13	12.00	9.40
S-44	10.00	12.10	9.00	9.85	8.00	8.32
S-46	9.67	10.67	8.67	9.26	7.67	8.03
S-47	10.33	12.03	9.33	10.47	8.21	8.38
S-49	11.33	12.67	10.33	11.34	9.33	9.32
S-54	10.67	11.89	9.67	10.35	8.67	9.05
S-55	11.33	12.18	10.33	11.44	9.23	9.55
S-58	10.00	11.73	9.00	10.26	8.00	8.33
Marmade Pool	11.67	12.94	10.67	11.31	9.67	9.88

S-101	12.33	13.01	11.33	12.53	10.23	10.59
4-6 P $_5$	11.67	12.85	10.67	11.41	9.67	10.06
Selection 21 Round P L1	16.67	16.89	11.00	11.89	10.00	10.33
59 P/2 Round Large	17.00	17.00	16.33	17.40	10.00	10.37
WI-321	10.53	11.89	9.33	10.37	8.45	8.90
Israel Selection	11.33	12.67	10.33	11.31	9.33	9.66
Selection 39	11.00	12.19	10.00	10.71	9.00	9.37
S-115	17.00	18.67	16.00	17.18	15.00	15.10
WI-181 Round Deep Red	11.33	12.68	10.33	11.36	9.20	9.23
B $_1$	10.33	11.83	9.33	10.70	8.36	8.69
Deep Red Marmade P $_9$	11.33	12.84	10.33	11.31	9.33	9.32
Punjab Ratta Check	15.00	16.67	14.00	15.02	12.00	12.43
Punjab Upma	10.00	11.74	9.00	10.08	8.00	8.43
Punjab Sartaj	11.67	12.67	10.67	11.42	9.67	10.06
C.D.	2.05	3.68	3.41	2.54	2.05	1.06
SE(m)	0.73	0.30	0.58	0.15	0.73	0.73
SE(d)	1.03	0.43	0.64	0.21	1.03	1.20
C.V.	4.87	4.10	4.84	4.02	4.56	4.21

Days to first flowering

The earliest flowering was observed in S-115 (33.21 days) in the first year under low tunnel conditions followed by Punjab Ratta (34 days) and S-21(35.65 days) respectively in the 1st year under low tunnel conditions. The reason behind this was estimated to be the congenial conditions under protected covering which was appropriate temperature, relative humidity and sunlight that has a paramount role in good quality characters of a plant. These results are identical to the the findings of Ramesh *et al*, (2022). The last first flowering was recorded in Paddy straw in 2nd year for variety S-58 which was 61.15 days. The interaction between a plant and a protective covering showed insignificant difference for the character of flowering.

Table 4: Mean performance of tomato genotypes for days to first flowering:

	Days to first flowering					
	Low tunnel (E1)		**Paddy(E2)**		**Open field (E3)**	
Genotypes	**1st**	**2nd**	**1st**	**2nd**	**1st**	**2nd**

	year	year	year	year	year	year
S-3	41.00	42.67	42.32	53.00	44.67	44.15
S-4	45.00	46.38	46.32	50.44	48.67	48.56
S-5	45.32	46.86	46.64	50.64	48.99	48.77
S-6	47.00	48.21	48.32	52.41	50.67	50.29
S-7	40.00	41.77	41.32	45.40	43.67	43.11
S-9	46.32	47.77	47.64	51.70	49.99	49.32
S-10	43.58	44.86	44.90	48.84	47.25	46.50
S-11	49.65	50.88	50.97	54.98	53.32	52.65
S-12	39.25	40.92	40.57	41.25	40.03	42.71
S-13	47.55	49.27	48.87	52.98	51.22	49.44
S-14	51.36	52.99	52.68	56.69	55.03	54.38
S-15	50.11	51.85	51.43	55.56	53.78	53.24
S-17	52.96	54.01	54.28	58.35	56.63	55.81
S-18	52.03	54.24	53.35	57.55	55.70	55.19
S-19	47.48	48.92	48.80	52.76	51.15	50.88
S-20	48.69	49.45	50.01	53.84	52.36	51.49
S-21	35.65	37.67	36.97	40.87	39.32	38.87
S-22	45.00	46.76	46.32	50.34	48.67	47.74
S-24	45.68	47.28	47.00	50.87	49.35	48.50
S-25	47.44	48.99	48.76	52.66	51.11	50.34
S-26	48.32	49.98	49.64	53.21	51.99	51.28
S-30	46.98	48.07	48.30	48.40	50.65	49.76
S-31	48.77	49.38	50.09	50.78	52.44	51.54
S-32	49.00	50.20	50.32	51.08	52.67	52.10
S-36	52.36	54.06	53.68	55.74	56.03	55.17
S-37	52.99	54.23	54.31	57.91	56.66	56.22
S-38	53.00	54.71	54.32	56.66	56.67	55.93
S-39	46.32	48.08	47.64	52.18	49.99	49.21
S-44	47.11	49.36	48.43	51.89	50.78	50.01
S-46	53.47	55.01	54.79	57.54	57.14	56.34
S-47	51.56	52.96	52.88	55.09	55.23	54.59
S-49	45.26	46.87	46.58	56.00	48.93	48.73
S-54	44.14	45.93	45.46	56.00	47.81	47.16
S-55	52.62	53.92	53.94	59.14	56.29	55.30
S-58	55.36	56.93	56.68	61.15	59.03	58.21
Marmade Pool	44.00	46.00	45.32	50.10	47.67	46.97
S-101	52.41	53.93	53.73	57.76	56.08	55.31
4-6 P_5	44.32	45.99	45.64	50.11	47.99	47.39

Selection 21 Round P L1	45.21	46.86	46.53	50.81	48.88	48.18
59 P/2 Round Large	43.69	44.99	45.01	49.06	47.36	46.36
WI-321	52.95	54.10	54.27	56.32	56.62	55.70
Israel Selection	53.21	54.81	54.53	58.40	56.88	56.03
Selection 39	53.66	55.56	54.98	59.29	57.33	56.38
S-115	33.21	35.36	34.53	38.95	36.88	37.03
WI-181 Round Deep Red	53.47	54.82	54.79	58.95	57.14	56.28
B_1	52.10	53.82	53.42	57.58	55.77	55.37
Deep Red Marmade P_9	53.22	54.83	54.54	58.14	56.89	56.52
Punjab Ratta Check	34.00	35.88	35.32	39.42	37.67	36.63
Punjab Upma	52.36	53.91	53.68	57.13	56.03	55.58
Punjab Sartaj	55.21	56.96	56.53	58.57	58.88	58.56
C.D.	N/A	0.60	2.46	1.56	2.10	3.41
SE(m)	0.91	0.21	0.88	0.56	0.03	0.85
SE(d)	1.28	0.30	1.24	0.79	0.04	0.64
C.V.	5.01	4.21	5.08	3.24	4.71	3.54

Days to first fruit set

This trait was highly influenced by varying environmental conditions and variety. The earliest fruit set (Table 5) was noted in S-14 (70 days) in the second years under paddy straw condition followed by S-19 (72.04 days) in the 2nd year under paddy straw. Similarly, Incalcaterra *et al*. (2004) revealed that early flowering plants were grown under protected covering and the plants grown on the bare soil conditions showed late flowering. The research results were in conformity with Melek and Atilla (2009) whose study concluded that the earliest flowering and fruit formation were earliest observed under protection in comparison to control. For the current study soil temperature may be regarded as the contributing factor. These results are also supported by Arin and Sozer (2001). The last first fruit set was recorded in S-38 (98.86 days), S-37 (98.85) in first year under open field conditions.

Table 5: Mean performance of tomato genotypes for days to first fruit set:

	Days to first set					
	Low tunnel (E1)		**Paddy(E2)**		**Open field (E3)**	
Genotypes	**1st year**	**2nd year**	**1st year**	**2nd year**	**1st year**	**2nd year**

S-3	78.22	72.50	79.21	76.54	75.63	77.03
S-4	76.25	76.11	76.26	78.25	79.63	79.00
S-5	75.32	75.77	76.58	77.22	79.95	79.00
S-6	77.00	78.52	78.26	80.00	81.63	80.21
S-7	78.23	78.96	79.21	79.00	79.63	79.44
S-9	76.32	77.11	77.58	78.23	80.95	78.64
S-10	76.11	77.02	77.69	78.02	78.21	79.66
S-11	85.65	86.99	80.91	82.42	90.28	81.98
S-12	75.96	76.08	76.56	77.03	77.21	78.35
S-13	83.55	84.92	78.81	79.33	88.18	76.55
S-14	87.36	88.19	82.62	70.00	91.99	83.74
S-15	86.11	87.14	81.37	71.65	90.74	82.84
S-17	88.96	89.99	84.22	72.41	93.59	84.84
S-18	88.03	89.19	83.29	73.25	92.66	84.84
S-19	83.48	85.01	78.74	72.04	88.11	81.00
S-20	84.69	86.27	79.95	75.00	89.32	80.41
S-21	75.25	75.36	77.05	76.04	76.28	75.36
S-22	76.00	76.18	76.26	79.66	79.84	76.54
S-24	76.04	77.17	76.94	78.20	80.52	77.48
S-25	77.65	79.05	78.70	80.33	82.28	79.48
S-26	78.53	80.12	79.58	81.28	83.16	80.54
S-30	77.19	78.34	78.24	79.66	81.82	78.65
S-31	90.00	91.28	80.03	82.54	94.63	80.41
S-32	90.23	91.26	80.26	82.63	94.86	81.62
S-36	93.59	95.01	83.62	85.36	98.22	84.11
S-37	94.22	95.19	84.25	86.33	98.85	86.00
S-38	94.23	95.13	84.26	87.45	98.86	85.11
S-39	87.55	88.96	77.58	82.33	92.18	78.33
S-44	83.54	84.90	78.37	80.47	88.17	79.14
S-46	89.90	91.08	84.73	86.42	94.53	85.41
S-47	87.99	88.99	82.82	84.33	92.62	83.99
S-49	81.69	83.15	76.52	78.15	86.32	79.00
S-54	80.57	82.01	75.40	77.19	85.20	76.52
S-55	89.05	90.14	83.88	84.26	93.68	84.00
S-58	91.79	92.95	86.62	88.22	96.42	87.25
Marmalade Pool	85.32	86.35	75.26	77.46	89.95	76.25
S-101	93.73	95.03	83.67	85.29	98.36	84.45
4-6 P_5	85.64	87.56	75.58	77.11	90.27	76.87

Selection 21 Round P L1	86.53	88.00	76.47	78.25	91.16	77.44
59 P/2 Round Large	85.01	86.18	74.95	77.42	89.64	75.02
WI-321	94.27	95.35	84.21	86.32	98.90	84.54
Israel Selection	93.43	94.39	84.47	86.41	98.06	85.00
Selection 39	93.88	95.12	84.92	86.58	98.51	85.14
S-115	72.56	73.56	74.23	74.39	75.01	74.26
WI-181 Round Deep Red	93.69	94.52	84.73	86.37	98.32	85.22
B_1	92.32	93.91	83.36	85.17	96.95	85.25
Deep Red Marmade P_9	93.44	94.27	84.48	86.41	98.07	86.45
Punjab Ratta Check	73.12	75.07	75.32	76.58	78.85	79.41
Punjab Upma	92.58	94.03	83.62	81.21	97.21	85.36
Punjab Sartaj	95.43	96.35	86.47	87.26	100.06	88.58
C.D.	N/A	0.62	0.04	0.81	0.60	0.50
SE(m)	1.33	0.22	0.02	0.29	0.21	0.31
SE(d)	1.87	0.31	0.02	0.41	0.30	0.40
C.V.	4.21	0.45	0.05	0.90	1.03	1.06

Days to first fruit harvest

Out of all the three environments the very first fruit set was observed in variety S-115 at 102.56 days under low tunnel conditions in the first year. It was followed by S-15 which showed first fruit setting at 102.65 days in the second years under paddy conditions. The impacting factor behind early harvest under low tunnel conditions can be attributed to hastened reproductive phase i.e. early fruit setting, early maturity due to high mean soil temperature as compared to bare soil. The results are in parallel with the results of Lamont (1999) who confirmed that mulches ameliorate the soil hydrothermal regime and therefore it leads to enhanced vegetative phase, advanced flowering and advanced harvest. These findings are also supported by Ham *et al*. (1991) that at least 9 day early flowering was noted for plants that were under some protected covering

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Table 6: Mean performance of tomato genotypes for days to first fruit harvest:

	Days to first fruit harvest					
	Low tunnel (E1)		Paddy(E2)		Open field (E3)	
Genotypes	1st year	2nd year	1st year	2nd year	1st year	2nd year
S-3	108.22	102.71	110.26	107.54	106.28	108.51
S-4	106.25	106.32	107.31	109.25	110.28	110.48
S-5	105.96	106.02	107.63	108.22	110.60	110.48
S-6	107.00	108.73	109.31	111.00	112.28	111.69
S-7	108.23	109.17	110.26	110.00	110.28	110.92
S-9	106.32	107.32	108.63	109.23	111.60	110.12
S-10	106.11	107.23	108.74	109.02	108.86	111.14
S-11	115.65	117.20	111.96	113.42	120.93	113.46
S-12	105.96	106.29	107.61	108.03	107.86	109.83
S-13	113.55	115.13	109.86	110.33	118.83	108.03
S-14	117.36	118.40	113.67	101.00	122.64	115.22
S-15	116.11	117.35	112.42	102.65	121.39	114.32
S-17	118.96	120.20	115.27	103.41	124.24	116.32
S-18	118.03	119.40	114.34	104.25	123.31	116.32
S-19	113.48	115.22	109.79	103.04	118.76	112.48
S-20	114.69	116.48	111.00	106.00	119.97	111.89
S-21	105.25	105.57	108.10	107.04	106.93	106.84
S-22	106.00	106.39	107.31	110.66	110.49	108.02
S-24	106.04	107.38	107.99	109.20	111.17	108.96
S-25	107.65	109.26	109.75	111.33	112.93	110.96
S-26	108.53	110.33	110.63	112.28	113.81	112.02
S-30	107.19	108.55	109.29	110.66	112.47	110.13
S-31	120.00	121.49	111.08	113.54	125.28	111.89
S-32	120.23	121.47	111.31	113.63	125.51	113.10
S-36	123.59	125.22	114.67	116.36	128.87	115.59
S-37	124.22	125.40	115.30	117.33	129.50	117.48
S-38	124.23	125.34	115.31	118.45	129.51	116.59
S-39	117.55	119.17	108.63	113.33	122.83	109.81
S-44	113.54	115.11	109.42	111.47	118.82	110.62
S-46	119.90	121.29	115.78	117.42	125.18	116.89
S-47	117.99	119.20	113.87	115.33	123.27	115.47
S-49	111.69	113.36	107.57	109.15	116.97	110.48
S-54	110.57	112.22	106.45	108.19	115.85	108.00
S-55	119.05	120.35	114.93	115.26	124.33	115.48
S-58	121.79	123.16	117.67	119.22	127.07	118.73
Marmade Pool	115.32	116.56	106.31	108.46	120.60	107.73

S-101	123.73	125.24	114.72	116.29	129.01	115.93
4-6 P $_5$	115.64	117.77	106.63	108.11	120.92	108.35
Selection 21 Round P L1	116.53	118.21	107.52	109.25	121.81	108.92
59 P/2 Round Large	115.01	116.39	106.00	108.42	120.29	106.50
WI-321	124.27	125.56	115.26	117.32	129.55	116.02
Israel Selection	123.43	124.60	115.52	117.41	128.71	116.48
Selection 39	123.88	125.33	115.97	117.58	129.16	116.62
S-115	102.56	103.77	105.28	105.39	105.66	105.74
WI-181 Round Deep Red	123.69	124.73	115.78	117.37	128.97	116.70
B $_1$	122.32	124.12	114.41	116.17	127.60	116.73
Deep Red Marmade P $_9$	123.44	124.48	115.53	117.41	128.72	117.93
Punjab Ratta Check	103.12	105.28	106.37	107.58	109.50	110.89
Punjab Upma	122.58	124.24	114.67	112.21	127.86	116.84
Punjab Sartaj	125.43	126.56	117.52	118.26	130.71	120.06
C.D.	4.59	5.23	4.63	12.38	5.23	5.67
SE(m)	1.63	1.54	1.71	4.40	2.54	1.62
SE(d)	2.31	2.58	2.43	6.23	4.65	2.84
C.V.	2.46	3.02	2.65	7.72	3.66	3.41

Days to last fruit harvest (no.)

The last fruit harvest was seen to be recorded at 177.24 days for variety S-115 for second years under the environmental conditions of paddy straw. It has been noticed that mulching the soil provided early growth season boost, enhanced growth and longer fruit duration may be due to more reflected sunlight and lesser rate of evapo-transpiration as well as good soil moisture content is maintained by mulches. These findings are in confirmation with Maida, Bisen and Diwan (2019).

Table 7: Mean performance of tomato genotypes for days to last fruit harvest:

	Days to last fruit harvest					
	Low tunnel (E1)		Paddy(E2)		Open field (E3)	
Genotypes	1st year	2nd year	1st year	2nd year	1st year	2nd year
S-3	163.00	164.00	162.01	168.02	163.07	165.74
S-4	165.00	166.17	165.33	170.42	166.08	168.74
S-5	165.67	162.35	166.01	171.48	166.15	168.82
S-6	165.00	164.95	163.39	169.08	165.01	167.68
S-7	165.00	166.22	162.00	167.35	163.07	165.74
S-9	164.33	165.00	166.67	172.18	167.12	169.78
S-10	167.67	162.28	165.67	171.63	168.16	170.82
S-11	166.00	165.23	172.00	173.22	166.00	175.88
S-12	166.00	167.07	170.52	174.00	173.21	172.20
S-13	164.00	165.26	166.00	171.24	166.11	168.77
S-14	167.33	167.99	171.00	176.18	161.20	174.82
S-15	164.00	165.12	65.00	70.99	166.07	168.74
S-17	166.00	167.01	166.33	172.02	166.74	169.40
S-18	164.00	165.15	162.67	168.20	163.79	166.45
S-19	162.67	162.92	161.67	166.32	162.88	165.55
S-20	163.67	164.00	164.77	170.37	154.88	157.55
S-21	166.02	168.04	170.00	175.26	172.15	174.52
S-22	164.67	165.08	165.68	171.70	167.11	169.78
S-24	166.00	167.18	170.70	175.72	169.90	172.56
S-25	165.00	166.19	167.02	172.91	168.23	170.89
S-26	165.33	165.83	165.35	171.47	165.25	167.92
S-30	167.00	167.85	167.34	171.84	166.80	169.46
S-31	165.67	166.17	166.34	172.56	166.07	168.74
S-32	162.67	163.46	164.33	169.37	163.13	165.80
S-36	165.33	166.24	167.01	172.22	169.21	171.88
S-37	163.00	164.24	167.67	173.19	167.09	169.76
S-38	165.67	166.18	167.33	173.11	165.88	168.54
S-39	165.33	166.29	167.33	119.56	165.98	168.64
S-44	168.00	165.18	164.00	175.28	171.14	173.81
S-46	165.33	166.18	166.00	171.27	168.03	170.69
S-47	165.33	166.18	170.33	175.15	169.10	171.77
S-49	165.67	166.17	165.00	170.17	165.40	168.07
S-54	165.33	166.07	173.00	174.39	171.05	173.72
S-55	165.33	166.15	168.00	173.29	166.19	168.85
S-58	165.67	166.28	166.00	171.07	168.13	170.79

Marmade Pool	162.67	163.40	166.00	171.83	168.11	170.77
S-101	164.00	165.15	164.00	169.82	165.01	167.67
4-6 P_5	166.33	163.55	168.67	174.02	168.11	170.78
Selection 21 Round P L1	167.67	168.22	172.01	173.00	171.78	174.45
59 P/2 Round Large	168.00	166.28	174.00	174.00	168.00	175.82
WI-321	164.33	165.11	167.00	172.24	167.09	169.76
Israel Selection	164.67	165.15	165.35	170.15	165.32	167.99
Selection 39	166.33	167.15	172.34	173.00	171.21	173.88
S-115	167.85	169.08	175.36	177.24	175.30	173.25
WI-181 Round Deep Red	163.67	164.19	163.33	168.27	163.15	165.82
B_1	164.67	165.29	169.33	174.25	169.21	171.88
Deep Red Marmade P_9	165.67	166.15	166.02	171.25	166.11	168.77
Punjab Ratta Check	168.00	169.19	174.62	176.30	175.78	172.00
Punjab Upma	164.67	165.62	166.01	172.01	166.22	168.89
Punjab Sartaj	166.00	167.04	167.01	172.74	167.12	169.78
C.D.	N/A	0.43	1.24	5.49	4.07	3.97
SE(m)	1.36	0.15	0.44	2.04	1.45	1.32
SE(d)	1.93	0.22	0.62	3.54	2.05	1.85
C.V.	1.43	0.16	0.46	2.05	1.50	1.35

4. CONCLUSION

It was concluded that for most of the characters maximum and ideal data was observed under low tunnel environment followed by paddy straw, which was then followed by open field conditions. Protected conditions provided favourable growing conditions leading to profuse growth. The maximum data for plant height was recorded in the genotype S-115 (220.54cm). Maximum number of primary branches was recorded in S-115 (18.667). Days to first flowering was revealed in S-115 (33.21 days, days to first fruit set was observed in

S-115 (72.56). Maximum value for days to first fruit harvest and last fruit harvest was observed also in S-115 (102.56) and (177.24) respectively.

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