

Phenotypic Characterization of Tomato (*Lycopersicon esculentum*) Germplasm to Develop the High Yielding Breeding Resource in Bangladesh

A. K. M. Quamruzzaman

Olericulture Division, Horticulture Research Center,
Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh

L. Akter

Olericulture Division, Horticulture Research Center,
Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh

F. Islam

Training and communication,
Bangladesh Agricultural Research Institute, Gazipur-1701, Bangladesh

ABSTRACT

A study was conducted with 28 tomato germplasm/variety at the Olericulture Division of Horticulture Research Centre, BARI, during the winter season of 2021-22 to evaluate the yield and yield related components. There was significant variability observed among the 28 tomato germplasm varieties. Significant variation was observed in the number of fruits per plant and single fruit weight, while the range was 15-52 and 23-97g, respectively. In this study, eleven germplasms produced more than 70.00 t/ha, with SLA34 producing the highest yield (95.24 t/ha), followed by SLA15-7 (91.24 t/ha), SLA15-1B (86.63 t/ha), SLA36 (85.47t/ha), BARI Tomato-15 (81.35 t/ha), SLA15-6 (79.43t/ha), SLA15-1 (77.22 t/ha). The range of yield was obtained from 26.57-95.24 t/ha. The range of TSS was 2.9% (SLA20) to 6.5% (SLA34), while higher TSS contained germplasm were viz., SLA34 (6.5%), SLA15-5, SLA15-6 (5.2%), SLA15, SLA32 (5.1%). Significant variation was observed for TYLCV infection and leaf-sucking pest infestation, which varied from 0-10% and 0-20%, respectively. Considering yield and yield contributing parameters, the germplasm viz., SLA34, SLA15-7, SLA15-1B, SLA36, SLA15-6, SLA30, SLA15-1, SLA15-4, SLA27, SLA15, SLA32, and SLA11 may be investigated further for developing better tomato varieties.

Keyword: Tomato, *Solanum lycopersicum*, breeding resource, phenotypic characterization.

INTRODUCTION

Tomato (*Solanum lycopersicum*) is a vital vegetable in Bangladesh and around the world. It is the second most important world consumable vegetable after potatoes, ranks first among the processing crops (FAO, 2008) and belongs to the Solanaceae family (Saravanan et al., 2003). It is rich in a plethora of natural antioxidants and bioactive compounds. The regular ingestion of

an adequate amount of fresh tomatoes or processed tomato products has been inversely correlated with the development of widespread human diseases (Agarwal and Rao, 1998; Erdman et al., 2009; Prakash and Kumar, 2014) and with an increase in plasma lipid peroxidation levels (Giovannucci, 1999; Balestrieri et al., 2004). This protective effect has been attributed primarily to the carotenoid constituents of the fruits, particularly lycopene and β -carotene, which act as antioxidants in detoxifying free radicals (Erdman et al., 2009; Mascio et al., 1989; Stahl and Sies, 1996; Clinton, 1998; Kotková et al., 2011). In addition to the large production values, the tomato is an important source of antioxidant intake. The essential phytonutrients found in the tomato fruit are lycopene, β -carotene, α -tocopherol, polyphenols, and ascorbic acid, and antioxidant activity depends on cultivar, environmental parameters, and method of production and processing. Ripe tomatoes have important quality characteristics, viz., uniform size, red color, and good aroma and texture.

However, the Bangladesh Agricultural Research Institute (BARI) has released 21 open-pollinated (OP) and 11 hybrid tomato varieties so far. Several leading seed companies are also supplying more tomato varieties and seeds, which are being imported from different countries. Though BARI released varieties are higher yielders, some varieties are prone to several pests and diseases. Besides this, growers' demand is for good quality, high-yielding varieties. So, growers are interested in getting good quality pest and disease resistant varieties with a good shelf life. In this context, BARI must develop quality tomato varieties with good keeping quality, higher yields, and resistance to pests and diseases. As a result, 27 tomato germplasm lines were collected and evaluated in Bangladesh in order to develop good quality, high yielding, pest and disease tolerant tomato varieties with good shelf life and sweetness.

MATERIALS AND METHODS

Experimental Site

The experiment was conducted at the Olericulture Division of Horticulture Research Centre, BARI during the winter season of 2021-22 with twenty-seven tomato germplasm. The experimental field was at 23.9920° N Latitude and 90.4125° E Longitudes having an elevation of 8.2 m above sea level. The experimental site is situated in the sub-tropical climatic zone and is characterized by scanty rainfall during the experimental period. The average minimum and maximum temperatures were 57.0-80.0 °F and 75.3-89.4°F and relative humidity was 3.0 to 65.0% (Fig 1).

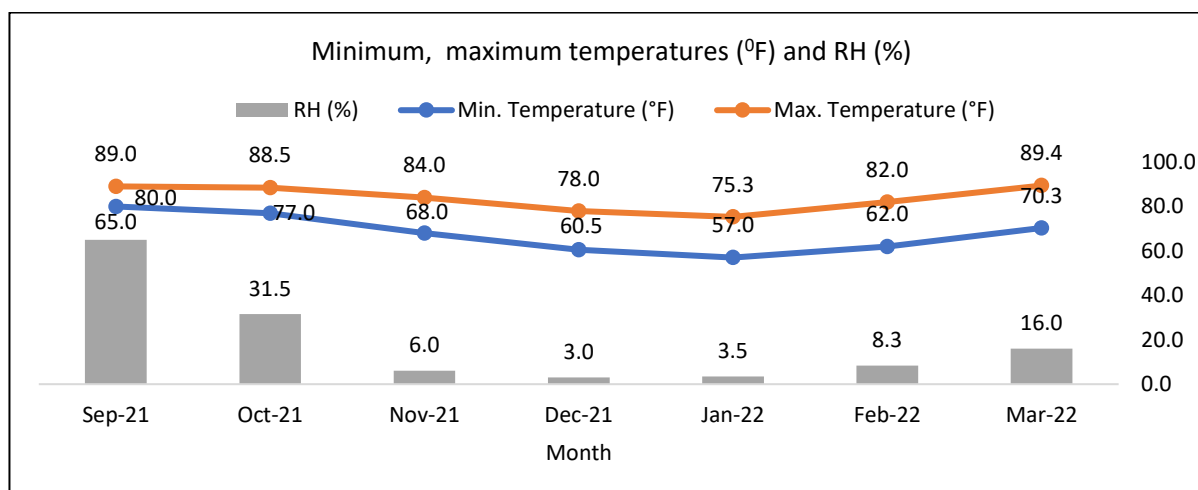


Fig 1. Average minimum, maximum temperature (°F) and RH (%) of the experimental area

Treatments and Plant Materials

The seeds of 28 tomato germplasm varieties were sown on the polypot on 05 October, 2021. Thirty-day days old seedlings were transplanted in the main field on 04 November, 2021. The experiment was laid out in a Randomized Complete Block design with three replications. The unit plot size was 5.0 x 1.0m, maintaining 60 x 50 cm spacing and a 0.5m drain.

Land Preparation and Fertilization

The experimental area was enriched with organic manure, Nitrogen, Phosphorus, Potassium, Sulphur, Zinc and Boron @ 3,000, 250, 90, 125, 20, 3 and 2 kg/ha, correspondingly. One third of the organic manure, 50% of Phosphorus and full of Sulphur, Zinc and Boron were incorporated for the period of last land-dwelling preparation. Rest of organic fertilizer and Phosphorus and 1/3 of Potassium were applied as basal in pit. Entire quantity of Nitrogen and rest of Potassium were applied in three equal portions beginning 20 days after transplanting. The remaining three portions were fertilized at 20, 40 and 60 days after transplanting. The intercultural operations (weeding, irrigation, etc.) were done as and when necessary.

Data Collection and Statistical Analysis

Data on days to first flowering, days to 50% flowering, days to first harvest, days to fruit maturity, no. of clusters per plant, no. of flowers per cluster, no. of fruits/cluster, no. of fruits/ plant, single fruit wt. (g), fruit yield/plant (kg), fruit length (cm), fruit diameter (cm), pericarp thickness (cm), TSS (%), no. of locules, plant height at last harvest (cm), TYLCV (%), and leaf sucking pest (%) were recorded from three randomly selected plants per plot. The information on different characters was statistically analyzed. Plot means for quantitative characters were used for the statistical analysis.

RESULTS AND DISCUSSION

Significant differences were observed among the 28 tomato germplasm varieties of tomato. A wide range was observed in days to first flowering, days to 50% flowering, days to first harvest, and days to fruit maturity, which were 59-70 days, 63-76 days, 98-113 days, and 35-39 days,

respectively. The range of the number of clusters per plant and the number of flowers per cluster were also found to be wide, with 9-70 and 5.0-15.0, respectively.

Table 1. Yield and yield contributing characters of 28 tomato germplasm/ variety

Germplasm	Days to first flowering	Days to 50% flowering	Days to first harvest	Days to fruit maturity	No. of cluster per plant	No. of flower per cluster
SLA11	61	65	101	36	70	7.2
SLA15	62	68	106	38	60	8.8
SLA15-1	60	64	101	37	35	7.8
SLA15-1B	59	64	100	36	37	8.0
SLA15-2	60	65	103	38	56	7.2
SLA15-3	61	66	105	39	30	5.2
SLA15-4	60	68	106	38	32	6.6
SLA15-5	68	67	104	37	25	6.4
SLA15-6	59	63	98	35	30	6.8
SLA15-7	60	65	101	36	45	5.6
SLA19	60	63	101	38	9	7.0
SLA20	62	67	104	37	34	15.0
SLA21	61	67	105	38	34	6.5
SLA22	61	68	107	39	21	9.0
SLA24	60	67	103	36	24	5.5
SLA25	59	65	102	37	33	9.0
SLA26	61	65	100	35	40	10.5
SLA27	65	72	107	35	29	6.6
SLA28	60	65	101	36	22	6.2
SLA29	62	66	103	37	25	8.4
SLA30	61	65	103	38	26	5.6
SLA31	64	72	109	37	28	5.4
SLA32	66	70	105	35	36	7.0
SLA33	64	63	100	37	28	5.4
SLA34	65	71	107	36	41	5.6
SLA35	68	69	107	38	31	5.0
SLA36	70	76	113	37	34	5.2
BARI Tomato-15	52	60	96	36	29	6.2
Range	59-70	63-76	98-113	35-39	9-70	5.0-15.0
St. Dev.	3.03	3.15	3.33	1.19	12.56	2.11
St. Error	0.54	0.57	0.60	0.21	2.25	0.38
CV (%)	0.05	0.05	0.03	0.03	0.37	0.30

In this study, the number of fruits per cluster was found to have a range of 3.0-16.0. The number of fruits per plant is the most important component trait which is directly related to increased fruit yield per plant. Significant variation was observed with fruits ranging from 15 (SLA19) to 52 (SLA11), with higher fruited germplasm including SLA11 (52), SLA25 (48), SLA34, SLA36 (37), and SLA20 (35) (Table 2). The variation in the number of fruits per plant may be due to

genetic differences among the germplasm since they were grown under the same environmental conditions. Higher fruiting traits have also been reported by Amin et al. (2017), Biswas et al. (2016), and Gautam et al. (2018). Single fruit weight has a direct contribution to fruit yield. SLA19 had the most weighed fruits (97g), followed by SLA15-7 (86g), SLA15-2 (85g), SLA15-3 (84g), and SLA15-6 (83g), with a range of 23g-97g (Table 2). The ultimate goal of any breeding program is to achieve a higher marketable yield per unit of area. Fruit-set in tomatoes influences yield through effects on both fruit number and fruit size (Bertin, 1995). In this study, eleven germplasms produced more than 70.00 t/ha, with SLA34 producing the highest yield (95.24 t/ha), followed by SLA15-7 (91.24 t/ha), SLA15-1B (86.63 t/ha), SLA36 (85.47t/ha), BARI Tomato-15 (81.35 t/ha), SLA15-6 (79.43t/ha), SLA15-1 (77.22 t/ha). The yield ranged from 26.57 to 95.24 t/ha. When we analyzed the data, we obtained a cherry type of tomato, viz., SLA11 (54.91t/ha), which may be selected for the development of cherry tomatoes. Higher fruit yield was reported by Veena et al. (2017), Kumar et al. (2017), and Hamisu et al. (2018). The development of fruit size depends on a number of factors such as the leaf-fruit ratio, genetic and climatic factors, position in the plant and the branch, plant age, number of seeds, and water and nutrient supply (Dennis, 1996). The range of fruit length and fruit diameter was 3.3-6.6cm and 2.1-6.0cm, respectively (Table 2). Higher length and diameter for these traits have also been reported by Kumar and Singh (2016) and Singh et al. (2012).

Table 2. Yield and yield contributing characters of 28 tomato germplasm/ variety

Germplasm	Fruit/ cluster	No. of fruit/ plant	Single fruit wt. (g)	Fruit yield (t/ha)	Fruit length (cm)	Fruit diameter (cm)
SLA11	6.4	52	32	54.91	3.9	2.1
SLA15	7.6	30	73	71.31	3.4	3.3
SLA15-1	8.0	30	78	77.22	5.0	3.8
SLA15-1B	8.1	35	75	86.63	3.4	6.0
SLA15-2	4.6	21	85	60.03	4.9	4.6
SLA15-3	4.2	25	84	69.30	5.3	5.6
SLA15-4	6.0	32	73	77.09	4.6	5.2
SLA15-5	5.4	21	70	48.97	4.4	4.2
SLA15-6	6.4	29	83	79.43	6.3	4.2
SLA15-7	3.8	32	86	91.24	6.6	4.1
SLA19	7.0	15	97	46.73	5.8	5.9
SLA20	16.0	35	23	26.57	3.3	2.4
SLA21	6.0	25	65	54.48	4.4	4.1
SLA22	8.0	16	63	33.89	4.2	4.3
SLA24	3.0	17	72	41.34	5.0	4.8
SLA25	7.5	48	28	43.56	3.4	3.4
SLA26	10.0	38	30	37.62	3.6	3.2
SLA27	5.6	39	59	75.93	4.4	4.7
SLA28	5.2	28	40	36.96	4.2	3.3
SLA29	7.8	28	55	50.64	4.7	4.4
SLA30	5.2	35	68	78.54	4.8	4.2
SLA31	4.2	27	59	52.39	3.6	5.0

SLA32	6.4	34	64	71.81	4.9	3.9
SLA33	4.8	26	64	54.07	4.8	4.3
SLA34	3.8	37	78	95.24	5.2	4.9
SLA35	3.8	21	74	52.01	5.3	4.9
SLA36	4.0	37	70	85.47	5.0	4.1
BARI Tomato-15	5.0	28	85	81.35	5.5	4.9
Range	3.0-16.0	15-52	23-97	26.57-95.24	3.3-6.6	2.1-6.0
St. Dev.	2.60	8.87	19.23	19.11	0.86	0.94
St. Error	0.47	1.59	3.45	3.43	0.16	0.17
CV (%)	0.42	0.29	0.30	0.31	0.19	0.22

Pericarp thickness is an important trait for keeping quality and shelf life in tomatoes. The range was found to be 0.2-0.8 cm, while a higher thickness was noticed in SLA19 (0.8 cm), followed by SLA15-7, SLA31, and SLA32 (0.6 cm). These results were in agreement with Tamta and Singh (2015) and Veena et al. (2017). A lower number of locules in a fruit is considered desirable. In tomatoes, locule number influences fruit shape and size. The locules are directly derived from the carpels in the flower. The range for this was 2.0–5.2. Total soluble solids (TSS) content is one of the most important quality parameters for the processing industry. It represents the sum total of all fruit components other than water and volatile compounds. The range of TSS was 2.9 (SLA20) to 6.5% (SLA34), while higher TSS contained germplasm were viz., SLA34 (6.5%), SLA15-5, SLA15-6 (5.2%), SLA15, SLA32 (5.1%) (Table 3). This confirms the findings of Amin et al. (2017), Raj et al. (2018), Solieman et al. (2013), and Veena et al. (2017). More plant height is considered desirable, because it leads to a greater number of branches and ultimately results in increased productivity, while the range that was observed in this study was 70–196 cm. The most important parameters to monitor during crop production were pest and disease infestation, with a negative or lower number of values considered desirable. TYLCV infection and leaf-sucking pest infestation showed significant variation, ranging from 0–10% and 0–20%, respectively (Table 3).

Table 3. Yield and yield contributing characters of 28 tomato germplasm/ variety

Germplasm	Pericarp thickness (cm)	No. of locules	TSS (%)	Plant height at last harvest (cm)	TYLCV (%)	Leaf sucking pest (%)
SLA11	0.2	2.0	4.9	196	10	0
SLA15	0.3	2.0	5.1	193	0	0
SLA15-1	0.4	2.0	4.2	80	0	10
SLA15-1B	0.4	3.0	4.7	95	0	0
SLA15-2	0.4	5.2	3.5	93	0	10
SLA15-3	0.5	3.4	4.1	71	0	0
SLA15-4	0.4	3.8	4.2	94	0	0
SLA15-5	0.5	2.0	5.2	90	10	10
SLA15-6	0.5	2.0	5.2	77	0	0
SLA15-7	0.6	4.8	3.6	92	0	10
SLA19	0.8	3.0	4.2	93	0	10
SLA20	0.4	2.0	5.6	115	0	10

SLA21	0.4	2.0	3.5	103	0	10
SLA22	0.4	2.5	4.3	144	10	10
SLA24	0.5	3.0	4.4	70	0	10
SLA25	0.3	3.0	3.5	109	10	20
SLA26	0.3	2.0	6.5	144	0	10
SLA27	0.4	2.8	2.9	83	0	10
SLA28	0.4	3.2	3.3	77	10	20
SLA29	0.4	3.4	4.1	96	0	10
SLA30	0.5	2.2	3.1	80	0	10
SLA31	0.6	2.6	4.0	86	10	10
SLA32	0.6	2.0	5.1	86	0	10
SLA33	0.5	2.6	3.0	102	10	20
SLA34	0.5	3.8	2.9	93	0	10
SLA35	0.5	3.0	4.2	102	0	10
SLA36	0.5	2.4	3.1	87	10	20
BARI Tomato-15	0.6	4.0	4.9	115	0	10
Range	0.2-0.8	2.0-5.2	2.9-6.5	70-196	0-10	0-20
St. Dev.	0.12	0.86	0.91	32.1	4.65	6.16
St. Error	0.02	0.15	0.16	5.8	0.84	1.11
CV (%)	0.26	0.31	0.31	0.31	1.57	0.66

CONCLUSION

The ultimate goal of this research program is to increase yield, which correlates directly or indirectly with other plant traits and biotic and abiotic stress. There was significant variability observed among the 28 tomato germplasm varieties. Significant variation was observed in the number of fruits per plant and single fruit weight, while the range was 15-52 and 23-97g, respectively. In this study, eleven germplasms produced more than 70.00 t/ha, with SLA34 producing the highest yield (95.24 t/ha), followed by SLA15-7 (91.24 t/ha), SLA15-1B (86.63 t/ha), SLA36 (85.47t/ha), BARI Tomato-15 (81.35 t/ha), SLA15-6 (79.43t/ha), SLA15-1 (77.22 t/ha). The yield ranged from 26.57 to 95.24 t/ha. The range of TSS was 2.9% (SLA20) to 6.5% (SLA34), while higher TSS contained germplasm were viz., SLA34 (6.5%), SLA15-5, SLA15-6 (5.2%), SLA15, SLA32 (5.1%). Significant variation was observed for TYLCV infection and leaf-sucking pest infestation, which varied from 0–10% and 0-20%, respectively. Considering yield and yield contributing parameters, the germplasm viz., SLA34, SLA15-7, SLA15-1B, SLA36, SLA15-6, SLA30, SLA15-1, SLA15-4, SLA27, SLA15, SLA32, and SLA11 may be investigated further for developing better tomato varieties.

ACKNOWLEDGEMENTS

This study was completed with the financial support of AFACI under the project of “Development of vegetable varieties in Asia Region”.

References

- Agarwal, S. and Rao, A.V. (1998) Tomato Lycopene and Low-Density Lipoprotein Oxidation: A Human Dietary Intervention Study. *Lipids*, 33, 981-984. <https://doi.org/10.1007/s11745-998-0295-6>
- Amin A, Wani KP, ZA Dar, Nayeema J, Faheema M. Heterosis studies in tomato (*Solanum lycopersicum* L.), *Journal of Pharmacognosy and Phytochemistry*, 2017; 6(6):2487-2490.
- Balestrieri, M.L., De Prisco, R., Nicolaus, B., Pari, P., Moriello, V.S., Strazzullo, G., Iorio, E.L., Servillo, L. and Balestrieri, C. (2004) Lycopene in Association with R-Tocopherol or Tomato Lipophilic Extracts Enhances Acylplatelet-Activating Factor Biosynthesis in Endothelial Cells during Oxidative Stress. *Free Radical Biology and Medicine*, 36, 1058-1067. <https://doi.org/10.1016/j.freeradbiomed.2004.01.014>
- Biswas A, Islam MS, Dey S, Shimu AA. Studies on heterosis for summer season tomato production, *American Journal of Experimental Agriculture*, 2016; 13(3):1-6.
- Clinton, S.K. (1998) Lycopene: Chemistry, Biology and Implications for Human Health and Disease. *Nutrition Reviews*, 56, 35-51. <https://doi.org/10.1111/j.1753-4887.1998.tb01691.x>
- Dennis FG. Fruit development. In: Maib, K. M., P. L. Andrews, G. A. Lang and K. Mullinix (eds.). *Tree fruit physiology: growth and development*. Good Fruit Growers, Yakima, WA. 1996, 107-116.
- Di Mascio, P., Kaiser, S. and Sies, H. (1989) Lycopene as the Most Efficient Biological Carotenoid Singlet Oxygen Quencher. *Archives of Biochemistry and Biophysics*, 274, 532-538. [https://doi.org/10.1016/0003-9861\(89\)90467-0](https://doi.org/10.1016/0003-9861(89)90467-0)
- Erdman, J.W., Ford, N.A. and Lindshield, B.L. (2009) Are the Health Attributes of Lycopene Related to Its Antioxidant Function. *Archives of Biochemistry and Biophysics*, 483, 229-235. <https://doi.org/10.1016/j.abb.2008.10.022>
- FAO (2008) Tomato Production Statistic. Food and Agriculture Organization of the United Nations, Rome Gautam N, Kumar M, Vikram A, Kumar S, Sharma S. Heterosis studies for yield and its components in tomato (*Solanum lycopersicum* L.) under North Western Himalayan Region, India, *International Journal of Current Microbiology and Applied Sciences* 2018; 7(02):1949-1957.
- Giovannucci, E. (1999) Tomatoes, Tomato-Based Products, Lycopene, and Cancer: Review of the Epidemiologic Literature. *Journal of the National Cancer Institute*, 91, 317-331. <https://doi.org/10.1093/jnci/91.4.317>
- Hamisu HS, Ado SG, Yeye MY, Usman IS, Mohammed SM, Usman A et al. Heterosis for fruit yield and heat tolerance traits in tomato (*Lycopersicon lycopersicum* Mill.) under field condition, *Journal of Agricultural Studies* 2018; 6(2):48-62.
- Kotíková, Z., Lachman, J., Hejtmánková, A. and Hejtmánková, K. (2011) Determination of Antioxidant Activity and Antioxidant Content in Tomato Varieties and Evaluation of Mutual Interactions between Antioxidants. *LWT-Food Science and Technology*, 44, 1703-1710. <https://doi.org/10.1016/j.lwt.2011.03.015>
- Kumar Chandan, Singh SP. Heterosis and inbreeding depression to identify superior F1 hybrids in tomato (*Solanum lycopersicum* L.) for the yield and its contributing traits, *Journal of Applied and Natural Science*, 2016; 8(1):290-296.
- Prakash, A. and Kumar, A. (2014) Implicating the Role of Lycopene in Restoration of Mitochondrial Enzymes and BDNF Levels in β -Amyloid Induced Alzheimer's Disease. *European Journal of Pharmacology*, 741, 104-111. <https://doi.org/10.1016/j.ejphar.2014.07.036>

Raj Tanvi, Bhardwaj Madan Lal, Pal Saheb. Performance of tomato hybrids for quality traits under Mid-hill conditions of Himachal Pradesh, *International Journal of Chemical Studies* 2018; 6(4):2565-2568.

Saravanan, S., Thamburaj, S., Veeraragavathatham, D. and Subbiah, A. (2003) Effects of Seaweed Extract and Chlormequat on Growth and Fruit Yield of Tomato (*Lycopersicon esculentum* Mill.). *Indian Journal of Agricultural Research*, 37, 79-87.

Singh NB, Shabir WH, Haribhushan A, Nongthombam R. Heterosis studies for yield and its components in tomato (*Solanum lycopersicum* L.), *VEGETOS*, 2012; 25(2):257-265.

Solieman THI, El-Gabryb MAH, Abidob AI. Heterosis, potence ratio and correlation of some important characters in tomato (*Solanum lycopersicum* L.), *Scientia Horticulturae* 2013; 150:25-30.

Stahl, W. and Sies, H. (1996) Lycopene: A Biologically Important Carotenoid for Humans. *Archives of Biochemistry and Biophysics*, 336, 1-9. <https://doi.org/10.1006/abbi.1996.0525>.

Tamta Savita, Singh JP. Heterosis for quality traits in tomato, *Asian Journal of Plant Science and Research*, 2015; 5(7):27-32.

Veena AM, Paliwal Ajaya, Pant SC, Mishra RC, Kumar Vijay, Bahuguna Pankaj. Hybridization studies in tomato (*Solanum lycopersicum* L.), *International Journal of Pure and Applied Bioscience* 2017; 5(6):64-70.