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Research Article

Variability analysis in tomato (*Solanum lycopersicum* L.) crosses under drought stress

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Abstract
Climate change in recent years has affected crop production to a greater extent. To overcome these effects, climate-resilient varieties are needed. Tomato is a versatile crop. However, its growth is hindered when it is affected by drought stress. Hence, a variability analysis of tomatoes under drought stress was carried out at Horticulture College and Research Institute, Coimbatore. Variability studies revealed that all the crosses for all parameters exhibited higher phenotypic coefficient of variation (PCV) values than genotypic coefficient of variation (GCV), indicating the influence of environmental effects. For all the crosses, *viz.,* EC169966 × LE118, EC177824 × LE27 and Arka Ashish × LE27, high PCV and high GCV were recorded for characteristics including fruit number per plant, yield per plant, lycopene content and peroxidase activity. Characteristics such as the number of flowers per cluster, fruit number per plant, individual weight of fruit, yield per plant, relative water content, proline content, peroxidase activity and ascorbic acid content recorded higher heritability coupled with high genetic advance as a percentage of the mean (GAM). Thus, direct selection of the above parameters improves drought-tolerant breeding programs in tomato.

Keywords: Tomato, drought, PCV, GCV, GAM

INTRODUCTION

Tomato is the flagship species in the family Solanaceae and is cultivated worldwide for its multifaceted uses. After potato, tomato is the second most vital species grown. It is now an undetached part of cuisine due to its taste and nutritional aspects (Hao *et al.,* 2016). The broad acceptance of tomato in domestic and foreign markets is the reason for its large-scale cultivation, where it is sold fresh as well assome processed products. Tomato is a genetically characterized species that can serve as an excellent model species for basic and applied research. This is because of various reasons, such as short duration, ease of cultivation, homozygosity, high self-fertility, ease of hybridization and high reproductive potential (Hassan *et al.,* 2021).

Drought stress is the single most devasting stress among all environmental stresses that hampers crop growth and productivity, including tomatoes (Ilakiya *et al.,* 2019). Drought stress is a shortage of water availability due to low soil moisture because of insufficient precipitation. There is a lack of availability of water during the critical life cycle of plants under drought stress that restricts the expression of the full genetic potential of the plant, limiting the crop from reaching its maximum potential yield (Seleiman *et al.,* 2021).

Tomato requires irrigation frequently and is mostly cultivated in a tropical and arid regions, where water deficit is a major problem. At all growth phases, tomato were found to be sensitive to drought conditions. It alters water metabolism, which in turn affects plant health (Jangid and Dwivedi, 2016). Drought-stressed plants show restricted growth due to a reduced photosynthetic rate. As drought stress persists to be the most devasting threat to crop growth worldwide, it is imperative to develop tomato varieties that are tolerant to drought (Patane *et al.,* 2016).

Evaluation and systemic study of tomato germplasm play a significant role in crop genetic improvement. Additionally, if a development program is to be carried out, evaluation of germplasm helps to know the genetic background and breeding value of crosses in F2 generation. Variability is greatly observed in F2 generation (segregating generation), where the selection of desired genotypes and selfing them generation after generation aids in developing inbred lines. Hence the present investigation was made to analyze variability in tomato (*Solanum lycopersicum* L.) crosses under drought stress.

MATERIALS AND METHODS

The variability analysis in tomato (*S. lycopersicum* L.) crosses under drought stress was carried out at college orchard, Horticulture College and Research Institute, Coimbatore. Here, selfing was carried out in a fully developed bud of three F_1 hybrids (EC169966 × LE118, EC177824 × LE27 and Arka Ashish × LE27). The flower that was to be opened the next day was bagged with a butter paper cover to obtain genetic purity. The cover was removed after a few days for the development of fruits. Thus, the seeds were collected from the ripe fruits and were used for the F_2 generation. The seeds obtained from the crosses were sown along with their parents in a portray and then transplanted to the main field. After 7 days of transplanting, gap filling was done. After 15 days of transplanting, drought stress was imposed by restricting irrigation for seven days (Zairi *et al.*, 2003). Uniform cultural practices were followed at regular intervals to maintain the crop stand adequately. More than 150 plants were maintained in the field per cross.

RESULTS AND DISCUSSION

The variability parameters, including phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability and genetic advance as percentage of means (GAM) for three different crosses, are given in Table 1 and Table 2.

High PCV and high GCV were recorded for parameters such as fruit number per plant, yield per plant and peroxidase activity for all the crosses, *viz.,* EC169966 × LE118, EC177824 × LE27 and Arka Ashish × LE27. Characteristics such as lycopene content for the cross EC169966 X LE118 and nitrate reductase activity for the cross EC177824 × LE27 were also recorded with high PCV and high GCV. It can be inferred that selection will be effective for these traits, as there is a greater amount of variability; hence, phenotypic selection for this trait would be rewarding (Kherwa *et al.,* 2018).

Characteristics such as root length, relative water content, proline and ascorbic acid recorded moderate PCV and moderate GCV for all three crosses. However, the number of flowers per cluster, individual fruit weight, fruit length, fruit diameter, chlorophyll stability index and titratable acidity for the crosses EC177824 × LE27 and Arka Ashish × LE27 and plant height and catalase recorded moderate PCV and moderate GCV, specifying that there is a fair scope for phenotypic selection (Panchbhaiya *et al.,* 2018).

The cross EC169966 X LE118 for titratable acidity, cross EC177824 × LE27 for days to first flowering and catalase, and the cross Arka Ashish × LE27 for plant height, days to first flowering, catalase and lycopene recorded low PCV and low GCV. Hence, direct phenotypic selection for these traits would not be rewarding, and a large population may be required for further improvement (Bhandari *et al.,* 2017; Somraj *et al.,* 2017).

High heritability coupled with high GAM was noted in the number of flowers per cluster, fruit number per plant, individual fruit weight, yield per plant, relative water content, proline content, and peroxidase activity ascorbic acid content for all three crosses. Characteristics such as plant height, root length and lycopene for the cross EC169966 × LE118, root length, nitrate reductase, chlorophyll stability index, titratable acidity and lycopene for the cross EC177824 × LE27 and fruit length, fruit diameter and chlorophyll stability index for the cross Arka Ashish × LE27 were also recorded with high heritability combined with high GAM, reporting that the heritability was due to additive gene effects. Thus, selection for these traits might be effective (Sureshkumara *et al.,* 2018; Shiksha and Sharma, 2018).

Fruit traits such as fruit length, fruit diameter, and biochemical traits, *viz.,* total soluble solids, chlorophyll stability index, nitrate reductase activity, catalase activity and acidity for EC 169966 × LE 118, and characteristics such as plant height, fruit length, fruit diameter and catalase for EC 177824 × LE 27, plant height, days to first flowering, nitrate reductase, catalase, titratable acidity and lycopene for Arka Ashish × LE 27 were reported to have high heritability and moderate GAM, indicating that these effects are due to additive gene action governing the traits (Buhroy, 2017; Mamatha *et al.,* 2017).

High heritability combined with low GAM was observed for days to first flowering in EC169966 × LE118 and EC177824 × LE27 and for root length in the Arka Ashish × LE27 cross, indicating that these traits are governed by non-additive gene action. The heritability might be because of the favorable influence of environ-

Table 1. Variability analysis for different morphometric and yield parameters of tomato under drought stress

Characters	Cross	Coefficient of Variation		Heritability (BS)	GA	GAM
		Phenotypic	Genotypic			
Plant height (cm)	C1	13.36	12.24	83.89	11.50	23.09
	C2	10.40	9.64	85.90	11.08	18.40
	C3	8.45	7.97	88.87	11.54	15.47
Days to first flowering (days)	C1	10.03	6.84	46.47	2.59	9.60
	C2	5.65	4.56	65.29	1.93	7.59
	C3	6.71	5.75	73.29	2.60	10.13
Root length (cm)	C1	15.49	12.41	64.15	4.40	20.47
	C2	12.36	11.02	79.37	5.19	20.22
	C3	15.47	11.85	58.61	4.37	18.68
Number of flowers per cluster	C1	21.38	17.32	65.61	1.25	28.90
	C2	15.06	14.05	87.04	1.25	27.01
	C3	15.33	14.28	86.70	1.20	27.39
Individual fruit weight (g)	C1	21.08	19.66	87.02	10.16	37.78
	C2	19.09	16.80	77.41	9.51	30.44
	C3	18.35	16.83	84.19	8.59	31.82
Fruit number per plant	C1	28.31	26.90	90.29	10.50	52.66
	C2	28.74	25.16	76.63	8.64	45.37
	C3	27.84	23.53	71.46	7.41	40.98
Yield per plant (g/plant)	C1	40.09	38.45	92.01	415.25	75.98
	C2	38.44	36.83	91.78	436.21	72.68
	C3	34.87	33.30	91.17	319.96	65.49
Fruit length (cm)	C1	11.77	9.53	65.63	0.60	15.91
	C2	12.82	10.29	64.40	0.66	17.01
	C3	15.16	12.71	70.26	0.75	21.94
Fruit diameter (cm)	C1	12.36	9.87	63.71	0.59	16.22
	C2	13.90	10.60	58.23	0.61	16.67
	C3	14.89	12.89	74.97	0.78	23.00

C1 -EC169966 × LE118, C2 - EC177824 × LE27 and C3 - Arka Ashish × LE27

Table 2: Variability analysis for different physicochemical and biochemical parameters of tomato under drought stress

Characters	Cross	Coefficient of Variation		Heritability (BS)	GA	GAM
		Phenotypic	Genotypic			
Relative water content (%)	C1	13.46	12.76	89.88	13.70	23.86
	C2	12.80	12.80	92.52	14.66	25.36
	C3	12.83	11.96	86.90	12.85	22.97
Chlorophyll stability index (%)	C1	11.32	9.62	72.17	9.16	16.79
	C2	13.00	13.00	89.68	15.31	25.37
	C3	15.69	14.16	81.50	14.34	26.34
Proline (µ/g fresh weight)	C1	14.22	13.03	84.02	63.70	23.69
	C2	12.06	12.06	76.89	71.30	21.78
	C3	15.03	14.31	90.64	83.43	28.06
Nitrate reductase (µg NO_2/g/h)	C1	12.83	10.98	73.23	16.59	19.67
	C2	21.47	21.47	93.30	52.76	42.73
	C3	10.71	9.48	78.35	14.23	17.28
Peroxidase (changes in OD/min/g leaves)	C1	38.35	30.29	62.41	0.92	45.65
	C2	37.94	37.94	80.05	1.53	69.93
	C3	38.31	33.42	75.03	0.61	59.22
Catalase (µg of H_2O_2/g/min)	C1	12.57	10.68	72.15	1.13	17.89
	C2	9.28	9.28	76.03	1.14	16.68
	C3	8.22	7.37	79.44	0.89	13.45
Titratable acidity (%)	C1	9.35	7.34	61.54	0.06	11.86
	C2	11.87	11.87	83.38	0.10	22.33
	C3	12.16	11.52	76.05	0.09	19.05
Lycopene (mg/100 g)	C1	23.66	22.66	91.74	0.84	43.18
	C2	15.62	15.62	86.64	0.61	30.13
	C3	9.90	8.50	72.42	0.30	14.77
Ascorbic acid (mg/100 g)	C1	16.54	15.57	88.59	15.12	29.40
	C2	13.99	13.99	89.43	11.61	27.26
	C3	15.67	13.84	77.96	9.52	25.17

C1 -EC169966 × LE118, C2 – EC177824 × LE27 and C3 - Arka Ashish × LE27 ments other than genotype, so simple selection is not effective, and selection is postponed to later generations (Dar and Sharma 2011).

Thus, in the cross EC169966 × LE118, fruit number per plant, yield per plant, peroxidase activity and lycopene content, for the EC 177824 × LE27, fruit number per plant, yield per plant, peroxidase activity and nitrate reductase activity and for the cross, Arka Ashish × LE27 fruit number per plant, yield per plant, peroxidase activity are the traits that can be selected for the further breeding program. As these traits possess higher PCV and higher GCV, indicating that the impact of the environment on the expression of these traits is less. Added, these traits also have higher heritability coupled with higher GAM, showing that these traits are governed through additive gene action and simple selection can be used (Kumar *et al.,* 2013).

Conclusion

High PCV and high GCV were recorded for the number of fruits per plant, peroxidase activity, fruit yield per plant and lycopene content for all three crosses. Characteristics such as lycopene content for the cross EC169966 × LE118 and nitrate reductase activity for the cross EC177824 × LE27 were also recorded with high PCV and high GCV. High heritability coupled with high GAM was noted in characteristics such as the number of flowers per cluster, fruit number per plant, individual fruit weight, yield per plant, relative water content, proline content, peroxidase activity and ascorbic acid content for all three crosses, showing that the heritability was due to additive gene effects. Thus, the selection might be effective for such parameters. Superior segregants identified in the crosses can be advanced to the next generation to identify the better progenies.

Conflict of interest

The authors declare that they have no conflict of interest.

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