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Genetic Diversity and Morphological characterization in Tomato (*Solanum lycopersicum*)

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ABSTRACT: Tomato is a vegetable of great commercial importance in India. Collection and maintenance of the diverse lines in tomato is important. The genetic and morphological diversity studies aid in this process. The present investigation was undertaken to characterize tomato germplasm using conventional morphological descriptors and also to study the variability among them. The descriptors clearly aided in distinguishing and identifying cultivars and germplasm characterization. In the study with 18 accessions, all accessions displayed one or more definite characters (presence of green shoulders and types of fruit cracking) that can be promising to identify the same, but it was not possible to clearly identify all cultivars using a single morphological trait. Variability studies revealed highest estimates of heritability along with high genetic advance were observed for average fruit weight, fruit width, fruit length, TSS and number of locules. The study also revealed other important traits like growth habit, fruit shape, fruit size, fruit weight, number of locules and fruit yield which is useful in selecting genotypes for breeding programme.

Keywords: Descriptor, Characterization, Germplasm, Variability.

INTRODUCTION

Tomato (*Solanum esculentum* L.) bags the second position in the world among the most consumed vegetable after potato with a production of 20573 thousand tonnes from 812 thousand ha area (NHB, 2020). Tomato is number one processing vegetable and is also popular due to its high vitamin A, vitamin C, potassium, phosphorous, magnesium and calcium contents. It is also rich in lycopene and beta-carotene, an antioxidant which promotes good health. Tomato finds various uses like for fresh market, processing, and also is one among the most preferred crop for protected cultivation, the crop being highly self-pollinated due to chasmogamy. Determinate growth habit is preferred for the processing tomatoes, whereas protected cultivation requires indeterminate varieties. Hence the objective of crop improvement in tomato is ever changing such as high yield, earliness and pest and disease resistance, improved fruit quality traits etc.

Characterization and diversity assessment are two pillars important for utilizing distinctive cultivars in breeding programs and in conserving the genetic resources (Sridhar *et al*., 2022). A thorough study and evaluation of available germplasm is of great significance for both genetic and agronomic improvement of the crop (Reddy *et al*., 2013). The genetic variability and diversity existing can be evaluated and recorded using morphological, biochemical and molecular markers, morphological being the most budget friendly and accessible one.

The present study focused on the aim of characterizing and assessing the variability of tomato accessions from different breeding environments.

MATERIALS AND METHODS

The study was conducted at Department of Vegetable Science, College of Agriculture, Thrissur, during 2020-2021. The experimental material comprised of exotic lines collected from World Vegetable Center, exotic lines collected from NBPGR, New Delhi, varieties and improved lines of Kerala Agricultural University. The experiment was laid out in randomized block design (RBD) with two replications with 20 plants per plot. All crop management practices were undertaken as per the Package of Practices Recommendations–Crops, Kerala Agricultural University, (2016). The data were recorded from five plants per replication on qualitative and quantitative characters following the International Plant Genetic Resources Institute (IPGRI) descriptors for tomato (Table 1). Data on plant height, days to flowering, days to harvest, fruit length, fruit width, fruit weight, number of locules per fruit and TSS.

Coefficients of variation were calculated as per Comstock and Robinson (1952). Heritability in broad sense and expected genetic advance were worked out as per Allard (1961) and Johnson *et al.* (1955), respectively.

Table 1: IPGRI descriptor for characterization of tomato.

Traits/ descriptors	Measuring/rating scale
Plant growth habit	1=Determinate, 2=semi determinate, 3=indeterminate
Leaf type	(1=dwarf, 2=potato leaf type, 3=standard, 4=*peruvianum*, 5=*pimpinellifoilium*, 6=*hirsutum*), 9=other
Plant growth type	1 = dwarf, 2 = determinate, 3= semi determinate, 4= indeterminate
Foliage density	3=sparse, 2 = intermediate 7=dense
Leaf type	1=Dwarf 5=Pimpinellifolium, 2= Potato leaf type, 3= Standard, 4= Peruvianum,6= Hirsutum, 7= Other
Corolla colour	1=White, 2=Yellow, 3=Orange, 4=Other
Corolla blossom type	1=Closed, 2=Open
Exterior colour of immature fruit	1= greenish white, 3= light green, 5= green, 7= dark green, 9 =very dark green
Presence of green (shoulder) trips on the fruits	1=present, 0=absent
Intensity of greenback (green shoulder)	3=Slight, 5=Intermediate, 7=Strong
Predominant fruit shape	1=flattened, 2=slightly flattened, 3=rounded, 4=high rounded, 5=heart shaped, 6=long oblong, 7=pyriform, 8=ellipsoid, 9=other
Exterior colour of mature fruit	1=Green, 2=Yellow, 3=Orange, 4=Pink, 5=Red, 6=Other
Fruit shoulder shape	1=Flat, 3=Slightly depressed, 5=Moderately depressed, 7=Strongly depressed
Fruit cross-sectional shape	1=Round, 2=Angular, 3=Irregular
Shape of pistil scar	1= dot, 2= stellate, 3= linear, 4 =irregular
Fruit blossom end shape	1 =indented, 2= flat, 3= pointed
Radial cracking	1=Corky lines, 3=Slight, 5=Intermediate, 7=Severe
Concentric cracking	1=Corky lines, 3=Slight, 5=Intermediate, 7=Severe
Plant height	Quantitative
Days to flower	Quantitative
Days to harvest	Quantitative
Fruit length	Quantitative
Fruit width	Quantitative
Fruit weight	Quantitative
Number of locules per fruit	Quantitative
Soluble solids	Quantitative
Fruit yield per plant	Quantitative

RESULTS AND DISCUSSION

Characterization based on 9 quantitative and 18 qualitative characters revealed significant variation among the genotypes (Table 2). 18 genotypes recorded determinate growth habit while, 7 were semi determinate. Similar difference in growth habit was reported by Agarwal *et al*. (2014). Leaf types varied from potato leaf, standard and peruvianum types. Potato leaves and standard leaves were observed in seven accessions each while 4 accessions was grouped under peruvianum type (Fig. 1). Presence of these three types of leaves were highlighted by Bhattarai *et al*. (2018). Foliage density varied among accessions. 5 accessions recorded dense foliage, 2 recorded sparse foliage and the remaining accessions had intermediate foliage (Fig. 7). All the accessions studied had yellow coloured perfect flowers with an open corolla blossom type. These results are in line with Salim *et al*. (2018).

Fruit descriptors were more promising to be utilized in differentiating cultivars (Arvindkumar *et al*., 2003) Fruit shape and size play an important role in consumer acceptability of tomato. A good shaped fruit also ensures better packaging of the fruits and optimizes the space requirement. Besides, Fruit shape could be easily noticed and utilized for identifying tomato cultivars. In the present study, the shape of fruits ranged from round to highly rounded, flat to slightly flattened. Two accessions produced oblate or flattened fruits, whereas, slightly flattened fruits and round fruits were observed in 7 accessions. Three genotypes produced round fruits while high round fruit were observed in six accessions. The results agreed with the findings of Bhattarai *et al*. (2018), who gave reports of various fruit shapes like flattened, slightly flattened, cylindrical, rounded, high-rounded, and heart-shaped. The accessions also showed variation in the exterior colour of the immature fruits. Nine genotypes were observed with greenish-white fruits at an immature stage, while seven produced light green and one produced green (Fig. 2). This variation in colour may be due to genotypic variation among the accessions and various environmental factors (Salim *et al*., 2018). Similar color variation in fruits at immature stage were reported by Bhattarai *et al*. (2018) where he reported the existence of greenish-white, green, light green, dark green, very dark green and dark color fruits.

Table 2: Morphological Characterization of tomato genotypes as per IPGRI descriptors.

Germplasm	LE 3	LE 6	LE 7	LE 9	LE 15	LE 19	LE 22	LE 24	LE 25	LE 26	LE 27	LE 32	LE 33	LE 34	LE 35	LE 37	LE 38	LE 39
Growth habit	1	1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	2
Leaf type	3	4	4	3	2	2	3	3	2	3	3	3	2	2	2	4	2	4
Foliage density	5	5	5	5	5	5	5	5	5	5	5	7	7	7	7	3	7	3
Flower size	5	5	5	5	7	7	5	3	3	3	3	3	3	3	3	7	7	7
Corolla colour	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
corolla blossom type	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Predominant fruit shape	2	4	4	4	4	4	4	2	3	2	2	2	2	2	1	3	1	3
Fruit blossom end shape	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2
Fruit shoulder shape	3	5	1	1	1	1	1	3	3	3	3	5	5	5	5	3	3	3
Immature fruit colour	5	1	1	1	1	1	1	2	2	1	2	2	2	2	2	1	1	1
Presence of green shoulders	1	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0
Intensity of green back	7	-	-	-	-	-	-	-	-	-	-	5	-	-	-	-	-	-
External colour of immature fruit	5	1	1	1	1	1	1	3	3	3	3	3	3	3	1	1	1	1
External colour of mature fruit	5	5	5	5	5	5	5	5	5	5	5	5	5	5	5	3	3	3
Pistil scar	3	4	4	1	1	1	1	2	3	3	1	1	4	1	1	2	4	4
Radial cracking	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	-	-
Concentric cracking	-	-	-	-	-	-	-	-	-	-	-	7	-	-	-	-	-	-
Fruit cross sectional shape	1	1	1	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1

Fig. 1. Variation in leaf type observed a) potato, b) standard, c) peruvianum.

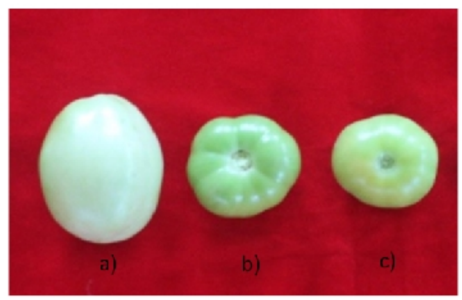

Fig. 2. Variation in immature fruit colour a) Greenish white, b) green, c) light green.

Mature fruit color was red for the fifteen accessions studied, while three gave orange coloured fruits. The results are in accordance with Parisi *et al*. (2016) who found three colour variations namely orange pink and red in tomato. Two among the studied accessions produced fruits with prominent green shoulders (Fig. 3). This is in line with the reports of Parisi *et al*. (2016); Sacco *et al*. (2015) where they emphasized the presence or absence of green shoulder in tomato. Fruit shoulder shape varied from flat, slightly depressed and moderately depressed. Four accessions produced fruits with flat shoulder, whereas, five accessions gave fruits of moderately depressed and nine showed slightly depressed fruit shoulder. These results agreed with the findings of Figas *et al*. (2014). Similar results were observed by Bhattarai *et al*. (2018) such as flat, slightly flat, notched, slightly-depressed, moderately-depressed, depressed and strongly-depressed shoulder shape. Fruit cross-sectional shape was categorized into rounded and irregular shape in the study. All accessions produced fruits with round cross section whereas, LE19 was unique in producing angular shaped fruits. All the four types of pistil scars namely dot, stellate, linear and irregular were observed (Fig. 4). This is in line with the findings of Terzopoulos and Bebeli (2010) who reported different cross sectional shapes and the presence of four types of pistil scar in tomato. Flat blossom end was observed in all the eighteen genotypes. Similar observation of predominant flat blossom end fruits was made by Salim *et al.* (2018). This character is a more stable one and is less effected by various biotic and abiotic stresses and is most reliable character for cultivar differentiation in tomato (Vishwanath *et al*., 2014). Among the studied, two accessions namely LE 32 and LE 22 exhibited fruit cracking – concentric and radial cracking respectively (Fig. 5, 6). These findings are in consonance with results of Figas *et al.* (2014) who reported radial and concentric cracking in tomato.

The analysis of variance revealed significant differences among the genotypes with respect to all the characters. The extent of variability in range, mean, genotypic co-efficient of variance (GCV), phenotypic co-efficient of variance (PCV), heritability, expected genetic advance and the expected genetic advance as per cent of mean are presented in Table 3. Plant height, fruit width and fruit weight showed high values for PCV, which indicated the influence of environment on these when compared to other characters. Majority of the characters showed moderate PCV and GCV whereas, fruit weight and yield per plant experienced a high GCV and PCV. This agreed with Patel *et al*. (2013) where they obtained moderate values for plant height, days to flowering, days to harvest and locules per fruit. High GCV and PCV for fruit weight, fruit yield per plant and moderate to high GCV and PCV was observed in fruit length and fruit width was reported in a study by Singh *et al*. (2019).

Table 3: Variability for quantitative characters in tomato.

Characters	Range	Mean	GV	PV	PCV	GCV	H^2	GA	GAM
Plant height (cm)	35.25-66.5	51.72	68.831	123.609	21.496	16.040	55.7	12.753	24.658
Days to flowering	47.5-57.9	55.09	3.141	9.619	5.629	3.216	25.7	2.086	3.786
Days to harvest	85-98.5	86.63	8.419	19.269	4.898	3.237	38.5	3.951	4.408
Fruit length (cm)	5.9-10.6	7.1	1.364	1.703	18.360	16.437	80.1	5.054	30.313
Fruit width (cm)	5.7-10.9	6.98	1.667	2.010	20.134	18.335	82.9	2.421	34.396
Fruit weight (g)	23.10-118.40	55.97	877.000	888.308	53.255	52.915	98.7	60.616	108.308
No of locules	3-4.6	3.72	0.268	0.329	15.445	13.942	81.5	22.520	25.926
TSS (^{o}brix)	4.4-7.15	6.07	0.472	0.595	12.708	11.308	79.2	1.475	20.728
Fruit yield per plant (Kg)	0.55-2.43	1.52	0.465	0.484	45.803	44.895	96.1	1.377	90.651

Fig. 3. Green (shoulder) trips on the fruit present b) absent.

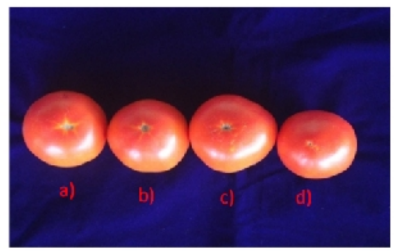

Fig. 4. Shape of pistil scars in ripe fruit a) Linear, b) Stellate, c) Irregular, d) dot.

Fig. 4(A). Variation in shape of pistil scars in ripe fruit a) Irregular, b) Linear, c) Stellate, d) dot.

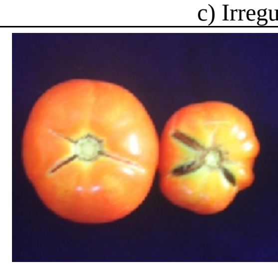

Fig. 5. Radial cracking. **Fig. 6.** Concentric cracking.

Fig. 7. Variation in foliage density a) sparse, b) intermediate, c) dense.

The relative magnitude of difference between PCV and GCV was low for all characters except plant height indicating the low influence of environmental factors on these characters. These findings suggested that selection on phenotypic basis is effective along with equal probability of genotypic values. GCV alone, cannot be used to conclude the extent of heritable variation and hence, the knowledge of heritability too is needed for selection. The genetic advance for quantitative characters helps in achieving selection. Highest heritability (broad sense) were found for average fruit weight (98.7%), fruit yield per plant followed by fruit width (82.9%), number of locules (81.5 %), fruit length (80.1 %) and TSS (79.2 %), as observed by Singh *et al*. (2019); Prakash *et al*. (2019), whereas, plant height and days to harvest exercised moderate heritability. Days to flowering recorded the lowest value for heritability at broad sense, which is in line with the results of Kerketta and Bahadur, (2019). Genetic advance as per cent of mean was highest for all characters except days to flowering and days to harvest. Highest estimates of heritability along with high genetic advance were observed for average fruit weight, fruit width, fruit length, TSS and number of locules. The above findings agreed with Tasisa *et al.* (2011).

CONCLUSION

Every genotype exhibited one or more unique characters (presence of green shoulders and types of fruit cracking) which could be used to pinpoint them. However, it was not possible to clearly identify all cultivars using a single morphological trait. This study clearly distinguished accessions with green shoulders and cracking fruits and thus these could be eliminated from being utilized in the crop improvement programme. The study helped to identify the genotypes with determinate growth habit, which could be exploited in the breeding developing processing tomatoes where mechanical harvesting could be employed. Highest genetic advance as percent of mean was observed for fruit weight followed by fruit width recorded high heritability also. The knowledge of heritability coupled with expected genetic advance suggested that these could be improved through direct selection.

FUTURE SCOPE

The study revealed the presence of ample amount of both morphological and genetic variability among genotypes studied. This information can be relied upon for future breeding programme for new varietal development and hence maximize the use of germplasm collected.

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Conflict of Interest. None.

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