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Genetic plasticity for yield and yield related traits in minicore accessions of tomato (*Solanum lycopersicum* L.)

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Abstract

Genetic plasticity for yield and quality traits in 260 minicore accessions of tomato was studied in Augmented Block Design (ABD). The genetic variability parameters were estimated for component parameters of yield. Analysis of coefficient of variation revealed that the magnitude of phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for all traits studied. High estimates of heritability and genetic gain were recorded for plant height, number of branches per plant, number of fruits per plant, number of locules per fruit, average fruit weight and total yield per plant. High level of variation was recorded for plant height (38.69 cm (Hisar Arun) (Sel-7) to 167.66 cm (VRT-101A)), number of primary branches per plant (4.08 (Fla -7421) to 11.11 (EC-620374)), number of fruits per plant (11.26 (Roma) to 286.29 (EC-520078)), number of locules per fruit (2.15 (BL-1208) to 7.23 (DMT1)), average fruit weight (1.45 g (EC-526139) to 118.76 g (EC-528372)), days to 50 per cent flowering (19.75 (Pusa Ruby) to 36.71 (EC-620370)), total soluble solids (3.00°B (WIR-13708) to 7.17°B (EC-620514)), yield per plant (7.75 kg (Pusa Ruby) to 42.75 kg (EC-520074)) and test seed weight (166.77 mg (97/754 (Kewalo) to 8596.4 mg (NDT-1)). Results suggested that straight forward simple selection for plant height, number of branches per plant, number of fruits per plant, number of locules per fruit, average fruit weight, days to 50 per cent flowering, total soluble solids, test seed weight and total yield per plant may bring significant gains in identifying superior genotypes in tomato. Accessions with desired traits can be directly used in generation of segregation population and F_1 hybrid development.

Keywords: Variability, range, heritability, genetic gain, yield, tomato

Introduction

Tomato is an important, popular and widely grown vegetable in India as well as in the world. It is grown in all seasons and consumed in a variety of forms. It is considered as ‘protective food’ due to special nutritive value and antioxidant properties including presence of lycopene and flavonoids (Sepat *et al*., 2013) [18]. However, the production and productivity of this crop in India is far below compared to the global scenario. Biotic and abiotic stresses largely contributed to the lower productivity of tomato in India. Nonetheless, higher yielding hybrids, if not the varieties, are made available by both public and private sector organizations. Most of the hybrids belongs to superior segment. There is need to develop superior varieties / hybrids for different agro-ecological conditions with specific end user requirements. Genetic diversity provides an opportunity for developing improved varieties / hybrids having production centric traits such as yield, pest resistance, disease resistance, photosensitivity, biotic stress tolerance, etc., and consumer preferred quality and taste related traits. Natural genetic variability has served as base for crop improvement ever since systematic plant breeding was started by the human. Recent advancements in of agricultural and related disciplines have added new techniques to the tools box of plant breeding. These new tools require genetic variability for engineering desired changes in the genome. Availability of desired genetic variability for the target traits determines success and pace of conventional breeding programme (Ara *et al*., 2009) [2]. The efficiency of selection depends on the nature and extent of genetic variability, degree of transmissibility of desirable characters and on the actual expected genetic gain for the character in a population (Golani *et al*., 2007) [9]. Primarily, the genetic resources enable plant breeders to create novel gene/allele genotypes that more suited to the target situation and consumer demands (Glaszmann *et al*., 2010) [8]. The magnitude of variability and the extent of heritability present in the gene pool of working collection are of utmost importance in immediate utility of germplasm in crop breeding. Tomato has great genetic diversity for most of the traits. In this study, an attempt was made to address the genetic variability, heritability and genetic gain for selected traits directly related to yield among different minicore accessions of tomato.

Material and Methods

The experimental material consisted of 260 minicore accessions of tomato (Table 1). The minicore collection was field evaluated during 2014- 2015. The experiment was laid out in Augment Block Design with checks repeating in regular intervals. A spacing of 45 cm × 60 cm and other recommended practices were followed. The observations were recorded on five randomly selected plants for plant height (cm), number of branches per plant, number of fruits per plant, number of locules per fruit, average fruit weight (g), days to 50 per cent flowering, total soluble solids (B°), test seed weight (g) and total yield per plant (kg). The analysis of variance was done as per Gomez and Gomez (1983) [10]. Phenotypic and genotypic coefficient of variation was estimated according to Burton and De Vane (1953) [4]. Heritability in broad sense and genetic advance as per cent of mean were calculated according to Allard (1960) [1] and Jhonson *et al*. (1955) [11], respectively.

Table 1: List of accessions constituting minicore collections used in the present study

Sl. No	Accessions/ germplasm	Sl. No	Accessions/ germplasm	Sl. No	Accessions/ germplasm
1	Ageta-32	41	DVRT-1	81	EC-538439
2	Angoorlata	42	DVRT-2	82	EC-538440
3	ArkaAbha	43	E-4-3	83	EC-538441
4	Arka Alok	44	EC-2791	84	EC-538455
5	Arka Meghalli	45	EC-13904	85	EC-552141
6	Arka Vikas	46	EC-317-6-1	86	EC-560340
7	Avinash-2-2-1	47	EC-273966	87	EC-570028
8	Azad T-2	48	EC-381263	88	EC-605694
9	Azad T-5	49	EC-381554	89	EC-605695
10	B-4-1	50	EC-501574	90	EC-605696
11	B-7-2	51	EC-501575	91	EC-620362
12	Bhillai	52	EC-501576	92	EC-620366
13	BL-1208	53	EC-501577	93	EC-620370
14	BTH-9 M	54	EC-501580	94	EC-620373
15	C-1-4	55	EC-501582	95	EC-620374
16	C-3-2	56	EC-501583	96	EC-620375
17	C-4-1	57	EC-519730	97	EC-620383
18	C-8-1	58	EC-520046	98	EC-620386
19	C-9-2	59	EC-520059	99	EC-620398
20	C-10-2	60	EC-520061	100	EC-620401
21	C-11-1	61	EC-520071	101	EC-620403
22	C-11-2	62	EC-520074	102	EC-620406
23	C-11-3	63	EC-520075	103	EC-620409
24	C-20-1	64	EC-520078	104	EC-620410
25	C-20-2	65	EC-521039	105	EC-620411
26	C-26-1	66	EC-521056	106	EC-620413
27	CHRT-4	67	EC-521078	107	EC-620419
28	CH-155	68	EC-526139	108	EC-620421
Sl. No	**Accessions/ germplasm**	**Sl. No**	**Accessions/ germplasm**	**Sl. No**	**Accessions/ germplasm**
29	Co-3	69	EC-528372	109	EC-620438
30	CLN-2026	70	EC-528374	110	EC-620444
31	CLN-2116	71	EC-529080	111	EC-620446
32	CLN-1621	72	EC-529083	112	EC-620455
33	CLN-2366	73	EC-538138	113	EC-620456
34	D-1-1	74	EC-538155	114	EC-620464
35	D-2-2-1	75	EC-538380	115	EC-620469
36	D-3-2	76	Ec-538404	116	EC-620470
37	D-5-1	77	EC-538405	117	EC-620474
38	DARL-66	78	EC-538408	118	EC-620476
39	Dhrubya	79	EC-538419	119	EC-620480
40	DT-10	80	EC-538423	120	EC-620486
121	EC-620500	161	H-88-78-5	201	NDT-1
122	EC-620502	162	Hawai	202	NDT-8
123	EC-620514	163	Hisar Anmol	203	NDT-4
124	EC-620519	164	Hisar Arun (Sel-7)	204	NDTVR-60
125	EC-620530	165	Hisar Lalit	205	NDTVR-73
126	EC-620533	166	I-4-4	206	NF37SB-8
127	EC-620540	167	IC-373378	207	Palam Pink
128	EC-620556	168	IC-427766	208	Pant T-3
129	EC-620568	169	IC-447708	209	Pant T-5
130	EC-620575	170	IC-469626	210	Parul
131	EC-620598	171	IIHR-01	211	Pb-Chhuhara
132	EC-625644	172	IIHR-2202	212	Pb-Upma

133	EC-625645	173	INDAM-2102	213	Persia Bed
134	EC-625651	174	INDAM-2103	214	PDT-3-1
135	EC-625652	175	INDAM-2103-1	215	PDVT-14
136	EC-625660	176	INDAM-2103-1-1	216	PKM-1
137	EC-6202041	177	INDAM-2103-4	217	PS-1
138	F-5020	178	INDAM-2103-6	218	Prestige
139	F-6022	179	INDAM-2103-6-1	219	Pusa Gaurav
140	F-6050-1	180	INDAM-2103-6-4	220	Pusa Ruby
141	F-6059	181	Jawahar-99	221	Pusa-120
142	F-7012	182	Kashi Hemant	222	Punjab Barkha Bahar-2
143	F-7025	183	Kashi Sharad	223	Pusa Hybrid-2
144	F-7028	184	Kashi Vishesh	224	Roma
145	F-6009	185	Kashi Amrit	225	Sanjeevani
146	FEB.-02	186	Kashi Anupam	226	Sankranti
147	FEB.-04	187	Kajla	227	Sel-18
148	FLA-7171	188	Kalyanpur Type-1	228	Sioux
149	FLA-7421	189	Kashmiriya	229	Solan Gola
150	Flora-Dade	190	LA-3772	230	SolanVajr
151	G-4-5	191	LA-3957	231	Sun-Cherry
152	G-5-4	192	LA-3997	232	Swarna Naveen
153	G-6-3	193	M-1-4	233	Swarna Vaibhav
154	GT-1	194	M-3-2	234	TLBR-6
155	GT-2	195	Mukthi	235	TLH-17
156	GT-3	196	Money Maker	236	TLH-27
157	H-88-78-1	197	Monte Favet	237	TLH-30
Sl. No	**Accessions/ germplasm**	**Sl. No**	**Accessions/ germplasm**	**Sl. No**	**Accessions/ germplasm**
158	H-88-78-2	198	N-2-2	238	Tripura Local
159	H-88-78-3	199	N-2-3	239	Utkal Pragyan
160	H-88-78-4	200	Nandhi	240	Utkal Raja
241	VRT-32-1	247	97/384	253	Switzerland
242	VRT-101A	248	97/753	254	Utkal Urvashi
243	WIR-3957	249	97/754 (Kewalo)	255	WIR-13717
244	WIR-5032	250	15 SB	256	Pallavi
245	WIR-13706	251	Rio Grande	257	Punjab Keshri
246	WIR-13708	252	S.Lalima	258	V. Pragyan
259	DMT1	260	DMT3		

Results and Discussion

Analysis of variance revealed a wide range of variations for all the traits studied among the 260 minicore accessions (Table 2). The *per se* variation for traits such as plant height ranged from 38.69 cm (Hisar Arun (Sel-7) to 167.66 cm (VRT-101A), number of primary branches per plant from 4.08 (Fla -7421) to 11.11 (EC-620374), number of fruits per plant from 11.26 (Roma) to 286.29 (EC-520078), number of locules per fruit from 2.15 (BL-1208) to 7.23 (DMT1), average fruit weight from 1.45 g (EC-526139) to 118.76 g (EC-528372), days to 50 per cent flowering from 19.75 (Pusa Ruby) to 36.71 (EC-620370), total soluble solids from 3.00°B (WIR-13708) to 7.17°B (EC-620514), yield per plant from 7.75 kg (Pusa Ruby) to 42.75 kg (EC-520074) and test seed weight from 166.77 mg (97/754 (Kewalo) to 8596.4 mg (NDT-1) (Table 3 and Figure 1). On the basis of different quantitative and qualitative characters observed, the genotypes *viz*., 97/754 (Kewalo), EC-520059, EC-520078, EC-528374 and EC-520074 were found promising to be used in tomato breeding programmes. The differences between phenotypic and genotypic coefficient of variation were very less but phenotypic coefficient of variation were slightly higher than the genotypic coefficient of variation for all the traits studied.

Genotypic and phenotypic coefficient of variability

The magnitude of the phenotypic coefficient of variability was higher than corresponding genotypic coefficient of variability for all the traits studied (Table 3). High phenotypic and genotypic coefficient of variability values were recorded for the traits such as number of fruits per plant (31.12% and 30.43%), test seed weight (29.70% and 27.60%) average fruit weight (25.08% and 23.09), yield per plant (22.68% and 21.67%), plant height (25.35% and 24.36%) and number of locules per fruit (24.11% and 22.81%). The minicore accessions of tomato were found to be diverse with respect to all the traits studied. The expression of phenotype was at its best. The component traits of yield such as number of fruits per plant, average fruit yield per plant and plant height known to have high phenotypic and genotypic coefficient of variation in tomato germplasm (Dar *et al*., 2011[6]; Buckseth *et al*., 2012 [3]). Further, a fruit trait such as number of locules per fruit and test weight of seed was reported to possess higher phenotypic and genotypic coefficient of variability in tomato (Rahaman *et al*., 2012 [17]; Manna and Paul, 2012 [15]).

However, moderate coefficient of variability both at phenotypic and genotypic level was recorded for total soluble solids (18.15% and 17.47%) among the minicore accessions. A total soluble solid is an inclusive parameter and it is component parameter that determines consumer preference in tomato (Kumar *et al*., 2013 [12]; Patel *et al*., 2013 [16]). Although the variability for these traits is high in some sets of germplasm, accumulation of favourable alleles for these traits in a working collection governs the realised variability (Chadha and Bhusan, 2013 [5]). On the other hand, days to 50 per cent flowering showed low values of phenotypic and genotypic coefficient of variability (8.47% and 7.13%) in the minicore collection. Although tomato crop as such known to have high diversity for this trait, depending of proportions of determinate, semi-determinate and non-determinate types of accessions have contribution to the variability to this trait (Fehmida and Ahmad, 2007 [7]; Ara *et al*., 2009 [2]).

Heritability and genetic gain

Broad sense heritability estimates ranged from (22.25%) to (97.48%) among the accessions. High heritability estimates were recorded for plant height (94.91%), number of branches per plant (91.9%), number of fruits per plant (97.48%), number of locules per fruit (94.16%), average fruit weight (94.75%), total yield per plant (91.93%) and test seed weight (87.56%). The characters like days to 50 per cent flowering (25.86%) and total soluble solids (22.25%) revealed low heritability range among the minicore accessions. Similar results were also previously reported in tomato germplasm accessions by Kumar (2010) [13].

Genetic gain is the genetic advance expressed as per cent of population mean. In the present study, genetic gain was high for plant height (46.05%), number of branches per plant (71.97), number of fruits per plant (84.1%), number of locules per fruit (73.39%), average fruit weight (48.04%), total yield per plant (67.75%), test seed weight (71.9%) and total soluble solids (39.36%). However, low genetic gain was observed for days to 50% flowering (16.74%). These traits recorded similar trends of genetic gain in the germplasm characterisation done by Kumar *et al*. (2012) [14] and Buckseth *et al*. (2012) [4].

High heritability with high estimates of genetic gain were observed for plant height (94.91% and 46.05%), number of branches per plant (91.90% and 71.97%), number of fruits per plant (97.48% and 84.10%), number of locules per fruit (94.16% and 73.39%), average fruit weight (94.75 and 48.04%), total yield per plant (91.93% and 67.75%) and test seed weight (87.56% and 71.9%). Further, low heritability was recorded for day to 50 per cent flowering (25.86 %). Similar results were also reported by Rahaman *et al*. (2012) [17] in tomato germplasm.

A high coefficient of phenotypic and genotypic variance were recorded for plant height, number of branches per plant, number of fruits per plant, number of locules per fruit, average fruit weight, total yield per plant, and test seed weight. Further, high estimates of heritability and genetic gain were recorded for plant height, number of branches per plant, number of fruits per plant, number of locules per fruit, average fruit weight, total yield per plant and test seed weight thereby suggesting that straight selection for these traits may bring worthwhile improvement in identifying superior accessions in tomato.

Table 2: Analysis of variance (ANOVA) for yield component and quality traits in minicore accessions

Source of variation	DF	Mean Sum of Squares								
		X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
Blocks	12	0.04	0.07	0.51	0.06	0.52	0.54	0.05	0.05	18.36
Entries	262	318.91**	5.71**	1641.11**	2.33**	370.65**	8.92**	2.31**	39.61**	311.54**
Checks	2	71.81**	15.21**	71.03**	2.31**	13.91**	19.51**	6.71**	274.01**	151.11**
Accessions	259	461.17**	5.61**	1733.11**	2.27**	231.41**	8.81**	3.35**	33.01**	312.51**
Checks vs. Accessions	1	9053.51**	4.41**	6321.81**	5.06**	39241.37**	5.81**	10.21**	219.50**	374.02**
Error	24	0.05	0.06	0.51	0.04	0.55	0.35	0.05	0.03	100.72

*Significant at 5 per cent probability level **Significant at 1 per cent probability level

X_1: Plant height (cm) X_2: Number of branches per plant
X_3: Number of fruits per plant X_4: Number of locules per fruit
X_5: Average fruit weight (g) X_6: Days to 50% flowering
X_7: Total soluble solids (B^O) X_8: Total yield per plant (kg)
X_9: Test seed weight (mg

Table 3: Genetic variability parameters for yield component and quality traits in minicore accessions

Trait	Range		Grand mean	PCV (%)	GCV (%)	Heritability (%)	GAM (%)
	Minimum	Maximum					
X_1	38.69	167.66	90.55	25.35	24.36	94.91	46.05
X_2	4.08	11.11	6.07	29.11	27.37	91.9	71.97
X_3	11.26	286.29	43.99	31.12	30.43	97.48	84.1
X_4	2.15	7.23	2.74	24.11	22.81	94.16	73.39
X_5	1.45	118.76	20.84	25.08	23.09	94.75	48.04
X_6	19.75	36.71	30.25	8.47	7.13	25.86	16.74
X_7	3.00	7.17	3.94	18.15	17.47	22.25	39.36
X_8	7.75	42.75	25.20	22.68	21.67	91.93	67.75
X_9	166.77	8596.40	2970.43	29.70	27.60	87.56	71.9

X_1: Plant height (cm) X_2: Number of branches per plant
X_3: Number of fruits per plant X_4: Number of locules per fruit
X_5: Average fruit weight (g) X_6: Days to 50% flowering
X_7: Total soluble solids (B^O) X_8: Total yield per plant (kg)
X_9: Test seed weight (g)

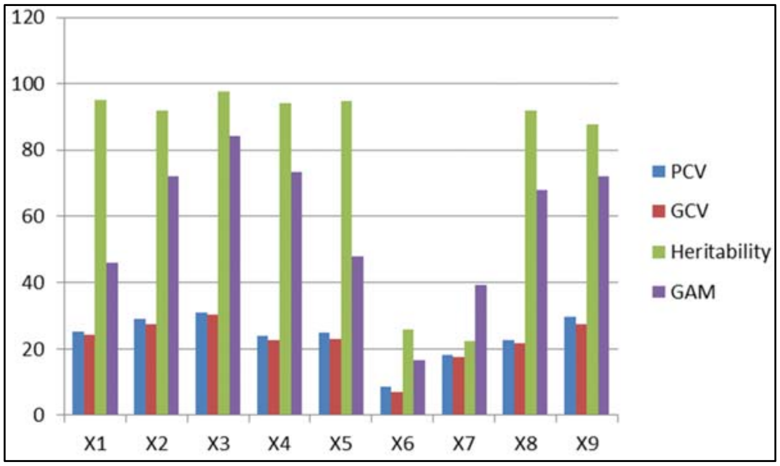

Fig 1: Frequency distribution of genetic variability parameters for yield component and quality traits in minicore accessions

Conclusion

Thus, the evaluation of 260 minicore accessions of tomato indicated a wide range of variability for different yield and quality traits. Trait such as number of fruits per plant, average fruit weight, fruit yield per plant, test seed weight, plant height, number of branches per plant and average fruit weight are the most important traits for which straight selection may bring worthwhile improvement in identifying superior minicore accessions of tomato.

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