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Genetic Variability and Association Studies in Tomato (*Solanum lycopersicon* L.) in Backcross Population of the Cross GPBT-08 × CLN2768A

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A B S T R A C T

The BC_2F_3 tomato population of the cross GPBT-08 × CLN2768A was evaluated to measure genetic variability, heritability, genetic advance and character association. Analysis of variance for each trait showed significant differences among BC_2F_3. Analysis of variance showed significant differences for all the traits studied. The study revealed the estimates of phenotypic and genotypic coefficient of variation showed the presence of variability among the BC_2F_3 for branches per plant, fruits per plant, average fruit weight, plant height and number of clusters per plant. High genotypic and phenotypic co-efficient of variation was observed for number of branches per plant (34.36 and 37.74), fruits per plant (27.49 and 28.11), average fruit weight (27.42 and 27.96), plant height (27.31 and 28.10) and number of clusters per plant (26.02 and 27.68). Significant and positive genotypic and phenotypic correlation of fruit yield per plant was observed with plant height, number of branches per plant, umber of clusters per plant, number of fruits per plant, equatorial length of fruit and fruit shape index was observed. Hence, straight selection for these traits may bring worthwhile improvement in identifying superior genotypes in tomato.

Introduction

In India as well as world tomato (*Solanum lycopersicum* L.) occupies the prime position among different vegetables and ranks second after potato. It can be grown in a variety of climatic conditions all over the world. It is highly self pollinated crop with chromosome number 24 and belongs to the family Solanaceae (Jenkins, 1948). It is highly demanding crop for fresh consumption as well as processing industry. Fresh fruits of tomato are in great demand round the year and throughout the country and also used to produce ketchup, paste, puree, juice and soup. Tomato is one of the most widely grown and eaten food crops in the world, with an annual global production of about 50 million metric tons. It is one of the most popular vegetable garden crops. India is the second largest vegetable producer after china with 11% production share in the world. It is second largest producer of tomato followed by potato at global level.

Tomato is a rich source of vitamin A, C, glutathione and mineral nutrients with preponderance of Ca, P and Fe (Dhaliwal *et al.,* 2013) and it is a main source of lycopene and other antioxidants in the human diet (Fraser, *et al.,* 2002). Antioxidant capacity is high in both fresh and processed tomatoes associated with the higher capacity to eliminate reactive oxygen species (ROS) and helps in lowering the incidence of certain forms of human cancer (Capanoglu *et al.*, 2010). Recent epidemiological studies have reported that their consumption helps to prevent cardiovascular disease (Arab *et al.*, 2000 and Jarquin-Enríquez, *et al.,* 2013) and some types of cancers, such as prostate cancer (Barber and Barber, 2002 and Shi *et al.*, 2002).

Nature and extent of genetic variability present in the population plays a major role in improving the productivity of tomato. Because of its highly self pollination, it is estimated that the genome of tomato cultivars contain <5% genetic variation of their wild species. Genetic variability is the material from which superior genotypes can be evolved after selection. Higher the amount of variability in the population, greater is the scope for improvement of yield by selection. As yield is the main objective of ant crop, it is important to have the knowledge of association between various characters which contribute to the yield. Therefore, the present investigation was conducted to determine the extent of genetic variability, heritability, genetic advance and correlation of different characters in tomato.

Materials and Methods

Present experiment was carried out at the Botany Garden, Department of Genetics and Plant Breeding, University of Agricultural Sciences, Dharwad.

The material consisting of twenty BC_2F_3 families which were developed by crossing GPBT-08 × CLN2768A by backcross method. These 20 BC_2F_3 lines were evaluated during *Rabi*, 2018. Seedlings were raised in the nursery bed and thirty days old seedlings were transplanted in the field at spacing 60cm × 60cm in randomized complete block design with two replication.

The observations were recorded for 14 characters *viz*., days to 50 per cent flowering (DFF), plant height (PH), number branches per plant (NBPP), number of cluster per plant (NCPP), number of fruits per cluster (NFPC), number of fruits per plant (NFPP), polar length of fruit (PLF), equatorial length of fruit (ELF), fruit shape index (FSI), pericarp thickness of fruit (PTF), number of locules per fruit (NLPF), total soluble solids (TSS), average fruit weight (AFW) and yield per plant (YPP) in five randomly selected plants from each genotype in each replication.

Morphological data which were taken were subjected to analysis of variance (ANOVA) as per Gomez and Gomez (1983). Genotypic and phenotypic co-efficient of variation was calculated according to Burton (1952).

Heritability and genetic advance were calculated according to Allard (1960) and genetic gain was estimated using the method of Johanson *et al.,* (1955). Genotypic and phenotypic correlations were calculated as per Al-Jibouri *et al.,* (1958). The genotypic and phenotypic correlation co-efficient were used to determine direct and indirect contribution toward yield per plant.

Results and Discussion

The analysis of variance revealed that there is a significant differences among BC_2F_3 families for all the traits studied (Table 1). These differences indicated variability in the backcross families had great opportunity for crop improvement.

Heritability estimates provides the assessment of amount of transmissible genetic variation to total variability. High variability reveals the improvement of that character is possible through selection, whereas low heritability indicates that characters are highly governed by the environment and large population has to be raised for selecting the desirable genotypes. Higher heritability was observed for the traits number of clusters per plant (98.88%), number of fruits per plant (97.16%), average fruit weight (96.51%), plant height (95.26%), days to 50 per cent flowering (95.18%) and yield per plant (94.83%) (Table 2).

Heritability alone does not provide full evidence about the amount of genetic progress. Therefore high heritability and high genetic advance is more reliable for making selection. High heritability coupled with high genetic advance was observed for number of fruits per plant (97.16% and 67.78%), number of clusters per plant (98.88% and 60.57%), average fruit weight (96.51% and 53.58%) and yield per plant (94.83% and 51.43%) (Table 2) which might be assigned to additive gene effect governing their inheritance and phenotypic selection for their improvement could be achieved by pure line selection or mass selection or bulk method or SSD method following hybridization and selection in early generations.

The phenotypic co-efficient of variation higher than genotypic co-efficient of variation for all the traits studied indicates the effect of environment on the expression of these traits (Chernet *et al.,* 2013 and Sunilkumar *et al.,* 2016). High genotypic and phenotypic co-efficient of variation was observed for branches per plant (34.36 and 37.74), fruits per plant (27.49 and 28.11), average fruit weight (27.42 and 27.96), plant height (27.31 and 28.10) and number of clusters per plant (26.02 and 27.68) (Table 2). This suggested greater phenotypic and genotypic variability among the BC_2F_3 and possibility for making further improvement in the selection. Mehta and Asati (2008) and Kumari and Sharma (2013) also reported similar results in tomato.

Association analysis

The correlation co-efficients among characters were determined at the phenotypic and genotypic levels (Table 3). Higher magnitude of genotypic correlation than phenotypic correlation co-efficient indicating predominant role of heritable factors. Positive and significant association of fruit yield per plant was observed for plant height, number of branches per plant, umber of clusters per plant, number of fruits per plant, equatorial length of fruit and fruit shape index and negative significant association was observed for days to 50% flowering. This indicates that the improvement in these traits will result in increased fruit yield per plant Singh *et al.,* (2007), Rani *et al.,* (2008) and Kumari and Sharma (2013) found similar results.

Days to flowering had significant positive correlation with number of fruits per cluster but had significant negative correlation with plant height, polar length of fruit, equatorial length of fruit, fruit shape index, average fruit weight and yield per plant. Plant height had positive significant association with number of branches per plant, number of cluster per plant, number of fruits per cluster, number of fruits per plant, fruit shape index and yield per plant.

Table.1 Analysis of variance (mean square) for yield and yield related traits in tomato

Source of variation	DF	DFF	PH	NBPP	NCPP	NFPC	NFPP	PLF	ELF	FSI	PT	NLPF	TSS	AFW	YPP
Replication	1	0.04	2.02	0.12	0.08	17.81***	0.0001	19.93	4.92	3.58	0.009	0.05	0.06	0.09	4.01
Treatment	19	28.96***	206.99***	0.099*	3.72***	141.01***	0.33***	1236.97***	65.18***	35.62***	0.02***	1.49***	0.33**	0.23*	402.76***
Error	19	0.72	5.02	0.04	0.28	0.79	0.019	17.82	4.77	3.65	0.003	0.17	0.09	0.10	7.14

* 5% level of significance, **1% level of significance and ***0.1%level of significance; **DFF**: Days to 50% flowering; **PH**: Plant height (cm); **NPB**: Number of primary branches; **NSB**: Number of secondary branches; **NCPP**: Number of clusters per plant; **NFPC**: Number of fruits per cluster; **NFPP**: Number of fruits per plant; **ELF**: Equatorial length of fruit (cm); **FD**: Fruit diameter (cm); **FSI**: Fruit shape index; **PTF**: Pericarp thickness of fruit (cm); **NL**: Number of locules; **TSS**: Total soluble solids (%); **AFW**: Average fruit weight (g); **YPP**: Yield per plant (Kg).

Table.2 Estimation of Genetic parameters for different characters under study in tomato

Trait	Mean	Minimum	Maximum	GCV	PCV	h^2 bs	GA	GAM
Days to 50% flowering	51.20	45.50	58.50	7.34	7.52	95.18	7.55	14.75
Plant height	63.53	44.45	81.15	15.82	16.21	95.26	20.21	31.80
Number of branches per plant	7.74	5.40	11.80	16.95	18.31	85.70	2.50	32.32
Number of clusters	28.32	9.30	46.40	29.57	29.74	98.88	17.15	60.57
Number of fruits per cluster	2.77	2.00	3.65	14.33	15.21	88.78	0.77	27.81
Total number of fruits per plant	73.96	19.50	120.85	33.38	33.87	97.16	50.13	67.78
Fruit length(mm)	46.04	38.10	57.85	11.94	12.85	86.36	10.52	22.85
Fruit width(mm)	43.72	38.76	53.40	9.14	10.14	81.39	7.43	16.99
Fruit shape index	1.06	0.86	1.29	9.78	11.27	75.34	0.18	17.49
Pericarp thickness(mm)	4.43	3.11	6.15	17.97	20.19	79.19	1.49	32.94
Number of locules	2.70	2.00	3.40	12.94	17.11	57.18	0.54	20.15
TSS	5.82	5.13	6.50	4.37	7.05	38.43	0.32	5.58
Average fruit weight(g)	53.12	34.81	76.65	26.48	26.95	96.51	28.46	53.58
Fruit yield per plant (Kg)	3.50	2.12	5.00	25.64	26.33	94.83	1.80	51.43

GCV: genotypic coefficient of variation; **PCV**: phenotypic coefficient of variation; **h^2 bs**: broad sense heritability; **GAM**: genetic advance as per cent mean

Table.3 Genotypic (G) and phenotypic (P) correlation co-efficients of yield and yield related traits of tomato

Trait		DFF	PH	NBPP	NCPP	NFPC	NFPP	PLF	ELF	FSI	PT	NLPF	TSS	AFW	YPP
DFF	G	1.00	-0.01	-0.29	-0.47**	0.13	-0.20	0.26	0.19	0.03	0.05	-0.49**	-0.43**	-0.27	-0.32
	P	1.00	0.12	-0.25	-0.34*	-0.18	-0.09	0.08	0.15	-0.12	0.02	-0.35*	-0.32*	-0.18	-0.18
PH	G		1.00	0.36*	0.22	0.30	0.30	0.23	0.21	0.02	0.07	0.17	-0.18	0.32	0.34*
	P		1.00	0.31	0.21	0.06	0.28	0.16	0.18	-0.07	0.06	0.06	-0.19	0.22	0.22
NBPP	G			1.00	0.44**	-0.14	0.34*	0.75	0.29	0.38*	0.14	0.01	0.26	0.04	0.27
	P			1.00	0.39*	-0.16	0.33*	0.63	0.26	0.27	0.14	0.05	0.23	0.02	0.31
NCPP	G				1.00	-0.10	0.56**	0.14	-0.40	0.83**	0.31	-0.06	0.25	0.53**	0.65**
	P				1.00	-0.10	0.51**	0.16	-0.38*	0.54**	0.26	-0.07	0.21	0.51**	0.26
NFPC	G					1.00	0.31	0.04	0.43**	-0.64**	-0.37	-0.18	0.22	-0.23	0.11
	P					1.00	0.17	0.13	0.26	-0.12	-0.34*	-0.12	0.22	-0.14	0.61**
NFPP	G						1.00	0.41	0.17	0.28	0.17	0.13	0.21	0.50	0.91**
	P						1.00	0.32	0.14	0.19	0.13	0.14	0.18	0.43**	0.01
ELF	G							1.00	0.70**	0.09	0.01	-0.14	-0.09	0.06	0.34*
	P							1.00	0.53**	0.27	-0.06	-0.13	-0.06	0.03	0.89**
FD	G								1.00	-0.75**	-0.49*	0.06	-0.23	0.10	0.14
	P								1.00	-0.59**	-0.36*	0.03	-0.19	0.04	0.23
FSI	G									1.00	0.69**	-0.22	0.17	0.00	0.25
	P									1.00	0.36*	-0.15	0.17	-0.01	0.12
PT	G										1.00	0.23	0.26	0.11	0.16
	P										1.00	0.14	0.17	0.12	0.12
NL	G											1.00	0.12	0.26	0.26
	P											1.00	0.16	0.20	0.18
TSS	G												1.00	-0.02	0.13
	P												1.00	-0.03	**0.23**
AFW	G													1.00	0.82
	P													1.00	**0.10**

* 5% level of significance, **1% level of significance and ***0.1%level of significance; **DFF**: Days to 50% flowering; **PH**: Plant height (cm); **NPB**: Number of primary branches; **NSB**: Number of secondary branches; **NCPP**: Number of clusters per plant; **NFPC**: Number of fruits per cluster; **NFPP**: Number of fruits per plant; **ELF**: Equatorial length of fruit (cm); **FD**: Fruit diameter (cm); **FSI**: Fruit shape index; **PTF**: Pericarp thickness of fruit (cm); **NL**: Number of locules; **TSS**: Total soluble solids (%); **AFW**: Average fruit weight (g); **YPP**: Yield per plant (Kg).

Number of branches per plant had positive significant association with number of clusters per plant, number of fruits per plant, polar length of fruit, fruit shape index and yield per plant and had significant negative correlation with pericarp thickness of fruit.

Number of cluster per plant had positive significant association with number of fruits per plant, fruit shape index, average fruit weight and yield per plant and had negative significant association with equatorial length of fruit. Number of fruits per cluster per plant had positive significant association with average fruit weight and yield per plant. Polar length of fruit had positive significant association with equatorial length of fruit and yield per plant. Equatorial length of fruit had negative significant association with fruit shape index and pericarp thickness of fruit (Table 3).

Thus, the present study suggests that number of fruits per plant, average fruit weight, fruit yield per plant, plant height, polar length of fruit, equatorial length of fruit and pericarp thickness of fruit are important characters for bringing the improvement through selection. Therefore, more emphasis should be given during selection for these traits.

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