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ASSESSMENT OF GENETIC VARIABILITY, HERITABILITY AND GENETIC ADVANCE AMONG TOMATO (*SOLANUM LYCOPERSICUM* L.) GERMPLASM

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ABSTRACT
The present investigation was carried out at Vegetable Research Farm, Department of Horticulture, SHIATS, Allahabad during 2012-13. The experiment was laid out in Randomized Block Design with three replications having thirty germplasm. Analysis of variance revealed significant differences among germplasm for all the traits studies, suggesting sufficient variability for yield and quality characters. The overall values of PCV were higher than those of GCV. Higher magnitude of GCV and PCV, respectively were recorded for leaf curl incidence per cent (35.45 and 35.46), followed by plant height, ascorbic acid and TSS °Brix. High values of GCV are an indication of high genetic variability among the germplasm and thus the scope for improvement of these characters through simple selection would be better. In present study, all the characters showed high heritability the magnitude of heritability ranged from 92% to 100% indicating that these traits are controlled by additive gene action which is very useful in standard selection. The traits like plant height, leaf curl incidence per cent, TSS °Brix and ascorbic acid with high GCV, PCV, heritability and genetic advance as percentage of mean, indicating that these characters are under additive gene effects and more reliable for effective selection.

INTRODUCTION

Tomato (*Solanum lycopersicon* L.) is one of the most important vegetable crops grown throughout the world because of its wider adaptability, high yielding potential and suitability for variety of uses in fresh as well as processed food industries. The red pigment in tomato (lycopene) is now being considered as the "world's most powerful natural antioxidant" (Jones, 1999). Therefore, tomato is one of the most important "protective foods" because of its special nutritive value. It is considered as an important source of vitamin A, C and minerals. In many countries it is considered as "poor man's orange" because of its attractive appearance and nutritive value.

The success of any crop improvement programme depends upon the nature and magnitude of genetic variability existing in breeding material with which plant breeder is working, choice of parents for hybridization and selection procedure (Meena and Vahadur, 2013). Genetic variability is essentially the first step of plant breeding for crop improvement which is immediately available for germplasm which is considered as the reservoir of variability for different characters (Vavilov, 1951). Phenotypic and genotypic coefficients of variation are useful in detecting amounts of variability present in germplasm. Heritability and genetic advance help in determining the influence of environment in expression of characters and the extent to which improvement is possible after selection (Robinson *et al.*, 1949). Heritable variation can be effectively studied in conjunction with genetic advance. High heritability alone is not enough to make efficient selection in segregating generation and needs to be accompanied by a substantial amount of genetic advance (Johanson *et al.*, 1955). Hence, an insight into the magnitude of variability present in available accessions of tomato is of utmost importance to a plant breeder for starting a judicious breeding programme (Kaushik *et al.*, 2011). Keeping in view of this, an attempt was made to know the nature and magnitude of genetic variability existing for yield and its contributing characters in the available germplasm of tomato.

MATERIALS AND METHODS

The present investigation was conducted at Vegetable Research Farm, Department of Horticulture, SHIATS, Allahabad during 2012-13. The experimental materials comprised of thirty indigenous germplasm of tomato collected from IIVR, Varanasi and VRS, JAU, Junagadh. The experiment was laid out in a randomized block design with three replications. Seeds were sown in the nursery bed on September, 30 and transplanting was done on 1st November, 2012. All the recommended agronomic package of practices was followed. The observation were recorded on five randomly selected plants per replication for each germplasm on fifteen quantitative characters, *viz.*, (i) plant height (cm), (ii) number of branches per plant, (iii) number of leaves per plant, (iv) days to 50% flowering, (v) number of flower clusters per plant, (vi) number of flowers per plant, (vii) number of fruits per plant, (viii) fruit set per cent, (ix) fruit weight (g), (x) radial diameter of fruit (mm),

(xi) polar diameter of fruit (mm), (xii) fruit yield per plant (g), (xiii) leaf curl incidence per cent, (xiv) TSSºB and (xv) ascorbic acid (mg/100g).

Analysis of variance was done by the method suggested by Panse and Sukhatme (1985). The genotypic and phenotypic coefficients of variation were calculated using the formulae of Burton and De Vane (1953). Heritability and genetic advance were calculated according to Allard (1960) and genetic advance as per cent of mean was estimated using the method of Johnson *et al.* (1955).

RESULTS AND DISCUSSION

Variability parameters

The extent of variability with respect to fifteen quantitative characters in thirty germplasm measured in term of mean performance, phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability, genetic advance and genetic advance as percent of mean are given in Table 2 and show in Fig 1. The success of breeding programme depends upon quantum of variability present in the available germplasm. Analysis of variance revealed significant differences among germplasm for all the traits studies indicating presence of significant variability in the materials which can be exploited through selection (Table 1). Similar results were noticed by Basavaraj *et al.* (2010), Singh and Cheema (2005), Kaushik *et al.* (2011) and Dar and Sharma (2011). The range of variation was high for fruit yield per plant (1124.48-2600.29g.), also reported by Kaushik *et al.* (2011), Haydar *et al.* (2007), Mehta and Asati (2008) and Ghosh *et al.* (2010) followed by plant height (54.92-152.64cm), number of leaves per plant (132.86 - 204.26) and leaf curl incidence per cent (11.79 - 55.18), similar finding were also reported by Golani *et al.* (2007) and Basavaraj *et al.* (2010), Shashikanth *et al.* (2010) for plant height, Kumar *et al.* (2001) for plant height and fruit yield per plant whereas the minimum range of variation was recorded for TSS ºBrix (2.46 - 6.16). The characters showing wide range of variation offers ample scope for improvement through efficient selection of desirable types. Similar reports have also been put forward by Golani *et al.* (2007) and Kaushik *et al.* (2011). In present investigation highest genotypic and phenotypic variance, respectively were recorded for fruit yield per plant (97062.21 and 98150.70) followed by plant height (555.39 and 555.95), number of leaves per plant (317.92 and 318.14), leaf curl incidence per cent (153.16 and 153.24), number of flowers per plant (90.02 and 90.36) whereas the lowest for TSS ºBrix (1.12 and 1.14). High genotypic variance indicating more contribution of genetic component for the total variation. Therefore, these characters could be considered and exploited for selection purpose whereas high phenotypic variance indicating the strong influence of environmental factors for their expression. Shashikanth *et al.* (2010) also observed high genotypic variance for most of the characters studied and high phenotypic variance for plant height and tomato leaf curl incidence.

A better idea can be gained by comparing the relative amount of coefficient of phenotypic and genotypic variance for the actual strength of variability. The estimates of phenotypic coefficient of variation (PCV) were higher than genotypic coefficient of variation (GCV) for all the traits studies which is an indicator of additive effect of the environment on the expression of the trait. Similar finding were also reported by Dar and Sharma (2011), Golani *et al.* (2007), Kaushik *et al.* (2011), Rani and Anitha (2011) and Chernet *et al.* (2013). Difference between phenotypic and genotypic coefficient of variations were less. This indicates the low impact of environment on the expression of characters and hence, they could be improved by following different phenotypic selections like directional, disruptive and stabilized selections. Higher magnitude of GCV and PCV, respectively were recorded for leaf curl incidence per cent (35.45 and 35.46), followed by plant height (30.49 and 30.50), ascorbic acid (25.71 and 25.74) and TSS ºBrix (25.24 and 25.43) indicating higher magnitude of variability for these characters. Similar finding were also reported by Narolia *et al.* (2012) for plant height, ascorbic acid and TSS, Kumar *et al.* (2001), Ahmed *et al.* (2006) and Kaushik *et al.* (2011) for plant height and Manna and Paul (2012), Shankar *et al.* (2013) for ascorbic acid. The moderate amount of GCV and PCV, respectively were recorded for average fruit weight (18.27 and 18.30), number of branches

Table 1: Analysis of variance for fifteen characters of tomato germplasm

S. No.	Source of Variance/ Characters	Mean Sum of Squares		
		Replication(d.f. = 2)	Treatment(d.f. = 29)	Error(d.f. = 58)
1.	Plant Height (cm.) at 120DAT	0.718	1666.732**	0.559
2.	No. of Branches/Plant at 120DAT	0.120	12.473**	0.166
3.	No. of Leaves/Plant at 120DAT	0.100	953.973**	0.217
4.	Days to 50 % Flowering	0.165	201.589**	0.202
5.	No. of flower clusters/Plant	0.396	11.558**	0.316
6.	No. of Flowers/Plant	0.136	270.400**	0.343
7.	Average No. of Fruits/Plant	0.004	92.438**	0.447
8.	Fruit Set (%)	0.144	184.286**	0.836
9.	Average Fruit Weight (gm.)	0.720	255.731**	0.308
10.	Radial Diameter of Fruit (mm.)	0.205	73.411**	0.259
11.	Polar Diameter of Fruit (mm.)	0.392	122.788**	0.282
12.	Fruit Yield/Plant (gm.)	1288.108	292275.128**	1088.491
13.	Leaf Curl Incidence (%)	0.075	459.558**	0.083
14.	TSS ºBrix	0.014	3.371**	0.017
15.	Ascorbic Acid (mg. /100gm.)	0.112	174.688**	0.131

** Significant at 0.1%

Table 2: Range, mean, variance, coefficient of variations, heritability, genetic advance and genetic advance as percent of mean for fifteen characters of tomato germplasm

S. No.	Characters	Range Min.	Max.	Mean	GV	PV	CV GCV (%)	PCV (%)	h^2 (bs) (%)	GA 5%	GA as % of Mean 5%
1.	Plant Height (cm.) at 120DAT	54.92	152.64	77.29	555.39	555.95	30.49	30.50	100	48.52	62.78
2.	No. of Branches/Plant at 120DAT	8.26	16.46	11.25	4.10	4.27	17.99	18.36	96	4.09	36.34
3.	No. of Leaves/Plant at 120DAT	132.86	204.26	162.68	317.92	318.14	10.96	10.96	100	36.72	22.57
4.	Days to 50 % Flowering	45.20	74.60	61.51	67.13	67.33	13.32	13.34	100	16.85	27.40
5.	No. of flower clusters/Plant	12.06	19.13	15.53	3.75	4.06	12.46	12.98	92	3.83	24.65
6.	No. of Flowers/Plant	69.86	105.46	79.61	90.02	90.36	11.92	11.94	100	19.51	24.50
7.	Average No. of Fruits/Plant	26.33	54.46	34.80	30.66	31.11	15.91	16.03	99	11.32	32.54
8.	Fruit Set (%)	24.96	55.24	44.26	61.15	61.99	17.67	17.79	99	16.00	36.15
9.	Average Fruit Weight (g.)	32.70	66.30	50.51	85.14	85.45	18.27	18.30	100	18.97	37.56
10.	Radial Diameter of Fruit (mm.)	42.63	64.47	49.19	24.38	24.64	10.04	10.09	99	10.12	20.57
11.	Polar Diameter of Fruit (mm.)	36.95	60.97	45.97	40.84	41.12	13.90	13.95	99	13.12	28.53
12.	Fruit Yield/Plant(g.)	1124.48	2600.29	1734.58	97062.21	98150.70	17.96	18.06	99	638.22	36.79
13.	Leaf Curl Incidence (%)	11.79	55.18	34.91	153.16	153.24	35.45	35.46	100	25.49	73.00
14.	TSS ^{0}Brix	2.46	6.16	4.19	1.12	1.14	25.24	25.43	98	2.16	51.59
15.	Ascorbic Acid (mg. /100g.)	17.67	43.04	29.67	58.19	58.32	25.71	25.74	100	15.70	52.90

per plant (17.99 and 18.36), fruit yield per plant (17.96 and 18.06), fruit set per cent (17.67 and 17.79), average number of fruits per plant (15.91 and 16.03), polar diameter of fruit (13.90 and 13.95), days to 50% flowering (13.32 and 13.34), number of flower clusters per plant (12.46 and 12.98), number of flowers per plant (11.92 and 11.94), number of leaves per plant (10.96 and 10.96) and radial diameter of fruit (10.04 and 10.09). Similar reports have also been put forward by Chernet *et al.* (2013) for polar diameter of fruit and days to 50% flowering, Narolia *et al.* (2012) for number of branches. High values of GCV are an indication of high genetic variability among the germplasm and thus the scope for improvement of these characters through simple selection would be better. The differences between PCV and GCV was minimum for number of leaves per plant, plant height, leaf curl incidence per cent, days to 50% flowering and number of flowers per plant suggesting that these traits were least affected by environment.

Heritability and Genetic advance

According to Johnson *et al.* (1955) and Panse (1957) with the help of GCV and PCV alone, it is not possible to determine the amount of variation which is heritable. The heritability along with genetic advance is more meaningful and helps in predicating the resultant effect of selection on phenotypic expression.

In present study, all the characters showed high heritability, the magnitude of heritability ranged from 92% to 100% indicating that these traits are controlled by additive gene action. The high values of heritability estimates in broad sense indicated that sustainable improvement can be made using standard selection procedures. Similar results were noticed by Aradhana and Singh (2003), Basavaraj *et al.* (2010), Parvinder *et al.* (2002), and Singh *et al.* (2001). Similarly, Chernet *et al.* (2013) reported high heritability estimates for TSS, fruit set per cent, days to 50% flowering, plant height and number of flowers per plant, Kumar *et al.* (2013) for plant height, number of fruits per plant, yield per plant and fruit weight, Mohamed *et al.* (2012) for plant height, fruit weight, and number of fruit per plant, Tasisa *et al.* (2011) for number of fruits per plant, plant height and days to 50% flowering, Kumar *et al.* (2001) for all characters studied, Mehta and Asati (2008) also found high heritability in broad sense for plant height and TSS.

The estimate of genetic advance showed a wide range from 2.16 for TSS ^{0}B to 638.22 for fruit yield per plant. In present study, the entire characters showed high genetic advance expressed as per cent of mean (GAM) and also showed a wide ranged from 20.57 (radial diameter of fruit) to 73.00 (leaf curl incidence per cent). This is in confirmation with the finding of Kumar *et al.* (2001) who reported high GAM for plant height, number of fruits per plant, fruit weight and fruit yield per plant and Shashikanth *et al.* (2010) for fruits per plant and fruit yield per plant. High heritability accompanied with high genetic advance were noted for fruit yield per plant (638.22), plant height (48.52), number of leaves per plant (36.72) and leaf curl incidence per cent (25.49) indicating that these characters are under additive gene effects and that these traits could be considered as reliable indices for selection and higher responses of this trait could be expected from selection. Similar

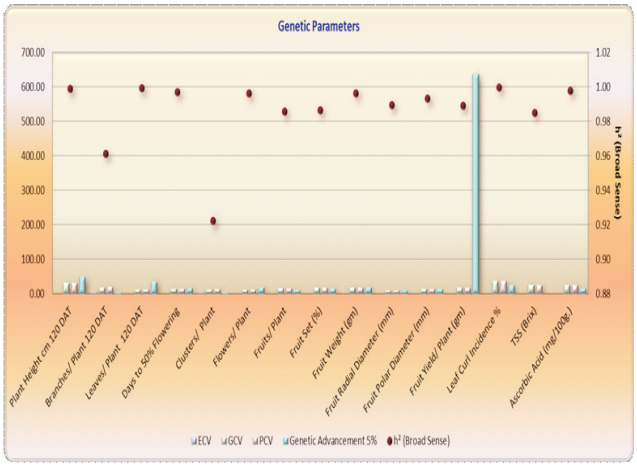

Figure 1: Range, mean, variance, coefficient of variations, heritability, genetic advance and genetic advance as percent of mean for fifteen characters of tomato germplasm

finding were also reported by Kumar *et al.* (2013) for plant height and yield per plant, Shashikanth *et al.* (2010) and Tasisa *et al.* (2011) for plant height. High heritability with low genetic advance was observed for number of branches per plant (4.09), number of flower clusters per plant (3.83) and TSS ^{0}B (2.16). Since, these characters are governed by non-additive gene action hybridization followed by selection may be used for improvement. The high heritability was associated with high genetic advance as per cent of mean for all the characters. The parallelism between the magnitude of heritability and degree of genetic gain has been due to the additive gene playing a predominant role and therefore, these were more reliable for effective selection. Similar finding were also reported by Ahmed *et al.* (2006), and Tasisa *et al.* (2011). Since the characters with high heritability coupled with high genetic gain would respond to selection better than those with high heritability along with low genetic gain (Johnson *et al.*, 1955). The traits like plant height, leaf curl incidence per cent, TSS ^{0}Brix and ascorbic acid with high GCV, PCV, heritability and genetic advance as percentage of mean. Similar results were noticed by Chernet *et al.* (2013) and Tasisa *et al.* (2011) for plant height. Therefore, this observation indicated that these characters are under additive gene effects and more reliable for effective selection.

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