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PCV, GCV, Heritability (Broad Sense) and Genetic Advance Present in Tomato Germplasm With Respect to Yield and its Components Characters

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ABSTRACT

Tomato (*Solanum lycopersicum* L. = *Lycopersicon lycopersicum* L. earlier known as *Lycopersicon esculentum* Miller) is an important vegetable crop in India. The present study involved evaluation of 153 genotypes of tomato germplasm collections. The experiment was conducted in Randomized Block Design with three replications at experimental farm of Indian Institute of Vegetable Research, Adalpura, Varanasi. The data obtained on various characters were analysed for analysis of variance, mean performance of genotypes, coefficient of variability, heritability (broad sense), genetic advance and correlation coefficients. Analyzis of variance for the design of experiments indicated highly significant differences among treatments for all characters. The entry CLN-1621, C-5-2, DMT- 1, C-10-1 and C-13-1 produced highest yield per plant. These lines also possessed average to high mean performance for most of the yield components. In general, phenotypic coefficient of variability (PCV) was higher than genotypic coefficients of variability (GCV) for all the characters. The highest phenotypic and genotypic coefficient of variability was observed for fruit weight, plant height, fruit width and number of fruit per plant, whereas days to first fruit setting, days to 50 % fruit setting and days to 50 % flowering showed moderate values. High estimates of heritability (85%) were observed for all traits. The high magnitude of heritability in broad sense coupled with genetic advance in percent of mean were observed for yield per plant, fruit weight, number of fruit per plant, number of branches per plant, locules, days to 50 % fruit setting, first fruit setting and days to 50 % flowering. A very strong and positive association of yield per plant was observed with days to 50% flowering, days to 50% fruit setting, days to first fruit setting, plant height, number of branches per plant, number of fruit per plant, fruit weight, fruit length, fruit width, locules, total soluble solid and yield per plant. However, number of branches per plant showed strong association with yield per plant in negative direction.

Keywords Tomato (*Solanum lycopersicum*), PCV, GCV, Genotypes, Heritability.

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INTRODUCTION

Tomato (*Solanum lycopersicum* L., 2n= 2x=24) is a very versatile vegetable for cul inary purposes. Ripe fresh tomato fruit is consumed as salads and after cooking fruit are utilized in the preparation of range of processed products such as puree, paste, powder, ketchup, sauce, soup and canned whole fruits. Unripe green fruits are used for preparation of pickles and chutney. The cultivated tomato is perennial, diploid, dicotyledon and belongs to the order Scrophulariales. The genus *Lycopersicon* consists of nine closely related species, namely *esculentum* and *lycopersicum*. Primitive relatives of the edible tomato occupy diverse environments based on latitude and represent an almost inexhaustible gene pool for improvement of the species (Alcazer- Esquinas 1981).

Tomato is extensively cultivated under the temperate, sub-tropical and tropical climate of the world. Usually tomato is prostrate and sexually propagated producing a strong tap root but very often it is damaged at the time of transplanting. Consequently, the lateral adventitious roots develop profusely. Ripe tomato fruits are good source of minerals and vitamins (Gopalan *et al.* 1999). The attractive red color of fruit is due to lycopene pigment and the yellow color is due to carotenoids and carotene, which the good source of vitamin A. Thus, lycopene has great beneficial effects on human health. It may also interfere with oxidative damage to DNA and lipoproteins and inhibits the oxidation of LDL (low-density lipoprotein) cholesterol.

Considering the potentiality (yield basis) of this crop, there is a need for improvement and to develop varieties suited to specific agro-ecological conditions and for specific end use. The genetic restructuring of plants is required for developing a high yielding crop variety by incorporating and/or improving the traits. The success of any crop-breeding program depends on nature and amount of genetic variability available in germplasm collection. The genetic variance of any quantitative trait is composed of additive variance (heritable) and non-additive variance and include dominance and epitasis (non-allelic interaction). Therefore, it becomes necessary to partition the observed phenotypic variability into its heritable and non-heritable components with suitable parameters such as phenotypic and genotypic coefficient of variation, heritability and genetic advance. Genetic advance can also be used to predict the efficiency of selection. The economic yield or seed yield in majority of crops is a complex entity whose manifestation results from multiplicative interaction of several yield components. Therefore, the breeder is required to simplify this complex situation by handling of the yield components. The correlation and path coefficient analysis provide information about the relative importance of the various yield components in manifestation of yield and thus, help us in formulation of appropriate selection strategy for attaining higher yield level. D^2 statistics developed by Mahalanobis (1928) provides a measure of magnitude of divergence between two groups under comparison.

Total soluble solid and yield in processing tomato are influenced by a range of factors including genetic variability and environmental condition such as temperature, nutrient availability, water and source–sink relationship within the plants. Recently, there is increasing concern about the decreasing trend of fruit solid content across the processing tomato industry. It has often viewed that T.S.S content (0^0 measured as O^0brix) within processing tomato plants at various stages of plants development may be correlated find fruits solid levels at harvest.

Therefore, studies on above aspects on the available germplasm under the environment where it is to be exploited and is essential for successful utilization of germplasm resources for the development of superior varieties. In view of the above facts, the present investigation was under taken with following objectives of "PCV, GCV, heritability (broad sense) and genetic advance present in tomato germplasm with respect to yield and its components characters".

MATERIALS AND METHODS

The material for present investigation comprised of 153 germplasm lines of tomato. Germplasm lines were grown under seed enhancement program of "NICRA" project of the division of crop improvement, IIVR, Varanasi. These germplasm lines exhibited wide spectrum of variability and collected from IARI (New Delhi) and various other institute of the country and maintained in the division (Table 1).The soil of the experimental site comprised of red soil. Before sowing a composite soil sample was drawn from the experimental area to a depth of 0-30 cm and

Table 1. Analysis of variance for twelve characters of tomato. DF - Days to 50% flowering, DFS - Days to 50% fruit setting, FSI -Days to first fruit setting, PH - Plant height, NBP -Number of branches per plant, NFP - Number of fruits per plant, Fwei - Average fruit weight, FL - Fruit length, Fwid -Fruit width, L – Loculs, TSS - Total soluble solid, YP -Yield per plant.

Source of variation	df	DF	DFS	FSI	PH	NBP	NFP
Replicate	2	16.66**	21.00**	13.25**	18.41	0.14	16.15
Treatments	152	105.82**	137.73**	86.85**	440.67**	3.88**	261.20**
Error	304	0.004	0.004	0.003	3.14	0.001	0.26

Table 1. Continued.

Source of variation	df	Fwei	FL	Fwid	L	TSS	YP
Replicate	2	27.73**	17.89	51.91	0.11**	0.04	1.15**
Treatments	152	1065.09**	248.95**	283.08**	4.30**	1.55**	2.91**
Error	304	0.05	14.31	20.02	0.001	0.163	0.006

analyzed for physical and chemical properties and the value obtained are furnished. The sowing was carried out in the nursery bed and seedlings of all genotypes were raised in nursery beds. Recommended cultural practices were taken up before and after sowing the seeds. The experimental plots were ploughed and brought into a fine tilth and raised the nursery bed, applied the recommended dose of fertilizers and farm yard manures (FYM). Seeds were sown in rows spaced at 10 cm apart, beds were watered regularly. Seedlings were raised using regular nursery practices. The experiment was laid out in Randomized Block Design (RBD). The seedlings were transplanted into the main field. Plant to plant and line-to-line distance was 60 X 45 cm. Light irrigation was given immediately after transplanting. Five competitive plants from each replication were randomly selected from recording observation for all the quantitative traits except days to 50% flowering and days to maturity, that was recorded on line basis. Average data collected from the sampled plant of each replication in various statistical analyses i.e. Days to 50% flowering, Days to 50% fruit setting, Days to first flowering, Plant height (cm), Number of branches per plant, Number of fruits per plant, Average Fruit Weight, Fruit Length (cm), Fruit Width (cm), Locules per Fruit, Total Soluble Solid, Yield per plant (kg).

RESULTS AND DISCUSSION

In order to make the effective selection one has to put attention on the component characters, which contributing to yield in positive directions. In such a situation, the available variability in the gene pool provides an opportunity for selecting superior types, which can be obtained through vigorous screening and evaluation.

The highest yield per plant was obtained in CLN-1621 and constituted the top significant group for high seed yield along with 43 entries. Among the high yielding genotypes 5 most promising genotypes in order of merit were CLN-1621, C-5-2, DMT- 1, C-10-1 and C-13-1. CLN- 1621 also exhibited above average mean performance for only number of fruit per plant. DMT-1 exhibited above average mean performance for all traits including yield. S. Gola has highest plant height and total soluble solid. Thus, the genotypes exhibiting highest mean performance such as for yield per plant, heavy fruit size, number of fruit per plant, earlier in days to 50% flowering and first fruiting, number of branches per plant, plant height, fruit length, fruit width, locule and yield per plant, respectively may be mentioned as elite lines for their probable genetic worth to be incorporated in hybridization program. Similar findings and suggestions were also reported by Srinivas (2011), Maya *et al.* (2003), Ibitoye *et al*. (2009).

The genetic variability present in the germplasm provides, the raw material for any plant breeding program on which selection acts to evolve superior genotypes. The phenotypic and genotypic coefficient of variations were estimated to assess the existing variability and presented in Table 2. The high magnitude of coefficients of variation of phenotypic as well as genotypic levels was observed for fruit weight, plant height, fruit width and number of fruit per plant. In tomato, days to first fruit setting, days to 50 % fruit setting and days to 50 % flowering showed moderate values of phenotypic and genotypic coefficients of variability. In general the phenotypic coefficient of variability was higher than genotypic coefficients of variability which indicated that environment influenced considerably in expression of these traits. The similar results were reported by Prema *et al.* (2011), Tayal *et al.*(1959).

The high magnitude of heritability in broad sense coupled with genetic advance in per cent of mean were observed for yield per plant, fruit weight, number of fruit per plant, number of branches per plant, locules, days to 50 % fruit setting, first fruit setting and days to 50 % flowering (Table 2) and indicated good response of selections for these characters. The existence of high heritability with moderate genetic advance in per cent of mean expressed for fruit length and plant height that these characters may also provide good response to selection owing to their moderate transmissibility and variability. The estimates of heritability and genetic advance for most of the characters under study in accordance with earlier reports by Tausa *et al*. (2011), Tayal *et al*. (1959).

The yield or economic yield, in almost all the crops, is referred to as super characters, which results from multiplicative interactions of several other characters that are termed as yield components. Thus, identification of important yield components and information about their interrelationship with each other will be very useful for developing efficient breeding strategy for developing high yielding variety. In this respect, the correlation coefficient, which provides symmetrical measurement of degree of association between two variables or characters, help us in un-

Table 2. Mean, range, genotypic and phenotypic coefficient of variability, heritability (broad sense), genetic advance and genetic advance in % of mean for 12 traits in Tomato. DF - Days to 50% flowering, DFS - Days to 50% fruit setting, FSI -Days to first fruit setting, PH - Plant height, NBP -Number of branches per plant, NFP - Number of fruits per plant, Fwei - Average fruit weight, FL - Fruit length, Fwid -Fruit width, L – Loculs, TSS - Total soluble solid, YP -Yield per plant.

Sl. No.	Traits	Grand mean (□X) + SE	Rang	Coefficient of variability		Heritability (broad sense)	Genetic advance	Genetic advance in % mean
				Genotypic	Phenotypic			
1	DF	33.83±0.03	19.38-48.96	35.27	35.27	1.00	12.23	36.16
2	DFS	37.78±0.04	17.34-47.94	45.91	45.91	1.00	13.96	36.94
3	FSI	30.01±0.03	15.30-42.84	28.95	28.95	1.00	11.08	36.93
4	PH	71.02±1.02	41.92-95.49	145.85	146.89	0.99	24.79	34.91
5	NBP	3.10±0.01	1.01-6.06	1.29	1.29	1.00	2.34	75.61
6	NFP	20.45±0.29	5.07-75.47	86.98	87.07	1.00	19.20	93.91
7	Fwei	39.96±0.12	8.53-102.30	355.01	355.03	1.00	38.81	97.13
8	FL	47.78±2.18	24.73-71.47	78.21	82.98	0.94	17.69	37.02
9	Fwid	52.01±2.58	24.50-75.83	87.69	94.36	0.93	18.60	35.75
10	L	3.50±0.00	2.05-8.20	1.43	1.43	1.00	2.47	70.41
11	TSS	4.21±0.23	1.99-6.10	0.46	0.52	0.89	1.33	31.47
12	YP	1.48±0.04	0.12-5.42	0.97	0.97	1.00	2.03	136.53

derstanding the nature and magnitude of association among yield and yield components.

In present study a very strong and positive association of yield per plant was observed with days to 50% flowering, days to 50% fruit setting, days to first fruit setting, plant height, number of branches per plant, number of fruit per plant, fruit weight, fruit length, fruit width, locules, total soluble solid and yield per plant. However, number of branches per plant showed strong association with yield per plant in negative direction. Total soluble solid exhibited highly significant and positive association with plant height, whereas locules was highly significantly and positively correlated with fruit weight and fruit width, while it was significantly and negative correlated with fruit weight, fruit length and number of branches per plant. Fruit width exhibited highly significantly and positive correlation with days to 50% fruit setting, fruit weight and fruit length, while it was significantly and negative correlated with number of fruit per plant. Simillar finding were also reported by Yadav and Singh (1998), Hindayatulah *et al*. (2008). Thus, these characters emerged as most vital component traits associated positively with yield per plant. However, negative association among yield per plant and number of branches per plant which appeared to be tightly linked together in present study, needs attention to be broken by applying suitable breeding techniques.

Path coefficient analysis is a tool to partition the observed correlation into direct and indirect effects of yield components on yield which provide clearer picture of character association for formulating efficient selection strategy. Path coefficient analysis differs from simple correlation in that in point out the course and their relative importance, whereas, the later measures simply the mutual association ignoring the causation. In the present study the path coefficient analysis was estimated at phenotypic and genotypic level (Table 3). A very high positive direct contribution towards yield per plant was exhibited by fruit weight, plant height, fruit width at both phenotypic as well as genotypic level. Similar findings were also reported by earlier workers. Number of pods per plant exerted highest indirect effect on yield per plant via fruit length and fruit width. The indirect effect on Number of branches per plant, number of fruit per plant and total soluble solid through days to 50 % flowering and number of branches per plant, number of fruit per plant, fruit weight, locule and total soluble solid through days to 50% fruit setting and days to first fruit setting had made considerable indirect negative contribution on yield at genotypic and phenotypic level. The contribution of residual factors forwards variation in yield was very low (-0.333).

The above discussions also revealed that important yield component effect directly like fruit weight, plant height and number of fruit per plant and indirect component such as number of branches per plant, number of fruit per plant and total soluble solid exhibited substantial positive effects via some other character. The occurrence of negative as well as positive indirect effects on yield by one or another character presents a complex situation where a com-

Table 3. Correlation for different traits in tomato germplasm. *, **Significant at 5% and 1% probability level. DF - Days to 50% flowering, DFS - Days to 50% fruit setting, FSI -Days to first fruit setting, PH - Plant height, NBP -Number of branches per plant, NFP - Number of fruits per plant, Fwei - Average fruit weight, FL - Fruit length, Fwid -Fruit width, L – Loculs, TSS - Total soluble solid, YP -Yield per plant.

Traits	DF	DFS	FSI	PH	NBP	NFP	Fwei	FL	Fwid	L	TSS
DFS	0.61**										
FSI	0.63**	0.55**									
PH	0.13	0.22**	0.10								
NBP	-0.10	-0.21*	-0.02	0.14							
NFP	-0.20*	-0.35**	-0.13	-0.05	0.25**						
Fwei	0.10	-0.16*	-0.07	-0.07	0.23**	0.01					
FL	0.20*	0.20*	0.06	0.11	-0.20*	-0.27**	0.21*				
Fwid	0.13	0.18*	0.00	0.08	-0.04	-0.31**	0.20*	0.63**			
L	0.08	-0.06	-0.06	0.04	0.09	-0.06	0.26**	-0.01	0.23**		
TSS	-0.13	-0.01	-0.07	0.24**	-0.18*	-0.11	-0.30**	-0.20*	-0.11	-0.08	
YP	-0.04	-0.34**	-0.14	-0.17*	0.34**	0.62**	0.72**	-0.01	-0.02	0.15*	-0.31**

promise balance is required to attain proper balance of different yield component, for determining the ideotype of yield in tomato.

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