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Studies on Genetic variability, Heritability, Genetic Advance and Trait Association in Tomato (*Solanum lycopersicum* L.)

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ABSTRACT: The present investigation was planned to estimate the variances between genotype and within genotype, to estimate genetic parameters and to identify superior genotype for further utilization at Department of Vegetable Sciences, Horticultural Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during *Rabi* season 2019-2020. Here fifteen tomato genotypes were evaluated in randomized block design with three replications. Based on analysis of variance along with genetic parameters *viz.*, range, means, GCV, PCV, heritability and genetic advance significant differences were observed for all twenty characters. On mean performance of tomato genotypes, it was found that the genotype 2019/TODVAR-9 followed by 2019/TODVAR-8 and Pant Tomato 3 recorded significantly higher yield per hectare and were most suitable for Raipur region. For all the parameters, PCV estimates were greater than GCV indicated that environmental factors stimulating the expression of all parameters. Occurrence of high heritability as well as genetic gain was recorded for the traits; secondary branches, days to first flowering, days to first fruiting, days to fruit maturity, fruit weight, polar diameter, equatorial diameter, pericarp thickness, calyx length, acidity and yield per plant. These indicated the influence of additive gene effect in heritability of these parameters. Hence, these traits are important for improvement of the genotypes therefore, these trials are important for further improvement of the genotypes.

Keywords*:* Heritability, Genetic variability, Genetic advance.

INTRODUCTION

Tomato (*Solanum lycopersicum* L.) with chromosome number 2n=24 belongs to the nightshade family Solanaceae. It is grown practically in all over the world in field conditions, greenhouses, net houses and in kitchen garden. Its cultivation and production has increased remarkably due to its various uses like raw for salad, cooked as vegetable and processed in different forms as soup, sauces, ketchups, preserves, paste and puree (Tiwari and Choudhury 1986). Apart from being tastier, tomato fruits are good source of vitamins, minerals and organic acids. Even though, the vitamins only account limited proportion of the total dry matter but they are highly nutritional. The area, production and productivity in India is 825000 ha, 20148000 MT, and 24.42 MT ha^{-1} respectively (1^{st} Advance Estimate in 2020-2021). Availability of genetic variability is the prerequisite for almost all breeding programme. In tomato, conventional breeding methods have been extensively used for developing new genetic variation in crop plants during improvement programme. The breeding strategy to obtained high yielding genotype depends upon the nature and magnitude of variation for various yield components, the assessment of genetic parameters like phenotypic coefficient of variation (PCV), genotypic coefficient of variation (GCV), heritability (h^2_{bs}) and genetic advance (GA%) is apre-requisite criteria for the effective selection. Hence, the important objective in tomato improvement is oriented to develop varieties, which have high yielding potential.

MATERIALS AND METHODS

The investigation was conducted at the Horticultural Research cum Instructional Farm, Department of vegetable Sciences, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during Rabi season 2019-20. The fifteen genotypes were planted in randomized block design with three replications. They were evaluated for yield as well as yield attributing traits. Observations were recorded on single plant basis from five randomly tagged competitive plants of each genotype for all the traits separately. Overall mean was computed over the replications. The analysis of variance for design of experiment was done for partitioning the variance into treatments and replications according to procedure given by Panse and Sukhatme (1967). Genotypic and phenotypic coefficients of variance were estimated according to Burton and Devane (1953) based on estimate of genotypic and phenotypic variance. The broad sense heritability (h^2_{bs}) was estimated by following the procedure suggested by Weber and Moorthy (1952) and Genetic advance as percent of mean was categorized as low, moderate and high as given by Johnson *et al.*, (1955).

RESULTS AND DISCUSSION

A. Analysis of variance

The analysis of variance indicated that mean sum of squares for most of the traits *viz.* plant height, number of primary branches, number of secondary branches, days to first flowering, days to fifty percent flowering, number of flower per cluster, days to first fruit setting, days to fruit maturity, fruit weight, polar diameter, equatorial diameter, number of fruit per cluster, pericarp thickness, calyx length, acidity, pulp juice ratio, fruit yield per plant, fruit yield per plot and fruit yield per hectare are highly significant at 1% and 5% level of significance. This indicated the presence of high degree of genetic heterogeneity among different tomato genotypes.

Table 1: Analysis of variance for yield and its components in Tomato.

Sr. No.	Observations	Mean sum of square		
		Replication	Genotype	Error
	d.f.	02	14	28
1.	Plant height (cm)	66.100	83.920*	38.881
2.	Number of primary branches	0.2900	7.04**	0.456
3.	Number of secondary branches	0.0900	22.09**	0.565
4.	Days to first flowering	3.360*	29.93**	0.760
5.	Days to fifty percent flowering	0.4700	32.28**	1.443
6.	No. of flowers per cluster	0.5300	0.78**	0.192
7.	Days to1st fruit setting	0.0200	9.18**	0.546
8.	Days to fruit maturity	0.0700	33.62**	0.900
9.	Fruit weight	6.6200	192.77**	11.645
10.	Polar diameter of fruit	0.0100	0.41**	0.017
11.	Equatorial diameter of fruit	0.0200	1.28**	0.027
12.	No. of fruit per cluster	0.300	0.85**	0.106
13.	Pericarp thickness	0.1800	3.64**	0.082
14.	Calyx length	0.040*	0.13**	0.012
15.	T.S.S.	0.0100	0.0600	0.045
16.	Acidity	0.01**	0.02**	0.001
17.	Pulp juice ratio	0.03**	0.03**	0.010
18.	Fruit yield per plant (kg)	0.020*	0.29**	0.005
19.	Fruit yield per plot (kg)	25.340*	384.12**	5.985
20.	Fruit yield per hectare (q)	897.620*	14047.57**	226.737

*Significant at 5% level of significant, ** Significant at 1% level of significant

B. Genetic parameters of variability

Range and mean: The plant height ranged from 50.37 cm (2019/TODVAR-6) to 74.31 cm (2019/TODVAR-9). The plant height was found highest for genotype 2019/TODVAR-9 (74.13 cm), which was followed by 2018/TODVAR-2 (61.82 cm) and 2019/TODVAR-3 (61.53 cm) with the general mean of 58.41 cm. The number primary of branches per plant ranged from 9.67 (2019/TODVAR-7) to 4.33 (2019/TODVAR-6). The maximum values of number of branches per plant was observed in the genotype 2019/TODVAR-7 (9.67) followed by 2019/TODVAR-6 (8.67) and 2019/TODVAR-8 (8.67), while the minimum values of number of branches per plant was observed in genotype 2018/TODVAR-1 (4.33). The number secondary of branches per plant ranged from 17.33 (2019/TODVAR-7) to 7.67 (2018/TODVAR-1) with the general mean of 11.71. Days to first flowering varied from 16 days (2019/TODVAR-1) to 26.67 days (2019/TODVAR-8) with general mean of 21.98 days. The earliest days to first flowering was obtained in genotype 2019/TODVAR-8 (26.67 days) and the genotype 2019/TODVAR-7 (26.33 days) was at par with the genotype 2019/TODVAR-8, whereas, the genotype 2019/TODVAR-1 found to be late flowering among all the genotype. Days taken to 50% flowering ranged from 30.33 days (2019/TODVAR-6) to 40.67 days (2019/TODVAR-7) with overall mean of 34.20 days. The genotype 2019/TODVAR-6 (30.33 days) took least number of days to reach 50% flowering which were followed by 2019/TODVAR-5 (31 days) and Pant Tomato 3 (31 days).

The genotypes 019/TODVAR-7, 2018/TODVAR-5 and 2018/TODVAR-3 taken longest number of days for 50% flowering. The number of flowers per cluster varied from 4.03 (2018/TODVAR-5) to 5.49 (Pant Tomato-3) with overall average of 5.02. Similar findings were also reported by Kerketta *et al*., (2018, Kiran *et al*., (2018); Prakash *et al*., (2019). The maximum number of flowers per cluster was recorded in genotype Pant Tomato-3(5.49) and 2019/TODVAR-8 (5.49) followed by2019/TODVAR-9 (5.44), 2019/TODVAR-1 (5.33) and 2019/TODVAR-7 (5.15), were at par with the genotype Pant Tomato-3, whereas, minimum number of flowers per cluster were found in genotype 2018/TODVAR-5 (4.03) followed by 2018/TODVAR-6 (4.16). The range for days to first fruiting varied from 30.33 days (2019/TODVAR-7) to 35.67 days (Pant Tomato 3) with general mean of 33.30 days. The earliest days to first fruiting was obtained in the genotype Pant Tomato-3 (35.67 days) followed by the genotype 2019/TODVAR-3 (35.33 days) and 2018/TODVAR-6, whereas, the genotype 2019/TODVAR-7 was taking lesser number of days to first fruiting among all the genotype. The mean values for days to fruit maturity varied from 60.33 days (2019/TODVAR-6) to 70.67 days (2019/TODVAR-7) with general mean of 64.33 days. The earliest days to fruit maturity was obtained in the genotype 2019/TODVAR-6 (60.33 days) followed by the genotype 2019/TODVAR-5 (69.67 days) and 2019/TODVAR-3 (68.67 days), whereas, the genotype 2019/TODVAR-6 was taking lesser number of days to first maturity among all the genotype. The polar diameter ranged from 4.08 cm (2019/TODVAR-3) to 5.25 cm (2019/TODVAR-8) with the general mean 4.60 cm. The genotype 2019/TODVAR-8 (5.25 cm)

recorded for maximum polar diameter followed by the genotypes 2019/TODVAR-9 (5.06 cm) and 2019/TODVAR-6 (5.05 cm), while the genotype 2019/TODVAR-3 (4.08 cm) showed minimum polar diameter. Weight of the fruit (g) exhibited a range of 58.74 g (2018/TODVAR-3) to 89.61 g (2019/TODVAR-9). The maximum weight of fruit was found in the genotype 2019/TODVAR-9 (89.61 g) followed by 2019/TODVAR-8 (5.49 g) and Pant Tomato 3 (5.93 g), whereas, the minimum weight of fruit was recorded in the genotype 2018/TODVAR-3 (4.03 g) and 2018/TODVAR-6 (4.16 g).Among all the genotype, the number of fruits per cluster ranged from 2.67 (2018/TODVAR-6) to 4.47 (2019/TODVAR-9) with the grand mean of 3.68. The maximum number of fruits per cluster was obtained in genotype 2019/TODVAR-9 (4.47) followed by Pant Tomato-3 (4.40), whereas, the minimum number of fruits per cluster was recorded in 2018/TODVAR-6 (2.67) and 2018/TODVAR-5 (2.73).Similar result also reported by Regassa *et al*. (2012), Kanaujia *et al*. (2016) and Kiran *et al*. (2018). Among all the genotypes, pericarp thickness ranged from 1.62 mm (2019/TODVAR-1) to 4.93 mm (2018/TODVAR-5). The maximum pericarp thickness was obtained in the genotypes 2019/TODVAR-8 (4.77 mm), 2019/TODVAR-9 (4.93 mm), Pant Tomato 3 (4.58 mm) followed by 2018/TODVAR-2 (4.51 mm), whereas, the minimum pericarp thickness was found 1.62 mm in the genotype 2019/TODVAR-1.

Table 2: Genetic parameters of variation for yield and its component characters in tomato.

Character	Range		Mean	Coefficient of variation		Heritability (H^2%)	Genetic advance as % of mean
	Min.	Max.		G.C.V.	P.C.V.		
Plant height (cm)	50.37	74.31	58.41	6.63	12.57	27.86	7.21
Number of primary branches	4.33	9.67	6.84	21.65	23.79	82.81	40.58
Number of secondary branches	7.67	17.33	11.80	22.87	23.76	92.70	45.36
Days to first flowering	16.00	26.67	21.98	14.19	14.73	92.75	28.15
Days to fifty percent flowering	30.33	40.67	34.20	9.37	10.01	87.69	18.08
No. of flowers per cluster	4.03	5.93	5.02	8.86	12.44	50.75	13.00
Days to1st fruit setting	30.33	35.67	33.04	5.14	5.60	84.06	9.70
Days to fruit maturity	60.33	70.67	64.33	5.13	5.34	92.38	10.16
Fruit weight	58.74	89.61	68.87	11.28	12.32	83.83	21.28
Polar diameter of fruit	4.08	5.25	4.60	7.87	8.37	88.49	15.26
Equatorial diameter of fruit	4.06	6.35	4.76	13.61	14.04	93.92	27.17
No. of fruit per cluster	2.67	4.47	3.68	13.53	16.17	69.95	23.30
Pericarp thickness	1.62	4.93	3.28	33.26	34.38	93.55	66.26
Calyx length	1.55	2.23	1.92	10.44	11.88	77.45	18.93
T.S.S.	4.27	4.67	4.53	1.28	4.85	6.98	0.70
Acidity	0.60	0.88	0.70	11.85	12.86	86.04	22.65
Pulp juice ratio	0.65	1.01	0.78	9.72	15.85	37.55	12.27
Fruit yield per plant (kg)	1.05	1.93	1.51	20.34	20.83	95.31	40.90
Fruit yield per plot (kg)	37.80	69.36	54.69	20.57	21.05	95.47	41.39
Fruit yield per hectare (q)	19.43	35.64	28.03	20.37	20.87	95.31	40.97

Where, GV-Genotypic Variance, PV-Phenotypic Variance, EV-Environmental Variance, PCV-Phenotypic Coefficient of Variance, GCV-Genotypic Coefficient of Variance,H2bs-Heritability in Broad Sense, GA-Genetic Advance as per cent mean

Phenotypic coefficient of variances and genotypic coefficient of variances: The PCV was slightly greater than corresponding GCV, which showed the impact of environment in the expression of various characters under study. The GCV ranged from (1.28) for TSS to (33.26 for) pericarp thickness. Similarly, PCV ranged from (4.85) for TSS to (34.38) for pericarp thickness. High magnitude of GCV as well as PCV were observed for the characters viz., pericarp thickness (33.26% and 34.38%), number of branches primary branches(21.65 % and 23.79 %), secondary branches (21.65 % and 23.76 %) and fruit yield per hectare (20.37 % and 20.87 %). Suggested these characters' account for high variation in tomato. These findings were in accordance with results of Somraj *et al.*, (2017). Saravanan *et al.*, (2019) and Verma (2020).

Heritability and Genetic advance: High estimate of heritability was recorded for yield per plant (95.31%), equatorial diameter (93.92%), pericarp thickness (93.53%), secondary branches (92.69%), days to first flowering (92.75%), 50% flowering (87.69%), days to first fruiting (84.06%), days to fruit maturity (92.377%), fruit weight (83.83%), polar diameter (88.49%), acidity (86.04%), and primary branches (82.814 %) and calyx length (77.45%). The moderate heritability was recorded in case of flowers per cluster (50.75%) and number of fruits per cluster (69.95%). The heritability percent recorded least in plant height (27.86%), TSS (6.98%) and pulp juice ratio (37.55%). These characters are under the influence of additive gene effect and therefore suggested that any selection in tomato based on phenotype of these characters will be effective in fruit yield. The genetic advances as per cent mean recorded highest with the parameters *viz*., pericarp thickness (66.26 %), number of branches (primary branches (40.58 %) & secondary branches (45.36 %)), yield per plot (41.39 %), yield per plant (40.90 %), yield per hectare (40.97 %), days to first flowering (28.15 %), fruit weight (21.28 %), equatorial diameter (27.17 %), number of fruits per cluster (23.30 %), acidity (22.65 %), calyx length (18.93 %). The variability such as days to 50% flowering (18.08 %), polar diameter (15.26 %), pulp juice ratio (12.27 %) and days to fruit maturity (10.16 %) recorded moderate genetic advances as per cent of mean and the rest of the variability showed lowest genetic advances as per cent of mean. Similar findings were reported by Vyas *et al*,. (2011) and Prajapati *et al*., (2015) and finally concluded

that estimates of heritability along with genetic advance are more reliable than the heritability estimates alone for identifying the suitable individual.

CONCUSIONS

In the present investigation most of the parameters showed significant mean sum of square except TSS content, which indicated that sufficient amount of variability is present among different genotypes. Based on mean performance of tomato genotypes it were found that the genotype 2019/TODVAR-9 followed by 2019/ TODVAR-8 and Pant Tomato 3 recorded significantly higher yield per hectare and were most suitable for Raipur region. For all the parameters the PCV estimates was greater than GCV indicated that environmental factors stimulating the expression of all parameters. Occurrence of high heritability as well as genetic gain was recorded for the traits secondary branches, days to first flowering, days to first fruiting, days to fruit maturity, fruit weight, polar diameter, equatorial diameter, pericarp thickness, calyx length, acidity and yield per plant. These indicated the influence of additive gene effect in heritability of these parameters. Hence, these traits are important for improvement of the genotypes hence, these trials are important for further improvement of the genotypes.

FUTURE SCOPE

This assessment precise improvement on tomato breeding programme and present efforts in tomato at Department of Vegetable Sciences, Horticultural Research cum Instructional Farm, Indira Gandhi Krishi Vishwavidyalaya, Raipur, Chhattisgarh during *Rabi*season 2019-2020. In addition, it points out latent challenges in using tomato genotypes and depicts future perspectives in tomato breeding programme with the emerging knowledge from tomato breeding programme.

Conflict of Interest. The authors have not affirmed any conflict of interest.

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