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Khushbu Kumari
Department of Horticulture Vegetable & Floriculture, Bihar Agricultural College, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Shirin Akhtar
Department of Horticulture Vegetable & Floriculture, Bihar Agricultural College, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Suman Kumari
Department of Horticulture Vegetable & Floriculture, Bihar Agricultural College, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Manish Kumar
Department of Horticulture Vegetable & Floriculture, Bihar Agricultural College, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Komal Kumari
Department of Horticulture Vegetable & Floriculture, Bihar Agricultural College, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Neha Kumari Singh
Department of Horticulture Vegetable & Floriculture, Bihar Agricultural College, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Aditya Ranjan
Department of Horticulture Vegetable & Floriculture, Bihar Agricultural College, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Corresponding Author:
Khushbu Kumari
Department of Horticulture Vegetable & Floriculture, Bihar Agricultural College, Bihar Agricultural University, Sabour, Bhagalpur, Bihar, India

Genetic variability and heritability studies in diverse tomato genotypes

Khushbu Kumari, Shirin Akhtar, Suman Kumari, Manish Kumar, Komal Kumari, Neha Kumari Singh and Aditya Ranjan

Abstract
Tomato is one of the most important solanaceous vegetable that can be grown throughout the year, although its main cultivation season is autumn-winter. The present experiment was conducted utilizing twenty-five diverse genotypes of tomato in the autumn-winter season of 2018-19 for assessing the variability, heritability and genetic advance for different growth, reproductive, fruit morphological, yield and important quality attributes. High degree of variability was observed for all the traits that showed the traits were suitable for selection for further breeding purposes. GCV was higher than PCV for all the characters under study. High PCV, GCV and heritability coupled with high genetic gain was observed for plant height, number of fruits per truss, polar diameter, equatorial diameter, pericarp thickness, locule number, average fruit weight, fruit number per plant, yield per plant, TSS, lycopene content, β-carotene content and total yield. This indicated that additive gene action plays a major role in governing these traits and these traits can be improved by simple selection in earlier generations.

Keywords: GCV, PCV, variability, heritability, genetic advance

Introduction
Tomato is one of the important solanaceous vegetable that can be grown round the year but its main season is autumn-winter. It is grown throughout the world due to its wider adaptability, high yielding potential, variety of uses in fresh as well as processed food industries and its health benefits. It is a pre-dominantly self-pollinated crop with chromosome number 2n = 2x = 24. The red colour of tomato is due to presence of lycopene pigment which is the world's most powerful natural antioxidant (Jones, 2000) [12]. Ripe tomatoes are rich sources of nutritive quality compounds, especially carotenoids such as lycopene, β-carotene (provitamin A) and ascorbic acid besides minerals like calcium, phosphorus and iron (Beecher, 1998) [4]. Tomato and its products, when consumed regularly, help in reduction of carcinogenesis, particularly prostate and mouth cancer. The antioxidants in tomato *viz*., carotenoids, particularly lycopene, beta-carotene, ascorbic acid, vitamin E, phenolic compounds and flavonoids are the reason for the health benefits (Frusciante, 2007) [9]. The crop is cultivated in an area of 0.809 million hectares in the country, producing 19.697 million metric tonnes yield with an average national productivity of 24.36 metric tonnes per hectare (Anonymous, 2017) [9]. The selection of genotype for breeding programme is based on variability present. So for estimating the variability present in the genotypes the phenotypic coefficient of variance, genotypic coefficient of variance, heritability, genetic advance and genetic advance as percent of mean has to be calculated.

Material and Methods
The present investigation was carried out at the Vegetable Research Farm of Bihar Agricultural University, Sabour, Bhagalpur located at 25º 15' 40" N latitude and 80º 2' 42" E longitude and altitude of 46m above mean sea level of India. Twenty five different lines of tomato were used to study variability among them. Randomized block design with three replications was laid out to carry the experiment maintaining a spacing of 50cm x 50cm and in each plot sixteen plants were transplanted. Twenty five days old seedlings were transplanted in each plot. Data on eighteen agronomic and quality traits were recorded, *viz*., plant height (cm), number of primary branches, days to 1st flowering (DAT), days to 50% flowering (DAT), days to 1st fruit harvest (DAT), polar diameter (cm), equatorial diameter (cm), pericarp thickness (mm), locule number, flowers number per truss, number of fruits per truss, average fruit weight (g), fruit number per plant, yield per plant (g), total yield (q/ha), total soluble solids (TSS) (ºBrix), lycopene content (mg/100g FW), β-carotene content (mg/100g FW). Analysis of variance for randomised block design was carried out as suggested by Fisher

(1948) [8] and Panse and Sukhatame (1967) [17]. Phenotypic and genotypic coefficient of variation (PCV and GCV, respectively) was calculated as per the method suggested by Burton and Devane (1953) [5] and Johnson *et al*. (1955) [11]. The expected genetic advance (GA) was estimated as per Lush (1949) [14] and Burton and Devane (1953) [5]. Genetic advance as percent of mean (GAPM) was calculated according to the following formula:

$$GAPM = \frac{GA}{X} x\ 100$$

where, GAPM= Genetic advance as percent of mean; GA= expected genetic advance; X = Mean of a character

Results and Discussion

The analysis of variance for 25 genotypes for eighteen characters showed that significant and wide range of variability were present among the genotypes for all the traits studied during investigation. The mean sum of squares due to replications, treatments and error are presented in Table 1. The variances due to treatment were found highly significant for all the traits. This revealed that there was a immense variability among the genotypes for all the traits that offered great scope for selection of breeding material to start any breeding programme for the improvement of crop. Saleem *et al.* (2013) [21], Ambresh *et al.* (2017) [2] also recorded high variability among tomato genotypes suggesting sufficient scope for selection.

Table 1: Analysis of variance for yield, yield contributing and quality characters in 25 tomato genotypes

Characters	Genotypes (df=24)	Replication (df=2)	Error (df=48)
Plant height (cm)	1661.86**	70.10	77.01
No. of primary branches per plant	1.41**	0.37	0.21
Days to 1st flowering (DAT)	23.55**	1.72	0.77
Days to 50% flowering (DAT)	15.02**	4.68	1.65
Days to 1st fruit harvest (DAT)	120.07**	11.29	11.58
Polar diameter (cm)	4.219**	0.187	0.076
Equatorial diameter (cm)	4.950**	0.232	0.083
Pericarp thickness (mm)	7.132**	0.177	0.097
Locule No.	2.462**	0.011	0.036
No. of flowers per truss	5.531**	0.816	0.463
No. of fruits per truss	3.836**	0.479	0.154
Average fruit weight (g)	2082.348**	0.873	13.689
Fruit per plant	1467.020**	0.214	15.013
Yieldt per plant (g)	200881.329**	6863.876	8092.292
Total yield (q/ha)	31220.511**	878.802	1404.804
TSS (ºBrix)	8.598**	0.329	0.106
Lycopene content (mg/100g FW)	3.905**	0.043	0.026
β-Carotene content (mg/100g FW	0.408**	0.002	0.002

*and** depict significance at $p \leq 0.05$ and $p \leq 0.01$ respectively

Table 2: Estimates of Genetic parameters for yield, yield contributing and quality characters in Tomato

Trait	Range			GCV (%)	PCV (%)	Heritability (%)	Genetic Advance	GA (% of mean)
	Minimum	Maximum	Overall Mean					
Plant height (cm)	51.06	112.31	81.69	25.74	27.55	87.28	44.23	49.53
Number of primary branches	4.50	6.67	5.59	11.36	14.09	65.03	1.05	18.87
Days to 1st flowering (DAT)	13.33	24.00	18.67	14.06	14.76	90.73	5.41	27.59
Days to 50% flowering (DAT)	18	26.6	22.30	9.33	10.92	72.96	3.72	16.41
Days to 1st harvest (DAT)	50.67	75.67	63.17	9.33	10.73	75.74	10.78	16.73
Number of flowers/truss	5.31	10.13	7.72	19.40	21.89	78.47	2.37	35.39
Number of fruits/truss	3.25	8.89	6.07	23.34	24.76	88.82	2.15	45.31
Polar diameter (cm)	1.54	6.09	3.82	31.80	32.67	94.75	2.36	63.76
Equatorial diameter (cm)	1.32	6.26	3.79	34.72	35.60	95.10	2.56	69.74
Pericarp thickness (mm)	1.20	6.45	3.83	43.18	44.07	96.01	3.09	87.16
Locule number	2	4.89	3.45	32.26	32.97	95.73	1.81	65.01
Average fruit weight (g)	8.02	95.32	51.67	74.88	75.62	98.05	53.57	152.75
Fruit number/plant	11.36	93.98	52.67	62.15	63.11	96.99	44.63	126.09
Yield/plant (g)	350.66	1350.69	850.68	31.24	33.14	88.82	492.15	60.64
TSS (ºBrix)	3.49	8.75	6.12	28.99	29.52	96.39	3.40	58.62
Lycopene(mg/100g FW)	0.45	5.36	2.91	36.80	37.17	98.00	2.32	75.05
β-carotene(mg/100g FW)	0.48	1.89	1.19	35.53	35.89	98.00	0.75	72.46
Total yield (q/ha)	138.22	532.25	335.24	31.16	33.29	87.62	192.23	60.08

According to Sivasubramanian and Madhavamenon (1973) [23], genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) have been classified into low when less than 10%, moderate when 10-20% and high when greater than 20%. The GCV obtained was high for average fruit weight (74.88%), number of fruit per plant (62.15%), pericarp thickness (43.18%), lycopene content (36.80%), β-carotene (35.53%), equatorial diameter (34.72%), locule number (32.26%), polar diameter (31.80%), fruit yield per plant (31.24%), total yield (31.16%), TSS (28.99%), plant height (25.74%), number of fruits per truss (23.34%), and moderate for number of flowers per truss (19.40%), days to 1st flowering (14.06%), number of primary branches (11.36%) and low for days to 50% flowering (9.33%) and days to 1st fruit harvest (9.33%). High PCV was obtained for the average fruit weight (75.62%), number of fruit per plant (63.11%), pericarp thickness (44.07%), lycopene content (37.17%), β-carotene (35.89%), equatorial diameter (35.60%), total yield (33.29%), fruit yield per plant (33.14%), locule number (32.97%), polar diameter (32.67%), TSS (29.52%), plant height (27.55%), number of fruits per truss (24.76%), number of flowers per truss (21.89%) and moderate for days to 1st flowering (14.76%), number of primary branches (14.09%), days to 50% flowering (10.92%) and days to 1st fruit harvest (10.73%).

High estimates of both PCV and GCV for the traits polar diameter, equatorial diameter, pericarp thickness, average fruit weight, fruit number/plant, fruit yield/plant, total yield, lycopene and beta-carotene pointed to the fact that the degree of variation among the genotypes was high. Previous study by Dar and Sharma (2011) [7] showed high values of GCV and PCV for fruit number/plant, total yield and beta-carotene, while Prema *et al*. (2011) [18] observed the same for pericarp thickness, average fruit weight, lycopene and fruit yield/plant. PCV and GCV were moderate for primary branch number/plant, days to first flowering, GCV was low for days to 50% flowering and first fruit harvest, whereas PCV for days to 50% flowering and days to 1st fruit harvest was found to be in moderate range. Sahanur *et al.* (2012) [20] and Madhurina and Paul (2012) [15] also reported moderate and low variability for these traits in tomato. The values of PCV were obtained higher than GCV suggested ample influence of environment on all the traits under study. Higher PCV values compared to GCV was earlier reported by Dar and Sharma (2011) [7], Ahirwar *et al*. (2013) [1], Kumar *et al*. (2016) [13] and Pandey *et al*. (2018) [16].

According to Johnson *et al*. (1955) [11], heritability estimates were classified into low, when less than 30%, moderate when 30-60% and high when greater than 60%. The estimates of heritability were high for all the traits under study, *viz*., average fruit weight (98.05%), lycopene content (98.00%), β-carotene (98.00%), number of fruits per plant (96.99%), TSS(96.39%), pericarp thickness (96.01%), locule number (95.73%), equatorial diameter (95.10%), polar diameter (94.75%), days to 1st flowering (90.73%), number of fruits per truss (88.82%), fruit yield per plant (88.82%), total yield (87.62%), plant height (87.28%), number of flowers per truss (78.47%), days to 1st fruit harvest (75.74%), days to 50% flowering (72.96%) and number of primary branches (65.03%). Heritability is calculated from the additive or fixable component of genetic variance and therefore governs the selection of elite lines from segregating population. High heritability for these traits suggested predominance of additive gene action for the traits.

However, when the estimate of expected genetic advance accompanies heritability, then the prediction of genetic gain under selection is more accurate (Johnson *et al*. 1955) [11]. The classification of genetic advance as percent of mean has been given by Johnson *et al*. (1955) [11] as low, when less than 10%, moderate when 10-20% and high when greater than 20%. High genetic gain (as percent of mean) was obtained for average fruit weight (152.75%), number of fruits per plant (126.09%), pericarp thickness (87.16%), lycopene content (75.05%), β-carotene content (72.46%), equatorial diameter (69.74%), locule number (65.01%), polar diameter (63.76%), fruit yield per plant (60.64%), total yield (60.08%), TSS (58.62%), plant height (49.53%), number of fruits per truss (45.31%), number of flowers per truss (35.39%), days to 1st flowering (27.59%), while it was moderate for number of primary branches (18.87%), days to 1st fruit harvest (16.73%) and days to 50% flowering (16.41%). When high heritability is accompanied with high genetic advance, it suggests preponderance of additive gene action and in such case selection would be effective. On the other hand, high heritability along with low genetic advance is resultant of non-additive gene action and the selection would be ineffective. Low heritability coupled with high genetic advance suggests additive gene effect in governance of the trait, but high interference of environment in expression of the trait and therefore selection in early generation would be ineffective. However, selection in the later generations might be effective in such cases. If low heritability is observed along with low genetic advance, then the character is predisposed to environmental effects leading to ineffective selection.

In the present study, high PCV, GCV and heritability accompanying high genetic advance as percent of mean was observed for plant height, number of fruits per truss, polar diameter, equatorial diameter, pericarp thickness, locule number, average fruit weight, fruit number per plant, yield per plant, TSS, lycopene content, β-carotene content and total yield. Thus selection in early generations would be effective in improvement of these traits. Singh and Singh (2018) [22] also observed high PCV and GCV with high heritability and genetic gain for number of fruits/plant, locule number and average fruit weight. High heritability for fruit weight, number of locules/fruit and yield of fruit was previously observed by Golani *et al.* (2007) [10]. Rai *et al*. (2016) [19] noticed high heritability with high genetic gain for number of fruits per plant, average fruit weight, fruit yield per plant, and lycopene content.

The genotypes under study possessed high variability for different yield and attributing traits and could be used in breeding programmes where simple selection would be effective in improving the different attributes.

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