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Estimation of genetic variability in advance breeding lines derived from inter-varietal crosses in chilli

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ABSTRACT

The experimental material comprised of 58 advance breeding lines derived from ten intervarietal crosses and six varieties including 'Surajmukhi' as standard check. The material was evaluated in randomized complete block design with three replications during summer 2015. Sufficient genetic variability was observed for yield and related traits. Phenotypic and genotypic coefficients of variation were high for primary branches/plant and green fruit yield/plant. Estimates of heritability and genetic advance were high for fruit length, fruit girth, pedicel length, leaf length, leaf width, primary branches/plant, oleoresin content, capsaicin content and green fruit yield/plant which indicated the importance of additive gene action. These traits along with average fruit weight and plant height revealed positive association with green fruit yield/plant. In view of the direct and indirect contributions of component traits, average fruit weight, plant height, leaf width and fruits/plant would be a paying preposition for selection and evolving high yielding genotypes of chilli.

Key words: Hot pepper, PCV, GCV, heritability, correlation, additive gene effects.

INTRODUCTION

Chilli or Hot pepper is an indispensable spice due to its pungency, taste, colour and flavor in every house of the tropical world and has its unique place in the diet both as a vegetable and spice crop. The green chilli fruits are rich source of ascorbic acid, phytonutrients, carotenoids and rutin which are of immense importance in pharmaceutical needs (Purseglove, 9). The alkaloid capsaicin present in placenta of the fruit responsible for its pungency has diverse prophylactic and therapeutic uses in Allopathic and Ayurvedic medicine (Sumathy and Mathew, 13).

In increasing the production of any crop, the initial and cheapest input is the continuous availability of high yielding and well adapted varieties through a strong breeding programme. Genetic diversity is the main source of variability in any crop improvement program. It serves as a reservoir for identifying superior alleles controlling key agronomic and quality traits. Genetic variability in germplasm determines their potential for improved efficiency and thereby, utilizing diverse genetic material in breeding programme which may eventually result in enhanced crop production. Keeping this in view, efforts have been made in recent years to isolate transgressive segregants from different intervarietal crosses keeping in view the farmer's preference for varieties having high yield along with desirable plant and fruit attributes. The phenotype is often not true indicator of its genotype; the phenotypic variability is the result of the effect of environment and genotype interaction. Hence, attempts have been made to determine the magnitude of heritable and non-heritable components and genetic parameters.

Since yield is a complex trait, indirect selection through correlated, less complex and easier measurable traits would be an advisable strategy to increase the yield. Efficiency of indirect selection depends upon the magnitude of association between yield and target yield components (Esposito *et al.*, 5). Correlation coefficients, in general, show association among characters which is not sufficient to describe their relationship when the causal association among characters is needed. The correlation *per se* does not give the complete picture of their interrelationships when more than two variables are involved. The path analysis has been used by the breeders to identify traits that are useful selection criteria to improve crop yield (Ali *et al.*, 1). Keeping this in view, present investigation was undertaken to gather information on genetic variability in 64 progenies derived from 10 diverse crosses of chilli.

MATERIALS AND METHODS

The present investigation was undertaken at the Experimental Farm of Department of Vegetable Science and Floriculture, Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya, Palampur (1, 290.8 m above mean sea level with 32° 6′ N latitude and 76° 3′ E longitudes). The location is characterized by humid and temperate climate with an annual rainfall

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of 2,500 mm of which 80 per cent is received during June to September and represents the mid-hill zone of Himachal Pradesh. The soil is classified as Alfisols typic Hapludalf clay having a pH of 5.7.

The experimental material for present study comprised of 64 genotypes of chilli including 58 F_5 advance breeding lines derived from ten intervarietal crosses and six varieties. These genotypes were sown on 19th March 2015 in the nursery bed. The seedlings of these 64 genotypes were transplanted on 7th May 2015 in randomized complete block design with three replications. Recommended practices were followed for successful cultivation.

The observations were recorded on five competitive plants taken at random in each entry over the replications on days to 50 per cent flowering, days to first harvest, fruit length (cm), fruit girth (cm), pedicel length (cm), leaf length (cm), leaf width (cm), plant height (cm), primary branches/plant, marketable fruits/plant, average fruit weight (g), marketable green fruit yield/ plant (g), harvest duration (days), ascorbic acid content (mg/100g) as described by Ranganna (10), oleoresin content (ASTA Units) as per procedure given by A.O.A.C. (2) and capsaicin content (%) using method by Bajaj (3). The data collected were subjected to analysis of variance and parameters of variability, heritability in broad sense and genetic advance (GA) resulting from selection of the top 5 per cent of individuals, phenotypic and genotypic coefficients of correlation and path coefficient analysis was done as per standard procedures.

RESULTS AND DISCUSSION

An insight into the magnitude of genetic variability present in a crop provides the basis for effective selection (Bora *et al.*, 4) and possibility to improve the yield and quality through strategic breeding programme (Singh *et al.*, 12). The knowledge of phenotypic coefficient of variation (PCV) and genotypic coefficient of variation (GCV) is helpful in predicting the amount of variation present in the given genetic stock which in turn helps in formulating an efficient breeding programme. The estimates of PCV were higher than corresponding GCV for all the characters studied (Table 1) which indicated that the apparent variation is not only due to genotypes but also due to the influence of environment. Therefore, caution has to be exercised in making selection for these characters on the basis of phenotype alone as environmental variation is unpredictable in nature. PCV and GCV were high for primary branches/plant, and marketable green fruit yield/plant. These high estimates indicated substantial

Table 1. Estimates of variability parameters for yield and yield contributing and quality traits in chilli.

Traits	Range	Population mean ± S.E	Genotypic coefficient of variation (%)	Phenotypic coefficient of variation (%)	Heritability (h^2_{bs}) %	Genetic advance (% of mean)
Days to flowering	38.33 - 57.67	45.40 ± 1.54	10.45	11.25	86.27	19.99
Days to first harvest	52.00 - 78.33	58.86 ± 1.68	8.57	9.26	85.66	16.34
Fruit length (cm)	4.00-13.73	11.84 ± 0.27	23.04	23.29	98.45	47.09
Fruit girth (cm)	2.56 - 6.23	3.93 ± 0.14	20.26	20.74	95.44	40.77
Pedicel length (cm)	2.81 - 5.90	3.95 ± 0.17	16.78	17.68	90.09	32.81
Leaf length (cm)	6.73 - 13.99	3.58 ± 0.26	22.93	23.17	97.89	46.73
Leaf width (cm)	2.36 - 5.71	3.99 ± 0.17	22.91	23.52	94.91	45.97
Plant height (cm)	43.18 - 83.55	65.66 ± 1.67	14.45	14.78	95.55	29.09
Primary branches/ plant	1.67 - 8.40	3.46 ± 0.24	40.65	41.54	95.78	81.96
Marketable fruits/ plant	27.71 - 87.76	54.97 ± 2.97	21.74	22.72	91.50	42.83
Average fruit weight (g)	2.56 - 6.99	4.18 ± 0.29	28.45	29.70	91.76	56.13
Marketable green fruit yield/ plant (g)	118.88 - 431.33	22.00 ± 9.68	31.73	32.16	97.32	64.49
Harvest duration (days)	53.67 - 65.33	59.65 ± 1.15	4.77	5.33	80.24	8.81
Ascorbic acid content (mg/100g)	91.73 - 128.07	109.43 ± 2.6	8.10	8.61	88.57	15.70
Oleoresin (ASTA Units)	38.01 - 75.99	56.38 ± 2.31	18.64	19.31	93.23	37.08
Capsaicin content (%)	0.35 - 0.89	0.61 ± 0.02	23.45	23.92	96.12	47.37

variability ensuring ample scope for improvement of these traits through selection (Ullah *et al.*, 14 and Yatung *et al.*, 16). In contrary, moderate PCV and GCV have been reported for these traits. Such variations in the magnitude of PCV and GCV may be ascribed to the differences in the genetic material and growing conditions. Moderate estimates of PCV and GCV were observed for majority of the traits which suggest that selection for the improvement of genotypes for these traits should be taken up with cautions (Janaki *et al.*, 6)

The magnitude of heritability in broad sense indicates the reliability with which a genotype can be recognized by its phenotypic expression. It is a measure of heritable variation and is helpful in predicting expected amount of improvement to be achieved through selection together with the genotypic coefficient of variation. High heritability estimates were observed for all the characters studied (Table 1), indicating lesser influence of environment and greater role of genetic components of variation. The response to selection for different characters showing high heritability needs to be given due emphasis for effective selection as these characters were under genetic control. Therefore, for improving these traits breeding program without progeny test can be used. However, the high heritability does not necessarily mean high genetic gain and is insufficient alone to make improvement through simple phenotypic selection.

Genetic advance may or may not be in proportion to genetic variability and heritability estimates because both high estimates of heritability and genetic variability are important to obtain higher genetic gain. Therefore, prediction on the basis of both heritability and genetic advance simultaneously could be more useful (Sharma *et al.*, 11). Keeping this in view, high heritability along with high genetic advance was observed for majority of the traits, namely fruit length, fruit girth, pedicel length, leaf length, leaf width, number of marketable fruits per plant, average fruit weight, dry yield per plant, number of primary branches per plant, oleoresin, capsaicin and marketable green fruit yield per plant (Table 1). This suggested the presence of additive gene action and hence these characters are likely to respond better to selection. Earlier workers who have also reported high heritability along with high genetic advance for different traits in their respective studies with different sets of genetic material includes Singh *et al.* (12) and Yatung *et al.* (16).

Selection for yield may not be effective unless other yield components influencing it directly or indirectly are taken into consideration. When selection pressure is exercise for improvement of any character highly associated with yield, it simultaneously affects a number of other correlated traits. Therefore, after getting the knowledge on the nature and magnitude of genetic variation, it is also important to gather information on association of yield with other characters and among themselves, and their basis to identify characters for increasing the efficiency of both direct and indirect selection and thereby, defining an ideal plant type. In general, the genotypic correlation coefficients were higher in magnitude than the corresponding phenotypic ones (Table 2) which revealed that though there is a strong inherent association between various characters, the phenotypic expression of the correlation gets reduced under the influence of environment (Pandit and Adhikari, 8). Marketable green fruit yield per plant showed positive and significant correlations with fruit length, fruit girth, pedicel length, leaf length, leaf width, plant height, marketable fruits per plant, average fruit weight, harvest duration and oleoresin content. Earlier reports of many research workers have also revealed significant and positive association for green fruits yield per plant with related attributes (Ullah et al., 14 and Janaki *et al.*, 6) through the evaluation of different breeding materials at their respective locations. Therefore, these traits need to be given special focus for the improvement of fruit yield.

Besides, marketable green fruit yield per plant showed negative and significant correlation with days to flowering and days to first harvest. This kind of association is quite desirable to select genotypes with early fruit harvest. Correlation coefficient between other pairs of traits revealed that fruit length, fruit girth, pedicel length, leaf length, leaf width and average fruit weight had significant and positive association among themselves. Harvest duration exhibited positive association with fruit length, leaf width, plant height and average fruit weight. Kumar *et al.* (7) have also reported positive association of these characters with each other. In contrary, number of marketable fruits per plant was negatively associated with average fruit weight indicating that breeder has to keep a balance to meet increase productivity and consumer preference. On the basis of correlation studies and their coefficients of determination, it can be concluded that the selection for days to flowering, days to first harvest, fruit length, leaf length, leaf width, plant height, number of marketable fruits per plant and average fruit weight can be effective for isolating plants with higher green as well as dry fruit yield.

The end product, yield has often been described as the product of its component traits which show inter-dependence (Wilson, 15). The path coefficient analysis allows partitioning of correlation coefficients into direct and indirect effects of various traits towards dependent variable and thus, helps in assessing the cause-effect relationship as well as effective selection. Average fruit weight had the maximum positive direct effect followed by number of marketable fruits per

Table 2. Estimates of phenotypic and genotypic coefficients of correlation for different pair of traits in chilli.

Traits		Days to flowering	Days to first harvest	Fruit length	Fruit girth	Pedicel length	Leaf length	Leaf width	Plant height	Primary branches/ plant	Marketable fruits/ plant	Average fruit weight	Harvest duration	Ascorbic acid	Oleoresin content	Capsaicin content
Days to first harvest	P	0.628**														
	G	0.681**														
Fruit length	P	-0.304**	-0.507**													
	G	-0.330**	-0.554**													
Fruit girth	P	-0.269**	-0.240**	0.404**												
	G	-0.293**	-0.258**	0.420**												
Pedicel length	P	-0.147*	-0.231**	0.483**	0.413**											
	G	-0.155*	-0.258**	0.535**	0.452**											
Leaf length	P	-0.270**	-0.303**	0.669**	0.475**	0.521**										
	G	-0.299**	-0.333**	0.684**	0.490**	0.553**										
Leaf width	P	0.127	-0.013	0.522**	0.268**	0.335**	0.724**									
	G	0.147*	-0.016	0.545**	0.286**	0.362**	0.749**									
Plant height	P	-0.138	-0.311**	0.449**	0.272**	0.330**	0.152*	0.076								
	G	-0.149*	-0.351**	0.466**	0.285**	0.353**	0.159*	0.083								
Primary branches/ plant	P	0.566**	0.451**	-0.363**	-0.452**	-0.092	-0.293**	-0.049	-0.225**							
	G	0.611**	0.490**	-0.378**	-0.467**	-0.100	-0.303**	-0.055	-0.238**							
Marketable fruits/ plant	P	-0.134	-0.152*	-0.078	-0.299**	-0.049	-0.111	-0.194**	0.005	0.221**						
	G	-0.139	-0.169*	-0.085	-0.320**	-0.049	-0.110	-0.202**	0.005	0.230**						
Average fruit weight	P	-0.251**	-0.417**	0.713**	0.582**	0.421**	0.611**	0.488**	0.485**	-0.382**	-0.247**					
	G	-0.290**	-0.464**	0.758**	0.619**	0.452**	0.633**	0.519**	0.515**	-0.405**	-0.210**					
Harvest duration	P	-0.018^{NS}	-0.100	0.235**	-0.021	0.112	0.060	0.144*	0.203**	-0.008	0.063	0.237**				
	G	-0.028^{NS}	-0.095	0.264**	-0.009	0.110	0.062	0.154*	0.248**	-0.006	0.077	0.275**				
Ascorbic acid	P	-0.329**	-0.247**	0.231**	0.502**	0.385**	0.268**	0.098	0.042	-0.443**	-0.355**	0.295**	-0.005			
	G	-0.358**	-0.262**	0.249**	0.541**	0.429**	0.286**	0.108	0.046	-0.483**	-0.400**	0.337**	0.008			
Oleoresin	P	-0.009	-0.060	0.020	0.000	0.108	0.072	0.142*	-0.035	0.130	0.129	0.077	0.080	0.056		
	G	-0.017	-0.081	0.018	0.003	0.116	0.074	0.153*	-0.044	0.132	0.137	0.089	0.103	0.061		
Capsaicin	P	0.080	0.301**	-0.493**	-0.303**	-0.338**	-0.675**	-0.686**	-0.135	0.293**	0.148*	-0.420**	0.075	-0.310**	-0.110	
	G	0.096	0.324**	-0.507**	-0.319**	-0.359**	-0.698**	-0.713**	-0.143*	0.303**	0.155*	-0.445**	0.072	-0.322**	-0.116	
Marketable fruit yield/plant	P	-0.361**	-0.503**	0.561**	0.286**	0.287**	0.428**	0.266**	0.464**	-0.221**	0.483**	0.693**	0.245**	0.022	0.183*	-0.216**
	G	-0.402**	-0.560**	0.579**	0.296**	0.300**	0.435**	0.281**	0.477**	-0.231**	0.502**	0.717**	0.273**	0.034	0.190**	-0.225**

**Significant at P ≤ 0.05

Table 3. Estimates of direct and indirect effects of different traits on marketable green fruit yield / plant at phenotypic (P) and genotypic (G) levels in chilli.

Traits		Days to flowering	Days to first harvest	Fruit length	Fruit girth	Pedicel length	Leaf length	Leaf width	Plant height	Primary branches/ plant	Marketable fruits/ plant	Average fruit weight	Harvest duration	Ascorbic acid	Oleoresin content	Capsaicin content	r
Days to flowering	P	**-0.019**	-0.030	0.004	0.010	0.011	-0.006	0.013	-0.012	-0.026	-0.092	-0.206	0.001	-0.019	0.000	0.011	-0.361**
	G	**-0.037**	-0.065	0.017	0.016	0.015	0.001	0.028	-0.015	-0.010	-0.095	-0.241	0.002	-0.036	0.000	0.018	-0.402**
Days to first harvest	P	-0.012	**-0.048**	0.007	0.009	0.017	-0.007	-0.001	-0.028	-0.021	-0.105	-0.343	0.004	-0.014	-0.003	0.041	-0.503**
	G	-0.025	**-0.095**	0.029	0.014	0.025	0.001	-0.003	-0.035	-0.008	-0.116	-0.386	0.006	-0.026	-0.002	0.062	-0.560**
Fruit length	P	0.006	0.025	**-0.014**	-0.016	-0.035	0.015	0.055	0.040	0.017	-0.054	0.586	-0.008	0.013	0.001	-0.067	0.561**
	G	0.012	0.053	**-0.052**	-0.023	-0.051	-0.002	0.105	0.047	0.006	-0.058	0.631	-0.018	0.025	0.001	-0.097	0.579**
Fruit girth	P	0.005	0.012	-0.006	**-0.038**	-0.030	0.010	0.028	0.024	0.021	-0.206	0.478	0.001	0.028	0.000	-0.041	0.286**
	G	0.011	0.024	-0.022	**-0.055**	-0.043	-0.001	0.055	0.029	0.008	-0.218	0.515	0.001	0.054	0.000	-0.061	0.296**
Pedicel length	P	0.003	0.011	-0.007	-0.016	**-0.073**	0.011	0.035	0.029	0.004	-0.034	0.346	-0.004	0.022	0.005	-0.046	0.287**
	G	0.006	0.025	-0.028	-0.025	**-0.096**	-0.001	0.070	0.036	0.002	-0.034	0.376	-0.007	0.043	0.003	-0.069	0.300**
Leaf length	P	0.005	0.015	-0.009	-0.018	-0.038	**0.022**	0.076	0.014	0.014	-0.077	0.502	-0.002	0.015	0.003	-0.092	0.428**
	G	0.011	0.032	-0.035	-0.027	-0.053	**-0.003**	0.145	0.016	0.005	-0.075	0.527	-0.004	0.029	0.002	-0.134	0.435**
Leaf width	P	-0.002	0.001	-0.007	-0.010	-0.025	0.016	**0.105**	0.007	0.002	-0.134	0.401	-0.005	0.006	0.006	-0.094	0.266**
	G	-0.005	0.001	-0.028	-0.016	-0.035	-0.002	**0.193**	0.008	0.001	-0.138	0.432	-0.010	0.011	0.004	-0.136	0.281**
Plant height	P	0.003	0.015	-0.006	-0.010	-0.024	0.003	0.008	**0.089**	0.010	0.003	0.398	-0.007	0.002	-0.002	-0.018	0.464**
	G	0.006	0.033	-0.024	-0.016	-0.034	0.000	0.016	**0.101**	0.004	0.003	0.429	-0.017	0.005	-0.001	-0.027	0.477**
Primary branches/plant	P	-0.011	-0.022	0.005	0.017	0.007	-0.006	-0.005	-0.020	**-0.046**	0.152	-0.314	0.000	-0.025	0.006	0.040	-0.221**
	G	-0.023	-0.046	0.020	0.026	0.010	0.001	-0.011	-0.024	**-0.017**	0.157	-0.337	0.000	-0.048	0.004	0.058	-0.231**
Marketable fruits/ plant	P	0.003	0.007	0.001	0.012	0.004	-0.002	-0.020	0.000	-0.010	**0.689**	-0.203	-0.002	-0.020	0.006	0.020	0.483.**
	G	0.005	0.016	0.004	0.018	0.005	0.000	-0.039	0.000	-0.004	**0.683**	-0.175	-0.005	-0.040	0.004	0.030	0.502**
Average fruit weight	P	0.005	0.020	-0.010	-0.022	-0.031	0.013	0.051	0.043	0.018	-0.170	**0.822**	-0.009	0.017	0.003	-0.057	0.693**
	G	0.011	0.044	-0.039	-0.034	-0.043	-0.002	0.101	0.052	0.007	-0.144	**0.832**	-0.018	0.034	0.002	-0.085	0.717**
Harvest duration	P	0.000	0.005	-0.003	0.001	-0.008	0.001	0.015	0.018	0.000	0.044	0.195	**-0.036**	0.000	0.004	0.010	0.245**
	G	0.001	0.009	-0.014	0.000	-0.011	0.000	0.030	0.025	0.000	0.053	0.229	**-0.067**	0.001	0.003	0.014	0.273**
Ascorbic acid	P	0.006	0.012	-0.003	-0.019	-0.028	0.006	0.010	0.004	0.020	-0.244	0.242	0.000	**0.057**	0.002	-0.042	0.022
	G	0.013	0.025	-0.013	-0.030	-0.041	-0.001	0.021	0.005	0.008	-0.273	0.280	-0.001	**0.100**	0.002	-0.062	0.034
Oleoresin	P	0.000	0.003	0.000	0.000	-0.008	0.002	0.015	-0.003	-0.006	0.089	0.063	-0.003	0.003	**0.044**	-0.015	0.183*
	G	0.001	0.008	-0.001	0.000	-0.011	0.000	0.030	-0.004	-0.002	0.093	0.074	-0.007	0.006	**0.028**	-0.022	0.190**
Capsaicin	P	-0.002	-0.015	0.007	0.012	0.025	-0.015	-0.072	-0.012	-0.014	0.102	-0.345	-0.003	-0.018	-0.005	**0.137**	-0.216**
	G	-0.004	-0.031	0.026	0.018	0.034	0.002	-0.138	-0.014	-0.005	0.106	-0.371	-0.005	-0.032	-0.003	**0.191**	-0.225**

Residual effect at phenotypic level (P) = 0.0160, and genotypic level (G) = 0.025. Significant at $P \leq 0.05$; bold values indicate direct effects.; r correlation coefficient with marketable green fruit yield/plant.

plant on fresh fruit yield per plant (Table 3). In addition, capsaicin content and leaf width had also substantial direct contribution. The earlier researcher workers have also reported direct and positive effect of these traits on fresh green fruit yield per plant in different studies in different environments (Janaki *et al*., 6; Kumar *et al.*, 7). A critical analysis of direct and indirect effects of various traits on marketable green fruit yield per plant revealed that average fruit weight had the maximum indirect contribution to the total magnitude of positive correlation coefficient of marketable yield per plant with fruit length, fruit girth, pedicel length, leaf length, leaf width, plant height and harvest duration. Also, negative association of primary branches per plant with fruit yield was the result of maximum negative indirect contribution via average fruit weight. Also, negative indirect contribution of average fruit weight squeezed the magnitude of positive direct effect of number of marketable fruits per plant to certain extent but could not affect the positive association of number of marketable fruits per plant with marketable yield per plant. The low magnitude of unexplained variations (0.016) indicated that the traits included in the present investigation accounted for the greater part of the variations present in the dependable variable i.e. green fruit yield.

It can be concluded that selection on the basis of average fruit weight, plant height, leaf width and number of marketable fruits per plant would be a paying preposition for evolving high yielding genotypes of chilli.

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