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Variability and Heritability Estimates in Some Reproductive Characters and Yield in Chilli (*Capsicum annuum* L.)

M. K. Pandit[1] and S. Adhikary[2*]

[1]Department of Vegetable Crops, Faculty of Horticulture, Bidhan Chandra Krishi Viswavidyalaya, Mohanpur, Nadia, West Bengal, India.
[2]Agricultural and Ecological Research Unit, Biological Science Division, Indian Statistical Institute, Kolkata, West Bengal, India.

Authors' contributions

This work was carried out in collaboration between all authors. All authors read and approved the final manuscript.

Original Research Article

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ABSTRACT

Forty one chilli genotypes were grown in a randomized block design with three replications during autumn-winter season of 2010-11, at the AB block Farm, Kalyani, Bidhan Chandra Krishi Viswavidyalaya, India, to estimate variability and heritability for important reproductive and yield characters. In the present experiment genotypic coefficient of variation and phenotypic coefficient of variation estimates closely corresponded with regard to days to 50% flowering, fruit length, placenta length and 1000 seed weight; in others it differed moderately, altogether suggesting low to medium influence of environment in the expression of these characters. Close estimates of phenotypic coefficient of variation and genotypic coefficient of variation were noted in all characters except fruit width, which imply that contribution towards final phenotypic expression of these characters are mostly genetic rather than environmental. Very high genetic advance as % of mean was recorded in fruit yield/plant and moderately high genetic advance as % of mean was recorded in days to 50% flowering, placenta length, fruit length, number of fruits/plant and number of seeds/plant, indicating that these characters are most likely governed by additive gene action and hence would be rewarding in selection.

**Corresponding author: E-mail: mkumarpandit@yahoo.com;*

Keywords: Chilli; fruit characters; variability; heritability estimates; correlation.

1. INTRODUCTION

Chillies (*Capsicum annuum* L., family Solanaceae) either green or as dried red ripe fruits, are used throughout world for their pungency in culinary preparations or as pickles. Chilli is consumed as fresh, dried or processed items and it is the most extensively used high value spices in India. India is a leading chilli producer and exporter and has a great diversity of this solanaceous fruit. It is a self-pollinated crop but on average 15-16% natural crossing has also been noted [1]. Chilli occupies an important place in Indian diet. It is consumed daily as a condiment in one form or the other. India is the only country which is rich in many varieties with different quality factors. Pungency in chilli is due to presence of an alkaloid “capsaicin” contained in the pericarp and placenta of fruits. India contributes about 36% to the total world production [2].

Any genetic improvement in a crop can be achieved by bringing beneficial and desirable genes in a genotype and discouraging genes that govern undesirable traits. Yield and productivity are the two major desirable attributes in chilli. Chilli in India is dominated by open pollinated varieties and area under hybrid varieties is there by low. That is why productivity of chilli in India is low, though the area under cultivation is huge. This crop has good export potential and a huge domestic demand. In India, wide range of genetic variability is available. So it is essential to assess the potential of the genetic stock and to have a clear picture on the genetic constitution of the genotypes and heritable proportion of important traits. To upscale such low yielding genotypes, it is mandatory to understand the basic genetic make-up, variability and interrelationships among various characters as well as yield components. So, for proper choice of parents and framing any future improvement programme in chilli, the present investigation was carried out to determine and illustrate the nature and magnitude of genetic variability, heritability and genetic advance among the genotypes in important growth and fruit characters, their interrelationships and their direct and indirect effects on yield.

2. MATERIALS AND METHODS

Forty one chilli genotypes were grown in a randomized block design with three replications during autumn-winter season of 2010-2011. Genotypes were collected from the farmers of different chilli growing areas in West Bengal, India, and designated as Bidhan Chandra Chilli (BCC) 1-41 Table 1. Seeds were sown in the nursery bed on September 3 and thirty-day-old seedlings were transplanted at a spacing of 45 x 45 cm, accommodating 20 plants per plot. Standard recommended crop management practices including plant protection were followed to raise the crop. Five randomly selected plants from each replication were used to record observations on days to 50% flowering, fruit length (cm), fruit pedicel length (cm), placenta length (cm), number of fruits/plant, fruit weight (g), number of seeds per fruit, 1000 seed weight (g) and fruit yield/plant (kg).Genotypic and phenotypic variance and coefficient of variance, heritability and genetic advance were estimated using the formula suggested by [3] by using the following equations:

Genotypic coefficient of variation (GCV) % = $\sqrt{\sigma^2 g} / X * 100$
Phenotypic coefficient of variation (PCV) % = $\sqrt{\sigma^2 ph} / X * 100$,

where $\sigma^2 g$ = genotypic variance, $\sigma^2 ph$ = phenotypic variance, X = sample mean and
$h^2 = (\sigma^2 g / \sigma^2 ph) \times 100$, where h^2 = Heritability in broad sense

$GA=K.\ \sigma ph.h^2$

where GA: genetic advance, K: constant = 2.06 at 5% selection intensity, *σph*: square root of phenotypic variance,

GA as % of mean = (GA/mean value) x 100

The phenotypic and genotypic correlation coefficient and path coefficient were calculated to estimate the direct and indirect effects among the characters as per [4].

Table 1. Source of chilli genotypes employed in the experiment

Genotypes	Place of Collection, District	State & Country
BCC-1	Nilgunge, North 24 Parganas	West Bengal, India
BCC-2	Chakdah, Nadia	West Bengal, India
BCC-3	Nilgunge, North 24 Parganas	West Bengal, India
BCC-4	Kalyani, Nadia	West Bengal, India
BCC-5	Chakdah, Nadia	West Bengal, India
BCC-6	Nilgunge, North 24 Parganas	West Bengal, India
BCC-7	Nilgunge, North 24 Parganas	West Bengal, India
BCC-8	Mohanpur, Nadia	West Bengal, India
BCC-9	Seoraphuli, Hoogly	West Bengal, India
BCC-10	Haringhata, Nadia	West Bengal, India
BCC-11	Kalyani, Nadia	West Bengal, India
BCC-12	Kalyani, Nadia	West Bengal, India
BCC-13	Garbeta, PurbaMedinipur	West Bengal, India
BCC-14	Kalyani, Nadia	West Bengal, India
BCC-15	Mohanpur, Nadia	West Bengal, India
BCC-16	Beldanga, Murshidabad	West Bengal, India
BCC-17	Nilgunge, North 24 Parganas	West Bengal, India
BCC-18	Gadamara, Barasat, North 24 Parganas	West Bengal, India
BCC-19	Andul, Howrah	West Bengal, India
BCC-20	Chakdah, Nadia	West Bengal, India
BCC-21	Arambagh, Hoogly	West Bengal, India
BCC-22	Seoraphuli, Hoogly	West Bengal, India
BCC-23	Bhangar, North 24 Parganas	West Bengal, India
BCC-24	Bhangar, North 24 Parganas	West Bengal, India
BCC-25	Suri, Birbhum	West Bengal, India
BCC-26	Seoraphuli, Hoogly	West Bengal, India
BCC-27	Seoraphuli, Hoogly	West Bengal, India
BCC-28	Mohanpur, Nadia	West Bengal, India
BCC-29	Seoraphuli, Hoogly	West Bengal, India
BCC-30	Madanpur, Nadia	West Bengal, India
BCC-31	Gadamara, North 24 Parganas	West Bengal, India
BCC-32	Gadamara, North 24 Parganas	West Bengal, India
BCC-33	Madandanga, Kalyani, Nadia	West Bengal, India
BCC-34	Arambagh, Hoogly	West Bengal, India
BCC-35	Seoraphuli, Hoogly	West Bengal, India
BCC-36	Barasat, North 24 Parganas	West Bengal, India
BCC-37	Barasat, North 24 Parganas	West Bengal, India
BCC-38	Andul, Howrah	West Bengal, India
BCC-39	Chakdah, Nadia	West Bengal, India
BCC-40	Bongaon, North 24-Parganas	West Bengal, India
BCC-41	Baidyabati, Hoogly	West Bengal, India

3. RESULTS AND DISCUSSION

Analysis of variance for different characters in chilli is given in Table 2. The extent of variability present in the genotypes was measured in terms of range, coefficient of variation, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), broad sense heritability and genetic advance (GA). It was found that moderate to high range of variation was recorded in all characters, indicating better scope for improvement through selection. The coefficient of variation in all the fruit traits ranged from 6.08 to 20.27; fruit width, number of fruits per plant and fruit yield recorded a slightly higher coefficient of variation (CV) values. In the present experiment GCV and PCV estimates were close in days to 50% flowering, fruit length, placenta length and 1000 seed weight; in others it differed slightly, altogether suggesting low to medium influence of environment in the expression as also noticed earlier by [5,6]. Higher PCV and GCV values were recorded in number of fruits/plant and green fruit yield per plant. In other characters, PCV and GCV values were medium to high. Higher magnitude of PCV and GCV indicate the existence of substantial variability that could be potently exploited through direct selection.

Table 2. Analysis of variance for different characters in chilli

Characters	Mean sum of squares		
	Genotypes	Replication	Error
Days to 50% flowering	432.79**	1.541	18.958
Fruit length (cm)	7.28**	0.100	0.338
Fruit width (cm)	0.149**	0.170	0.037
Fruit Pedicel length (cm)	0.702**	0.047	0.125
Placenta length (cm)	6.37**	0.016	0.304
No. of fruits/plant	698.94**	251.75	83.58
Fruit weight (g)	0.417**	0.009	0.067
No. of seeds/plant	984.88**	26.718	86.319
1000 seed weight (g)	2.024**	0.146	0.092
Fruit yield/plant	4796.32**	109.50	273.58

**Significant at p = 0.05; ** Significant at p = 0.01*

Close estimates of PCV and GCV were noted in all characters except fruit width, which imply that contributions towards final phenotypic expression of these characters are mostly genetic rather than environmental influence. This finding is in consonance with that of [7]. Hence, selection only on the basis of phenotypic attributes would be effective with equal probability of success. But, to be conclusive on fair estimation of genetic make ups and their contribution to phenotypic expression of characters, such evaluation experiments should be conducted over multiple seasons at different locations. High GCV values were noted in the number of fruits/plant and fruit yield/plant, and this finding has earlier been supported by [8, 9,10,11] and many others. However, GCV alone provides insufficient evidence to indicate that the majority of variation is inheritable.

The majority of the traits Table 3 exhibited high heritability. The GCV x selection differential estimates the maximum effectiveness of selection and heritability indicates how closely the goal can be achieved [12]. In the present case very high broad sense heritability (> 80%) was noted in days to 50% flowering, fruit length, placenta length, 1000 seed weight and fruit yield/plant, as also earlier recorded by [9,11,13,14]. Selection for such traits would act as important selection indices due to closer correspondence between genotype and phenotype arising from relatively smaller contribution of environment to the phenotype. High heritability

estimates (60-80%) were observed in number of fruits/plant, fruit weight [15] and number of seeds/plant. High estimates of heritability in quantitative characters have been found to be useful for selection based upon phenotypic performance [16].

Johnson et al. [17] suggested that heritability estimates along with genetic gain is usually helpful rather than heritability alone in predicting the resultant effect for selecting the best individuals with reference to a defined population of genotypes. Very high genetic advance (as % of mean) was recorded in fruit yield/plant and moderately high in days to 50% flowering, placenta length, number of fruits/plant and number of seeds/plant, indicating that these characters are most likely governed by additive gene action [13,18]. Other characters have been under the influence of pre-dominantly non-additive gene action and hence are comparatively less reliable for direct selection; these characters need to be improved through hybridization [19]. The expected genetic advance values Table 3 shows the gain that may be obtained from selecting the top 5% of the genotypes and varied from 0.29 (fruit width) to 73.61(green fruit yield/plant). In the same way, expected genetic advance-values (as % of mean) recorded satisfactory variation that ranged from 21.6 (fruit pedicel length) to 75.6 (green fruit yield/plant). For indirect selection, the mutual relationships between various characters have to be worked out through correlation studies. In general, estimates of genotypic correlations were higher than the phenotypic ones in the present investigation, which is supported by earlier works of Krishna et al. [20]. With phenotypic correlations taken as reference, it is found that fruit yield/plant is significantly and positively correlated with fruit length, fruit pedicel length, placenta length, number of fruits/plant, fruit weight and 1000 seed weight Table 4. These findings are in consonance with Dutta et al. [21]. Both genotypic and phenotypic correlation profiles indicate that fruit length and weight are important yield components; this is in tune with an earlier finding of Pandit et al. [22].So, it is suggested that fruit yield in chilli could be increased by giving weightage to fruit length, number of fruits/plant, fruit weight and 1000 seed weight and consequent selection would be rewarding.

Phenotypic correlations of the different characters were partitioned to path coefficient Table 5 with the view to identifying important fruit characters having direct effect on yield. Highest direct positive effects on yield were given by the number of fruits/plant (0.626), followed by 1000 seed weight (0.174) and placental length (0.171). This finding is supported by the some earlier reports [9,23,24,25]. From the study of character associationship, combining correlation and path coefficient, the characters, namely, fruits/plant, placenta length, fruit weight and 1000 seed weight, emerged as the most important fruit yield components. Genetic variability parameters for these characters were also considerably high. Significance of these characters as important selection indices was also suggested by some earlier workers [26,27,28].

Table 3. Genetic variability and heritability estimates for different characters in chilli

Characters Components of variation	Days to 50% flowering	Fruit length (cm)	Fruit width (cm)	Fruit pedicel length (cm)	Placenta length (cm)	No. of fruits/plant	Fruit weight (g)	No. of seeds/plant	1000 seed weight(g)	Green fruit yield/plant
Range	29.00-70.33	4.23-9.74	0.58-1.60	2.22-4.42	4.0-9.45	22.50-86.35	1.53-2.82	32.51-110.84	3.46-6.80	50.40-218.70
Grand mean	49.60	6.36	1.01	3.10	6.06	45.09	2.16	73.06	4.99	97.34
S. Em	0.36	0.47	0.15	0.28	0.45	0.74	0.211	0.75	0.24	0.13
Coefficient of variation (CV %)	9.10	9.14	19.19	11.41	9.10	20.27	11.95	12.71	6.08	16.99
PCV (%)	26.16	23.94	27.23	17.99	25.16	38.86	19.58	27.00	17.18	43.37
GCV (%)	24.50	22.13	19.31	13.90	23.45	36.16	15.86	23.82	16.07	39.90
Heritability (%)	87.5	85.4	50.3	59.7	86.9	72.8	63.5	77.8	87.5	84.5
Genetic Advance(GA)	22.57	2.68	0.29	0.69	2.73	26.28	0.56	31.62	1.55	73.61
GA % of mean	46.3	43.1	26.5	21.6	45.0	58.2	25.8	43.2	31.0	75.6

Table 4. Genotypic and phenotypic correlations among different characters of chilli

Characters		Days to 50% flowering	Fruit length (cm)	Fruit width (cm)	Fruit pedicel length (cm)	Placenta length (cm)	No. of fruits/plant	Fruit weight (g)	No. of seeds/plant	1000 seed weight(g)	Fruit yield/plant
Days to 50% flowering	G	1.000	-0.113	0.461	0.290	-0.109	0.000	0.072	-0.080	0.431	0.043
	P	1.000	-0.100	0.283**	0.179	0.090	0.013	0.041	-0.062	0.366**	0.074
Fruit length (cm)	G		1.000	-0.589	0.256	0.980	0.408	0.040	-0.192	0.028	0.405
	P		1.000	-0.325*	0.177	0.837**	0.306**	0.052	-0.189	0.007	0.318**
Fruit width (cm)	G			1.000	-0.181	-0.529	-0.219	0.121	0.445	0.332	-0.108
	P			1.000	-0.046	-0.324**	-0.156	0.124	0.221*	0.170	-0.008
Fruit pedicel length (cm)	G				1.000	0.211	0.270	0.266	-0.060	0.410	0.387
	P				1.000	0.125	0.200*	0.229*	-0.047	0.280**	0.272**
Placenta length (cm)	G					1.000	0.447	0.057	-0.222	0.030	0.417
	P					1.000	0.331**	0.032	-0.170	0.010	0.355**
No. of fruits/plant	G						1.000	0.039	0.092	0.383	0.957

Table 4. Continued……..

	P	1.000	0.024	-0.064	0.348**	0.735**
Fruit weight (g)	G		1.000	0.589	0.376	0.558
	P		1.000	0.363*	0.259**	0.327**
No. of seeds/plant	G			1.000	0.135	0.173
	P			1.000	0.157	0.151
1000 seed weight(g)	G				1.000	0.603
	P				1.000	0.477**
Fruit yield/plant						1.000

**, ** indicate significant at 5% and 1% probability, respectively*

Table 5. Phenotypic path analysis for green fruit field

Characters	Days to 50% flowering	Fruit length (cm)	Fruit width (cm)	Fruit pedicel length (cm)	Placenta length (cm)	No. of fruits /plant	Fruit weight (g)	No. of seeds /plant	1000 seed weight(g)	Phenotypic correlation with fruit yield
Days to 50% flowering	0.039	0.001	0.022	0.008	-0.015	-0.008	0.008	-0.006	0.064	0.074
Fruit length (cm)	-0.004	-0.005	-0.025	0.008	0.143	0.192	0.011	-0.019	0.001	0.318
Fruit width (cm)	0.011	0.002	0.078	-0.002	-0.055	0.197	0.025	0.022	0.029	-0.008
Fruit pedicel length (cm)	0.007	-0.001	-0.004	0.046	0.021	0.125	0.047	-0.005	0.049	0.272
Placenta length (cm)	-0.004	-0.005	-0.025	0.006	0.171	0.207	0.006	-0.017	0.002	0.355
No. of fruits/plant	-0.001	-0.002	-0.012	0.009	0.057	0.626	0.005	-0.006	0.060	0.735
Fruit weight (g)	0.002	0.000	0.010	0.011	0.005	0.015	0.203	0.036	0.045	0.327
No. of seeds/plant	-0.002	0.001	0.017	-0.002	-0.029	-0.040	0.074	0.099	0.027	0.151
1000 seed weight(g)	0.014	0.000	0.013	0.013	0.002	0.218	0.053	0.016	0.174	0.477

Direct effects are in main diagonal (bold)

4. CONCLUSION

It may be concluded from this study that for a rewarding selection, characters such as days to 50% flowering, placenta length, fruit length, number of fruits/plant and number of seeds/plant, which are most likely governed by additive gene action, should be given due weightage while framing any future improvement programme in chilli. There is enough scope for future study involving multi-location trials.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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