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Genetic variability and correlation studies for growth and yield characters in chilli (*Capsicum annuum* L.)

K Amit*, I Ahad, V Kumar[1] & S Thakur[2]

Krishi Vigyan Kendra, Malangpora, Pulwama,
Sher-e-Kashmir University of Agriculture, Science & Technology-Kashmir, Jammu & Kashmir.
**E-mail: khokherak@rediffmail.com*

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Abstract

Twenty three genotypes were used to study the genetic variability, heritability, genetic advance and correlation for growth and yield contributing characters in chilli under Kashmir conditions. Significant variations were observed for all the characters studied except for days to flowering and crop duration [mature (green) as well as dry (red)]. High Phenotypic Coefficient Variation (PCV) and Genotypic Coefficient Variation (GCV) were recorded for number of fruits plant^{-1}, fruit weight and dry (red) yield. All the characters showed high heritability estimates. However, number of the fruits plant^{-1}, green fruit yield plant^{-1}, dry (red) yield plant^{-1}, number of seeds plant^{-1} and plant height exhibited high genetic advance as percentage of mean indicating additive gene effect. Fruit yield (green and red) plant^{-1} was positively and significantly correlated with number of fruits plant^{-1} and fruit length. It revealed that the characters *viz*., plant height, fruit length, number of fruits plant^{-1}, fruit weight and fruit yield (green & red) are the most important traits for genetic improvement of chilli.

Keywords: chilli, correlation, genetic variability, growth, heritability, yield

Introduction

Chilli (*Capsicum annuum* L.) also known as red pepper is mainly cultivated for fruits which are used as vegetable in medicine as a stimulant and source of oleoresin (Samadia 2007). Fruit yield as well as quality improvement efforts continue to be the major objective of chilli improvement programme. Fruit yield is a complex inherited character influenced by several attributes of the plant. Datta & Jana (2004) reported that the productivity of chilli can be increased by cultivating new genotypes. So area based screening for improving the productivity of this crop is an important step to increase the production. A wide range of variability is available in chilli genotypes which provide great scope for improving fruit yield through systematic breeding. Estimation of genetic variability present in the germplasm of a crop is a pre-requisite for designing effective

[1]Division of Vegetable Science, Sher-e-Kashmir University of Agriculture, Science & Technology-Jammu, Jammu & Kashmir.
[2]Vegetable Research Station, Kalpa, Kinnaur, Himachal Pradesh.

breeding programme (Parkash 2012). However, utilization of this variability requires its systematic evaluation to understand and to estimate the genetic variability, heritability and genetic advance of various yield and physio-chemical components. Therefore, an attempt was made in the present investigation to estimate the extent of genetic variability, heritability and correlation in 23 diverse genotypes of chillies for various compositional and yield attributes for identifying superior genotypes for involvement in future breeding programme.

Materials and methods

The planting material for the present study comprised of the 23 genotypes (released varieties, breeding lines and local collection) which were collected from different sources (Table 1). The experiment was laid out in randomized block design with three replications at the experimental farm of Krishi Vigyan Kendra, Pulwama, Sher-e Kashmir University of Agriculture, Science & Technology-Kashmir during *kharif* season 2010 and 2011, it is located at 33º North and 74° East at an altitude of 1601 m MSL. The mean annual rainfall ranges from 500-850 mm. The minimum and maximum temperature of the station during summer ranges between 10-30°C. Sowing of seeds was done in the first week of April and transplanting in last week of May in both the years. Row to row and plant to plant distance was kept at 75 cm and 45 cm and all the recommended agronomic package of practices to raise chilli crop in temperate region of Kashmir valley were followed. In each genotype, 10 plants were randomly selected for recording the observations. Observations were recorded on days to first flowering, days to 50% flowering, fruit length (cm), fruit breadth (cm), fruit weight (g), plant height (cm), number of branches plant^{-1}, number of fruits plant^{-1}, number of seeds fruit^{-1}, maturation days (green), maturation days (red), 1000 seed weight (g), green fruit yield (g plant^{-1}), dry fruit yield (g plant^{-1}). Genotypic and phenotypic coefficients of variation (GCV and PCV, respectively) were calculated as per the formula suggested by Burton & DeVane (1953). Heritability in broad sense and expected genetic advance were calculated as per the formula given by Allard (1960) and Johnson *et al*. (1955), respectively. The correlation coefficient was calculated for all the characters with fruit yield and among the characters themselves as suggested by Al-Jibouri *et al.* (1958). Statistical analysis was done as per the method suggested by Gomez & Gomez (1984).

Table 1. List of chilli genotypes and their sources used in the study

Genotypes	Source	Genotypes	Source
Arka Lohit	IIHR, Bengaluru	DCL-520	IARI, New Delhi
CH-1	PAU, Ludhiana	*Kashmir Long*	SKUAST-Kashmir (J &K)
Bhagyalakshami	RARS, Lam, Guntur (AP)	PUP-CH-08	CSK HPKV, Palampur
Pusa Sadabahar	IARI, New Delhi	NCH-162	CSK HPKV, Palampur
Anugraha	KAU, Thrissur, Kerala	DCL-352	IARI, New Delhi
PCP-CH-4-08	CSK HPKV, Palampur	*Pusa Jawala*	IARI, New Delhi
K-1	ARS, Kovilpatti, (TN)	AG-08	CSK HPKV, Palampur
LCA-357	RARS, Lam, Guntur (AP)	1118-14	CSK HPKV, Palampur
Pant C-1	GBPUAT, Pantnagar	PKM-1	ARS, Kovilpatti, (TN)
CPC-08-E	CSK HPKV, Palampur	PCP-08-CH	CSK HPKV, Palampur
PH-08	CSK HPKV, Palampur	*Surajmukhi*	CSKHPKV, Palampur
CCH-05	SKUAST-Jammu (J & K)		

Results and discussion

Significant differences were obtained among the genotypes for all the characters in both the years. Pooled data of two years indicated adequate variability among all the genotypes tested (Table 2). PUP-CH-08 took minimum number of days (58.83 days) for initiation of first flowering which was statistically at par with *Kashmir Long* (60.20 days), CPC-08-E (60.31 days) and CH-1 (60.38 days), however, 50% of flowering was noticed earlier in *Kashmir Long* (70.53 days) closely followed by PUP-CH-08 (72.05 days). DCL-352 took maximum number of days for first flowering (86.30 days) and 50% of flowering (94.13 days). Maximum fruit length (14.70 cm), fruit breadth (2.80 cm) and fruit weight (5.19 g) was registered in LCA-357 which was significantly higher among all the cultivars for fruit length and fruit breadth whereas in case of fruit weight it was statistically at par with *Pusa Jawala* (5.16 g), CH-1 (5.12 g) and *Kashmir Long* (5.08 g). Minimum fruit length (4.16 cm) and fruit weight (1.71 g) was recorded in K-1, however, PH-08 registered minimum fruit breadth (0.88 cm). *Pusa Sadabahar* (10.62) scored maximum number of branches closely followed by *Pusa Jawala* (10.47) whereas, PCP-08-CH (4.70) recorded minimum number of branches per plant. Maximum plant height was attained in *Surajmukhi* (120.23 cm) which was statistically at par with *Pusa Sadabahar* (116.40 cm), however, minimum plant height was recorded in DCL-352 (52.40 cm). *Surajmukhi* (198.25) registered maximum number of fruits plants^{-1} closely followed by *Pusa Jawala* (194.26), whereas, CCH-05 registered minimum number of fruits plants^{-1}. Maximum number of seeds fruit^{-1} (116.90) along with maximum weight of 1000 seeds (5.56 g) was recorded in *Pusa Jawala* and minimum in PCP-08-CH i.e. 35.84 and 1.98 g, respectively. *Surajmukhi* took minimum number of days to mature green (101.26 days) and red ripe (121.67 days) chilli fruits which were statistically at par with CH-1 (102.60 & 121.77 days), PUP-CH-08 (102.96 & 122.59 days) and *Kashmir Long* (103.38 & 123.29 days) in both cases of maturing green and red ripe chillies. However, PCP-CH-4-08 took maximum number of days to mature green (124.11 days) and red ripe (140.26 days) chillies. Maximum fruit yield of green mature chillies was recorded in CH-1 (854.64 days) which is statistically significant, however, minimum green fruit yield was recorded in AG-08 (258.85 g). LCA-357 (102.24 g) recorded maximum dry (red) fruit yield which was statistically at par with CPC-08-E (98.39 g), CH-1(98.33 g) and *Kashmir Long* (95.55 g) whereas, minimum was observed for AG-08 (20.73 g). Earlier Deb *et al*. (2008) and Warshamana *et al*. (2008) also reported similar results while working on chilli genotypes.

The extent of variability present in 23 genotypes of chilli was measured in terms of range, mean, PCV, GCV, heritability in broad sense and genetic advance (Table 3). All the genotypes differed significantly with respect to different characters studied. Wide range of variation was observed in all the characters. Munshi & Behra (2000), Warshamana *et al*. (2008) and Gupta *et al*. (2009) also reported wide range of variation for most of the characters. The GCV and PCV were high for dry (red) yield (45.41 & 45.98), green fruit yield (38.43 & 38.46), fruit weight (35.37 & 35.47), fruit length (35.04 & 35.06), number of fruits plant^{-1} (34.14 & 35.57) and number of seeds fruit^{-1} (34.19 & 35.96) indicating greater diversity for these traits. GCV in general, were lower than the PCV (Table 3) which indicated close association between phenotype and genotype. These results are in agreement with those reported by Munshi & Behra (2000), Singh *et al*. (2005) and Gupta *et al*. (2009). Low GCV and PCV were recorded for days to 50% flowering (9.04 & 9.20), maturation days (green) (5.79 & 5.93) and maturation days (red) (4.13 & 4.31). These results are in conformity with the findings of Kumar *et al*. (1999), Singh *et al*. (2005) and Samadia (2007).

Heritability is a parameter of tremendous significance to the breeders as its magnitude indicates the reliability with which a genotype can be recognized through its phenotypic expression (Table 3). Johnson *et al*. (1955) stressed that for estimating the real effect of selection, heritability estimates along with genetic advance are more meaningful.

Table 2. Mean performance of chilli genotypes with respect to various characters

Genotypes	Days taken to first flowering	Days taken to 50% flowering	Fruit length (cm)	Fruit breadth (cm)	Fruit weight (g)	Number of branches plant^{-1}	Plant height (cm)	Number of fruits plant^{-1}	Number of seeds fruit^{-1}	Maturation days (green)	Maturation days (red)	1000 seed weight (g)	Green fruit yield (g plant^{-1})	Dry fruit yield (g plant^{-1})
Arka Lohit	67.27	78.37	11.12	2.18	4.72	9.17	96.37	162.27	92.05	108.47	126.07	4.89	702.20	80.19
CH-1	60.38	72.86	12.16	2.44	5.12	8.80	90.20	150.48	96.53	102.60	121.77	5.10	854.65	98.33
Bhagyalakshami	84.21	91.84	11.88	2.20	4.94	9.78	100.74	177.98	87.00	122.43	136.10	4.75	734.49	88.42
Pusa Sadabahar	61.64	73.40	10.80	2.06	4.54	10.62	116.40	170.93	109.22	109.83	124.39	4.43	752.44	70.53
Anugraha	81.85	88.14	7.72	1.48	2.60	9.96	104.51	156.37	52.21	112.38	127.42	3.15	360.70	22.57
PCP-CH-4-08	85.63	93.36	9.01	1.80	4.01	8.65	88.33	114.60	68.03	124.11	140.26	3.80	642.31	50.40
K-1	72.06	82.57	4.16	0.90	1.71	8.12	72.84	101.46	40.24	115.50	131.47	4.35	312.55	40.47
LCA-357	64.39	77.63	14.70	2.80	5.19	7.56	66.30	88.56	100.28	111.38	126.45	5.02	830.70	102.24
Pant C-1	83.65	90.58	6.89	1.32	2.48	6.32	58.71	72.35	55.65	121.00	137.34	2.69	341.00	34.64
CPC-08-E	60.31	72.49	10.17	2.00	4.32	8.56	106.69	114.45	78.36	108.50	126.34	4.79	781.87	98.39
PH-08	66.14	76.52	4.20	0.88	1.96	8.71	78.04	110.11	48.68	117.68	132.49	2.42	296.11	28.63
CCH-05	80.23	87.84	7.36	1.52	2.80	6.68	56.02	66.64	76.41	117.90	130.56	4.02	404.54	53.49
DCL-520	77.76	86.15	6.69	1.30	2.32	4.94	93.89	118.70	43.32	119.88	135.30	3.58	338.61	28.59
Kashmir Long	60.20	70.53	12.85	2.16	5.08	9.62	101.49	146.35	103.42	103.38	123.29	4.63	817.11	95.55
PUP-CH-08	58.83	72.05	10.02	1.92	4.29	9.81	110.18	153.50	109.99	102.96	122.59	5.19	738.62	78.19
NCH-162	75.40	86.20	5.30	1.16	2.12	4.80	80.27	111.45	61.78	118.47	133.64	3.33	388.25	46.12
DCL-352	86.30	94.13	5.18	1.21	2.03	5.63	52.40	70.33	72.07	123.52	138.86	2.28	280.09	30.60
Pusa Jawala	64.62	77.67	13.38	2.40	5.16	10.47	112.47	194.26	116.90	114.47	131.27	5.56	840.49	85.07
AG-08	72.35	81.18	4.50	1.06	1.88	7.78	82.75	90.41	57.72	119.47	136.17	3.97	258.85	20.73
1118-14	79.53	89.72	7.58	1.50	2.72	7.36	69.19	72.10	40.67	120.52	135.40	2.05	410.15	36.41
PKM-1	71.56	81.61	8.00	1.72	3.16	6.14	80.49	96.56	113.85	108.55	126.44	4.15	498.29	52.32
PCP-08-CH	74.31	84.25	8.10	1.61	3.48	4.70	61.68	80.42	35.84	116.70	132.62	1.98	553.60	58.29
Surajmukhi	63.34	75.47	9.18	1.77	4.05	10.30	120.23	198.25	99.02	101.26	121.67	5.28	612.42	89.53
Mean	72.17	81.94	8.74	1.71	3.51	8.02	86.97	123.50	76.49	113.69	129.98	3.97	554.35	60.25
CD (P<0.05)	2.12	2.32	0.19	0.15	0.16	0.17	6.14	6.63	14.02	2.37	2.67	0.25	13.64	7.17

Table 3. Genetic variability components for major characters in chilli

Characters	Range	Mean	Coefficient of variance (%)		Heritability (%)	Genetic advance	Genetic gain (%)
			GCV	PCV			
Days taken to first flowering	58.83 - 86.30	72.17	12.35	12.48	97.96	18.17	25.18
Days taken to 50% flowering	70.53 - 94.13	81.94	9.04	9.20	96.51	14.99	18.29
Fruit length (cm)	4.16 - 14.70	8.74	35.04	35.06	99.86	6.30	72.12
Fruit girth (cm)	0.88 - 2.80	1.71	30.09	30.54	97.04	1.05	61.05
Fruit weight (g)	1.71 - 5.19	3.51	35.37	35.47	99.42	2.55	72.66
Number of branches plant^{-1}	4.70 - 10.62	8.02	23.63	23.67	99.70	3.90	48.61
Plant height (cm)	52.40 - 120.23	86.97	23.29	23.68	96.72	41.03	47.18
Number of fruits plant^{-1}	66.64 - 198.25	123.85	34.14	35.57	92.13	82.63	67.51
Number of seeds fruits^{-1}	35.84 - 116.9	76.49	34.19	35.96	90.40	51.23	66.97
Maturation days (green)	101.26 - 124.11	113.69	5.79	5.93	95.44	13.26	11.66
Maturation days (red)	121.67 - 140.26	129.98	4.13	4.31	91.64	10.59	8.14
1000 seed weight (g)	1.98 - 5.56	3.97	27.71	27.97	98.14	2.25	56.55
Green fruit yield (g plant^{-1})	258.85 - 854.65	554.35	38.43	38.46	99.85	438.54	79.11
Dry fruit yield (g plant^{-1})	20.73 - 102.24	60.25	45.41	45.98	97.53	55.66	92.38

Heritability in broad sense was observed to be high for all the traits studied. High heritability estimates were also reported earlier by Verma *et al*. (2004) and Samadia (2007). Heritability estimates alone are not an ideal parameter for predicting the effect of selecting the desired individual. Heritability estimates along with genetic advance are more useful than heritability values alone in predicting the selection of best individuals. In the present investigations, number of the fruits plant^{-1}, green fruit yield plant^{-1}, dry (red) yield plant^{-1}, number of seeds plant^{-1} and plant height exhibited high genetic advance as percentage of mean along with high heritability. These results indicated the influence of additive gene action. High genetic advance for number of fruits plant^{-1} and fruit yield plant^{-1} were also recorded earlier by Sreelathakumary & Rajamony (2002), Warshamana *et al*. (2008) and Gupta *et al*. (2009).

The data on correlations showed that most of the correlation coefficients at genotypic level were greater than the corresponding phenotypic correlation coefficients (Table 4). This suggested the predominance of genotypic effects over environmental factors. Genotypic correlation of 14 yield and yield attributing characters presented in Table 4 indicated that green fruit yield plant^{-1} had positive and highly significant correlation with 1000 seed weight (0.7497), number of seeds fruit^{-1} (0.7654), fruit weight (0.9839), fruit breadth (0.9459) and fruit length (0.9443), Similar correlation was noticed for dry (red) yield with 1000 seed weight (0.7856), number of seeds fruit^{-1} (0.7458), fruit weight (0.9219), fruit breadth (0.8844) and fruit length (0.8791). Green fruit yield plant^{-1} (0.6585) and dry (red) yield (0.6245) had significant positive correlation with number of fruits plant^{-1}. Number of fruits plant^{-1} was positively and high significantly correlated with number of branches plant^{-1} (0.8464) and plant height (0.9211), whereas number of seeds fruit^{-1} had positive and highly significant correlation with fruit length (0.7421), fruit breath (0.7649) and fruit weight (0.7684). Earlier Hosamani & Shivkumar (2008), Gupta *et al*. (2009) and Singh & Singh (2011) also reported that fruit yield plant^{-1} had positive and highly significant correlation with number of fruits plant^{-1} and fruit length.

Days to first flowering and days to 50% flowering had negative and non-significant correlation with most of the characters except plant height (- 0.5401 & - 0.5682), number of seeds fruit^{-1} (- 0.5657 & - 0.5725), 1000 seed weight (- 0.6018 & - 0.5819) dry (red) yield plant^{-1}. Green fruit yield plant^{-1} (- 0.5917 & - 0.5874) & (- 0.5973 & - 0.5960). Fruit weight was positively correlated with fruit length (0.9729) & fruit breadth (0.9708). The positive association of fruit weight with fruit breadth and fruit length indicated that selection of only one of the traits might lead to an increase in the size of fruit (Gupta *et al*. 2009).

Based on the overall performance of various genotypes under study the genotypes LCA-357 and CH-1 were found to be best under Kashmir conditions. These can either directly be used as cultivar or may be involved in breeding programmes to evolve superior cultivars and hybrids. On the basis of mean performance and other genetic parameters of different growth and yield characters it was revealed that the characters *viz*., plant height, fruit length, number of fruits plant^{-1}, fruit weight and fruit yield (green & red) are the most important traits for improving the genotypes while number of branches plant^{-1} can be considered as the second most important character for selection in chilli genotypes. Based on estimates of correlation coefficient, numbers of fruits plant^{-1} and fruit weight were adjudged as yield attributing characters which need to be focussed during selection.

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Table 4. Correlation coefficient (genotypic) of different characters in chilli germplasm

Characters	1	2	3	4	5	6	7	8	9	10	11	12	13	14
1	1.0000	0.9726**	- 0.4440	- 0.4559	- 0.5081	- 0.4643	- 0.5401*	- 0.5183	- 0.5657*	0.5297	0.5272	- 0.6018*	- 0.5917*	- 0.5973*
2		1.0000	- 0.4553	- 0.4403	- 0.5149	- 0.5020	- 0.5682*	- 0.5276	- 0.5725*	0.5782*	0.5850*	- 0.5819*	- 0.5874*	- 0.5960*
3			1.0000	0.9913**	0.9729**	0.5188	0.4679	0.5774*	0.7421**	- 0.2201	- 0.2361	0.6751**	0.9443**	0.8791**
4				1.0000	0.9708**	0.4729	0.4185	0.5403*	0.7649**	- 0.2532	- 0.2706	0.6613**	0.9459**	0.8844**
5					1.0000	0.5796*	0.5428*	0.6635**	0.7684**	- 0.2571	- 0.2547	0.7320**	0.9839**	0.9219**
6						1.0000	0.7659**	0.8464**	0.5440*	- 0.1598	- 0.1799	0.5574*	0.5603*	0.4904
7							1.0000	0.9211**	0.5446*	- 0.3195	- 0.2810	0.5784*	0.5601*	0.4838
8								1.0000	0.6225*	- 0.3555	0.3283	0.6681**	0.6585*	0.6245*
9									1.0000	- 0.4546	- 0.4765	0.5249	0.7654**	0.7458**
10										1.0000	0.9947**	- 0.2040	- 0.2720	- 0.3894
11											1.0000	- 0.2043	- 0.2675	- 0.3817
12												1.0000	- 0.7497**	0.7856**
13													1.0000	0.9354**
14														1.0000

1. Days taken to first flowering
2. Days taken to 50% flowering
3. Fruit length (cm)
4. Fruit breadth (cm)
5. Fruit weight (g)
6. Number of branches plant^{-1}
7. Plant height (cm)
8. Number of fruits plant^{-1}
9. Number of seeds fruit^{-1}
10. Maturation days (green)
11. Maturation days (red)
12. 1000 seed weight (g)
13. Green fruit yield (g plant^{-1})
14. Dry fruit yield (g plant^{-1})

*Significant at P<0.01; **Significant at P<0.05

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