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Studies on variability, heritability and genetic advance for yield and yield contributing characters in chilli (*Capsicum annuum* L.)

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Abstract

In order to determine the magnitude of variability, 11 genotypes of chilli were evaluated at AICRP on Vegetable crops, Bhubaneswar centre. Through analysis of variance, a high significant difference was found for almost all characters indicating a greater opportunity of exploit variability. Genotypic and phenotypic variances were highest for fruit yield /plant followed by fruit weight and no. of fruits/plant. Phenotypic co- efficient of variation (PCV) and Genotypic co-efficient of variation (GCV) were maximum in case of no. of plants affected by leaf curl/plot followed by fruit weight and no. of wilted plants/plot. Heritability (bs) was highest for fruit weight followed by no. of fruits/plant and no. of borer affected fruits /plant. The maximum genetic advance (% of mean) was observed in case of no. of plants affected by leaf curl/plot followed by fruit weight and fruit borer/plant. Genotypic coefficient of variation, heritability and predicted genetic gain were high for the characters fruit weight, leaf curl incidence, fruit borer incidence and no. of fruits/plant suggesting that additive gene action is responsible for expression of these characters.

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

Introduction

Chilli (*Capsicum annuum* L.) (2n = 24) is one of the most popular vegetables, originated from South and Central America (Bahurupe *et al*. 2013) [1]. It is the second most important solanaceous vegetable after tomato grown worldwide both as a spice or vegetable crop (Hasan *et al.* 2014) [8]. It genetically self-pollinated and chasmogamous crop whose flowers open only after pollination (Lemma 1998) [12].

To initiate any breeding work, it is necessary to assess the genetic variability present in the indigenous genotypes for yield and its components. Parameters of genotypic and phenotypic coefficients of variation are useful in detecting the amount of variability present in the germplasm. Heritability and genetic advance help in determining the influence of environment in expression of the characters and the extent to which improvement is possible after selection. Hence, new genotypes must be characterized to assess the variability and identify promising genotypes which can be used in further breeding programmes (Munshi *et al.* 2000; Sarma and Roy, 1995 and Sreelathakumary and Rajamony, 2004) [16, 22, 26].

The Indian germplasm is mainly represented by two species, *Capsicum annuum* and *Capsicum frutescens*, with a number of varieties cultivated throughout the country and mainly in southern states of India nearer to the tropics where climate is very favourable for *C. annuum.* Genetic resources play a pivotal role in its economical utilization and desirable traits improvements. Genetic improvement mainly depends upon the amount of genetic variability present in the population.

Collection and maintenance of the genetic diversity in capsicum are important to avoid genetic erosion. Besides the identification of species, the characterization and evaluation of genotypes maintained in gene banks are of fundamental importance (Sudre *et al.*, 2010) [29]. Genetic cataloguing based on standard descriptors helps to easily describe the morphological features of a genotype and thus helps exchange of information about new genotypes. Characterization and evaluation of germplasm are prerequisites for the utilization of the available diversity in the chilli improvement programmes. Desirable parental combinations provide the basis for selection in the follow up hybrid breeding process for exploitation of heterosis (Thul *et al.*, 2009) [30]. Desirable parental combinations can be identified on the basis of cluster analysis.

Material and Methods

The study was carried out at All India Coordinated Research Project on Vegetable Crops, O.U.A.T, Bhubaneswar during rabi season of 2016 in a randomized block design with three replications to evaluate most promising genotypes with respect to growth and yield attributing parameters among the 11 genotypes of chilli. Each genotype was raised in 8.1 m2 area with a spacing of 50 cm x 30 cm accommodating 54 plants per plot. The crop was grown with standard package of practices. The observations were recorded on sixteen economic traits from five randomly selected competitive plants from each genotypes and replication. The data were subjected to analysis as per procedure described by Panse and Sukhatme (1954) [17]. The coefficient of phenotypic and genotypic variation were calculated according to Burton and De Vane (1953) [3], heritability, genetic advance and genetic gain were calculated according to the formulae of Johnson *et al.* (1955) [10].

Results and Discussion

Table 1 reveals the ANOVA for various biometrical traits in chilli. The mean squares for genotypes were maximum in case of fruit yield/plant followed by average fruit weight number of fruits/plant. The values indicate highly significant differences for all the characters under study, thereby suggesting existence of large amount of variations among the genotypes.

As per the data Table 3, among all the genotypes, 2014/CHIVAR-9 (15.14 g) recorded highest fruit weight followed by 2014/CHIVAR-7(8.23 g) and 2014/CHIVAR-4. KA-2(3.18 g) was noticed as having lowest fruit weight. A wide range of variation (22.64 to 94.85) was noticed among 11 genotypes for number of fruits/plant. 2014/CHIVAR-10(94.85) had the maximum number of fruits/plant followed by 2014/CHIVAR-8 and LCA-334. However, the minimum number of fruits/plant was recorded in 2014/CHIVAR-9(22.64). The genotype 2014/CHIVAR-7 produced the highest fruit yield/plant to the tune of (161.74g) which was better than LCA-334(48.54 g) and KA-2(83.19 g). LCA-332 (48.54 g) recorded the lowest fruit yield/plant. A moderate range of yield/ha was found among 11 genotypes of chilli. Genotype 2014/CHIVAR-7 recorded the highest yield (103.41q/ha) followed by 2014/CHIVAR-3 (91.93 q/ha) and 2014/CHIVAR-10 (86.26 q/ha). However, lowest yield/ha was recorded in KA-2.

The data of varietal trial on chilli were subjected to further analysis of genetic variability. A perusal of Table 4 shows that the genotypic and phenotypic variances were highest for fruit yield /plant followed by fruit weight and no. of fruits/plant. Minimum difference existed between the values of GV and PV for most of the traits studied except plant spread (E-W), leaf curl incidence and wilt incidence and fruit yield per plant.

A perusal of Table 5 reveals that there was a very wide range of variation among the characters in respect of Genotypic coefficient of variation (GCV) and Phenotypic coefficient of variation (PCV). Phenotypic co- efficient of variation (PCV) and Genotypic co-efficient of variation (GCV) were maximum in case of no. of plants affected by leaf curl/plot followed by fruit weight and no. of wilted plants/plot. There was close proximity between the values of PCV and GCV in respect of most of the characters except branches/plant, leaf area, plant spread (E-W), anthracnose, leaf curl and wilt incidence.

Heritability values ranged from the lowest of 54.72 % in case of branches/plant to the highest of 99.84 % in respect of fruit weight. Heritability (bs) was highest for fruit weight followed by no. of fruits/plant and no. of borer affected fruits /plant. Majority of the traits showed high to moderate levels of heritability. The maximum genetic advance (% of mean) was observed in case of no. of plants affected by leaf curl/plot followed by fruit weight and fruit borer/plant. The characters fruit weight, leaf curl incidence, fruit bore incidence had high GCV, heritability and GA (%). No. of fruits/plant showed moderate GCV with high heritability and GA (%).

On examining the ANOVA, the nature and magnitude of variability for 16 different quantitative characters are clearly observed among the chilli genotypes. The values indicate highly significant differences for all the characters under study, thereby suggesting existence of large amount of variations among the genotypes. So, there is a scope for considerable improvement in this crop through the characters studied. Similar to the present findings, investigations carried out earlier also revealed wide variations for various characters (Patel *et al*., 2015; Janaki *et al*., 2015 and Mishra *et al*., 2015) [18, 9, 15].

It may be contemplated from the statistics of range and general mean values of the characters that there is a great deal of variability for characters under study. These statistics quite hopefully provide a strong impetus for selecting promising genotypes for specific objectives, because of the magnitude and wide to moderately wide spectrum of variations observed in each character among the genotypes under evaluation. Further, the coefficient of variation (C.V.) being less than 20% for all the characters studied except leaf curl and wilt, as such indicates that good precision was maintained in conducting the experiment.

Among the genotypes evaluated, 2014/CHIVAR-7, 2014/CHIVAR-3 and 2014/CHIVAR-10 performed better than the rest suggesting suitability and better adaptability of these genotypes for cultivation at Bhubaneswar in Odisha. Other researchers (Srilakshmi, 2006; Jyothi *et al.*,2008; Sharma *et al*., 2010) have also indicated better suitability of some varieties over the rest.

For understanding the breeding principles in any crop improvement programme, two aspects are most important i.e. (i) selection cannot create variability but act only on that which is already in existence (ii) selection can act effectively only on heritable differences (Allard, 1960). Thus the first and foremost necessity for selection is to ascertain whether the genetic variability for these characters is present in the population at significant level or not. Further, the phenotypic mean values which are the basis of comparison, may fall far short of requirement and may even be misleading as the phenotypic expressions are sometimes influenced by environment and thereby may not necessarily represent the genotypic values. To avoid this misleading information for the correct interpretation of data, on the sound genetic principle, statistics such as variance and coefficient of variation etc. are to be computed for proper evaluation. The estimates of genetic parameters such as phenotypic and genotypic variance computed here as per method suggested by Burton and Devane (1953) [3] along with the coefficients of variation permits a sound basis to determine the variability components as well as to know the relative amounts of heritable and non-heritable variation for each of these characters.

From the present study, it is clearly observed that there exists a wide range of phenotypic as well as genotypic variation for majority of the 16 quantitative characters in chilli. Minimum differences were evident between the values of GV and PV for most of the traits studied except plant spread (E-W), leaf curl and wilt incidence and fruit yield per plant. The existence of minimum variation between these two parameters indicated that environment has a little effect in expression of these characters and phenotype truly represents the genotype.

In comparing the phenotypic coefficient of variation and genotypic coefficient of variation values it is observed that in general the former values are greater than the latter in respect of all the 16 quantitative characters under study. However, there was close proximity between the values of PCV and GCV in respect of most of the characters except branches/plant, leaf area, plant spread (E-W),anthracnose, leaf curl and wilt incidence suggesting a negligible influence of environment on expression of most of the characters.

In the present study, presence of high to moderate coefficients of variation in case of no. of plants affected by leaf curl/plot, fruit weight and no. of wilted plants/plot, fruit borer(no. of fruits/ plant), anthracnose (no.of fruits/plant), no. of fruits/plant, fruit yield/plant, fruit length and days to initial flowering indicated the presence of good amount of variability among the materials evaluated and therefore, selection for these characters may be quite hopefully used in chilli improvement programme. Cherian (2000) [4], Shivkumar and Hosamani (2006) [25], Bharadwaj *et al.* (2007) [2] and Shirshat *et al.* (2007) [24] observed similar trends, which are in agreement with the present findings. Rest of the characters showing low values for this parameter may be of least significance for chilli improvement programme.

Heritability is an index of transmissibility and is of primary interest to a plant breeder. Poehlman and Borthakur (1972) [19] opined that the characters not influenced by environment will have high heritability. According to Randhawa *et al*. (1975) [20] higher the heritability value of a character, less will be the environmental influence on expression of that character, thereby indicating better opportunity for selecting a genetically good individual. In the present experiment, heritability (bs) was highest for fruit weight followed by no. of fruits/plant and no. of borer affected fruits /plant. Majority of the traits showed high to moderate levels of heritability suggesting that these characters might be highly heritable and less influenced by environment and selecting genotypes on the basis of such characters would be worthwhile in chilli improvement. The results obtained are in agreement with the findings of Subhashri and Natarajan (2000) [28], Gogoi and Gautam (2002), Manju and Sreelatha kumary (2002) [14] and Dipendra and Gautam (2003) [5].

It was suggested by Weber and Moorthy (1952) that information concerning heritability of quantitative characters and their genetic and environmental variances when considered together might be useful for improving the efficiency of selection. Considering the heritability estimates with genotypic coefficient of variation values, it is observed that high values were obtained for both the parameters in case of fruit weight, leaf curl incidence, fruit borer incidence and no. of fruits/plant. So, selection may be quite effective based on these characters. Similar results were reported by Bharadwaj *et al.* (2007) [2]. On the other hand, deviations noticed in the present study from the findings of previous workers may be due to differences in genetic stock and environmental variations.

Though the studies of heritability estimates are important, their scope is limited since they are estimated in broad sense and are prone to change with changes in environment and the testing material. Further, the heritability estimate by itself may not be alone a useful index of genetic potentiality of a character. According to Eswro *et al*. (1963) [6], genetic advance (GA) indicates the potentiality of selection at a particular level of selection intensity. Thus, heritability estimates along with genetic advance are more valuable than heritability alone in predicting the response of selection (Johannsen *et al*., 1955; Robinson, 1963) [21]. High heritability does not necessarily mean that the character will show high genetic advance, but when such compatible association exists (high heritability and high GA) additive genes come into prominence because no genetic advance is due to non-additive genes. The selection based on a character showing high genetic gain (GA) may be desirable particularly in case of directional selection, when the main aim of the selection is to change the mean value of a character to have better standards. On the other hand, high heritability accompanied with low genetic advance indicates the prominence of non-additive gene effect, suggesting the adoption of heterosis breeding (hybridization) instead of direct selection.

In the present investigation, high estimates of heritability coupled with high genetic advance for characters such as fruit weight, leaf curl incidence, fruit borer incidence and no. of fruits/plant may be ascribed to effect of additive genes (Panse and Sukhatme, 1954; Liang and Walter, 1968) [17] and may be amenable for selection. Considering the three genetic parameters together such as genotypic coefficient of variation, heritability and predicted genetic gain at a glance it is observed that the characters like fruit weight, leaf curl incidence, fruit borer incidence and no. of fruits/plant showing high to moderate values for the above three important genetic parameters suggested that additive gene action is responsible for expression of these characters**.** So, direct selection through these characters will be effective in improvement of chilli. This is in agreement with the findings of Bharadwaj *et al.* (2007) [2].

Tables

Table 1: Analysis of variance (mean squares) for various biometrical traits

Characters	Mean squares		
	Replications	Genotypes	Error
Plant height(cm)	153.7237	429.5307**	17.4709
Branches/plant	1.1817	4.001**	0.8652
Fruit length(cm)	0.4906	10.9712**	0.2557
Fruit girth(cm)	0.3412	0.2289**	0.0245
Average fruit weight (g)	0.2010	3536.0359**	1.8799
Leaf area(cm^2)	1.1237	10.2787**	1.3198
Plant spread(E-W)(cm)	3.5763	125.6779**	10.7417
Plant spread(N-S) (cm)	0.8413	139.3378**	5.6966
Days to initial flowering	2.2805	176.7182**	7.1636
Days to 50% flowering	3.2358	98.0229**	3.7431
No. of fruits/plant	13.9634	1271.0138**	29.1233

Fruit borer(no. of affected fruits/ plant)	0.9204	32.8727**	0.4866
Anthracnose(no. of affected fruits/ plant)	0.6093	1.9714**	0.0870
Leaf curl (no. of affected plants/plot)	4.3712	264.7061**	9.1379
Wilting(no.of plants/plot)	1.4621	29.8682**	5.5705
Fruit yield/plant(g)	154.3636	21508.6836**	1002.2473

** Significant at 1%

Table 2: Mature green fruit colour of chilli genotypes

Genotypes	Mature green fruit colour
2014/CHIVAR-2	Green
2014/CHIVAR-3	Green
2014/CHIVAR-4	Green
2014/CHIVAR-5	Light green
2014/CHIVAR-6	Light green
2014/CHIVAR-7	Light green
2014/CHIVAR-8	Deep green
2014/CHIVAR-9	Light green
2014/CHIVAR-10	Green
KA-2(C)	Light green
LCA-334(C)	Light green

Table 3: Mean performance of different genotypes in chilli (Pooled).

Genotypes	PH	BP	PSEW	PSNS	LA	DIF	DFF	FW	FL	FG	NFP	FYP	YQH
2014/CHIVAR-2	91.47	14.00	57.10	48.07	22.28	43.83	53.50	5.31	9.29	3.61	54.75	146.14	76.26
2014/CHIVAR-3	79.72	12.83	55.05	52.35	22.99	37.00	55.17	4.57	9.16	3.37	63.29	150.99	91.93
2014/CHIVAR-4	79.01	12.00	51.50	45.83	22.20	26.33	42.17	7.18	9.00	3.78	31.04	149.12	70.09
2014/CHIVAR-5	83.40	13.00	54.20	52.14	21.32	42.17	52.17	4.50	8.62	3.27	37.91	53.13	36.16
2014/CHIVAR-6	71.20	13.00	49.83	43.31	25.58	52.83	61.17	6.21	8.79	4.12	45.60	126.51	73.30
2014/CHIVAR-7	81.37	13.67	55.00	44.91	23.41	32.33	47.00	8.23	10.01	3.75	52.06	161.74	103.41
2014/CHIVAR-8	89.80	11.00	60.13	60.13	23.82	35.83	51.83	3.78	6.53	3.30	76.55	94.82	56.76
2014/CHIVAR-9	78.48	12.67	45.90	42.71	25.44	43.17	57.17	15.14	13.75	3.89	22.64	101.45	50.22
2014/CHIVAR-10	64.73	12.83	67.47	62.08	23.54	38.50	50.50	3.95	7.17	3.42	94.85	152.12	86.26
KA-2(C)	52.97	10.00	63.62	57.80	22.25	49.50	57.33	3.18	7.64	3.33	44.21	83.19	50.35
LCA-334(C)	92.90	12.00	63.07	54.07	18.99	34.33	44.83	3.52	7.75	3.64	65.73	48.54	55.41
SEm(±)	3.41	0.76	2.68	1.95	0.94	2.18	1.58	0.11	0.41	0.13	4.41	17.11	0.94
CD at 5%	7.12	1.58	5.58	4.06	1.96	4.56	3.30	0.24	0.86	0.27	9.19	50.47	2.78

PH-Plant Height(cm), BP- Branches/Plant, FL- Fruit Length(cm), FG- Fruit Girth(cm), FW- Fruit weight(g), LA- Leaf Area(cm^2), PSEW - Plant Spread(E-W)(cm), PSNS - Plant Spread(N-S)(cm), DIF- Days Initial Flowering(DAP), DFF- Days 50% Flowering(DAP), NFP- No. of Fruits/Plant, FYP- Fruit Yield/Plant(g), YQH-Yield(q/ha).

Table 4: General mean, range, co-efficient of variation (C.V.), genotypic variance and phenotypic variance for 16 characters of genotypes in chilli.

Characters	General mean	Range	C.V. (%)	Genotypic variance	Phenotypic variance
Plant height(cm)	78.641	52.967 -92.900	4.33	137.353	154.824
Branches/plant	12.455	10.000-14.000	6.09	1.045	1.911
Fruit length(cm)	8.882	6.533-13.750	4.64	3.572	3.828
Fruit girth(cm)	3.589	3.887-4.120	3.56	0.068	0.093
Fruit weight(g)	5.961	3.183-15.138	1.87	1178.052	1179.932
Leaf area(cm^2)	22.891	18.990-25.577	4.09	2.986	4.306
Plant spread(E-W)(cm)	56.624	49.833-67.467	4.7	38.312	49.054
Plant spread(N-S)(cm)	51.219	42.713-62.080	1.83	44.547	50.244
Days to initial flowering	39.621	26.333-52.833	5.51	56.518	63.682
Days to 50% flowering	52.076	42.167-61.167	3.03	31.427	35.170
No. of fruits/plant	52.713	22.643-94.847	8.35	413.964	443.087
Fruit borer (no. of fruits/ plant)	5.877	1.753-13.417	9.69	10.795	11.282
Anthracnose (no. of fruits/plant)	1.895	1.123-3.580	12.70	0.628	0.715
Leaf curl(no. of plants/plot)	10.576	2.667-29.500	23.33	85.189	94.327
Wilting(no. of plants/plot)	6.212	2.500-13.833	31.02	8.099	13.670
Fruit yield/plant(g)	117.180	48.54-161.740	9.41	6835.479	7837.726

Table 5: Genotypic co-efficient of variation (GCV), Phenotypic co-efficient of variation (PCV), Heritability (in broad sense) and Genetic advance (GA) for 16 characters of genotypes in chilli.

Characters	GCV	PCV	Heritability (%)	GA(% of mean)
Plant height(cm)	14.9029	15.8223	88.72	28.9160
Branches/plant	8.2096	11.0983	54.72	12.5099
Fruit length(cm)	21.2773	22.0256	93.32	42.3419
Fruit girth(cm)	7.2715	8.4786	73.55	12.8468
Fruit weight(g)	57.5827	57.6286	99.84	118.5258
Leaf area(cm^2)	7.5493	9.0652	69.35	12.9509
Plant spread(E-W)(cm)	10.9311	12.3690	78.10	19.9005
Plant spread(N-S)(cm)	13.0311	13.8392	88.66	25.2765

Days initial flowering	18.9743	20.1410	88.75	36.8231
Days 50% flowering	10.7650	11.3880	89.36	20.9626
No. of fruits/plant	38.5978	39.9325	93.43	76.8541
Fruit borer(no. of fruits/ plant)	55.9069	57.1530	95.69	112.6572
Anthracnose (no.of fruits/plant)	41.8125	44.6157	87.83	80.7219
Leaf curl(no. of plants/plot)	87.2733	91.8348	90.31	170.8530
Wilting(no. of plants/plot)	45.8123	59.5168	59.25	72.6427
Fruit yield/plant(g)	30.1010	32.2323	87.21	57.9079

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