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Genetic divergence, path coefficient and cluster analysis of chickpea (*Cicer arietinum*) cultivars, in the mid-altitudes of Meghalaya

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ABSTRACT

Twenty two chickpea (*Cicer arietinum* L.) genotypes were evaluated during *rabi* seasons of 2007-08 and 2008-09 to explore the possibility of introducing chickpea crop into the cropping system of the mid-altitudes of Meghalaya. Luxuriant chickpea growth with a wide spectrum of variability for plant height, number of branches/plant, days to flowering, number of pods/plant and 100 seed weight was observed. The genotypic variance was moderate to high for the said characters which resulted in moderate to high heritability and genetic advance values. Grain yield/plant was positively and significantly correlated with days to flowering, plant height, number of branches/plant, number of pods/plant and 100 seed weight. Moderate to high heritability and genetic advance of these plant characters vis-a-vis their positive association and direct positive effect on grain yield/plant suggested for their consideration during selection of high yielding genotypes. All the test chickpea genotypes could be grouped into five distinct clusters. An analysis of the percentage contribution of individual characters towards genetic diversity revealed that days to flowering, 100-seed weight and number of pods/plant were the major characters contributing to genetic diversity in chickpea. Based on the results it may be concluded that chickpea can be successfully grown in Meghalaya and chickpea improvement can be undertaken in the mid hill conditions of north eastern hill region of India.

Key words: Chickpea, D^2 statistic, Genetic advance, Genotypic coefficients of variation, Heritability Phenotypic coefficients of variation

The cropping system of north east hill region of India is predominantly monocrop type with rice and maize being the principal *kharif* season crops. After the harvest of these crops the fields are left fallow till the next *kharif* season. This region of the country has about 7.74% share in total pulse area, while contributing 7.94% of the total pulse production of the country. Pea, chickpea and lentils are the important protein providers in the diets of local people. Heavy rainfall and stiff competition with rice and maize during *kharif*, make this season unsuitable for pulses production. *Rabi* season offers a greater opportunity for growing pulses due to following reasons: (1) availability of large tracks of best cultivable land, (2) bright sunshine occurs for 6-7 hours during winter season, (3) the ability of *rabi* pulses to withstand cold and (4) retention of soil moisture in the lowland areas suitable for growing these crops. For exploring the suitability of chickpea (*Cicer arietinum* L.) in this region it is necessary to estimate the genetic variability of different plant characters of economic importance and their heritability. The association pattern among various traits and their direct and indirect effect on yield would be useful to ascertain the selection criteria for high yielding genotypes. For further crop improvement with desired character combinations, it is required to hybridize diverse parents and for this, a measure of genetic diversity in the available genotypes is required. The objective of this study was to characterize chickpea genotypes, study yield attributing components, their heritability and genetic advance.

MATERIALS AND METHODS

Twenty-two genotypes of chickpea were evaluated during post rainy season in two consecutive years of 2007-08 and 2008-09 at the experimental farm of Plant Breeding Division, ICAR Research Complex for NEH Region, Umiam, Meghalaya. The experiment was laid out in a randomized block design (RBD) with three replications, with a spacing of 30 × 10 cm, and a gross plot size measuring 2.7 m × 5.0 m. The recommended agronomic practices and plant protection

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measures were followed to ensure a normal crop growth. Observations were recorded for days to flowering, plant height, days to maturity, number of branches/plant, number of pods/plant, number of seeds/pod, 100 seed weight and grain yield/plant on ten randomly selected plants in each treatment across all replications. Mean values were taken for analysis of variance as per Panse and Sukhatme (1978). Phenotypic and genotypic variances of the genotypes were estimated as described by Burton and Devane (1953), heritability as described by Hanson *et al*. (1956) and genetic advance was estimated using the formula suggested by Johnson *et al*. (1955). The genotypic and phenotypic correlation coefficient and path coefficient were estimated as suggested by Dewey and Lu (1959). The data were subjected to analysis of genetic divergence through D^2 statistic (Mahalanobis 1936) to measure genetic divergence as suggested by Rao (1952), while Tocher's method was used to form clusters.

RESULTS AND DISCUSSION

Genetic variability, heritability and genetic advance

Analysis of variance (data not presented) revealed that genotypic differences were significant for all the characters except that of days to maturity and number of grains/pod. Range of variation was highest for number of pods/plant followed by days to flowering and plant height (Table 1).

Genotypes had the least range of variation for number of grains/pod and days to maturity. High coefficients of variation were observed for number of pods/plant and grain yield/plant. Genotypic coefficients of variation closely followed the phenotypic coefficients of variation in all the characters except days to maturity and 100-seed weight. Very low proportion of genotypic variation in these two traits showed the influence of environment and resulted in the least heritability and genetic advance values. In all of the other characters the heritability and genetic advance values were moderate to high. High heritability and genetic advance values were observed in days to flowering, number of grains/pod, plant height and number of pods/plant. High coefficients of variation, heritability and genetic advance for these four characters suggest the least effect of environment and probably prevalence of additive gene action. These characters would be responsive to selection.

Climatic conditions of Meghalaya are different from that of conventional chickpea growing areas. In Meghalaya temperature is relatively low during winters and many genotypes which flowered during extreme winter could not set pod till there was a rise in temperature.

Rise in temperature was not much and this favoured the continuation of vegetative growth, flowering and pod formation for a longer time. There occurred a very short span (10 -12 days) of high temperature regime that was sufficient for chickpea maturity. This short maturity period resulted in lower values of genetic estimates like GCV, h^2_b and genetic advance for 100 seed weight and days to maturity. Results 100 seed weight from conventional chickpea growing areas exhibit very high heritability and genetic advance estimates (Tomar *et al*. 2007, Parameshwarappa 2009).

Correlation coefficients and path coefficient analysis

Genotypic and phenotypic correlations were estimated among eight traits in 22 genotypes and these indicated the inherent association between any two variables, which might have occurred due to the pleiotropic action of genes, linkage or more likely both. Grain yield/plant was positively and significantly correlated with days to flowering, plant height, number of branches/plant, number of pods/plant and 100 seed weight (Table 2).

The significant positive association of grain yield/plant with number of branches/plant and number of pods/plant have reported in earlier studies (Vaghela *et al*. 2009, Kumar *et al*. 2012). Sidramappa *et al*. (2008) have also observed the significant positive association of grain yield/plant with plant height, number of pods/plant, number of branches/plant and 100 seed weight. Genotypes requiring more number of days to flower had more plant height and 100 seed weight. Numbers of pods/plant were more in taller genotypes. Days to maturity were negatively associated with plant height and 100 seed weight. Number of pods/plant was more in those genotypes which had more number of grains/pod. Genotypes with bold seeds had less number of seeds in their pods.

In the present investigation the path coefficient analysis was performed to estimate the direct and indirect contribution

Table 1 Estimation of GCV, PCV, h^2_b and GA of eight characters of chickpea

Characters	Mean	Range	GCV (%)	PCV (%)	h^2_b (%)	GA (%)
Days to flowering	90	6-99	14.41	14.80	94.90	26.99
Plant height (cm)	48.21	35.97-67.33	16.15	19.11	71.40	28.13
Days to maturity	159.98	156-163	0.51	2.00	06.50	0.27
Branches/plant (no.)	11.11	8.00-17.00	18.63	24.98	55.60	28.62
Pods/plant (no.)	43.56	15.87-87.07	43.18	52.75	67.00	72.82
100 seeds weight(g)	16.51	12.37-26.33	10.85	29.19	13.80	0.61
Grains/pod (no.)	1.20	0.94-1.64	26.00	26.78	94.30	71.83
Grain yield/plant (g)	8.92	3.24-18.47	36.92	61.40	36.20	45.74

Table 2 Genotypic (G) and phenotypic (P) correlation coefficients among the eight characters of chickpea

Characters		Plant height (cm)	Days to maturity	Branches/ plant (no.)	Pods/plant (no.)	100 seed weight (g)	Grains/pod (no.)	Grain yield/ plant (g)
Days to flowering	G	0.461*	0.150	0.363	0.067	0.378*	0.261	0.576*
	P	0.375	0.007	0.318	0.027	0.351	0.008	0.322
Plant height (cm)	G		0.068	0.107	0.678**	0.114	0.301	0.792**
	P		0.043	0.073	0.387*	0.088	0.130	0.558**
Days to maturity	G			0.336	0.250	0.394*	0.091	0.082
	P			0.100	0.149	0.088	0.146	0.030
Branches/plant (no.)	G				0.046	0.142	0.362	0.390*
	P				0.020	0.114	0.042	0.303
Pods/plant (no.)	G					0.349	0.605**	0.568**
	P					0.258	0.151	0.396*
Grains/pod (no.)	G						0.568	0.183
	P						0.333	0.097
100 seed weight (g)	G							0.575**
	P							0.394*

of various plant characters to grain yield/plant. Further compartmentalization of correlation coefficients into direct and indirect effects discerned the true nature of association between observed characters. Except for plant height and days to maturity all other characters exhibited positive direct effect on grain yield (Table 3).

Number of pods/plant exhibited maximum direct effect followed by 100 seed weight and number of grains/pod. Significant positive association of number of pods/ plant with grain yield/plant and high direct positive effect of number of pods/plant on grain yield/plant was also reported by Farshadfar and Farshadfar (2008). Parameshwarappa (2009) has also stressed on significant positive association and very high direct positive effect of pods/plant and 100 seed weight with grain yield/plant. Number of pods/plant not only had the maximum direct effect, indirect effect of plant height and number of grains/pod through this character was also very high. Except for plant height all the characters which had significant positive correlation with grain yield also exerted high direct positive effect on grain yield. Plant height had negative direct effect on grain yield but its very high indirect positive effect through number of pods/plant made its association with grain yield significantly positive. This implies that increase in grain yield on selection of taller chickpea genotypes is basically because of increase in number of pods/plant, otherwise plant height has the negative direct effect on plant grain yield. So, during selection genotypes with more number of pods should be preferred over taller genotypes with less number of pods/plant. Results of the correlation and path analysis suggest that all the characters having positive association with grain yield are also directly contributing to grain yield and selection of genotypes may reliably be done based on these characters.

Genetic divergence analysis

All of the 22 chickpea genotypes grouped into five clusters (Table 4). Maximum number of genotypes were retained in cluster III (8) followed by cluster I (7).

Genotype B-50 which alone formed cluster V exhibited least values for all the traits except days to maturity which

Table 3 Genotypic path coefficient showing direct (bold) and indirect effect of observed characters on grain yield per plant in chickpea

Characters	Days to flowering	Plant height (cm)	Days to maturity	Branches/ plant (no.)	Pods/ plant (no.)	100 seed weight (g)	Grains/ pod (no.)	Genotypic correlation Grain yield/ plant (g)
Days to flowering	0.283	–0.167	–0.004	0.083	0.080	0.207	0.093	0.576**
Plant height (cm)	0.130	–0.364	0.025	0.024	0.806	0.062	0.107	0.792**
Days to maturity	0.043	0.369	–0.025	0.077	–0.297	–0.216	–0.032	–0.082
Branches/plant (no.)	0.103	–0.039	–0.008	0.228	0.055	–0.078	0.129	0.390*
Pods/plant (no.)	0.019	–0.247	0.006	0.010	1.000	–0.191	0.216	1.000**
100 seeds weight (g)	0.107	–0.041	0.010	–0.032	–0.415	0.548	–0.359	–0.183
Grains/pod (no.)	0.074	–0.109	0.002	0.083	0.719	–0.551	0.357	0.575**

Residual effect G = –0.2633 and P = 0.04823

Table 4 Inter (bold)- and intra- cluster distances (D^2) in chickpea

Clusters	I	II	III	IV	V	No. of genotypes	Genotypes
I	31.27	131.37	124.71	65.44	349.17	7	B-24, B-42, B-102, B-103, B-106, B-107, B-108
II		31.97	187.21	184.21	400.99	4	B-20, B-28, B-49, B-17
III			23.49	55.59	59.59	8	B-39, B-30, B-33, B-34, B-40, B-101, B-104, B-105
IV				8.13	196.13	2	B-12, B-21
V					0.00	1	B-50

Table 5 Cluster means for different characters in chickpea

Cluster	Days to flowering	Plant height (cm)	Days to maturity	Branches/ plant (no.)	Pods/ plant (no.)	100 seed weight (g)	Grains/ pod (no.)	Grain yield/ plant (g)
I	95.71	50.63	160.67	12.32	51.71	14.79	1.25	11.82
II	93.17	50.86	159.31	10.00	30.58	24.61	0.97	6.94
III	73.87	43.76	159.42	10.92	34.84	14.92	1.18	6.86
IV	79.00	58.30	159.50	11.27	78.00	13.92	1.53	13.83
V	55.67	35.97	163.33	8.33	32.07	14.03	0.85	3.33

was maximum in this cluster. B-50 was the only kabuli genotype among 22 genotypes and flowered in significantly early (56-60) as compared to mean flowering duration of 90 days. Early flowering of this genotype could not contribute towards yield because at the time of flowering of this genotype (~ 20 December) the temperature was too low and this resulted in drop of flowers. This genotype was susceptible to low temperature and in spite of early flowering, it took maximum number of days to maturity. This may be one of the reasons of recording least values for most of the characters in this genotype which ultimately distanced this genotype from other genotypes and it alone formed one cluster (V). This cluster was one of the clusters involved in first three top genetically distant cluster pairs (II & V, I & V and IV & V) (Table 4). Separation of kabuli and desi chickpea genotypes in different clusters has also been reported by Sefera *et al*. (2011). The highest mean values for grain yield/plant, number of grains/pod, number of pods/plant and plant height were depicted by cluster IV (Table 5).

Cluster I exhibited maximum mean values for days to flowering and number of branches/plant and cluster II had the highest mean value for 100 seed weight. The maximum contribution towards divergence was due to days to flowering followed by 100 seed weight and number of pods/plant. Days to maturity and grain yield/plant contributed least to the total diversity. Kayan and Adak (2012) have demonstrated the involvement of pods/plant in genetic diversity. Very high contribution of number of pods/plant and 100 seed weight towards total diversity was also reported by Malik *et al*. (2010). The results of D^2 analysis could be utilized in identifying the best parental combination for generating variability with respect to various traits under study. For creating wide spectrum of variability and improving the grain yield the genotypes in cluster IV would be crossed with genotypes in cluster V. Since cluster V contained only one genotype and this genotype was not suitable for most of the characters, another option of crossing genotypes of cluster IV with genotypes of cluster I may be explored for creating wide spectrum of variability.

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