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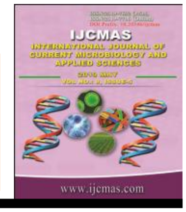

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Genetic Variability, Correlation and Path Coefficient Analysis in Chickpea (*Cicer arietinum* L.) for Yield and its Component Traits

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The present study was conducted to evaluate 50 chickpea germplasm accession to understand the magnitude of variability, heritability, genetic advance and the association of various yield components and their direct and indirect influence on yield of chickpea based on twelve agro-morphological traits. These traits included three vegetative traits (plant height, number of primary branches and number of secondary branches), one flowering trait (days to 50 % flowering), seven yield related traits (days to maturity, number of pods per plant, number of seeds per pod, biological yield per plant, harvest index, 100 seed weight and seed yield per plant) and one quality trait (protein content). ANOVA revealed significant variation existed for most of the traits. High genotypic coefficient of variation (PCV and phenotypic coefficient of variation was found for 100 seed weight and plant height recorded high heritability coupled with high genetic advance. Traits such as number of secondary branches, number of seeds per plant, 100 seed weight, protein content, biological yield per plant and harvest index exhibited significant positive correlation with seed yield per plant, whereas biological yield per plant followed by harvest index had positive and greater direct effects on single plant yield.

Introduction

Chickpea (*Cicer arietinum* L.) is a self-pollinated crop, with 2n = 2x = 16 chromosomes and genome size of 732 Mb. Vavilov (1926) designated southwest Asia and the Mediterranean as primary and Ethiopia as secondary centres of diversity. India contributes major share of world's chickpea area (70%) and production (67%) and continues to be the largest chickpea producing nation. To meet domestic demand, India also imports large quantity of *desi* chickpea, but in past decade, it has emerged as a major exporter of *kabuli* chickpea.

In India chickpea is cultivated mostly in as a rainfed crop (68 % area) in all parts of the country (Dixit *et al.,* 2019). During 2016-17, chickpea was cultivated in an area of 99.27 lakh ha with production of 98.80 lakh tons and productivity of 995 kg/ha. 2017-18, chickpea production has been estimated to be about 11.23 million tonnes, which is 46 % of the total pulse production (23.95 m t) in India. To attain self-sufficiency by 2050, the total pulse production in the country needs to reach 39 MT (Annual Report, DPD 2016-17).

The improvement in crop yield depends upon the magnitude of genetic variability available in breeding material and the extent to which the yield component traits are heritable from generation to generation. The genetic variability can thus be a choice for selecting suitable parents; however, the quantitative characters are prone for environmental influence that necessitates the partitioning of overall variances as heritable and non - heritable components for efficient breeding programme (Hamdi, 1992). Absolute variability in different characters cannot be the decisive factor for deciding as to which character is showing the highest degree of variability. The relative values of phenotypic and genotypic coefficient of variation, therefore gives an idea about the magnitude of variability present in a population since the estimate of genotypic and phenotypic coefficient of variation, heritability and expected genetic advance are useful for yield improvement and the above values were estimated to know the scope of improvement in the yield of chickpea genotypes.

Yield is a complex character and influenced by many environmental factors, direct selection based on yield may not be rewarding. Therefore a basic understanding of the nature and magnitude of correlation among component traits towards yield is essential. Correlation coefficient and path analysis offers a means of determining the important traits influencing the dependent trait such as seed yield and it also helps in the determination of the selection criteria for simultaneous improvement of various characters along with economic yield. Hence in the present study an attempt was made to assess the factors seed yield in chickpea though association and path coefficient analysis.

Materials and Methods

Fifty chickpea germplasm accessions maintained at Department of pulses, TNAU, Coimbatore. Evaluation was conducted at New Area, TNAU Coimbatore which is located at about 11°N latitude and 77°E longitude at an altitude of 427 meters above MSL. The accessions were evaluated in a randomized block design with two replications. Each accession was planted in a single row of five meters length with a spacing of 60 cm between rows and 30 cm between plants. The recommended agronomic practices and crop protection measures were followed during the crop growth period. Observations were recorded on five randomly selected plants per replication for 12 quantitative traits *viz.*, days to 50 % flowering (DFF), days to maturity (DTM), plant height (PH), number of primary branches per plant (NPB), number of secondary branches per plant (NSB), number of pods per plant (NPP), number of seeds per plant (NSP), biological yield per plant (BYP), harvest index (HI), 100 seed weight (100 SW), protein content (PC) and seed yield per plant (SYP). The mean data were subjected to the following statistical analysis. Descriptive statistics like mean, maximum minimum, SD, CV were obtained using MS Excel. Biometrical methods were followed to estimate genotypic and phenotypic coefficient of variation (Burton 1952), heritability in broad sense (Lush 1940), genetic advance (Johnson *et al.*, 1955) and correlation and path coefficient analysis (Singh and Chaudhry, 1979).

Results and Discussion

The basic statistical measures *viz.,* mean, minimum, maximum, PCV, GCV, heritability and genetic advance (GA) (% of mean) for the measured traits were presented in Table 1. The analysis of variance significant differences among the genotypes for all the characters indicates the presence of adequate variability in experimental material. The range was more for number of pods per plant followed by harvest index, 100 seed weight and seed yield per plant.

The estimates of genotypic and phenotypic coefficient of variation are necessary to understand the role of environmental influence on different traits. The differences between the GCV and PCV indicate the level of environmental variations that contributes a major part in the expression of traits (Majumdar *et al.,* 1974). In the present investigation, variances in terms of coefficient of variation indicated there is little difference between phenotypic and genotypic variance for the days to 50 % flowering and days to maturity whereas the characters number of secondary branches per plant, number of pods per plant, number of seeds per plant and seed yield per plant were more influence by the environment which is indicated by more difference between the phenotypic and genotypic coefficient of variation.

Heritability and genetic advance as per cent of mean is a reliable tool in selection programme to get a clear picture of the scope of improvement of various characters through selection. In the present investigation, days to 50% flowering showed high heritability coupled with moderate genetic advance, while plant height recorded high heritability coupled with high genetic advance. It may be due to some amount of additive gene action. Hence, phenotypic selection for this trait may be effective. The present findings are in support with Sharma and Saini (2010) and Sidramappa *et al.,* 2008. In case of days to maturity high heritability accompanied with low genetic advance was recorded, which may be due to the effect of non-additive genetic variance and the selection may not be rewarding. It is in accordance with the findings of Vaghela *et al.,* (2009) and Sharma and Saini (2010).

High heritability coupled with high genetic advance for traits like number of primary branches per plant, harvest index and 100 seed weight was observed. This indicated the predominance of additive gene effects and selection for these traits will be effective in the segregating generation. Medium heritability coupled with high genetic advance was observed for traits like number of secondary branches, number of pods per plant, number of seeds per plant, biological yield per plant and grain yield per plant. This suggested high component of heritable portion of variation for these traits and hence, simple selection for these traits could be achieved through their phenotypic performance. Similar findings have been reported by Vaghela *et al.,* (2009). In case of protein content medium heritability accompanied with medium genetic advance indicates that the character is influenced by environmental effects and hence the selection would be ineffective.

Yield is a complex traits controlled by several simply inherited traits. The correlation coefficients highlight the pattern of association among such yield components and helps determine how a complex trait such as yield can be improved. Phenotypic and Genotypic correlations for all possible combinations are presented in Table 2. Seed yield per plant showed positively significant correlation with number of secondary branches, number of seeds per plant, 100 seed weight, protein content, biological yield per plant and harvest index at both phenotypic and genotypic levels, the results obtained from the present investigation are in strong agreement with findings of Samyukta *et al.,* (2017) and Agarwal *et al.,* (2018).

Table.1 Estimation of genetic variability parameters for quantitative traits of chickpea

Characters	Mean	Minimum	Maximum	PCV	GCV	Heritability	GA (% of mean)
DFF	49.54	44.00	65.00	10.27	9.05	77.63	16.43
DTM	89.01	82.00	105.00	5.83	5.05	75.24	9.03
PH (cm)	33.09	26.58	44.75	12.64	10.34	66.92	17.42
NPB	2.66	1.67	3.83	20.97	16.67	63.17	27.29
NSB	9.40	4.60	15.25	28.26	18.71	43.81	25.51
NPP	34.65	12.50	62.18	37.03	26.66	51.86	39.55
NSP	39.35	19.53	65.85	36.42	21.62	35.25	26.45
BYP (g)	15.06	7.70	33.19	35.42	26.57	56.24	41.04
HI (%)	54.76	30.62	70.42	19.34	16.22	70.33	28.02
100 SW (g)	23.64	11.98	42.79	37.45	31.04	68.67	52.98
PC (%)	22.16	14.29	28.90	14.89	11.27	57.28	17.57
SYP (g)	8.21	2.37	16.01	38.32	28.09	53.73	42.41

Characters - DFF (Days to 50 % flowering), **DTM** (Days to maturity), **PH** (Plant height), **NPB** (Number of primary branches), **NSB** (Number of secondary branches), **NPP** (Number of pods per plant), **NSP** (Number of seeds per pod), **BYP** (Biological yield per plant), **HI** (Harvest index), **100 SW** (100 seed weight), **PC** (Protein content), **SYP** (Seed yield per plant)

Table.2 Genotypic and phenotypic correlation between yield and yield components in chickpea

		DFF	DTM	PH	NPB	NSB	NPP	NSP	100 SW	PC	BYP	HI	SYP
DFF	rG	1	0.766**	-0.073	0.186	0.122	-0.098	-0.138	0.058	-0.214	0.407**	-0.452**	0.095
	rP	1	0.704**	-0.103	0.147	0.065	-0.012	-0.081	0.068	-0.105	0.244	-0.284*	0.069
DTM	rG		1	0.053	0.210	0.125	-0.106	-0.309*	0.241	-0.094	0.340*	-0.386**	0.041
	rP		1	0.065	0.184	0.090	0.021	-0.070	0.172	-0.149	0.241	-0.225	0.102
PH	rG			1	-0.311*	-0.156	-0.055	-0.449**	0.563**	0.432**	0.177	0.022	0.140
	rP			1	-0.169	-0.011	-0.004	-0.063	0.350*	0.242	0.185	0.016	0.174
NPB	rG				1	0.076	-0.263	-0.390**	0.348*	-0.082	0.063	0.035	0.086
	rP				1	0.122	-0.020	-0.086	0.263	-0.027	0.142	-0.072	0.113
NSB	rG					1	-0.054	0.353*	0.083	0.197	0.373**	0.294*	0.481**
	rP					1	0.048	0.346*	0.006	0.128	0.323*	0.111	0.330*
NPP	rG						1	0.019	-0.039	-0.200	-0.238	0.256*	-0.068
	rP						1	0.259	-0.093	-0.031	0.055	0.186	0.160
NSP	rG							1	-0.605**	0.385**	-0.030	0.654**	0.334*
	rP							1	-0.364**	0.117	0.383**	0.425**	0.598**
100 SW	rG								1	0.396**	0.745**	0.040	0.647**
	rP								1	0.218	0.460**	-0.013	0.377**
PC	rG									1	0.386**	0.441**	0.593**
	rP									1	0.229	0.195	0.288*
BYP	rG										1	-0.031	0.809**
	rP										1	-0.062	0.838**
HI	rG											1	0.554**
	rP											1	0.462**
SPY	rG												1
	rP												1

* Significance at 0.05 level of probability ** Significance at 0.01 level of probability rG - Genotypic correlation rP - Phenotypic correlation

Characters - DFF (Days to 50 % flowering), **DTM** (Days to maturity), **PH** (Plant height), **NPB** (Number of primary branches), **NSB** (Number of secondary branches), **NPP** (Number of pods per plant), **NSP** (Number of seeds per pod), **BYP** (Biological yield per plant), **HI** (Harvest index), **100 SW** (100 seed weight), **PC** (Protein content), **SYP** (Seed yield per plant)

Table.3 Direct and indirect effects of component traits on seed yield per plant as revealed from path analysis

	DFF	DTM	PH	NPB	NSB	NPP	NSP	100 SW	PC	BYP	HI	Genotypic correlation with SYP
DFF	**-0.034**	-0.034	-0.010	0.032	-0.001	-0.007	-0.017	-0.006	0.002	0.373	-0.204	0.095
DTM	-0.026	**-0.045**	0.008	0.036	-0.001	-0.008	-0.038	-0.024	0.001	0.311	-0.174	0.041
PH	0.003	-0.002	**0.141**	-0.054	0.001	-0.004	-0.055	-0.057	-0.004	0.162	0.010	0.140
NPB	-0.006	-0.009	-0.044	**0.173**	0.000	-0.019	-0.048	-0.035	0.001	0.058	0.016	0.086
NSB	-0.004	-0.006	-0.022	0.013	**-0.004**	-0.004	0.043	-0.008	-0.002	0.342	0.132	0.481**
NPP	0.003	0.005	-0.008	-0.046	0.000	**0.073**	0.002	0.004	0.002	-0.219	0.115	-0.068
NSP	0.005	0.014	-0.063	-0.068	-0.002	0.001	**0.123**	0.061	-0.004	-0.028	0.295	0.334*
100 SW	-0.002	-0.011	0.080	0.060	0.000	-0.003	-0.074	**-0.100**	-0.004	0.684	0.018	0.647**
PC	0.007	0.004	0.061	-0.014	-0.001	-0.015	0.047	-0.040	**-0.010**	0.354	0.199	0.593**
BYP	-0.014	-0.015	0.025	0.011	-0.002	-0.017	-0.004	-0.075	-0.004	**0.917**	-0.014	0.809**
HI	0.015	0.017	0.003	0.006	-0.001	0.019	0.080	-0.004	-0.005	-0.028	**0.451**	0.554**

* Significance at 0.05 level of probability ** Significance at 0.01 level of probability

Characters - DFF (Days to 50 % flowering), **DTM** (Days to maturity), **PH** (Plant height), **NPB** (Number of primary branches), **NSB** (Number of secondary branches), **NPP** (Number of pods per plant), **NSP** (Number of seeds per pod), **BYP** (Biological yield per plant), **HI** (Harvest index), **100 SW** (100 seed weight), **PC** (Protein content), **SYP** (Seed yield per plant)

Days to 50 % flowering showed positive correlation with days to maturity at the same time it had significantly negative correlation with harvest index. Days to maturity had negative genotypic correlation value with number of seeds per plant and harvest index and also it had positive correlation with biological yield per plant. Though early accessions produce more biomass but resulted in less number of seeds with low harvest index leads to lower yield than the late flowering/maturing ones. Hence evolving early flowering genotypes with high seed yield remains a key objective in chickpea breeding programmes. Plant height had negative correlation with number of primary branches and number of seeds per plant. It suggests that tall plants will have less number of branches and seeds per plant and at the same time it will have more seed size and weight. Number of primary branches showed negative correlation with number of seeds per plant in terms of genotypic level. Number of secondary branches had significant positive correlation with number of seeds per plant and biological yield per plant. Number of seeds per plant showed negative correlation with 100 seed weight and positive correlation with harvest index. Profuse branching plant types produce more growth/biomass. These results in production of more number of flowers and have more number of seed per plant and at the same time seed parameters get compensated. 100 seed weight had positive correlation with protein content and biological yield per plant.

Seed yield is determined by the number of seeds formed per unit area of the plant and also the average weight of the individual seeds. As the seed size and number plays a vital role in chickpea improvement programmes, knowledge of these traits contributing towards phenotypic variation for both these traits and their direct and indirect share towards yield is essential (Monpara and Gaikwad, 2014). Path coefficient analysis is one of the reliable statistical techniques in quantifying the interdependence of characters and the extent of influence of independent characters either directly or indirectly on seed yield (Mushtaq *et al.,* 2013). The knowledge of direct and indirect influence of yield contributing characters on the ultimate end product yield in any crop is of prime importance in selecting high yielding genotypes. The direct and indirect effects of twelve characters are presented in Table 3. Residual effect was low (0.124) which measures the effects of those variable not included in the study was negligible, hence indicating the number of characters chosen for the study were appropriate. The path analysis showed that the maximum positive direct effects contributing to single plant yield was exhibited by biological yield per plant, harvest index followed by number of primary branches per plant and plant height which implies that direct selection for these traits would improve the single plant yield. The results were in arguments with the findings of Agarwal *et al.,* (2018).

The indirect effect biological yield per plant *via* days to 50 % flowering, days to maturity, number of secondary branches, 100 seed weight and protein content which were positive and greater in extent. However number of pods per plant was negative. Contribution of harvest index through number of seeds per plant, number of secondary branches, protein content, number of pods per plant were considerably positive, plant height, number of primary branches, 100 seed weight merely positive values and remaining traits shown negative effects only. From the path analysis the traits biological yield per plant and harvest index showed maximum direct effects on single plant yield. Both these traits exhibited significant and positive association with single plant yield. Therefore to increase the yield potential in chickpea the importance should be given to the selection based on these traits.

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