Original Research Article

Genetic variability, correlation and path coefficient analysis for quantitative traits in chickpea genotypes

Abstract

Thirty eight genotypes of chickpea were undertaken to determine the variability, interrelationship among yield and its components, their direct and indirect effects on seed yield. The present investigation was carried out at Regional Research Station, Faculty of Agriculture, Shere-Kashmir University of Agriculture Science and Technology during the rabi season of 2017-18. The treatment differences were statistically highly significant for all the traits along with higher magnitude of genotypic and phenotypic coefficient of variation indicating presence of good amount of variability. The trait, plant height exhibited highest range of variability followed by number of pods per plant, days to maturity, days to 50 per cent flowering, seed yield per plant, 100 seed weight, number of secondary branches per plant, number of primary branches per plant and number of seeds per pod. The estimates of genotypic as well as phenotypic coefficient of variation were highest for seed yield per plant followed by plant height, number of pods per plant, number of secondary branches, number of seeds per pod and 100-seed weight. The highest heritability (b.s.) was observed for number of pods per plant, plant height, days to maturity (99%) followed by number of secondary branches per plant, days to 50% flowering (98%), 100-seed weight, seed yield per plant (96%). Seed yield per plant exhibited highest genetic advance as per cent of mean (54.17) followed by plant height (50.93) and number of pods per plant (50.02). The seed yield per plant showed highly significant and positive correlation with number of pods per plant, number of secondary branches per plant, number of seeds per pod, and 100-seed weight. Path coefficient analysis revealed that number of pods per plant had highest direct effect on seed yield per plant followed by number of seeds per pod, 100-seed weight, number of primary branches.

Key words: Chickpea, Genetic variability, Correlation, Path analysis, Pods plant^{-1}, Seed yield plant^{-1}.

Introduction

Chickpea (*Cicer arietinum* L.) is a self-pollinated crop belonging to the *Leguminaceae* family of the Tribe *Cicereae*. Chickpea (*Cicer arietinum* L.) commonly known as Gram, Chana, Bengal gram and Garbanzo bean is the most important pulse crop of arid and semiarid regions. The somatic chromosome number in chickpea is 2n = 16. Two major cultivar types designated as 'desi' (=microsperma) and 'kabuli' (=macrosperma) have emerged under domestication. Desi chickpeas are small and angular with rough brown to yellow testas, while Kabuli types are relatively large, plump and with smooth cream colored testas. Kabuli types are considered relatively more advanced because of their larger seed size and reduced pigmentation achieved through conscious selection (Smartt and Simmonds, 1995). Desi chickpea cultivated mostly in Indian subcontinents, Ethiopia, Mexico and Iran.

They have markedly higher fiber content than Kabulis and hence a very low glycemic index which makes them suitable for people with blood sugar problems. Kabuli, mainly grown in southern Europe, Northern Africa, Afghanistan, Pakistan, Turkey and India. Kabuli (meaning from Kabul) is also called as Safed Chana. Chickpea (*Cicer arietinum* L.) is the third most important food legume. It is grown in over 45 countries round the world. India is the largest producer sharing 75% of total world production. It provides high quality protein to the people. People in the developed countries consider it as a health food. Chickpea grain contains 18-24% protein, 2.0-7.0% fats, 64% total carbohydrates (47% starch, 6% soluble sugar) and 6% crude fiber. Being a legume crop it takes care of soil fertility by fixing 41-65 kg atmospheric nitrogen per hectare through *Rhizobium* spp. It is mostly used in the form of 'Dal'. About 75 per cent of the total production is consumed as 'Dal' in India. India ranked first in area (99.27 lakh ha) and production (98.80 lakh tones) of chickpea in the world followed by Pakistan, Iran and Australia. The highest productivity of 3759 kg/ha is observed in China followed by Israel, Bosnia and Herzegovina. In India productivity was 995 kg/ha (annual report of DPD, 2016-17). Mature chickpeas can be cooked and eaten cold in salad. It is cooked in stews, ground into flour called gram flour (also known as chickpea flour and besan and used primarily in Indian cuisine). Chickpeas are used to make curries and are one of the most popular vegetarian food in India, Pakistan, Bangladesh and UK. Green leaves/twigs of a chickpea are used in preparing a nutritious vegetable in the countries of South Asia. These are also used as high protein fodder mixed with cereal leaves. Chickpea stover is fed to the cattle/goats as nutri-rich supplement to their major cereal fodder in the lean season. Chickpea (*Cicer arietinum* L.) is the premier pulse crop of Indian subcontinent. Chickpea is cultivated in diverse agro-climatic conditions in India and grown under both rainfed and irrigated conditions. Majority of the area is under rainfed farming which is one of the causes of low productivity in the country. Chickpea remarkably predominates among other pulse crops in terms of both area and production.

Improvement of yield and quality of crop is the primary objective of plant breeder. Selection of superior plants is the basis of crop improvement. The efficiency of selection depends on the identification of genetic variability from the phenotypic expression of the character. Variability means differences among the individuals of a single species or different species. The variability may be due to environment or genotypes or interaction of both. Assessment of genetic variability in the base population is the first step in any breeding programme.

The concept of correlation was first proposed by Galton (1889) which was later elaborated by Fisher (1918). It is a very useful technique for a plant breeder to quickly assess high yielding genotypes in the selection programme. Here, the correlation reflects the extent of association between a particular character and seed yield but they do not provide a complete picture as to how those components affect the seed yield. Path coefficient analysis developed by Wright (1923) is a standardized partial regression analysis which further permits the partition of correlation coefficient into components of direct and indirect effects. It reveals the true nature of cause and effect relationship of some of the yield contributing characters with yield. By using path coefficient analysis, the direct and indirect effects of one variable on another can be estimated.

Materials and Methods

The present investigation was conducted at Regional Research Station, Faculty of Agriculture, Wadura Sopore during rabi season of 2017-18. The experimental material used for the study consisted of 38 genotypes which were obtained from the ICARDA-BIGMP. Thirty five genotypes and 3 varieties of chickpea as checks were evaluated in a Randomized Block Design (RBD) with three replications during Rabi 2017-2018. Each genotype was sown in three rows of 2m length with spacing 30 cm between rows and 10 cm within rows. Standard agronomic practices were adopted. Observations were recorded on days to flowering and maturity (50%), plant height (cm), number of primary and secondary branches, pods plant^{-1}, 100-seed weight (g), seeds pod^{-1} and yield plant^{-1} (g). The data were subjected to the analysis of variance (Panse and Sukhatme, 1967) and further, biometrical procedures were followed to estimate genotypic and phenotypic coefficient of variation (Burton, 1952), heritability in broad sense (Burton and Devane, 1953), genetic advance (Johnson *et al*. 1955) and correlation and path coefficient analysis (Singh and Chaudhry, 1979).

Results and Discussion

Variability Studies: Wide range of variability was observed for almost all the characters except number of seeds per pod, primary branches per plant. Plant height exhibited highest range of variability followed by Number of pods per plant, days to maturity, days to 50 per cent flowering, 100 seed weight showed considerable amount of variability. The variability was lowest for number of seeds per pod, number of primary branches per plant. Similar results were obtained by Mushtaq *et al*. (2013), Gul *et al*. (2013). Dumbre *et al*.

(1984), Akhtar *et al*. (2011) reported highest range of variability for pods per plant. The existence of genetic variability is advantageous to the evolutionary survival of a species. Yield improvement in any crop can be brought about through plant breeding but necessary variability upon which selection is to be practiced must be available in the genetic material. Therefore, before embarking on any crop improvement programme, a plant breeder must survey and assess the variability for a given agronomic or yield component characters which can be estimated through variance, coefficient of variability (GCV, PCV), heritability and genetic advance.

Genetic variability is the basis for any heritable improvement in the crop plants. The estimates of GCV and PCV for all the characters studied showed little difference the latter being slightly greater than the former, thus indicating that the variability existing in these characters was not only due to genetic factors but also due to environmental factors. The estimates of genotypic (GCV) and phenotypic coefficients of variation (PCV) in the present study were highest for seed yield per plant, followed by plant height, number of pods per plant showing wide variation among the genotypes with respect to these characters. Bhanu *et. al* (2017) reported high GCV and PCV in case of seed yield per plant. Shinde (1996) reported highest GCV for 100 seed weight followed by seed yield per plant, pods per plant and seeds per pod under rainfed condition. GCV and PCV estimates lowest for days to maturity. This is also reported by Jeena *et al*. (2005), Zali *et al*. (2011). Mushtaq *et al*. (2013) reported highest values of GCV and PCV for 100 seed weight and lowest for days to maturity.

The estimates of GCV, PCV, heritability (b.s.) and genetic advance as per cent of mean for the different characters studied are presented in Table1. The magnitude of genotypic variance was highest for plant height (246.77) followed by number of pods per plant (88.31), days to maturity (38.88) and days to 50% flowering (30.39). The phenotypic variance, ranged between 0.03 and 246.94. Plant height recorded highest phenotypic variance (246.94) followed by number of pods per plant (88.51) and days to maturity (39.17). The environmental variance ranged from 0.006 (number of seeds per pod) to 0.325 (days to 50% flowering). Genotypic coefficient of variation (GCV) was highest for seed yield per plant (26.77) followed by plant height (24.73), number of pods per plant (24.31), number of secondary branches per plant (21.41) and 100 seed weight (10.63).The maximum phenotypic coefficient of variation was recorded for seed yield per plant (27.26) followed by plant height (24.74), number of pods per plant (24.33), number of secondary branches per plant (21.60) and 100 seed weight (10.85) . In general, the magnitude of phenotypic coefficient of variation was higher than the genotypic coefficient of variation. Genotypic coefficient of variation alone does not indicate the proportion of total heritable variation. However, the heritability estimates are better indicators of heritable portion of the variation. The broad sense heritability includes the contribution of additive gene effects, allelic interactions due to dominance and non-allelic due to epistasis. In the present investigation, number of pods per plant, days to maturity, plant height (99%) followed by days to 50% flowering, number of secondary branches (98%) and all other characters showed high estimates of heritability (b.s.). Similar findings were reported by Saleem *et al.* (2002). In the present investigation, seed yield per plant, plant height, number of pods per plant, number of secondary branches, 100 seed weight showed high estimates of heritability (b.s.) accompanied by high genetic advance as per cent of mean indicating that these traits could be prominently governed by additive gene action and selection of these traits could be more effective for desired genetic improvement. It is supported by similar finding of Saleem *et al*. (2002), Kumar *et al*. (2012), Mushtaq *et al*. (2013), and Padmavathi *et al*. (2013). Thus considering the estimates of genetic parameters like genotypic coefficient of variation, heritability and genetic advance as percent of mean, selection must be done in the characters like seed yield per plant, number of pods per plant, plant height, number of secondary branches per plant and 100 seed weight for improving the yield in chickpea. Maximum heritability was observed for days to maturity, plant height, number of pods per plant, (99%) followed by days to 50 per cent flowering, number of secondary branches (98%), 100-seed weight, seed yield per plant, (96%). High heritability was observed for all the studied characters. The estimates of GA as per cent of mean ranged from 7.02 to 54.17 with the highest estimate in case of seed yield per plant. The highest genetic advance as percent of mean was observed for seed yield per plant (54.17) followed by plant height (50.93) and number of pods per plant (50.02).

Table1: Variability parameters for nine different characters in chickpea.

S. No.	Parameters	Range	PV	GV	E.V	PCV	GCV	h^2 (b. s)	G.A
1	DF	135-155	30.71	30.39	0.325	3.80	3.78	0.98	7.75
2	DM	171-195	39.17	38.88	0.292	3.43	3.42	0.99	7.02
3	NPB	2.70-4.06	0.31	0.12	0.194	16.50	10.20	0.38	12.99
4	NSB	6.06-14.70	3.64	3.58	0.064	21.60	21.41	0.98	43.72
5	PH	31.56-95.90	246.94	246.77	0.165	24.74	24.73	0.99	50.93
6	NPP	21.70-64.60	88.51	88.31	0.192	24.33	24.31	0.99	50.02
7	NSP	1.03-1.63	0.03	0.02	0.006	14.65	14.65	0.83	25.10
8	100-SW	17.09-27.15	6.13	5.88	0.248	10.85	10.63	0.96	21.45
9	SYP	5.83-18.69	8.90	8.58	0.315	27.26	26.77	0.96	54.17

PV= Phenotypic variance, GV= Genotypic variance, EV= Env. Variance, PCV= Phenotypic coefficient of variation, GCV= Genotypic coefficient of variation, h^2(b.s)= Heritability(broad sense),G.A.= Genetic advance as % of mean, DF = Days to 50% flowering, DM = Days to maturity, PH = Plant height (cm), NPB = Number of primary branches, NSB = Number of secondary branches, NPP = Number of pods per plant NSP = Number of seeds per pod, SW = Seed weight, SYP = Seed yield per plant.

Correlation coefficient analysis: Correlated characters are of interest for three chief reasons, firstly, in connection with the genetic cause of correlation through the linkage and pleiotropic action of genes, secondly it is important to know how the improvement of one character causes simultaneous changes in other characters and thirdly in connection with natural selection (Falconer, 1960). Strong association between number of secondary branches per plant and number of pods per plant was noticed through the highly significant positive values of correlation coefficients. This indicates the simultaneous improvement of these characters through selection. Similarly, days to 50 per cent flowering was strongly associated with days to maturity and plant height suggesting that maturity period can be predicted by days taken to 50 per cent flowering. A negative correlation of these characters observed with seed yield per plant would help in developing early maturity varieties.

The genotypic and phenotypic correlations for nine characters studied are presented in Table2. In general, genotypic correlation coefficients were higher than their corresponding phenotypic correlations. Similar results were also reported by Khan *et al.* (2013) and Tadesse *et al.* (2016). It is revealed from Table2 that, significant positive correlation was reported between seed yield per plant with number of pods per plant, number of secondary branches per plant, number of seeds per pod. Results to certain extent are in accordance with the findings of Saleem *et al.* (2002); Yucel *et al.* (2006); Amjad *et al.* (2009) and Zali *et al.* (2009).Non-significant positive correlation was reported between seed yield per plant with

100-seed weight and plant height. Seed yield per plant had significant negative correlation with days to 50 per cent flowering, days to maturity while it has non-significant negative correlation with number of primary branches per plant.

Path coefficient analysis: It provides basis for selection of superior genotypes from the diverse breeding population. Seed yield is the product of interaction of component traits. Apart from correlation studies, path coefficient analysis is important to obtain information about how the component characters influence the seed yield through each other. To find out the direct and indirect contribution from each of the characters towards seed yield per plant, path coefficient analysis was carried out. The genotypic correlation coefficients being more important were only partitioned into direct and indirect effects which are presented in Table 3.

In the present investigation, path coefficient analysis revealed that number of pods per plant had highest direct effect (1.02) on seed yield per plant followed by number of seeds per pod, 100 seed weight and number of primary branches per plant. These direct effects are mainly responsible for positive association of these characters with seed yield per plant. This highest direct effect of number of pods per plant reported by Saleem *et al*. (2002), Padmavathi *et al*. (2013). The number of secondary branches per plant had negative direct effect on seed yield. Earlier workers Yadav *et al*. (2012), Ali *et al*. (2009) also found negative direct effect of secondary branches on seed yield. Based on findings of the present investigations it could be enforced that the most desirable plant type in chickpea should possess more number of primary branches per plant, number of pods per plant, number of seeds per pod and higher 100 seed weight, i.e. bold seeds.

Table2: Estimation of genotypic (above diagonal) and phenotypic (below diagonal) correlation coefficients in chickpea

S. No.	DF	DM	NPB	NSB	PH	NPP	NSP	100-SW	SYP
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	**1.00**	0.885*	-0.216	-0.130	0.800*	-0.138	-0.200	-0.269	-0.303
2	0.883*	**1.00**	-0.251	-0.209	0.376*	-0.187	-0.214	-0.235	-0.334
3	-0.112	-0.145	**1.00**	0.641*	0.014	-0.145	0.537*	-0.185	-0.114
4	-0.128	-0.206	0.634*	**1.00**	0.088	0.989*	0.034	-0.101	0.839*
5	0.079	0.017	0.006	0.088	**1.00**	0.028	-0.074	0.265	0.074
6	-0.137	-0.187	-0.091	0.985*	0.028	**1.00**	0.054	-0.584*	0.855*
7	-0.180	-0.193	0.037	0.017	-0.070	0.044	**1.00**	-0.384*	0.364*
8	-0.261	-0.227	0.037	-0.102	0.260	-0.118	-0.360*	**1.00**	0.128
9	-0.295	-0.325	-0.027	0.812*	0.072	0.837*	0.392*	0.129	**1.00**

***, indicate significant at 5 % level of probability or level of significance**

DF = Days to 50% flowering, DM = Days to maturity, PH = Plant height (cm), NPB = Number of primary branches, NSB = Number of secondary branches, NPP = Number of pods per plant NSP = Number of seeds per pod, SW = Seed weight, SYP = Seed yield per plant.

Table3: Direct (diagonal) and indirect effect of eight causal variables on seed yield in chickpea

S. No.	Parameters	DF	DM	NPB	NSB	PH	NPP	NSP	100-SW	SYP
1.	**DF**	**0.0255**	0.0226	-0.0055	-0.0033	0.0020	-0.0035	-0.0051	-0.0069	-0.3031
2.	**DM**	0.0315	**0.0356**	-0.0090	-0.0075	0.0006	-0.0067	-0.0076	-0.0084	-0.3345
3.	**NPB**	-0.0109	-0.0126	**0.0501**	-0.0071	0.0007	-0.0073	-0.0027	0.0009	-0.1141
4.	**NSB**	0.0161	0.0258	0.0174	**-0.1229**	-0.0109	-0.1217	-0.0043	0.0125	0.8394
5.	**PH**	-0.0024	-0.0005	-0.0004	-0.0026	**-0.0294**	-0.0008	0.0022	-0.0078	0.0743
6.	**NPP**	-0.1412	-0.1919	-0.1482	1.0113	0.0288	**1.0216**	0.0553	-0.1210	0.8553
7.	**NSP**	-0.1002	-0.1073	-0.0269	0.0174	-0.0375	0.0271	**0.5002**	-0.1921	0.3648
8.	**100-SW**	-0.1215	-0.1062	0.0084	-0.0459	0.1199	-0.0534	-0.1732	**0.4509**	0.1282

DF = Days to 50% flowering, DM = Days to maturity, PH = Plant height (cm), NPB = Number of primary branches, NSB = Number of secondary branches, NPP = Number of pods per plant NSP = Number of seeds per pod, SW = Seed weight, SYP = Seed yield per plant.

Conclusion

The range of variability, genotypic and phenotypic coefficient of variation, heritability percentage and genetic advance as per cent of mean were worked out. The character plant height exhibited highest range of variability followed by number of pods per plant and days to maturity. The variability was lowest for number of seeds per pod. The estimates of genotypic as well as phenotypic coefficient of variation were highest for seed yield per plant followed by plant height, number of pods per plant. High heritability estimates associated with high genetic advance as per cent of mean were observed for seed yield per plant, plant height, number of pods per plant, number of secondary branches per plant, 100 seed weight, suggesting that, these traits are under control of additive gene action and possibilities exist for the improvement of these characters through simple selection. Correlation studies at both genotypic and phenotypic levels were made to resolve the direction and magnitude of association among characters. The significant positive correlation was reported between seed yield per plant with number of pods per plant, number of secondary branches per plant, number of seeds per pod, plant height, 100 seed weight. This indicate simultaneous improvement of these characters through selection whereas days to 50 per cent flowering showed significant negative correlation with seed yields per plant at genotypic as well as phenotypic level indicates early genotype also produce higher grain yield. Path coefficient analysis revealed that number of pods per plant had highest direct effect (1.02) on seed yield per plant followed by number of seeds per pod (0.50), 100 seed weight (0.45), number of primary branches per plant (0.05), therefore emphasis should be given on these characters while making selection for desired improvement for grain yield in chickpea. These traits also showed significant positive association with seed yield per plant. The number of secondary branches exerted its effect on seed yield through number of pods per plant and 100 seed weight suggesting that the indirect selection through such traits would be effective in yield improvement.

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