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Genetic variability and correlation studies for some quantitative traits in chickpea (*Cicer arietinum* L.)

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Abstract
An experiment was conducted with twenty genotypes of chickpea (*Cicer arietinum* L.) to examine the presence of genetic variability which may further be utilized in breeding program. The experimental material was laid out in randomized block design with three replications at the experimental field of Himgiri Zee University, Dehradun during 2019-2020. Analysis of variance revealed that genotypes possessed significant genetic variability for all traits studied. The experimental results showed that the phenotypic coefficient of variation values were slightly higher than the genotypic coefficient of variation (GCV) values indicating the variation is not only due to genotype but also due to favorable influence of the environment. The high estimates of genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were observed for 100 seed weight (81.14, 83.25) respectively, followed by seed yield per plant (24.93, 25.10), number of primary branches (23.78, 23.96) and number of pods per plant (20.91, 21.11).High heritability (h2) coupled with high genetic advance as percent of mean (GAM) were observed for seed yield per plant, number of pods per plant, number of primary branches, number of secondary branches, 100 seed weight, plant height and protein content indicating that the heritability may be due to additive gene effects and selection may be effective for these characters for crop improvement Seed yield was significant and positively correlated with number of secondary branches (0.817* & 0.820*) at the genotypic and phenotypic level. Path coefficient results revealed Days to 50% flowering (0.3262), number of secondary branches (1.1094), 100 seed weight (0.0086) and Protein content (0.5648) had positive direct effects on the grain yield per plant.

Keywords: Chickpea, genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability, genetic gain, protein content and additive gene effects

Introduction
Chickpea (*Cicer arietinum* L.) is a one of the world's first cultivated legumes. Chickpea, also called garbanzo beans, are some amazing versatile legumes. It originated from western Asia. India is the largest producer in the world contributing 65% (9,075 million tonnes) of the total production of chickpea followed by Australia with 14% of share of total production. (FAO, 2021) [7]. In India, Madhya Pradesh (40%) is the leading state followed by Uttar Pradesh (16%) and Rajasthan (14%) of production. There are two distinct types of chickpeas i.e Desi and Kabuli. The seeds of desi types are yellow to dark brown in colour, irregular or wrinkled shaped, small in size and cultivated in larger areas. The seeds of Kabuli types are white or pale cream in colour smooth in shape and bold in size and cultivated in lesser areas. Chickpea is a good source of Protein, folate and fiber, 100grams of chickpea contains 105mg calcium, 0.8mg copper, 6.2mg iron, 115mg magnesium, 2.2mg manganese, 366 mg phosphorus, 875mg potassium, 8.2 mg selenium and 3.4mg zinc. Genetic improvement of all crops mainly depends on the magnitude of genetic variability present in the plant breeding material. The estimation of PCV and GCV are required for understanding the effects of environment on various traits. Estimation of heritability and genetic advance in a population gives information about the future gain in the following generations. The partitioning of correlation into direct and indirect effects by path coefficients analysis was suggested by Wright (1921 which gives us important information on the relative advantages of the selection criteria's traits. Path coefficient analysis is essential to determine the direct effects of traits on other traits as well as their indirect effects on other traits.

Materials and Methods
The experiment was carried out during rabi season 2019-2020 in the research field of the

Department of Agriculture, Himgiri Zee University, Dehradun, Uttarakhand. Twenty chickpea genotypes obtained from IIPR, Kanpur, Uttar Pradesh and VNMKV, Prabhani, Maharashtra were used in the study. The genotypes were grown in Randomized Block Design with three replications. Each replication consisted of three rows of each genotype. Standard package of practices were followed to raise a good crop with row to row distance of 50 cm and plant to plant distance of 10 cm. The observations were taken on five randomly selected plants from the middle of the plot for the collection of the data on the various quantitative traits like Number of primary branches, number of secondary branches, plant height(cm), number of pods per plants,100 seed weight, seed yield per plant and Protein content, while the data for Days to 50% flowering and days to maturity were taken on plot basis when fifty percent of the plants showed flowering and maturity. The analysis of variance was done according to Panse and Sukhatme (1967) [14]. Heritability in broad sense was calculated by the formula suggested by Burton and Devane (1953) [3]. Genetic advance was studied by the formula suggest by Johnson *et al.* (1955) [9]. Path coefficient analysis was carried out according to Dewey and Lu (1959) [5].

Results and Discussion

Analysis of Variance

Analysis of variance revealed significant difference between the 20 genotypes for all the nine traits showing the high genetic variability between the genotype for entire traits. The characters studied are days to 50% flowering, days to maturity, number of primary branches, number of secondary branches, plant height at maturity, number of pods per plants, 100 seed weight, protein content and seed yield per plant (Table 1). Similar results were reported by Kumar *et al.* (2017) [13], Banik *et al.* 2018 [2] and Paul *et al.* 2018 [15].

Phenotypic and Genotypic Coefficient of Variation

According to Burton and Devane (1953) [3] they classified PCV and GCV value as high (>20%), medium (10-20%) and low (<10%).On the basis of this, in the present study indicated that four characters showed high PCV and GCV values *viz*., Number of primary branches, Number of pods per plant, 100 seed weight and Seed yield per plant.

All the characters studied explained that the values of phenotypic variances were higher than genotypic variances for all the traits which reflected that the variation was not due to the genotypes but also due to the favorable influence of the environment. The phenotypic co-efficient variation ranged from 6.09 per cent to 83.25 per cent for days to maturity and 100 seed weight respectively. High PCV values obtained from 100 seed weight (83.25). Moderate PCV was observed from six character *viz.*, seed yield per plant (25.1062), number of primary branches per plant (23.96), number of pods per plant (21.10), number of secondary branches (17.97), plant height at maturity (13.67) and protein content (10.52). Low PCV was obtained from days to maturity (6.09), days to fifty% flowering (9.32), it was the only two characters express low PCV.

The Genotypic coefficient of variation ranged from 5.47 per cent to 81.14 per cent for days to maturity and seed yield per plant respectively. Moderate GCV was observed from seven characters *viz.*, seed yield per plant (24.93), number of primary branches (23.78), number of pods per plant (20.91), number of secondary branches (17.73), plant height at maturity (13.36), protein content (10.12). Low GCV was observed from two character *viz.*, days to maturity (5.47), days to fifty % flowering (8.89). A higher genotypic coefficient of variation for grain yield may help in selecting better genotypes through breeding program for higher grain productivity under diverse climatic condition. Similar results were found by Thakur *et al.* (2018) [18] and Anusha *et al.* (2020) [1] for all the characters studied.

Heritability (h^2)

Robinson *et al.* (1949) classified heritability values as high (>60%), moderate (30-60%) and values less than 10% low. Heritability ranged out of (80.67) for days to maturity to (99. 80) for 100 seed weight. High heritability was obtained for eight characters *viz.*, 100 seed weight (99.80), seed yield per plant (98.62), number of primary branches (98.49), days to fifty % flowering (98.05), number of pods per plant (98.08), number of secondary branches (97.35), plant height at maturity (95.47), protein content (92.49). Moderate heritability was obtained for only one trait *i.e.*, days to maturity (80.67 per cent). The above results were supported by the findings of Paul *et al.* (2018) [15], Kumar *et al.* (2019) [11].

Genetic advance as percent of mean (GAM)

Falconer and Mackay (1996) classified genetic advance as percent of mean as low (0-10%), medium (10 - 20%) and high (20% and above). Genetic advance as percent of mean was maximum for 100 seed weight (32.83) and minimum for fifty % flowering(17.45).While, high for six characters *viz.*, seed yield per plant(51.00), number of primary branches (48.62), number of pods per plant (42.66), number of secondary branches (36.05), plant height at maturity (26.90), protein content(20.06) respectively. The above results were well supported by the similar findings of Kishor *et al.* (2018) [10], Thakur *et al.* (2018) [18] and Kumar *et al.* (2019) [11].

Genotypic and phenotypic correlations

Seed yield was significantly and positively correlated with number of secondary branches (0.817* & 0.820*) followed by protein content (0.779* & 0.776*), and plant height (0.681* & 0.686*). Such association indicates the possibility of selection of genotypes with high number of secondary branches and plant height. Similar results were reported by Singh *et al.* 2015, Shafique *et al.* 2016, Banik *et al.* 2018 [2], and Anusha *et al.* 2020 [1].

Path co-efficient analysis

Path coefficient is a standardized partial regression coefficient which measures the direct and indirect influence of one variable upon another thereby permitting the separation of the correlation coefficient into the components of direct and indirect effects. The path coefficient analysis was carried out according to the method suggested by Dewey and Lu (1959) [5]. To know the direct and indirect effects of these traits on seed yield correlations were further partitioned into direct and indirect genotypic and phenotypic effects through path coefficient analysis (table 4). Path coefficient analysis was carried out by taking grain yield per plant as dependent variables and rest of the quantitative traits as independent variables. Days to 50% flowering (0.3262), number of secondary branches (1.1094), 100 seed weight (0.0086) and

Protein content (0.5648) had positive direct effects on the grain yield per plant. The result are well supported by the findings by Jha *et al.* 2015 [8], Kumar *et al.* 2017 [13], Kumar *et al.* 2021 [12] and Tengse *et al.* 2022 [19].

Table 1: Analysis of variance for nine morphological characters in 20 chickpea genotypes

S.N.	Characters	Mean sum of Square		
		Replications df(2)	Genotypes df(19)	Error df(38)
1.	Days to 50% flowering	0.94	204.04*	6.67
2.	Days to maturity	2.03	194.93*	14.41
3.	Number of primary branches	0.23	1.156*	0.486
4.	Number of secondary branches	0.06	7.11*	0.06
5.	Plant height	0.35	138.76*	2.16
6.	Number of pods per plant	0.51	343.27*	2.21
7.	100 seed weight	0.80	2078.43*	1.47
8.	Protein content	0.06	13.37*	0.35
9.	Seed yield per plant	0.04	14.54*	0.06

DF= Degrees of freedom, *=significant at 0.05% probability level and **=significant at 0.01% level

Table 2: Estimates of mean, range, coefficients of variability, heritability and genetic advance as percent of mean for nine characters of chickpea (*Cicer arietinum* L.)

S.N.	Characters	Range	Mean	GCV%	PCV%	H^2 (%)	GAM%
1.	Days to 50% flowering	82.41-107.00	91.24	8.89	9.32	98.05	17.45
2.	Days to maturity	132.00-157.00	141.68	5.47	6.09	80.67	10.12
3.	Number of primary branches	1.26-3.71	2.60	23.78	23.96	98.49	36.05
4.	Number of secondary branches	7.20-11.13	8.64	17.73	17.97	97.35	36.05
5.	Plant height	37.14-61.70	50.48	13.36	13.67	95.47	25.90
6.	Number of pods per plant	34.86-66.66	50.98	20.91	21.11	98.08	42.66
7.	100 seed weight	12.00-28.49	23.25	81.14	83.25	99.80	32.83
8.	Protein content	17.01-24.54	20.57	10.12	10.52	92.49	20.06
9.	Seed yield per plant	5.07-13.98	8.81	24.93	25.10	98.62	51.00

Table 3: Genotypic and Phenotypic correlation analysis for nine characters in 20 chickpea genotypes

Character	Genotypic and Phenotypic correlation	Days to 50% flowering	Days to maturity	Number of primary branches	Number of secondary branches	Plant height	Number of pods per plant	100 seed weight	Protein content	Seed yield per plant
Days to 50% flowering	G	1.000	0.993	-0.922	-0.600	-0.730	-0.339	0.254	-0.913	-0.807*
	P	1.000	0.980	-0.842	-0.522	-0.624	-0.283	0.250	-0.767	-0.735*
Days to maturity	G		1.000	-0.970	-0.684	-0.824	-0.434	0.265	-0.919	-0.834*
	P		1.000	-0.821	-0.544	-0.644	-0.331	0.249	-0.696	-0.703*
Number of primary branches	G			1.000	-0.544	-0.644	-0.331	0.249	-0.696	-0.703*
	P			1.000	0.666	0.867	0.428	-0.127	0.851	0.752*
Number of secondary branches	G				1.000	0.867	0.743	-0.006	0.400	0.817*
	P				1.000	0.870	0.749	-0.001	0.424	0.820*
Plant height	G					1.000	0.677	-0.031	0.538	0.681*
	P					1.000	0.684	-0.024	0.564	0.686*
Number of pods per plant	G						1.000	-0.043	0.067	0.420
	P						1.000	-0.038	0.101	0.429
100 seed weight	G							1.000	-0.151	-0.112
	P							1.000	-0.138	-0.108
Protein content	G								1.000	0.779*
	P								1.000	0.776*
Seed yield per plant	G									1.000
	P									1.000

*=significant at 0.05% probability level and **=highly significant at 0.01%

Table 4: Path co-efficient analysis for nine characters of chickpea

Character	Days to 50% flowering	Days to maturity	Number of primary branches	Number of secondary branches	Plant height	Number of pods per plant	100 seed weight	Protein content	Seed yield per plant
Days to 50% flowering	0.3262	-0.5414	0.0608	-0.6661	0.5020	0.0251	0.0022	-0.5159	-0.1959
Days to maturity	0.3239	-0.5453	0.0640	-0.7584	0.5667	0.0321	0.0023	-0.5190	0.3727
Number of primary branches	-0.3007	0.5289	-0.0659	0.7385	-0.5961	-0.0317	-0.0011	0.4807	-0.0439
Number of secondary branches	-0.1959	0.3728	-0.0439	1.1094	-0.5959	-0.0550	-0.0001	0.2260	1.1093

Plant height	-0.2382	0.4493	-0.0572	0.9613	-0.6877	-0.0501	-0.0003	0.3039	0.5958
Number of pods per plant	-0.1107	0.2365	-0.0283	0.8245	-0.4656	-0.0740	-0.0004	0.0381	-0.0550
100 seed weight	0.0829	-0.1444	0.0084	-0.0064	0.0214	0.0032	0.0086	-0.0855	-0.0001
Protein content	-0.2980	0.5010	-0.0561	0.4439	-0.3699	-0.0050	-0.0013	0.5648	-5159.0

Residual effect t± 0.1084

Conclusion

From the experimental findings it was indicated that positive and strong association of number of secondary branches, plant height with seed yield per plant could be important characters in determining yield. Grain yield per plant recorded high heritability (98.62%) coupled with high genetic advance as percent of mean (51.00%) which indicates that most likely the heritability is due to additive gene effects and selection will be effective.

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