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Study on Variability and Character Association Analysis in Chickpea (*Cicer arietinum* L.)

Vaishnavi Vilasrao Deshmukh [a], Sam A. Masih [b], Krishan Kumar Yadav [a] and Ann Maxton [a*]

[a] Department of Genetics and Plant Breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj-211007, India.
[b] Department of Molecular and Cellular Engineering, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj-211007, India.

Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Chickpea (*Cicer arietinum L.)* is a legume crop belonging to the family *Leguminosae* (Fabaceae). Therefore, a better insight to the association of yield with its component traits can be helpful in improving the chickpea yield. The present study was conducted with 25 chickpea genotype to understand the magnitude of variability, heritability, genetic advance and the association of various yield components and their direct and indirect effect on yield of chickpea based on twelve traits at Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj during October–January 2022. ANOVA revealed significant variation existed for most of the trait. High GCV, PCV, heritability and genetic advance recorded by harvest index, seed yield, number of pod per plant, number of seed per pod. Seed yield per plant shows highly significant and positive association with harvest index, number of pod per plant. Harvest index number of pod per plant and biological yield per plant showed highest direct effect on seed yield per plant.

**Corresponding author: E-mail: ann.maxton@shiats.edu.in;*

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1. INTRODUCTION

"The chickpea or Bengal gram (*Ciicer arietinum* L.) is a legume crop of the Fabaceae family. The origin of the chickpea is thought to be somewhere between southeast Turkey and neighbouring Syria. There are four hubs of diversity which are the Mediterranean, Central Asia, Near East, and India. The *Cicer arietinum* L is annual, with a 738 Mb haploid genome, 2n = 2x =16 chromosomes" [1]**.** "It is a legume crop grown during the winter that does well at temperatures between 20 and 25 °C during the day and 15-20 °C at night effectively in dry weather. Chickpeas can be widely divided into two categories based on the shape of their seeds: desi, which has little seeds with a brown coat colour, and kabuli, which has large seeds with a cream or beige-colored coat" [2,3].

"Chickpea seeds are mostly made up of carbohydrates (50–58%), proteins (15–22%), moisture (7-8%), fat (3.8–10.20%), and micro-nutrients (1%). Chickpeas have a greater protein level than other beans with a typical Chickpeas have a greater protein level than other beans, at about 18% greater protein content than field peas and lentils. It contains many essential amino acids, including lysine, methionine, and other essential vitamins and minerals. ß-leucine, valine, anthreonine magnesium, phosphorus, calcium, and potassium" [4,5]**.** "Chickpea productivity is reduced by abiotic factors (Drought, Heat, Excessive salt, and Cold) and biotic factors (*Ascochyta blight*, Fusarium wilt, and *Helicoverpa*)" [6,7]**.**

Genetic variability is an important index for plant breeders because it provides a source of variation as well as raw material for yield enhancement**.** The selection of yield contributing characters is important for crop improvement and the selection of such characters depends mainly on heritable variation as well as the heritability of the trait concerned. It is necessary to have a highly accurate and appropriate method for estimating genetic variability that is not affected by environmental factors in order to promote a valid estimation of parameters. Specifically, the magnitude of genetic variability present in breeding material has a significant impact on the amount of progress that has been made in crop improvement as a result of selection. Its expression is also influenced by the prevailing environment conditions. Hence, to fulfil growing demand for varietal improvement and increased productivity, it is essential to collect, analyse, and record all available genetic variability on genotypes. Knowledge and experience of variability is a prerequisite for breeder in any crop improvement programme. Both variability as well as heritability are important parameters that can aid breeders at various phases of crop improvement. For hybridization programmes, a wide range of genetic variety among the parents is required, the genetic variance is understood using the morphological characterization of the germplasm.

Genetic diversity is necessary for features that have significant economic quantitative and qualitative qualities in any crop improvement effort. The chickpea lacks sufficient pollen because it is a self-pollinating plant. The diversity and susceptibility of existing cultivars to various abiotic and biotic stresses are principal challenges in raising output [8]**.** Studies on genetic variability in chickpea have been carried out using a variety of economically significant factors, including flowering time, grain weight, grain yield, etc. The linked qualities that are associated with yield, which is a complicated attribute, regulate how it is expressed. While the correlation coefficient can be used for identifying this relationship, path analysis can also explain both the direct and indirect relationships between the qualities [9]**.** The present study was conducted to evaluate the genetic variability, correlation, and route analysis for yield and yield component traits.

2. MATERIALS AND METHODS

The present investigation was carried out at the Research Farm, Department of Genetics and Plant Breeding, SHUATS, Prayagraj, during the *Rabi* season 2022. The experimental material is comprised of 25 genotype along with check variety. Three replications of a randomized complete block design were used for the experiment. In three replications with 30 × 10 cm inter and intra- row spacing in 1 × 1 m plots. For this chickpea crop, recommended agronomical and plant protection practice were followed. In order to select the best yield giving genotype in the agro climatic conditions of Prayagraj region observation were recorded for various quantitative traits like plant height, days to 50%

flowering, days to 50% pod setting, days to maturity and seed index, harvest index were recorded on plot basic, while for traits like plant height, primary branch count, number of pods, biological yield, seed yield, and others five plants were chosen at random and the harvest index was recorded. Thereafter the phenotypic quantitate traits were compared with high yielding check varieties for varietal selection. During the study, used genotype were:

1. NBEG-3 , 2. FLIP-09 162 , 3. RVG-202 , 4. IPC-11-85 17 , 5. ICC-2211 ,6 IPCK-9-40, 7. RATILA , 8. ICC-230 , 9. IPC-12-100, 10. CSJ-515 23, 11. RSG-931, 12. FLIP-97-53C 25, 13. IPC-11-09, 14. IPC-10-134, 15. JG-36, 16. IPC-2000-17, 17. ICC-495, 18. RSG-963, 20. ICC-4968 , 21. ILC-0, 22. BG-212 , 23. ICC-313, 24. IPC25, 25. UDAY (CHECK VARITY).

2.1 Statistical Analysis

2.1.1 Genetic variability

Genotypic (GCV and phenotypic coefficient of variation (PCV) was calculated as per formula prearranged by Burton [10], heritability in the broad sense (h2) as suggested by Burton and De [11] and genetic advance as per the method described by Johnson et al. [12].

2.1.2 Correlation coefficient analysis

The correlation coefficients were determined by the degree of a character's relationship with yield as well as among the variables that contributed to yield. The Miller et al. [13] formula was used to calculate the correlations between genotype and phenotype.

2.1.3 Path coefficient analysis

The method initially given by Sewall Wright and later developed by Dewey and Lu [14] were used to perform path coefficient analysis in order to figure out the direct and indirect impacts of the various characters on yield.

3. RESULTS AND DISCUSSION

3.1 Variability Studies

The Two way ANOVA implies (Table 1) that the mean sums of squares due to genotypes were significant for all the traits under study viz., days to 50% flowering, days to 50 % pod setting, days to maturity, plant height, number of pods per plant, number of seed per pods, number of primary branches per plant, numbers of secondary branches, seed index, biological yield per plant, harvest index and seed yield per plant. This substantial variability provides a good prospect for improving traits of interest in chickpea breeding programmes. These results were in agreement with the finding of Katkani et al. [15] and Sharma et al. [16].

Genetic parameters of yield and their components are given in Table 2. Results showed that PCV% was higher than the GCV% for all the traits under study. High genotypic and phenotypic coefficient of variance were recorded for harvest index. Similarly, the moderate estimates of PCV and GCV were recorded seed yield followed by number of pods per plant, numbers of secondary branches, seed index and number of primary branches. While the least estimate of PCV and GCV was recorded for biological yield, plant height, days to maturity, days to 50% flowering and days to 50 % pod setting. These results were in agreement with the finding of Kumar et al. [17] under similar conditions.

High estimates of heritability in broad sense were recorded for Harvest index followed by seed yield, number of pods per plant, number of seed per pods, seed index, numbers of secondary branches, biological yield and number of primary branches. Moderate estimates of heritability in broad sense were recorded for days to maturity and low heritability were recorded for days to 50 % pod setting, days to 50% flowering and plant height. These results were in close conformity with the findings of Malik et al. [18] for 100 seed weight, harvest index, secondary branches yield per plant, Babbar and Tiwari [19] for days to 50% flowering, days to maturity, plant height, 100 seed weight and yield per plant, Pandey et al. [20] for days to 50% flowering, number of seeds per pod, plant height and number of pods per plant, Monpara and Gaikwad [21] for seed yield per plant, 100 seed weight, plant height and primary branches per plant, Sowjanya et al. [22] for all traits and for number of seeds per pod, biological yield per plant, 100 seed weight and yield per plant.

The higher genetic advance recorded for harvest index followed by seed yield, number of pods per plant, number of seed per pods, seed index and numbers of secondary branches. Moderate estimate of genetic advance as percent of means was recorded for number of primary branches

Table 1. Analysis of variance for 12 characters of chickpea genotypes

Source	Degrees of freedom	Days to 50% flowering	Days to 50% pod setting	Plant height (cm)	Number of pods per plant	Number of seeds per pod	Days to maturity	Number of primary branches	Number of secondary branches	Seed yield	Biological yield	Harvest index	Seed Index
Repecation	**2**	3.453	3.72	3.639	2.474	0.015	46.84	0.085	0.357	0.02	1.008	12.474	0.903
Treatment	**24**	9.164*	12.553**	31.097*	74.294**	0.166**	104.209**	0.221**	4.849**	4.089**	8.286**	156.824**	16.984**
Error	**48**	4.648	5.553	17.065	3.94	0.015	23.271	0.037	0.474	0.119	1.265	4.317	1.634

Table 2. Parameters of genetic variability for grain yield and its attributing traits

Characters	General Mean	Range		PCV (%)	GCV (%)	Heritability h^2 (%)	GA as % of mean
		MIN	MAX				
Days to 50% flowering	78.69	72.67	80.67	3.152	1.559	24.467	1.589
Days to 50 % pod setting	91.64	85.33	94.67	3.065	1.667	29.586	1.868
Plant height (cm)	55.77	51.27	66.33	8.361	3.878	21.513	3.705
Number of Pods per plant	30.36	23.80	43.13	17.239	15.951	85.615	30.404
Number of seed per Pods	1.45	1.07	1.87	17.604	15.393	76.457	27.727
Days to maturity	143.76	129.00	150.67	4.931	3.613	53.69	5.454
Number of primary branches	2.48	2.03	2.93	12.625	9.985	62.555	16.269
Numbers of secondary branches	8.35	4.53	10.40	16.637	14.454	65.485	25.87
Seed yield	6.18	4.40	10.00	19.444	18.626	91.762	36.755
Biological yield	20.71	17.87	24.33	9.167	7.386	64.921	12.26
Harvest index	30.60	21.27	55.53	24.267	23.298	92.172	46.077
Seed index	18.71	14.33	25.33	13.884	12.087	75.791	21.676

Table 3. Genotypic and phenotypic correlation coefficient for yield and its attributing character in chickpea

Genotypical and phenotypic Correlation Matrix													
		Days to 50% flowering	**Days to 50% pod sett**	**Plant height (cm)**	**No. of pods per plant**	**No. of seeds per pod**	**Days to maturity**	**No.of primary branches**	**No.of secondary branches**	**Biological yield**	**Harvest index**	**Seed Index**	**Seed yield**
Days to 50% flowering	G	1.0000	0.0250	-0.0671	-0.255*	0.0061	0.1915	-0.0843	0.1078	0.348*	-0.435**	0.1704	-0.414**
	P	-	0.0124	-0.0753	-0.259*	-0.0005	0.1973	-0.0877	0.1078	0.363*	-0.439**	0.1785	-0.415**
Days to 50% pod set	G		1.0000	-0.1513	-0.1485	-0.0324	-0.0859	0.1157	-0.1795	-0.0839	0.0334	0.241*	-0.0317
	P		-	-0.1573	-0.1471	-0.0355	-0.0784	0.1133	-0.1819	-0.0760	0.0380	0.247*	-0.0310
Plant height (cm)	G			1.0000	0.0478	0.0940	-0.0490	0.0197	0.0046	0.1699	-0.0202	0.0362	0.1118
	P			-	0.0449	0.0894	-0.0541	0.0191	0.0045	0.1765	-0.0225	0.0405	0.1134
No. of pods per plant	G				1.0000	-0.1510	-0.270*	0.0786	0.1545	-0.1699	0.375**	-0.0629	0.398**
	P				-	-0.1572	-0.288*	0.0805	0.1558	-0.1697	0.371*	-0.0602	0.400**
No. of seeds per pod	G					1.0000	-0.0939	0.0811	0.0733	0.2187	0.1727	0.0283	0.1447
	P					-	-0.1040	0.0815	0.0737	0.2254	0.1695	0.0331	0.1466
Days to maturity	G						1.0000	-0.279*	0.0120	0.243*	-0.435**	0.1129	-0.414**
	P						-	-0.279*	0.0139	0.247*	-0.455**	0.1191	-0.418**
No. of primary branches	G							1.0000	0.0503	-0.1112	0.2267	0.0212	0.230*
	P							-	0.0499	-0.1099	0.229*	0.0217	0.230*
No. of secondary branch	G								1.0000	-0.0960	0.318*	0.228*	0.303*
	P								-	-0.0958	0.320*	0.228*	0.303*
Biological yield	G									1.0000	-0.279*	0.0615	-0.0970
	P									-	-0.281*	0.0571	-0.0988
Harvest index	G										1.0000	0.0709	0.903**
	P										-	0.0736	0.907**
Seed Index	G											1.0000	0.1266
	P											-	0.1257
Seed yield	G												1.0000
	P												-

Table 4. Genotypic path coefficient for yield and its attributing traits of chickpea genotypes

	PATH matrix of Seed yield											
	Days to 50% flowering	**Days to 50% pod sett**	**Plant height (cm)**	**No. of pods per plant**	**No. of seeds per pod**	**Days to maturity**	**No.of primary branches**	**No.of secondary branch**	**Biological yield**	**Harvest index**	**Seed Index**	**Seed yield**
Days to 50% flowering	-0.0871	-0.0022	0.0058	0.0223	-0.0005	-0.0167	0.0073	-0.0094	-0.0303	0.0379	-0.0148	-0.414**
Days to 50% pod sett	-0.0013	-0.0503	0.0076	0.0075	0.0016	0.0043	-0.0058	0.0090	0.0042	-0.0017	-0.0121	-0.0317
Plant height (cm)	-0.0054	0.0121	0.0798	0.0038	0.0075	-0.0039	0.0016	0.0004	0.0136	-0.0016	0.0029	0.1118
No. of pods per plant	-0.0113	0.0066	0.0021	0.0442	0.0067	-0.0120	0.0035	0.0068	-0.0075	0.0166	0.0028	0.398**
No. of seeds per pod	-0.0004	0.0020	0.0059	0.0094	0.0625	0.0059	-0.0051	-0.0046	-0.0137	-0.0108	0.0018	0.1447
Days to maturity	-0.0117	0.0053	0.0030	0.0165	0.0058	-0.0612	0.0171	-0.0007	-0.0149	0.0266	0.0069	0.414**
No.of primary branches	-0.0028	0.0039	0.0007	0.0026	0.0027	-0.0093	0.0334	0.0017	-0.0037	0.0076	0.0007	0.230*
No.of secondary branch	0.0026	-0.0043	0.0001	0.0037	0.0017	0.0003	0.0012	0.0237	-0.0023	0.0075	0.0054	0.303*
Biological yield	0.0679	0.0164	0.0332	0.0332	0.0427	0.0474	-0.0217	-0.0187	0.1951	-0.0545	0.0120	-0.0970
Harvest index	-0.3783	0.0290	0.0175	0.3262	0.1501	-0.3780	0.1970	0.2762	-0.2426	0.8691	0.0616	0.903**
Seed Index	0.0140	0.0199	0.0030	0.0052	0.0023	0.0093	0.0018	0.0188	0.0051	0.0058	0.0824	0.1266
Seed yield	-0.414**	0.0317	0.1118	0.398**	0.1447	-0.414**	0.230*	0.303*	-0.0970	0.903**	0.1266	1.0000
Partial R^2	0.0360	0.0016	0.0089	0.0176	0.0090	0.0253	0.0077	0.0072	-0.0189	0.7845	0.0104	

Table 5. Phenotypic path coefficient for yield and its attributing traits of chickpea genotypes

PATH matrix of Seed yield												
	Days to 50% flowering	**Days to 50% pod sett**	**Plant height (cm)**	**No. of pods per plant**	**No. of seeds per pod**	**Days to maturity**	**No.of primary branches**	**No.of secondary branch**	**Biological yield**	**Harvest index**	**Seed Index**	**Seed yield**
Days to 50% flowering	-0.0824	-0.0010	0.0062	0.0214	0.0000	-0.0162	0.0072	-0.0089	-0.0299	0.0362	-0.0147	-0.415**
Days to 50% pod sett	-0.0007	-0.0546	0.0086	0.0080	0.0019	0.0043	-0.0062	0.0099	0.0042	-0.0021	-0.0135	-0.0310
Plant height (cm)	-0.0061	-0.0128	0.0812	0.0037	0.0073	-0.0044	0.0016	0.0004	0.0143	-0.0018	0.0033	0.1134
No. of pods per plant	-0.0134	-0.0076	0.0023	0.0516	-0.0081	-0.0148	0.0042	0.0080	-0.0088	0.0192	-0.0031	0.400**
No. of seeds per pod	0.0000	0.0021	-0.0052	0.0091	-0.0581	0.0060	-0.0047	-0.0043	-0.0131	-0.0098	-0.0019	0.1466
Days to maturity	-0.0076	0.0030	0.0021	0.0111	0.0040	-0.0387	0.0108	-0.0005	-0.0096	0.0176	-0.0046	-0.418**
No.of primary branches	-0.0030	0.0038	0.0006	0.0027	0.0028	-0.0094	0.0338	0.0017	-0.0037	0.0077	0.0007	0.230*
No.of secondary branch	0.0016	-0.0027	0.0001	0.0023	0.0011	0.0002	0.0007	0.0147	-0.0014	0.0047	0.0034	0.303*
Biological yield	0.0700	-0.0147	0.0340	-0.0327	0.0434	0.0476	-0.0212	-0.0185	0.1927	-0.0541	0.0110	-0.0988
Harvest index	-0.3880	0.0336	-0.0199	0.3280	0.1497	-0.4015	0.2025	0.2823	-0.2481	0.8832	0.0650	0.907**
Seed Index	0.0143	0.0198	0.0032	-0.0048	0.0027	0.0095	0.0017	0.0183	0.0046	0.0059	0.0802	0.1257
Seed yield	-0.415**	-0.0310	0.1134	0.400**	0.1466	-0.418**	0.230*	0.303*	-0.0988	0.907**	0.1257	1.0000
Partial R^2	0.0342	0.0017	0.0092	0.0207	-0.0085	0.0162	0.0078	0.0045	-0.0190	0.8006	0.0101	

and biological yield and low estimate of genetic advance as percentage of mean was recorded for days to maturity, days to 50 % pod setting, days to 50% flowering and plant height, showed similarity with Solanki et al. [2] under similar conditions.

3.2 Correlation Coefficient Analysis

Correlation coefficient and path analysis is a method for identifying the important characteristics influencing the dependent characteristics, such as seed yield, and they assist in developing the selection criteria for simultaneously improving several characters and economic production.

Highly significant positive genotypic correlation (Table 3) of seed yield per plant was recorded with harvest index followed by number of pod per plant and number of secondary branches per plant and number of primary branches, whereas it exhibited significant negative correlation with days to maturity, days to 50% flowering and days to 50% pod setting. These findings showed close similarity with earlier work of Jain et al. [23] for primary branches per plant and for number of pod per plant and for number of pod per plant. While highly significant positive phenotypic correlation (Table 3) of seed yield per plant was recorded with harvest index and number of primary branches per plant, number of secondary branches, number of seed per pod, plant height. “Whereas, it exhibited significant negative correlation with days to maturity, days to 50% flowering, biological yield, days to 50% pod setting. These findings showed close similarity with earlier work” [23,24].

3.3 Path - Coefficient Analysis

The direct and indirect effects of different independent characteristics on the dependent character are measured via path coefficient analysis. It demonstrates the relationship between these independent characters and seed yield results from their direct influence on yield or from their indirect impact through other component characters. The direct and indirect effects of various yield components towards yield are shown in table.

Path coefficient analysis at genotypic level (Table 4) revealed that harvest index was observed the maximum positive direct effect on seed yield per plant followed by number of pod per plant, biological yield per plant, seed index, plant height, number of primary branches per plant, number of secondary branches per plant. While substantial negative direct effects on seed yield per plant were contributed by days to 50 % flowering, followed by number of seed per pod, days to 50 % pod setting, days to maturity.

These findings revealed direct positive effect on 100 seed weight, which were observed close similarity with earlier work [23] work showed close association with this investigation for days to 50% flowering, secondary branches per plant plant height, number of pods per plant and days to maturity. Same work observed with direct negative effect on number of primary branches per plant [24].

Path coefficient analysis at phenotypic level (Table 5) that revealed that harvest index was observed the maximum positive direct effect on seed yield per plant followed by biological yield per plant, plant height, seed index, primary branches per plant, secondary branches per plant While substantial negative direct effects on seed yield per plant were contributed by days to 50% flowering, number of seed per pod, day to 50% pod setting, and days to maturity. These findings showed close similarity with earlier work [23,24].

4. CONCLUSION

According to present study, the characters like harvest index, seed yield, number of pod per plant, number of seed per pod, number of secondary branches, showed high genotypic coefficients variation (GCV), phenotypic coefficients variation (PCV), and high heritability is coupled with genetic gain as percent of mean. Seed yield per plant shows highly significant and positive association with harvest index, number of pod per plant, and number of secondary branches per plant. The path analysis revealed that harvest index showed highest direct effect on seed yield per plant followed by number of pod per plant, biological yield per plant, and seed index. Therefore, these traits may be considered as the most important yield contributing characters.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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