Genetic Variability and Correlation Studies for Grain Yield and its Component Traits in Desi Chickpea (*Cicer arietinum* L.)

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ABSTRACT

This study involved 40 genotypes of Desi chickpea to evaluate the extent of genetic variability and the correlations between grain yield and its component traits. The experiment was conducted at Bihar Agricultural University, Sabour (Bhagalpur). The results indicated a high magnitude of genetic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) for grain yield per plot, seed index, total effective pods per plant and secondary branches. This suggests that the variability among the genotypes provides significant potential for improving these traits through breeding programs. High heritability, combined with a high genetic advance as a percentage of the mean, was observed for traits such as the seed index, biological yield, grain yield per plot and total effective pods per plant. This indicates that these traits are primarily governed by additive gene effects, making them favorable for selection. Phenotypic correlation analysis revealed that grain yield per plot exhibited a highly significant and positive association with traits such as primary and secondary branches per plant, total pods per plant, total effective pods per plant, biological yield per plant, seed index, grain yield per plant and days to 50% flowering. These positive and significant relationships indicate a true linkage between these traits and grain yield. Therefore, direct selection for these traits is likely to be highly effective in improving grain yield.

Keywords Chickpea (*Cicer arietinum* L.), Genotypes, Genetic variability, Correlation analysis.

INTRODUCTION

Chickpea is one of the most significant legumes among pulse crops, belonging to the family *Leguminaceae*. It has a chromosome number of 2n=16 and a genome size of 740 Mbp. It thrives in a cool-season climate with warm humidity, which is ideal for its cultivation. Chickpea is renowned for its nutritional and medicinal benefits, containing approximately 22% protein, 63% carbohydrates, 8% crude fiber, 4.5% fat, and 2.7% ash (Hirdyani 2014). India accounts

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for a significant share of global chickpea production, with 10.47 million hectares of land producing 12.27 million tonnes at an average productivity of 1172 kg/ha (Directorate of Pulses Development 2024). In Bihar, chickpea cultivation spans about 52,000 hectares, yielding 55,000 tonnes with an average productivity of 1045 kg/ha although the yield potential of chickpea can exceed 5.0 t/ha, the average yield remains stagnant at approximately 0.8 t/ha. One of the primary challenges in chickpea cultivation is its narrow genetic diversity. With the rising demand for chickpea as a cost-effective source of dietary protein to meet the nutritional needs of a growing population, bridging the significant gap between the current average yield and its potential yield is critical. By analyzing data on production and demand, the study uncovers significant trends in chickpea farming, highlighting major production areas and their respective contributions to the global supply chain. It reviews the current trading patterns of chickpea and explores the crop's increasing importance in global markets. Additionally, the research evaluates the expected future trajectory of chickpea production by considering factors such as rising demand, changes in regional production and potential challenges. In summary, the study provides vital insights into the dynamics of chickpea production and trade, offering a comprehensive analysis of its economic significance and prospects in global agriculture. It emphasizes the need for advanced breeding technologies that can enhance production, focusing on economic traits that benefit farmers. However, it is noteworthy that chickpea have not received as much research attention compared to other major cereal crops like wheat and rice. To bridge the gap between average and potential yields of chickpea, it is essential to utilize appropriate breeding programs. This can be achieved by adopting effective breeding programs likes, the selection efficiency of yield contributing characters depends on the heritability which brings out the genetic gain from the selection. Therefore, using metrics like PCV, GCV, heritability and genetic advancement to quantify variability is crucial for breeders. Therefore, information about the existence of genetic variability for various traits in the available germplasm is provided by these factors. Independent factors have a complex interrelationship and can have a direct or indirect impact on yield (Singh and Chaudhary 1995).While simple correlation analysis can reveal the relationships and linear associations between independent traits, it does not fully capture the detailed and precise relationship between dependent variables and predictors. The correlation coefficient, however, provides insights into how complex traits, such as yield, can be enhanced through indirect selection. The goal of chickpea breeding efforts is to evaluate and identify new sources of germplasm with valuable traits for improving yield and grain quality. As such, breeders often rely on genetic variability studies and correlation analyses to select the most promising genotypes for optimizing chickpea breeding programs (Mohan and Thiyagarajan 2019).

MATERIALS AND METHODS

The present investigation was administrated in the *rabi* season, 2023- 2024 at the BAC, Sabour farm Pulse experimental unit of Bihar Agricultural University, Sabour (Bhagalpur). In this experiment forty genotypes were taken including four checks BG 3043, GNG 2207, GNG 2299, PG 186, the design of experiment was RBD (Randomized Block Design), with three replication, total number of rows was four, Gross/net plot size was 4.8 m². The observation was recorded on these five randomly selected plants in each line and each replication and their mean values were used for statistical analysis. For the twelve quantitative characters viz., days to 50% flowering and days to maturity, plant height, primary branches, secondary branches, total pods per plant, total effective pods per plant, biological yield, grain yield per plant observations were recorded on plot basis. The data obtained was subjected to the analysis of variance (ANOVA), for Randomized Block Design (RBD) was done for each character as per Panse and Sukhatme (1985). This indicates a substantial level of variability among the genotypes, suggesting considerable potential for incorporating promising genotypes into breeding programs aimed at improving yield and its component traits. The genotypic coefficient of variances (GCV) and phenotypic coefficient of variances (PCV) were calculated using the formulas proposed by Burton (1952), Heritability in broad sense using the formula was given by Allard (1960) and genetic advance as percent of mean according to Lush (1949). Correlation coefficient is the mutual

association between variables without implying any cause effect relationship and genotypic and phenotypic correlation coefficient between traits and its component were estimated as per formula given by Johnson *et al.* (1950) and Al-Jibouri *et al.* (1958).

RESULTS AND DISCUSSION

Analysis of variance showed significant differences among the genotypes for all the studied characters, indicating a considerable level of genetic variability in the materials used are presented investigation (Table 1) as well as the result of genetic variability, heritability, and genetic advance as mean percent for Desi chickpea germplasm are presented Table 2. Significant phenotypic variability among the genotypes under investigation was indicated by the present study's findings, which showed that higher magnitudes of the phenotypic coefficient of variation (PCV) were noted for grain yield per plot, seed index, total effective pods per plant and secondary branches per plant. Significantly, a greater estimate of the genotypic coefficient of variation (GCV) for the seed index was found, indicating less environmental effect and strong genetic control over this feature. Ali *et al.* (2020) revealed similar results, highlighting the chickpeas' aptitude for efficient selection in breeding programs by observing high PCV for grain production, seed weight and pod-related variables. Plant height, principal branches, total number of

pods per plant, biological yield per plant and grain yield per plant all showed moderate estimates of the genotypic and phenotypic coefficient of variation. There is room for future development of these traits through selection because the moderate GCV and PCV values show that there is enough genetic variability with some environmental influence. Similar findings were reported by Kumar *et al.* (2020), who found that the number of primary branches and plant height in chickpeas had moderate phenotypic and genetic coefficients of variation (GCV and PCV), respectively, suggesting that there is enough variety available for breeding efforts.

Days to 50% flowering, days to maturity and harvest index showed the lowest magnitude genotypic and phenotypic coefficients of variation. These parameters are generally stable across genotypes but provide less room for selection-based improvement. Nikita and Lal (2022) revealed similar results, highlighting the fact that these features are mostly controlled by the environment. They found low GCV and PCV for days to 50% flowering and days to maturity in chickpea. Reddy *et al*. (2018) found that high heritability combined with strong genetic advance expressed as a percentage of mean was more useful in forecasting the effect of selection than low variability for the days to maturity and harvest index, which indicated stability but restricted possibility for genetic gain.

Table 1. Analysis of variance for twelve quantitative characters in Desi chickpea. **, * = Significant at 5% and 1% level of probability, respectively.

Sl. No.	Characters	Mean sum of squares		
		Replication (df= 02)	Treatment (df=39)	Error (df=78)
1	Days to 50% flowering	42.43	36.83**	6.47
2	Days to maturity	14.42	33.16**	7.61
3	Plant height (cm)	58.16	189.03**	15.64
4	Primary branches per plant	0.96	0.38**	0.12
5	Secondary branches per plant	11.66	2.95**	0.57
6	Total no. of pods per plant	382.19	148.04**	29.49
7	Effective pods per plant	232.21	130.08**	23.16
8	Biological yield per plant (g)	20.81	22.21**	1.28
9	Harvest index (%)	105.85	36.65**	12.43
10	1000-seed weight (g)	11.26	45.66**	2.15
11	Grain yield/plant (g)	13.66	3.55**	0.78
12	Grain yield /plot (kg/ha)	269235.40	232233.87**	26770.78

Table 2. Estimates of genetic parameters of variability for twelve quantitative characters of forty genotypes in Desi chickpea. VG= Genotypic variance, VP= Phenotypic variance, GCV = Genotypic coefficient of variation, PCV = Phenotypic coefficient of variation, h²= Heritability and GA as % of mean= Genetic advance as percent of mean (aberrations, DFF- Days to 50% flowering, DM- Days to maturity, PHT- Plant height (cm), PBPP- Primary branches per plant, SBPP- Secondary branches per plant, TPPP- Total no. of pods per plant, TEPP- Total no. of effective pods per plant, BY- Biological yield, HI- Harvest index, SI- Seed index, GYPP- Grain yield per plant (g), GYPP- Grain yield per plot (kg/ha).

Sl. No.	Characters	Range	VG	VP	GCV	PCV	h² (Broad-sense)	Genetic adv	Genetic advance as % of the mean
1	DFF (50%)	66.00-88.00	10.12	16.58	3.99	5.11	61.04	5.12	6.42
2	DM	109.00-128.33	8.51	16.12	2.44	3.36	52.80	4.36	3.66
3	PHT	46.20-73.60	57.79	73.43	13.27	14.96	78.70	13.89	24.25
4	PBPP	2.16-3.64	0.10	0.20	11.16	16.84	43.90	0.41	15.23
5	SBPP	3.62-7.82	0.79	1.36	15.50	20.33	58.20	1.39	24.36
6	TPPP	28.13-56.33	39.51	69.00	14.97	19.79	57.30	9.80	23.35
7	TEPP	23.66-52.00	35.88	59.04	16.55	21.22	60.80	9.62	26.57
8	BY	12.15-24.31	6.97	8.25	15.63	17.01	84.50	5.02	29.60
9	HI	35.72-49.50	8.07	20.50	6.80	10.84	39.40	3.67	8.79
10	SI	12.19-26.53	14.50	16.65	20.43	21.90	87.10	7.32	39.29
11	GYPP (g)	5.34-9.59	0.92	1.70	13.65	18.54	54.20	1.45	20.70
12	GYPP (kg/ha)	765.44-1921.92	68487.69	952558.48	19.51	23.20	71.90	457.11	34.09

High heritability and high genetic advancement, as measured as a percentage of mean, were found in the current study for the seed index, biological yield per plant, grain yield per plot, and total effective pods per plant. Kumar *et al*. (2020) also showed similar results for the chickpea seed index and biological yield per plant. In line with the current study, Swetha *et al.* (2024) and Patel *et al.* (2019) also noted strong heritability and genetic advancement for seed index, total pods per plant, and grain yield per plant. High heritability and high genetic advancement as a percentage of mean for biological yield and grain yield per plot in chickpea genotypes were reported by Reddy *et al.* (2021). The findings showed that these traits are primarily caused by additive gene action, meaning that genetic selection could be applied to these traits to increase seed output.

In the present examination correlation coefficient analysis measures the mutual relationship between characters to determine the component character on which selection can be intensify for improving yield. The phenotypic correlation coefficients are presented in Table 3. Grain yield per plot showed a highly significant and positive association with primary branches per plant, secondary branches per plant, total pods per plant, total effective pods per plant, biological yield per plant, seed index, grain yield per plant, and days to 50% flowering. This was the result of a phenotypic and genotypic correlation analysis among twelve yield and its attributed traits for Desi chickpea genotypes. Table 3 shows the non-significant association for the other characteristics that were examined. Primary branches per plant, secondary branches per plant, total pods per plant, total effective pods per plant, biological yield per plant, seed index, grain yield per plant, and days to 50% flowering all exhibited highly significant and positive correlations with grain yield per plot, while the correlation for the other characters under study was found to be non-significant.

Kumar *et al*. (2017) found similar results, finding strong positive relationships between grain production and the chickpea's biological yield per plant, seed index, and total pods per plant. Additionally, Reddy *et al.* (2020) discovered a strong positive association between biological yield, secondary branches, and grain yield. Additionally, Ali *et al*. (2018) found that the seed index, total effective pods per plant, and biological production per plant all strongly positively correlated with grain yield per plot. Similar findings were made by Sharma *et al.* (2021), who found that while other characteristics exhibited non-significant

Table 3. Phenotypic correlation coefficient between yield and its component characters in forty genotypes of Desi chickpea. *, ** = Significant at 5% and 1% level of probability, respectively. (Abbreviation: DM= Days to maturity, PH= Plant height, PBPP=Primary branches, SBPP= Secondary branches per plant, TPPP=Total pods per plant, EPPP=Effective pods per plant, BY= Biological yield per plant, HI= Harvest index (%), SI=Seed index, GYPP=Grain yield per plant (g), GYPP=Grain yield per plot (kg/ha).

Characters	DFF	DM	PHT	PBPP	SBPP	TPPP	TEPP
Days to 50% flower		0.5021**	0.0608	0.0228	0.2087*	-0.0370	-0.0327
Days to maturity			0.1197	0.0435	0.1868*	-0.0276	0.0294
Plant height (cm)				-0.0046	0.0704	-0.0671	-0.0361
Primary branches per plant					0.4441**	0.4120**	0.4255**
Secondary branches per plant						0.2991**	0.3462**
Total no. of pod per plant							0.9450**
Total effective pods per plant							
Biological yield per plant (g)							
Harvest index (%)							
Seed index (g)							
Grain yield per plant (g)							

Table 3. Continued.

Characters	DFF	BYPP (g)	HI (%)	SI (g)	GYPP (g)	GYPP (kg/ha)
Days to 50% flower		0.0178	0.1065	0.0356	0.0813	0.2035*
Days to maturity		-0.0396	0.2432**	0.1088	0.1027	0.1184
Plant height (cm)		-0.0046	0.0293	0.0484	0.0105	0.0822
Primary branches per plant		0.4816**	0.1285	0.4635**	0.5269**	0.4337**
Secondary branches per plant		0.6015**	0.1890*	0.4645**	0.6642**	0.5537**
Total no. of pod per plant		0.4011**	0.0695	0.4095**	0.4025**	0.4174**
Total effective pods per plant		0.3687**	0.1469	0.4552**	0.4161**	0.4005**
Biological yield per plant (g)			-0.1666	0.5004**	0.8157**	0.5989**
Harvest index (%)				0.1508	0.4260**	0.054
Seed index (g)					0.5508**	0.6514**
Grain yield per plant (g)						0.5708**

correlations, grain production per plot was significantly correlated with features such as seed index, biological yield and secondary branches per plant. They underlined that these characteristics should be prioritized in breeding efforts since they significantly increase grain output. Singh *et al.* (2017) found that certain qualities have little effect on grain yield and are less useful in selection, which is consistent with the non-significant association found for other traits in the current study. While there was a positive non-significant correlation with plant height (cm), primary branches per plant, biological yield per plant (g), harvest index (%), seed index (g), and grain yield per plant (g), there was a negative non-significant correlation with the remaining characters, such as total pods per plant and total effective pods per plant, which was similar to the findings of Kumar *et al.* (2017). Days to 50% flowering also showed a highly significant

and positive association with days to maturity. Singh *et al.* (2018) discovered a substantial and positive correlation between days to maturity and secondary branches per plant. Secondary branches per plant, harvest index (%), seed index, grain yield per plant, and grain yield per plot all exhibited a non-significantly positive correlation with plant height. Nevertheless, it has a negative and non-significant association with other similar studies that Eshetu *et al.* (2024) looked at. Regarding the relationship between plant height and other characteristics, no noteworthy findings were discovered. Secondary branches per plant, total pods per plant, total effective pods per plant (Vaghela *et al.* 2009), biological yield per plant, seed index, grain yield per plant, and grain yield per plot were all significantly and favorably correlated with primary branches per plant (Bhanu *et al.* 2017). Secondary branches per plant demonstrated a strong and posi-

tive correlation with harvest index (%) and a highly significant and positive association with biological yield per plant, seed index, total pods per plant, total effective pods per plant and biological yield per plant. The total number of pods per plant showed a non-significantly positive correlation with the harvest index, but a highly significant and positive correlation with the total effective pods per plant, biological yield per plant, seed index, and grain yield per plant. Biological yield per plant, seed index, grain yield per plant, and harvest index all exhibited a strong and positive correlation with grain yield per plot, as did the total effective pods per plant.

Grain yield per plant, as reported by Kumar *et al.* (2018), showed a non-significant and negative correlation with the harvest index, while biological yield per plant shown a highly significant and positive correlation with the seed index. Similar research by Shedge *et al*. (2019) found that the harvest index had a positive and significant connection with grain yield per plant, whereas the seed index showed a non-significant and positive association. Both grain yield per plot (kg/ha) and grain yield per plant (g) showed a significantly significant positive connection with the seed index. Likewise, there was a highly significant positive association between grain yield per plot and grain yield per plant.

CONCLUSION

The genotypes of all the features under investigation showed highly significant differences according to analysis of variance, indicating that the materials used in the study had a significant level of genetic diversity. As a result, there is enough room for breeding efforts to include promising genotypes for yield and its constituent traits. For every character, the estimates of the phenotypic coefficient of variation (PCV) were higher than the estimates of the genotypic coefficient of variation (GCV), indicating that the environment has a significant influence on the apparent variation in addition to the genotypes. Significant phenotypic variability among the genotypes under study was indicated by the present study's findings, which showed higher magnitudes of phenotypic coefficient of variation (PCV) for grain yield per plot, seed index, total effective pods per plant and secondary branches

per plant. Notably, the seed index had a larger estimate of the genotypic coefficient of variation (GCV), indicating less environmental influence and greater genetic control over this attribute. Traits such as seed index, biological yield per plant, plant height, grain yield per plot, and days to 50% flowering showed higher heritability. For grain yield per plot plant, a high level of genetic advancement was noted. Seed index, biological yield, grain yield/plot and total effective pods/plant all showed high heritability and higher genetic advance above mean, indicating that these traits may be viewed as advantageous for selection-based improvement. This suggested that these characteristics might be viewed as advantageous for enhancement through selection. The additive gene impact, which would enable selection to proceed without generation testing, may be the reason of this. In order to enhance genotypes for higher grain production in the future, these features can thus be utilized for direct selection. Grain yield/plot was found to have a highly significant and positive correlation with the following variables: Biological yield/plant, seed index, total number of pods/plant, total effective pods/plant, principal branches/plant and secondary branches/plant. It is suggested that these characteristics be applied as selection criteria going forward in order to increase the yield of Desi chickpeas.

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