Genetic variability, heritability and genetic advance studies in chickpea (*Cicer arientinum* L.)

Abstract

Chickpea (*Cicer arietinum* L.), an essential legume for sustainable agriculture and human nutrition, exhibits considerable genetic variability that holds promise for varietal improvement. This study evaluated 40 diverse chickpea genotypes during the Rabi season of 2021–22 at the Oil Seed Research Farm, Chandra Shekhar Azad University of Agriculture and Technology, Kanpur. Significant genetic variability was observed across key agronomic traits, including days to 50% flowering (73.67–95.67), plant height (25.55–42.47 cm), days to maturity (125.33–150.00), and grain yield per plant (8.38–18.63 g). Traits such as 100-seed weight (37.71–65.48 g), biological yield (11.14–31.84 g), and harvest index (21.83%–36.13%) demonstrated high genotypic and phenotypic coefficients of variation, heritability, and genetic advance, indicating the predominance of additive gene action. High heritability and genetic advance were observed for traits like pods per plant, biological yield, and 100-seed weight, suggesting these are promising targets for selection in breeding programs. Early flowering genotypes and those with superior seed weight and grain yield emerged as candidates for improving productivity and adaptability under diverse agroecological conditions. Additionally, traits with strong positive correlations with seed yield, such as the number of pods per plant and biological yield, offer valuable insights for breeding strategies.

Keywords- variability, Genotypes, traits, yield

Introduction

Chickpea (*Cicer arietinum* L.) originated in Southeastern Turkey and Syria, with India and the Mediterranean recognized as centres of origin (**Ahmad *et al*., 2005**). It belongs to the Fabaceae family and includes two cultivated species in India: *Cicer arietinum* and *Cicer songaricum*. Cultivated chickpeas are classified as desi (small, dark, rough-coated seeds) and kabuli (large, white, smooth-coated seeds). Chickpeas, also known as Bengal gram or Egyptian pea, are rich in protein, carbohydrates, essential minerals, and amino acids. They contribute significantly to combating malnutrition in developing countries and are consumed in various forms, including dhal, flour, and tender leaves as vegetables (**Dixit *et al*., 2019**).

India leads in chickpea production with 28.83 million ha under cultivation in 2020–21, producing 25.72 million tonnes (**FAO, 2019**). Rajasthan and Madhya Pradesh are key contributors. However, low productivity necessitates imports despite India being the largest producer. Enhancing productivity through varietal improvement and advanced production technologies is vital for meeting dietary protein needs and improving agricultural sustainability. Nutritionally, chickpea seeds contain 23% protein, 64% carbohydrates, and essential minerals like phosphorus (340 mg/100 g), calcium (190 mg/100 g), and iron (7 mg/100 g) **(Singh *et al.*, 2021)**. They play a critical role in vegetarian diets and are used for medicinal purposes such as treating stomach aches and purifying blood (**Dubey & Srivastava, 2007**). Chickpea plants enhance soil health by fixing nitrogen, improving aeration, and mobilizing nutrients, making them essential for sustainable agriculture. Studies of chickpea genetic variety are essential for crop development because they reveal the extent of genetic diversity that can be bred. These investigations aid in the identification of desirable characteristics like stress tolerance, disease resistance, and high yield (**Upadhyaya *et al*., 2002**). Breeders can select and recombine features to create better chickpea varieties for sustainable agriculture using metrics like genotypic and phenotypic coefficients, heritability, and genetic advancement to understand variability.

Material and Method

The experiment was carried out at the Oil Seed Research Farm of Chandra Shekhar Azad University of Agriculture and Technology Kanpur (UP) during Rabi season, 2021–22. The experiment was conducted to evaluate 40 diverse chickpea genotypes in a randomized block design. A study of 40 chickpea genotypes found high genetic heterogeneity across many variables. The data was recorded on 5 randomly selected plants from each genotype for different characters, viz. Days to 50% blooming, Plant height (cm), Days to maturity, Number of branches per plant, Number of pods per plant, Number of seeds per pod, Biological output, Weight of 100 seeds (g), Seed size (cm), Harvest index (%), Grain production per plant, Seed yield per plant, and Biological yield per plant. Data based on the above parameters was subjected to analysis of genetic variability (**Burton & De Vane, 1953; Hanson *et al*., 1956; Johnson *et al*., 1955**).

Results and discussion

The study of genetic variability among chickpea genotypes demonstrated significant differences in key agronomic traits, highlighting the scope for genetic improvement. Days to 50% flowering ranged from 73.67 to 95.67, with the earliest flowering genotype exhibiting potential for breeding early-maturing varieties suitable for shorter growing seasons. Plant height varied between 25.55 cm and 42.47 cm, indicating genotypes with both compact and taller growth habits that could be utilized for specific agroecological conditions. Days to maturity spanned from 125.33 to 150.00, suggesting variability in growth duration among the genotypes, with early-maturing lines offering an advantage in drought-prone or late-sown environments. The number of branches per plant ranged from 2.67 to 4.67, indicating genotypes with differing capacities for branching, which directly influences pod-bearing sites. The number of pods per plant exhibited a range of 64.00 to 77.00, reflecting variability in reproductive efficiency among genotypes. Seeds per pod ranged from 1.00 to 2.00, with some genotypes showing superior seed development traits. Biological yield ranged from 11.14 g to 31.84 g, highlighting differences in overall biomass production. The 100-seed weight showed a significant range of 37.71 g to 65.48 g, indicating the potential for selecting genotypes with larger seed sizes, an important trait for market preference and yield. Harvest index varied from 21.83% to 36.13%, showcasing differences in the efficiency of biomass partitioning into grains. Grain yield per plant ranged from 8.38 g to 18.63 g, with some genotypes demonstrating high yield potential under the given conditions.

The genotypic coefficient of variation (GCV) and phenotypic coefficient of variation (PCV) were highest for seeds per pod, harvest index, and biological yield per plant, reflecting substantial variability in these traits. For traits such as days to flowering, plant height, and days to maturity, the GCV and PCV values were comparatively low, indicating limited variability and higher environmental influence. The heritability estimates were highest for seeds per pod, pods per plant, and biological yield, signifying strong genetic control and limited environmental effects on these traits. High heritability coupled with high genetic advance as a percentage of the mean was observed for traits such as pods per plant, biological yield, and 100-seed weight, suggesting the predominance of additive gene action and potential for improvement through simple selection strategies (**Ahmad *et al.*, 2005; Jeena *et al*., 2005**).

The observed genetic variability provides a foundation for the development of improved chickpea varieties tailored to specific agronomic and environmental requirements. Genotypes with favourable traits such as early flowering, high seed weight, and superior grain yield can be prioritized in breeding programs to enhance productivity and adaptability. These results underscore the importance of comprehensive genetic studies in identifying and utilizing genotypic diversity for sustainable chickpea improvement.

The highest broad-sense heritability was recorded for days to 50% flowering, days to maturity, seed yield per plant, plant height, and 100-seed weight, indicating that these traits are largely controlled by genetic factors with minimal environmental influence. Following these, traits such as the number of pods per plant, biological yield, and harvest index also exhibited high heritability, suggesting the potential for effective selection and breeding based on these characteristics (**Hanson *et al.*, 1956**). The highest genetic advance was observed for 100-seed weight, followed by days to 50% flowering, plant height, days to maturity, seed yield per plant, and biological yield. Similar observations were noted by **Dubey *et al* 2007**. These traits, with high genetic advance, are likely to show significant improvement through selection due to the additive nature of their genetic control. In contrast, harvest index, number of branches, and number of pods per plant displayed relatively moderate genetic advance. This comprehensive genetic assessment highlights key traits with both high heritability and genetic advance, emphasizing the potential for genetic improvement in chickpea breeding programs. Selection for these traits could lead to enhanced productivity and adaptation to diverse environments.

Conclusion

The study found substantial genetic variability among chickpea genotypes, with larger phenotypic variation indicating that environmental factors impact variables such as pod quantity, seeds per pod, plant height, and seed output. Traits with high heritability and genetic progress, such as 100-seed weight, days to 50% blooming, and seed output per plant, have the potential for improvement by selection. The number of pods per plant, biological yield, and 100-seed weight all exhibited significant positive associations with seed output. Genetic variety, as evidenced by considerable intra- and inter-cluster distances, supports the use of different parents in high-yield chickpea breeding.

Table 1: Analysis of variance for ten traits in chickpea

Source of variation	Degree of freedom	Days to 50% flowering	plant height (cm)	Days to maturity	No of branches per plant	No of pods per plant	No of seeds per pod	100 seed weight (g)	Biological yield (g/plant)	Harvest index (%)	Grain yield (g/plant)
Rep.	2	15.21**	3.49*	3.33	3.01*	1.81	0.83**	21.85	125.63*	32.06	1.50
Treat.	39	82.41**	42.54**	50.62**	1.92**	27.31**	0.46**	59.71**	191.18**	19.84**	18.15**
Error	78	1.25	1.04	2.34	0.82	7.32	0.24	21.72	34.21	10.82	0.74

**** = Significant at 1% level of significance;*=significant at 5% level of significance**

Table 2 : Estimation of Genetic Variability parameters for various traits in chickpea

Character	Mean	Range	Range	Heritability (%)	Genetic advance	Genetic advance % mean	GCV(%)	PCV(%)
		Minimum	Maximum					
Days to 50% flowering	83.37	73.67	95.67	95.6	10.475	12.565	6.239	6.382
Plant height (cm)	36.31	25.55	42.47	93	7.39	20.352	10.243	10.621
Days to maturity	119.57	105.00	125.33	87.3	7.721	6.458	3.355	3.591
Number of branches per plant	3.54	2.67	4.67	3.8	0.072	2.046	5.089	26.074
Number of pods per plant	69.63	64.00	77.00	47.7	3.671	5.272	3.707	5.371
Number of seeds per pods	1.53	1.00	2.00	04.5	0.046	2.998	6.875	32.469
Biological yield (g)	20.19	11.41	31.84	36.8	4.449	22.040	17.63	29.049
100 seed weight	56.94	37.71	65.48	60.9	11.74	20.617	12.823	16.83
Harvest index (%)	26.43	21.83	36.13	21.7	1.664	6.297	6.558	14.07
Seed yield per plant (g)	15.04	8.38	18.63	88.7	4.673	31.07	16.017	17.01

References

Ahmad, F., Gaur, P. M., & Croser, J. (2005). Chickpea (Cicer arietinum L.). In: Genetic resources, chromosome engineering, and crop improvement- grain legumes, 1: 187-217.

Burton, G. W., & De Vane, E. H. (1953). Estimations of heritability in tall festca (*Festuca arundinacea*) from replicated clonal materials. Agronomy Journal, 45: 487-488.

Dixit, G. P., Srivastava, A. K., & Singh, N. P. (2019). Marching towards self-sufficiency in chickpea. Curr. Sci., 116(2): 239-42.

Dubey, K. K., & Srivastava, S. B. (2007). Analysis of genetic divergence for yield determinants in chickpea (Cicer arietinum L.). Plant Archives, 7(1): 153-155.

FAO. (2019). FAOSTAT Statistical Database of the United Nations Food and Agriculture Organization (FAO) statistical division. Rome.

Hanson, C. H., Robinson, H. F., & Comstock, R. E. (1956). Biometrical studies of yield in segregating populations of Korean lespedeza 1. Agronomy Journal, 48(6): 268-272.

Jeena, A. S., Arora, P. P., & Ojha, O. P. (2005). Variability and correlation studies for yield and its components in chickpea. Legume Research-An International Journal, 28(2): 146-148.

Johnson, H. W., Robinson, H. F., & Comstock, R. E. (1955). Genotypic and phenotypic correlations in soybeans and their implications in selection. Agronomy Journal, 47(10): 477-483.

Singh, B., Kumar, V., & Mishra, S. P. (2021). Genetic variability, path analysis and relationship among quantitative traits in chickpea (Cicer arietinum L.) genotypes. The Pharma Innovation Journal, 10(5): 1564-1568.

Upadhyaya, H. D., Ortiz, R., Bramel, P. J., & Singh, S. (2002). Phenotypic diversity for morphological and agronomic characteristics in chickpea core collection. Euphytica, 123(3): 333-342.