***Original Research Article***

**Studies on Genetic Variability, Heritability and Genetic Advance in Chickpea (*Cicer arietinum* L.)**

**ABSTRACT**

For plant breeding efforts looking to increase resilience, yield and stress tolerance, the diversity is essential since it allows for efficient selection and hybridization of elite genotypes. An experiment was performed to investigate the variability and heritability of characters under 11 different parameters in 35 diverse genotypes of chickpea (*Cicer arietinum* L.) with Randomized Block Design (RBD) in three replications during Rabi Season 2023-24 at Genetic and Plant Breeding Research Farm of Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Ayodhya (U.P). In general, the phenotypic coefficient of variation PCV was higher than GCV for all the characters. The maximum PCV as well as GCV were observed by seed yield per plant. High heritability with high genetic advance was exhibited for plant height, number of pods per plant, 100 seed weight, biological yield per plant and seed yield per plant. The genetic variability and heritability studies reported that seed yield per plant exhibited the highest range of variability followed by biological yield per plant, 100 seed weight, plant height. High heritability estimates were observed for 100 seed weight followed by biological yield per plant, plant height, seed yield per plant, days to 50% flowering. The analysis of variance (ANOVA) indicated the presence of sufficient genetic variation among the genotypes for all the eleven traits. High genetic advance as percentage of mean was displayed by seed yield per plant and biological yield per plant.

 **Keywords**: Heritability; genetic variability; traits.

1. **INTRODUCTION**

One of the first legumes to be cultivated was the chickpea (*Cicer arietinum* L.), sometimes referred to as Garbanzo beans, Bengal Gram, or Gram. About 7500 years ago, this crop was first discovered in the Mediterranean and Middle East region. Today, it is one of the most significant legume crops, flourishing all over the world and ranking third in terms of production among pulses. The French term "chiche" and the Latin word for chickpea, "*Cicer*," are the sources of the name chickpea. The chickpea (*Cicer arietinum* L.) is a member of the tribe Cicereae and family Fabaceae. It is an annual grain legume crop that is diploid, self-pollinating, and native to Southwest Asia. Its genome size is 1C=740 Mbp, and its genome count is 2n=2x=16. In India area, production and productivity of chickpea is 9.46 m ha, 11.46 m t, 1224 kg/ha respectively (ICAR- All India Coordinated Research Project on Rabi Pulses 2023-24).

Pulses are rich in protein, carbohydrates, dietary fibres, vitamins, minerals and phytochemicals. The plant is well regarded in both the traditional medical system, the Unani and the Ayurvedic medical traditions. Many people around the world rely on pulses to satisfy their protein needs and eat them as a staple diet along with cereals. Pulses' high lysine and folate content makes them perfect for making mixed flours with cereals. Comparable levels of fat, niacin, riboflavin, thiamine, vitamin B6, and total carbohydrates are found in pulses and cereal grains. (Ref. should be cited here, to make the statement more scientific)

Mature chickpea seeds can be used whole or divided into flour and "Dal" vegetables for a number of recipes. It is an ancient, widely grown, domesticated pulse crop in India that has several applications in both food and feed. Chickpeas are used to purify blood and are believed to have therapeutic benefits. It's important to note the chickpea's therapeutic usefulness here. Because of the glandular fluids they contain, chickpea leaves and seeds are frequently used as medicine. (Again a generalized statement, incorporate ref.)

For growth and pod filling, chickpeas thrive in between the temperatures 30°C and 15 °C (day maximum and night minimum). Due to a number of biotic and abiotic stressors, productivity of chickpea is still low in the field, and a temperature of 35°C was found to be crucial in distinguishing between genotypes that are heat tolerant and susceptible. One of the most significant, costly, and damaging biotic stressors affecting chickpeas is collar rot disease, which is caused by *Sclerotium rolfsii*.

Chickpea has two cultivated types i.e. (desi and kabuli) on the basis of seed size, shape and colour and within these types there are variations with respect to yield components. Kabuli have large creamy seeds with no anthocyanin pigmentation while the desi chickpeas are small seeded with various colours, purplish flowers and have anthocyanin pigmentation. The very large kabuli domestic types have evolved from the smaller seeded desi types. (Moreno and Cubero, 1978).

Axillary flowers can be found alone, in pairs, or in clusters of three. They can be blue, purple, pink, or white. With very few exceptions, the corolla is typically white in the kabuli type and purple in the desi form. Each flower of cicer plants contains a single carpel. Nine of the diadelphous stamens in chickpea's tiny papilionaceous blossoms have joined filaments, while the tenth is free. As the flower bud develops, the filaments lengthen and the anthers spread pollen onto the pistil. Both the anther and the pistil stay inside the keel. Pulses have a deep root system, mobilize insoluble soil nutrients, fix biological nitrogen and significantly alter the physico-chemical properties of soil. Pulses have the potential to reverse the productivity reduction in cereal based farming systems. In an intensive agricultural system focused on cereals, pulses aid in achieving integrated nutrient delivery.

The *Kharif, Rabi*, and *Zaid* agricultural seasons are when pulse crops are grown. throughout the planting stage. Rabi crops need a mildly cold climate; throughout the vegetative to pod development stage, they need comparatively cold climate during maturity and at harvest, they need a warm climate. From planting to harvesting, Kharif pulse crops also needs a warm climate. Warm areas are home to summer pulses. Germination, seedling, vegetative, flowering, fruit setting, pod development, and grain maturity/harvesting are the steps that a seed must go through in order to be produced.

One of the few pulse crops with a wealth of genetic resources is the chickpea. In 1967, as part of the All India Coordinated Pulses Improvement Project (AICRP), systematic study on chickpeas was initiated. Through the transfer of beneficial genes, the creation of more useful variability, and the reconstitution of genomes through widespread hybridization, the potential for improvement has been realized in breeding varieties for multiple disease resistance, high input management, terminal heat tolerance, and varieties amenable to late planting (mid-December) to popularize rice-chickpea sequential cropping in command areas of NWPZ and NEPZ, including rice-fellow in northern India.

1. **Materials And Methods**

Experiment was conducted at Genetic and Plant Breeding Research Farm of Acharya Narendra Deva University of Agriculture and Technology, Narendra Nagar, Kumarganj, Ayodhya (U.P.) during *Rabi* season in randomized block design with 35 genotypes along with three checks) GNG 2299, BG 372 and Pant G 186 replicated thrice. The experimental research farm was geographically located at in between 24.470 to 26.56°N latitude and 82.120 to 83.980°E longitude at about 42 km away from district head quarter of Ayodhya and on 113 metres altitude above the mean sea level in the Gangetic Alluvial Plains of Eastern Uttar Pradesh. The climate of district Ayodhya is semi-arid with hot summer and cold winter. Nearly 80% of the total rainfall is received during the monsoon ( only up to September ) with a few showers in the winter. Maximum rains in this area is received from July to the end of September. The winter months are usually cool and dry but occasional light showers are also not uncommon. All recommended cultural and management practices were followed to raise the healthy crop. Five competitive plants were selected randomly in each row for recording the observations on 11 parameters *viz.* days to 50% flowering, days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, number of pods per plant, number of seeds per pod, 100 seed weight, biological yield per plant, harvest index and seed yield per plant. The recorded data were analysed as suggested by Panse and Sukhatme (1954) for analysis of variance. The genotypic and phenotypic coefficient of variance was calculated as per the formula suggested by Burton (1952) and Johnson *et al*., (1995) for heritability and genetic advance.

## **Table 1. Chickpea genotypes used in the studies carried out for the layout**

|  |  |
| --- | --- |
| Number of genotypes | 35 including checks |
| Experimental design | Randomised Block Design |
| Season | *Rabi* (2023-24) |
| Row length | 4 m |
| Spacing | 30X10 (Row to row and plant to plant) |
| Rows | 4 |
| Replication | 3 |

**Table 2. List of thirty five genotypes of chickpea**

|  |  |
| --- | --- |
| **S. No.** | **Genotypes** |
| **1** | **GJG 2108** |
| **2** | **RSGD 1274** |
| **3** | **BG 372 (Ch.)** |
| **4** | **IPC 2019-126** |
| **5** | **TRSCH 2** |
| **6** | **Pant G 186 (Ch.)** |
| **7** | **Phule G 1511-29-1** |
| **8** | **RKG 23-5** |
| **9** | **GNG 2299 (Ch.)** |
| **10** | **PG 353** |
| **11** | **JG 2023-82** |
| **12** | **NDG 22-9** |
| **13** | **BG 4050** |
| **14** | **H 20-41** |
| **15** | **NBeG 1427** |
| **16** | **PG 344** |
| **17** | **NDG 22-3** |
| **18** | **KCD 11** |
| **19** | **DLC 2305** |
| **20** | **GNG 2615** |
| **21** | **GJG 2105** |
| **22** | **Phule G 1517-1-8** |
| **23** | **IPC 2020-230** |
| **24** | **RVSSG 130** |
| **25** | **H 140** |
| **26** | **BRC 2023-13** |
| **27** | **RKG 23-6** |
| **28** | **GL 18152** |
| **29** | **DLC 2301** |
| **30** | **JG 2023-83** |
| **31** | **NBeG 1487** |
| **32** | **BG 4049** |
| **33** | **GNG 2633** |
| **34** | **GL 19026** |
| **35** | **RSGD 1300** |

1. **RESULTS AND DISCUSSION**

The analysis of variance revealed highly significant genotypic differences for three characters (number of primary branches per plant, number of secondary branches per plant & seeds per pod) and significant for other characters studied, indicated the presence of wide variability in the existing material selected for present investigation (Table 3).

* 1. **Estimates of Components of Variation**

The estimates of genotypic coefficient of variation (GCV), phenotypic coefficient of variation (PCV), heritability (broad sense ) and genetic advance as per cent of mean for eleven different characters studied are presented in Table 4. GCV is greater than PCV for all the chararcters studied. The genotypic coefficient of variation (GCV) was highest for seed yield per plant (25.931) followed by biological yield per plant (23.641) and 100 seed weight (18.591). The genotypic coefficient of variation (GCV) was lowest for days to maturity (1.323) followed by days to 50% flowering (4.292) and number of seeds per pod (6.538). The maximum phenotypic coefficient of variation (PCV) was recorded for seed yield per plant (27.510) followed by biological yield per plant (24.245) and primary branches per plant (21.663). The phenotypic coefficient of variation (PCV) was lowest for days to maturity (1.728) followed by days to 50% flowering (4.589) and number of seeds per pod (9.80).

Fisher first presented a method to separate the genotypic effects based on phenotype and environmental factors. Mathur and Mathur reported high GCV and PCV in case of 1000 grain weight. Aung *et al.* (2023) studied on the Desi and Kabuli types of chickpea genotypes, significant values of PCV% and GCV% were found for the number of pods, number of empty pods, pod weight, biological yield, and seed yield per plant. Thakur *et al*. 2018). reported high estimates of GCV and PCV for 100 seed weight, seed yield per plant and plant height. In present investigation GCV and PCV estimates found lowest for days to maturity.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Source of variation**  | **d.f**  | **Days to 50% flowering**  | **Days to maturity**  | **Primary branches** **Per plant**  | **Secondary** **Branches** **Per plant**  | **Plant** **Height** **(cm)**  | **Pods** **Per** **Plant**  | **Seeds Per pod**  | **100 seeds Weight** **(g)**  | **Biological Yield per plant**  | **Harvest** **Index** **(%)**  | **Seed** **Yield** **Per** **Plant (g)**  |
| Replications | 2  | 15.238 \*\* | 5.514  | 0.266  | 5.609\*\*  | 17.152\*  | 111.971\*\*  | 0.010  | 1.008  | 37.057  | 10.989  | 11.038  |
| Treatments  | 34  | 27.610 \* | 9.449\*  | 0.560\*\*  | 2.340\*\*  | 158.571\*  | 273.237\*  | 0.067\*\*  | 42.736\*  | 972.634\*  | 71.872\*  | 126.870\*  |
| ERROR  | 68  | 1.257  | 1.798  | 0.256  | 0.658  | 5.485 | 17.471  | 0.019  | 0.449  | 16.478  | 8.877  | 5.093  |

**Table 3. Analysis of variance for eleven characters in chickpea**

\*Significant at 5% probability level (Significant)

\*\*Significant at 1% probability level (Highly significant)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Characters** | **Range** |  | **Grand Mean** | **Coefficient of variation** | **Heritability in broad sense** | **Genetic advance** | **Genetic advance as % mean** |
| **Minimum** | **Maximum** | **GCV (%)** | **PCV (%)** |
| Days to 50% flowering | 63 | 75.33 | 69.05 | 4.292 | 4.589 | 87.5 | 5.710 | 8.270 |
| Days to maturity | 116.33 | 123.67 | 120.69 | 1.323 | 1.728 | 58.6 | 2.519 | 2.088 |
| Primary branches per plant | 2.33 | 3.67 | 2.76 | 11.514 | 21.663 | 28.2 | 0.348 | 12.606 |
| Secondary branches per plant | 4.33 | 8.33 | 6.15 | 12.169 | 17.946 | 46 | 1.046 | 16.998 |
| Plant height (cm) | 36.33 | 63 | 48.38 | 14.765 | 15.538 | 90.3 | 13.983 | 28.902 |
| Pods per plant | 45.67 | 80.67 | 63.46 | 14.551 | 15.972 | 83 | 17.328 | 27.307 |
| Seeds per pod | 1.13 | 2 | 1.92 | 6.538 | 9.80 | 44.5 | 0.173 | 8.984 |
| 100 seed weight (g) | 12.67 | 27.88 | 20.19 | 18.591 | 18.886 | 96.90 | 7.614 | 37.702 |
| Biological yield per plant (g) | 39 | 120.33 | 75.51 | 23.641 | 24.245 | 95.10 | 35.861 | 47.489 |
| Harvest index (%) | 20.66 | 40.39 | 32.65 | 14.035 | 16.741 | 70.3 | 7.914 | 24.239 |
| Seed yield per plant (g) | 13.73 | 33.12 | 24.57 | 25.931 | 27.510 | 88.9 | 12.372 | 50.352 |

**Table 4. Estimates of variability parameters for eleven different characters in chickpea**

* + 1. **Range of variability**

Wide range of variability was observed for almost all the characters except number of seeds per pod (1.13-2.00) and number of primary branches per plant (2.33-3.67). Biological yield per plant (39.00-120.33) exhibited a highest range of variability followed by number of pods per plant (45.67-80.67), plant height (36.33-63.00), harvest index (20.66-40.39), seed yield per plant (13.73-33.12), 100 seed weight (12.67-27.88), days to 50% flowering (63.00-75.33), days to maturity (116.33-123.67), number of secondary branches per plant (4.33-8.33). Mihoariya *et al.* (2023) observed high GCV and PCV for the numbers of pods per plant and biological yield indicating the presence of a substantial amount of genetic variability in the experimenting material.

* + 1. **Heritability and genetic advance**

Maximum heritability was observed for 100 seed weight (96.90%) followed by biological yield per plant (95.10%), plant height (90.3%), seed yield per plant (88.9%), days to 50% flowering (87.5%) and pods per plant (83%). The moderate estimate of heritability were observed in harvest index. Saleem *et al.* assessed that 100 seed weight, days took to flowering were characterized by high (broad sense) heritability estimates, which indicated the presence of a considerable proportion of total variability due to genetic causes. Johnson *et al*. (2021) reported that heritability estimates were high for 100 seed weight and seed yield.

Genetic advance is a measure of genetic gain under selection which depends upon main factors *viz.,* genetic variability, heritability, selection index. High genetic advance was observed for biological yield per plant (35.861) followed by pods per plant (17.328), plant height (13.983) and seed yield per plant (12.372). The moderate estimate of genetic advance in per cent of mean were recorded by primary branches per plant, secondary branches per plant and harvest index. While low estimates of genetic advance in per cent of mean were recorded in days to 50% flowering, days to maturity and number of seeds per pod Arora *et al*. (2018)

In the present investigation, plant height, pods per plant, 100 seed weight, biological yield per plant and seed yield per plant showed high estimates of broad sense heritability accompanied by high genetic advance as per cent of mean indicating that these traits could be prominently governed by additive gene action. Therefore, the selection of these traits could be more effective for desired genetic improvement. It is supported by similar findings of Banik *et al.*(2018).

1. **CONCLUSION**

The assessments of genetic parameters like genotypic coefficient of variation, heritability and genetic advance as per cent of mean indicated that selection must be done in the characters like plant height, pods per plant, 100 seed weight, biological yield per plant, harvest index and seed yield per plant for improving the yield in chickpea. High heritability associated with high genetic advance as per cent of mean was observed for number pods per plant, days to 50% flowering, 100 seed weight and plant height indicating that these characters governed by additive gene action. Hence, selection for genetic improvement of characters like number of pods per plant, days to 50% flowering, 100 seed weight and plant height would be effective for increasing seed yield in chickpea.

**REFERENCES**

1. Ali, Q., Ahsan, M. and Saleem, M., 2010.Genetic variability and trait association in chickpea (*Cicer arietinum* L*.).* *Electronic Journal of Plant Breeding*, **1**(3):328-333.
2. Arora, R. N., and Kumar, K. 2018. Genetic variability studies for yield contributing traits in Kabuli chickpea (*Cicer* *arietinum* L.). *Journal of Pharmacognosy and Phytochemistry*, **7**(2): 2675-2677.
3. Babbar, A., Kujur, M. J., Sharma , P., Chaudhary, B., Patel, M., & Shakya, A. 2023. Elucidating genetic diversity and variability in Chickpea (*Cicer* *arietinum* L.) using yield attribution traits. *Environment Conservation Journal*, **24**(4): 140–147.
4. Babbar, A., and Tiwari, A. 2018. Assessment of genetic variability and yield stability in chickpea genotypes under diverse environments. *International Journal of Current Microbiology and Applied Sciences*, **7**(12): 3544-54.
5. Balpande, R., Gaur, R. S., Pandey, A. P., Sao, B., Singh, P., & Gupta, A. 2022. Assessment of genetic variability and heritability in chickpea (*Cicer* *arietinum* L.). *The Pharma Innovation Journal*, **11**(8): 325-330.
6. Banik, M., Deore, G. N., Mandal, A. K., and Mhase, L. B. 2018. Genetic variability and heritability studies in chickpea (*Cicer* *arietinum* L.). *Current Journal of Applied Science and Technology*, **31**(1): 1-6.
7. Basu, U., Bajaj, D., Sharma, A., Malik, N., Daware, A., Narnoliya, L., 2019. Genetic dissection of photosynthetic efficiency traits for enhancing seed yield in chickpea. *Plant Cell Environ*. 42: 158–173.
8. Bhoite, K.D., Deore, G.N. and Kusalkar, D.V., 2020.Studies on genetic variability and heritability in chickpea (*Cicer arietinum* L*.).* *Journal of Pharmacognosy and Phytochemistry*, **9**(2): 678-681.
9. Chaudhary, N. K., Kumar, M., Chand, P., Singh, S. K., Yadav, M. K., & Gangwar, L. K. 2020. Estimation of heritable relationship and variability of yield and yield determinants in chickpea (*Cicer* *arietinum* L.). *International Journal of. Current Microbiology and Applied Sciences*, **9**(6): 2511-2519.
10. Gautam, A., Panwar, R. K., Verma, S. K., Arora, A., Gaur, A. K., and Chauhan, C. 2021.Assessment of genetic variability parameters for yield and its components in chickpea (*Cicer arietinum* L.). *In Biological Forum–An International Journal* **13**(2): 651-655.
11. Hailu, F. 2020. Genetic variability, heritability and genetic advance of kabuli chickpea (*Cicer arietinum* L.) for agronomic traits at Central Ethiopia. *International Journal of Plant Breeding and Crop Science*, **7**(1): 710-714.
12. Hasan, M. T., and Deb, A. C. 2017. Assessment of genetic variability, heritability, character association and selection indexes in chickpea (*Cicer* *arietinum* L.). *International Journal of Biosc*iences **10**(2): 111-129.
13. Karthikeyan, M., Pandey, S., Synrem, G., Sharma, P., & Singh, V. 2022. Genetic variability and correlation studies for some quantitative traits in chickpea (*Cicer* *arietinum* L.). *The Pharma Innovation Journal*, **11**(1): 1706-1709.
14. Kishor, L., Swarup, I., Nehra, A., Kirar, G., and Jeeterwal, R. C. 2018. Genetic variability, heritability and genetic advance analysis in chickpea (*Cicer* *arietinum* L.). *International Journal of Pure and Applied Biosci*ences **6**(4): 141-144.
15. Mihoariya, M., Tiwari, S., Yadav, R. K., Asati, R., Solanki, R. S., Tiwari, P. N., ... and Tripathi, M. K. 2023. Genetic variability and diversity analysis for yield and its associated traits in chickpea (*Cicer* *arietinum* L.). *Current Journal of Applied Science and Technology*, **42**(16): 17-33.
16. Shahnaz, Z., Shahnaz, A., Ismail, A., Manzoor, Z., Iqbal, R., & Zia, M. A. B. 2025. Chickpea (*Cicer* *arietinum*) genetic diversity: genetic resources, breeding progress, and future prospects. *Crop and Pasture Science*, **76**(1).
17. Sharma, R. N., Johnson, P. L., Nanda, H. C., Sao, A., Sarawgi, A. K., Verma, S. K., ... & Singh, A. K. 2021. Genetic variability, character association and coheritability for yield traits over the locations in chickpea (*Cicer* *arietinum* L.). *Legume Research-An International Journal*, **44**(7): 859-863.
18. Singh, B., Kumar, V., and 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.
19. Singh, R. K., Singh, C., Ambika, Chandana, B. S., Mahto, R. K., Patial, R., ... & Kumar, R. 2022. Exploring chickpea germplasm diversity for broadening the genetic base utilizing genomic resourses. *Frontiers in Genetics*, 13: 905771.
20. Thakur, N. R., Toprope, V. N., & Phanindra, K. S. 2018. Genetic diversity analysis in chickpea (*Cicer* *arietinum* L.). *International Journal of Current Microbiology and Applied Sciences*, 6: 904-910.
21. Thapa, R.S., Singh, T., Kumar, A., Kumar, H. and Pratap, D., 2022.Genetic divergence, variability and character association analysis in chickpea *(Cicer arietinum* L.) genotypes under normal and late sown conditions. *Electronic Journal of Plant Breeding*, **13**(2): 616-623.
22. Vikram, T. H., Haritha, T., Satyanarayana, H. N., Swapna, M., & Jayalakshmi, V. 2020. Variability and Character Association Studies in Chickpea (*Cicer* *arietinum*. L). *Int. J. Plant Soil Sci*, **34**(23): 1076-1085.
23. Vishnu, B., Jayalakshmi, V., & Rani, M. S. 2018.Genetic variability studies on mechanical harvesting traits in chickpea (*Cicer arietinum* L.). *Journal of Food Legumes*, **31**(2): 75-78.
24. Vishnu, B., Jayalakshmi, V., & Rani, M. S. 2020. Genetic diversity studies among chickpea (*Cicer* *arietinum* L.) genotypes under rainfed and irrigated conditions for yield attributing and traits related to mechanical harvesting. *Legume Research: An International Journal*, **43**(2): 202-205
25. Yadav, A., Nath, S., Bharti, B., Singh, S., Yadav, S., Bhardwaj, R., and Yadav, S. K., 2024. Genetic Variability Studies in Chickpea (*Cicer arietinum* L.) for Yield and Contributing Traits Through Half-diallel Mating Strategy under Late-sown Conditions. *Legume Research-An International Journal*, **1**(7).