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Heritability and genetic advance: Acomprehensive study of genetic analysis in chickpea (*Cicer Arietinum* L.)

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ABSTRACT

The trial was carried out involving 25 chickpea genotypes during the Rabi season of 2020-21 at the Research Farm in Karguaji, under the Dept. of G&PB at the Institute of Agricultural Sciences, Bundelkhand University, Jhansi. The aim of this research was to assess the extent of genetic variability concerning yield and its associated traits. The data encompassed observations on nine distinct yield and contributing characteristics, revealing that, on the whole, the PCV exceeded the GCV for all traits under study. The high estimate of PCV and GCV were observed for character such as 100 seed weight (23.78% and 23.33%) followed by Number of secondary branches plant¹ (20.75% and 18.77%), Seed plant¹ (18.60% and 15.98%), Plant height (12.08% and 11.48%) and Number of primary branches per plant (11.96% and 9.43%), respectively. It is important to highlight that characteristics such as seed weight, number of sec. branches per plant, seed count per plant, plant height, and the number of pri. branches per plant, demonstrated high h^2b along with significant genetic advancement (% mean). This indicates the existence of additive genetic effects for these traits, suggesting that they can be improved effectively through selective breeding.

Key words: Phenotypic, Genotypic coefficient variance, Heritability, Genetic advance

INTRODUCTION

The chickpea (*Cicer arietinum* L.) serves as a vital food source in tropical and subtropical climates and is recognized as one of the oldest and most widely cultivated legumes in the Fabaceae (Leguminosae) family. This crop is classified as diploid (2n=2x=16) and mainly reproduces through self-pollination; however, there are occasional occurrences of cross-pollination by insects (Ahmad *et al.,* 2005). Its seeds boast a rich nutritional profile, comprising 23% protein, 64% total carbohydrates, 5% fat, and various micronutrients such as phosphorus, calcium, magnesium, iron, and zinc. However, despite its nutritional value, the per capita net availability of pulses in India falls significantly below the World Health Organization's recommended intake, leading to protein malnutrition and emphasizing the urgent need to address nutritional security for the growing population. In the 2018-2019 period, the country's pulse crops occupied a substantial area of 29.03 million hectares, yielding 23.40 million tones with an average productivity of 8.06 quintals per hectare. Among pulses, chickpea dominates, accounting for the largest area and production globally, with India leading in both metrics. Madhya Pradesh stands out with the highest area and production figures, while Maharashtra follows closely behind, highlighting regional disparities in chickpea cultivation and productivity (Directorate of Economics and Statistics, 2020). The genetic advancement of chickpea, akin to other agricultural crops, is largely influenced by the degree of genetic variation found within breeding resources and the heritability of yield and quality traits through multiple generations. Understanding the influence of environmental factors on these traits necessitates the estimation of genotypic and phenotypic coefficients. India holds a prominent position as both the largest producer and consumer of pulses globally (Verma *et al.,* 2018: Gaur *et al.,* 2020). The success of the breeding initiative is contingent upon the level of variation and heritability observed in early-generation populations regarding significant economic characteristics (Pal *et al.,* 2018). To predict the specific results of choosing the most suitable individuals for a particular scenario, it is crucial to combine heritability estimation with advancements in genetics (Johnson *et al.,* 1955). Hence, this study utilized potential genotypes to assess variability, heritability, and genetic advancement for yield and its contributing traits in chickpea.

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MATERIAL AND METHODS

The experiment was conducted during *Rabi* season 2020-21 at Research Farm, Karguaji, Department of Genetic and Plant Breeding, Institute of Agricultural Sciences, Bundelkhand University, Jhansi. For this research, the experimental material consisted of 25 distinct chickpea genotypes, which included ICC-15936, BGD-209, BCP-02-3, ICC-12369, JG-16, BGD-72, ICC-12416, IPC-2005-62, IPC-2010-72, ICC-1708, ICC-10911, ICC-5439, DG-96006, ICC-124106, GNG-469, IPCK-2002-29, ICC-15562, ICC-11163, ICC-1009, K-850, NBEG-47, ICC-3020, RUG-202, IPC-6-77, and IPC-2004-01.

Documented features and sampling data

The traits observed and the measurements taken were derived from five randomly selected plants within a single row of each chickpea genotype, focusing on yield and its related characteristics (see Table 1). The recording of observations was done on a per-row basis for days to flowering and days to maturity. However, for variables like seed weight (SW) and harvest index (HI), observations were taken on a composite sample basis.

Table 1: Observation recorded for yield and yield attributing observation

S. No.	Characters
1.	(D50%F) Days to 50% Flowering
2.	(DM) Days to maturity
3.	(PH) Plant height (cm.)
4.	(NPBPP) Number of pri. branches per plant
5.	(NSBPP) Number of sec. branches per plant
6.	(NPPP) Number of pods per plant
7.	(NSPP) Number of seeds per pod
8.	(100SW) 100 seed weights (g)
9.	(SYPP) Seed yield per plant (g)

Statistical analysis

The analysis conducted involved the computation of the PCV and GCV as per the methodology introduced by Burton in 1952. The computed values were then classified into three categories: high (exceeding 20%), moderate (ranging from 10% to 20%), and low (below 10%), in line with the classification by Sivasubramanian and Menon from 1973. Additionally, the heritability for each trait was determined using the method suggested by Hanson *et al.,* in 1956.

RESULTS AND DISCUSSION

Estimation of genetic variability parameter: A critical observation of Table 2 shows that the different genotypes have significant phenotypic variation. The high estimate of PCV also indicated in figure-2 were observed for character such as 100 seed weight (23.78%) followed by Number of secondary branches plant^{-1} (20.75%), Seed plant^{-1} (18.60%), Plant height (12.08%) and Number of primary branches per plant (11.96%). Fig 1 With respect to the moderate PCV were reported *viz*., Number of pod per plants (11.78%), Number of seed per pod (11.24%), where as the minimum PCV were observed in Days to 50 % flowering (9.47%) and Days to maturity (1.74%). The findings of Kumar and Abbo (2001), Upadhyaya *et al.* (2002), and Dubey and Srivastava (2007) previously provided evidence that aligns with the results obtained in this study. As shown in Table 2 and Figure 1, the GCV analysis revealed that the maximum estimate for 100 seed weight (23.33%) followed by Number of secondary branches plant^{-1} (18.77%),

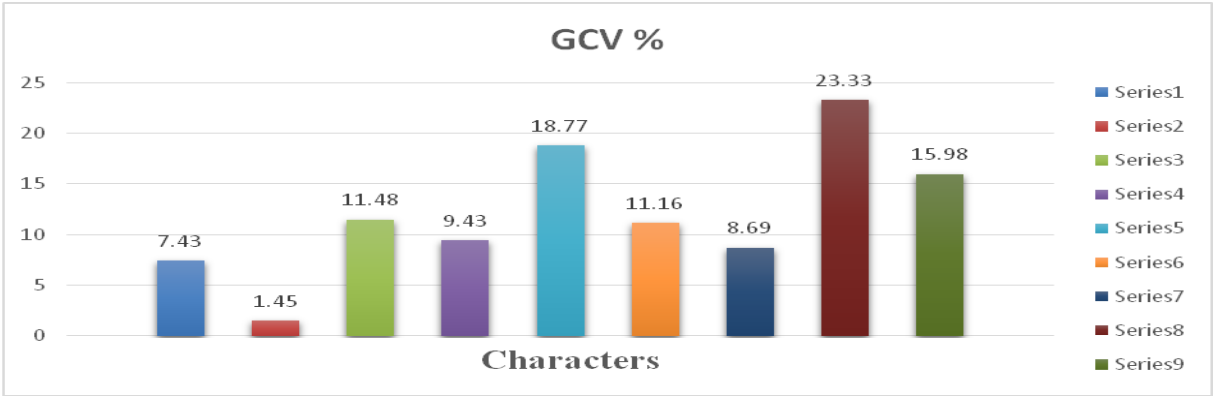

Figure 1: GCV for different growth and yield characters of chickpea

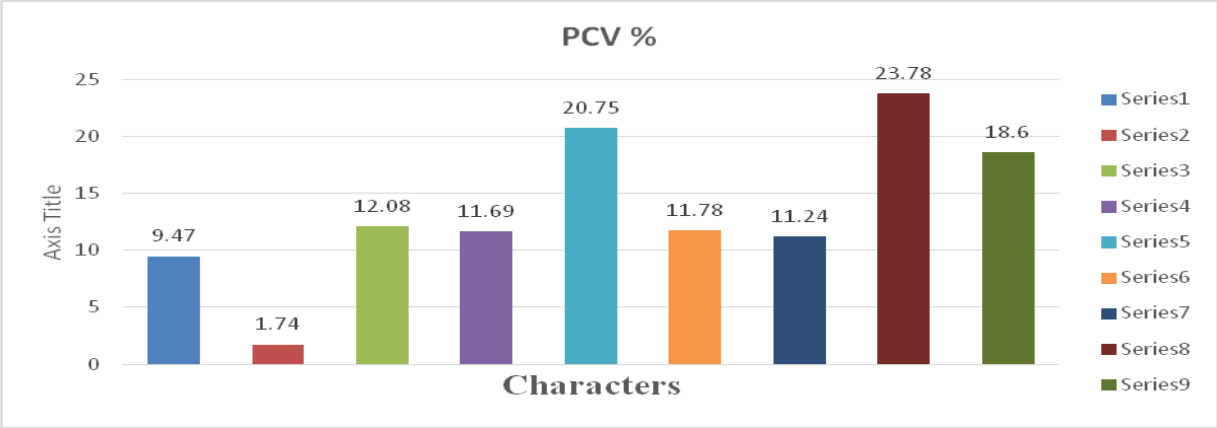

Figure 2: PCV for different growth and yield characters of chickpea

Seed plant^{-1} (15.98%), Plant height (11.48%) and Number of primary branches per plant (9.43%). While the moderate GCV were reported *viz*., Number of pod per plants (11.16%), Number of seed per pod (8.60%), where as the minimum GCV were observed in Days to 50 % flowering (7.43%) and Days to maturity (1.45%). The research conducted by Wanjari *et al.* (1996); Jeena *et al.* (2005); and Soni *et al.* (2024) aligns with the findings of the previous study. Findings indicated that the PCV consistently surpassed the GCV for all traits examined. This elevated PCV relative to GCV suggests a significant influence of environmental factors on trait expression. Notably, the traits demonstrated both high PCV and high GCV are 100 seed weight (100SW), number of secondary branches (NSBPP), seed yield per plant (SYPP), yield per plant (YPP), and biomass yield (BY).

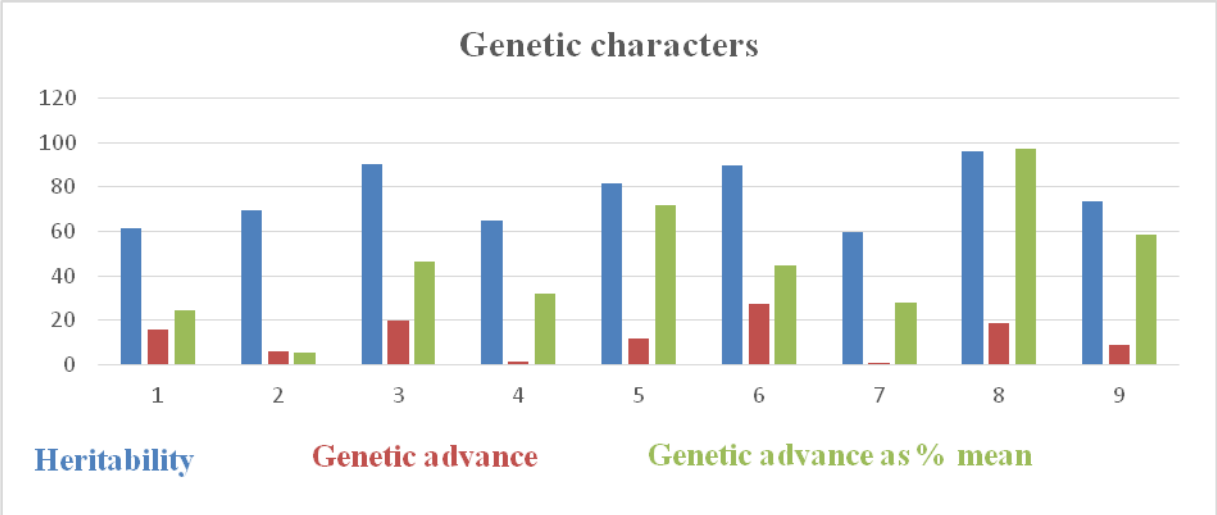

Figure 3: Heritability, GA as % of mean for different growth and yield characters of chickpea

Heritability measures also indicated in Figure 3 the transmissibility of traits from generation to generation. The maximum heritability were observed for different character such as 100 seed weight (g) (96.31%), Plant height (90.3%), Number of pods per plant (89.8%), Number of secondary branches per plant (81.9%) Seed yield per plant (73.8%). While the analysis revealed moderate heritability for several characteristics, such as days to maturity (69.41%), number of primary branches per plant (65.11%), and days to 50% flowering (61.51%). In contrast, the trait with the lowest heritability was the Number of Seeds per Pod (59.81%). These results align with the findings of Kumar and Abbo (2001); Upadhyaya *et al.* (2002); Dubey and Srivastava (2007); Monpara and Gaikwad (2014); and Soni *et al.* (2024).

As per the study of Johnson *et al.* (1955), utilizing both heritability and genetic advance provides a more comprehensive estimate for predicting the impact of selection than relying

solely on heritability. The GA% was recorded significant for Number of pods per plant (27.27%), Plant height (cm) (19.92%), 100 seed weight (g) (18.56%). While the moderate GA% were found in observation such as Days to 50% Flowering (15.94%), Number of secondary branches per plant (11.80%) and the minimum GA were found in observation such as Seed yield per plant (g) (8.80%), Days to maturity (6.14), Number of primary branches per plant (1.21%), Number of seeds per pod (0.43%).

According to Raval (2001), a high genetic advance (% mean) was found for both the number of pods per plant and plant height. Conversely, Days to 50% Flowering and Number of secondary branches per plant exhibited a moderate to low genetic advance (% mean), and the minimum GA were found in observation such as Seed yield per plant (g), Number of primary branches per plant, Number of seeds per pod (Table 2 and Figure 1). The similar findings were reported by Raval (2001) and Arshad *et al.* (2004).

A high h^2b, accompanied by a significant (GA) genetic advance as percent of mean, was recorded for traits such as 100 seed weight (g) at 96.31%, plant height at 90.31%, number of pods per plant at 89.81%, number of secondary branches per plant at 81.91%, and seed yield per plant. The outcomes of the current study suggest that effective selection for these characteristics is achievable. The research by Singh *et al.* (2021) similarly identified a considerable genetic advance alongside high h^2b for these traits.

Table 2: The range, average, coefficient of variation (%), heritability, and genetic improvement for nine traits of chickpea germplasm

Characters	Range		Grand Mean	Coefficient of variation		Heritability	Genetic advance	Genetic advance as % mean
	Maximum	Minimum		GCV (%)	PCV (%)			
D50% F	71.61	57.61	64.48	7.4	9.5	61.51	15.94	24.24
DM	124.31	116.61	119.7	1.45	1.74	69.40	6.2	5.14
PH (cm)	56.16	36.76	43.04	11.5	12.1	90.30	19.92	46.3
NPBPP	4.41	3.02	3.78	9.43	11.69	65.1	1.21	32.01
NSBPP	22.81	8.93	16.3	18.77	20.75	81.90	11.80	72.05
NPPP	71.71	43.61	60.77	11.2	11.78	89.80	27.3	44.87
NSPP	1.69	1.25	1.5	8.69	11.25	59.8	0.43	28.11
100 SW	30.61	13.71	19.11	23.3	23.78	96.30	18.56	97.12
SYPP	20.65	10.68	15.1	15.98	18.61	73.8	8.81	58.25

Correlation coefficients:

The economic yield, or grain yield, in most crops is a complex trait that results from the multiplicative interactions among several characteristics referred to as yield components. The correlation coefficient functions as a metric for assessing the degree of symmetrical association between two variables or traits, which is instrumental in analyzing the nature and strength of the relationship between yield and its component characteristics.

A highly significant and positive interrelation was identified between (SYPP) seed yield per plant with 100 seed weight (0.511), and plant height (0.371). On the other hand, a significant negative correlation exists between seed yield per plant and the number of pods per plant (-0.42) as well as the number of seeds per pod (-0.39), while the other measured traits showed negative correlations.

The number of seeds contained in each pod revealed a highly significant and positive correlation with the total number of pods per plant (0.864). In contrast, a non-significant negative correlation was noted with plant height (-0.260). The total number of pods per plant presented a non-significant positive correlation with the number of secondary branches per plant (0.184) and the number of primary branches per plant (0.106). Additionally, it exhibited a non-significant negative correlation with plant height (-0.309) and the duration to reach 50% flowering (-0.163). Secondary branches per plant exhibited highly positive correlation with number of primary branches per plant (0.794). The non-significant but negative correlation was with plant height (-0.271) and days to maturity (-0.241). The number of primary branches per plant was found to have a non-significant negative correlation with both plant height (-0.251) and the time

Table 2.2: Estimates of simple correlation coefficients between nine characters in chickpea genotypes (Phenotypic)

Traits	Days to 50% Flowering	Days to maturity	Plant height (cm)	No. of Pri. Branches/ plant	No. of Sec. Branches/ plant	No. of pods/ plant	No. of seeds per pod	100 seed weight (g)	Seed yield per plant (g)
Days to 50% Flowering	1.000	0.312	0.153	-0.001	0.019	-0.163	-0.023	0.278	0.119
Days to maturity		1.000	0.020	-0.212	-0.241	-0.064	0.025	0.207	0.019
Plant height (cm)			1.000	-0.251	-0.271	-0.309	-0.260	0.597**	0.374
No. of pri. branches per plant				1.000	0.794**	0.106	0.171	-0.064	-0.134
No. of sec. branches per plant					1.000	0.184	0.255	-0.135	-0.122
Number of pods per plant						1.000	0.864**	-0.423*	0.143
Number of seeds per pod							1.000	-0.399*	0.161
100 seed weight (g)								1.000	0.505**
Seed yield per plant (g)									1.000

** Significant at 5% probability level and ** Significant at 1% probability level*

taken to reach maturity (-0.212). On the other hand, plant height exhibited a non-significant positive correlation with the days to achieve 50% flowering (0.153). Moreover, the duration until maturity also showed a non-significant positive correlation with the days to 50% flowering (0.312). The significant positive relationship between seed yield and the previously mentioned characteristics has been corroborated in earlier research on chickpea, including findings by Singh and Shindhu (2008), Yaqoob *et al.,* (2009), Gohil and Patel (2010), Aycicek and Babagil (2013), Kumar *et al.,* (2016), Tadesse *et al.,* (2016), Hasan and Deb (2017), and Kumar *et al.,* (2018).

CONCLUSIONS

The existence of genetic variability is recognized as a vital element in the enhancement of crops. This study's findings reveal a significant degree of variability across all examined traits. The PCV consistently exceeded the GCV, suggesting that environmental factors play a role in the manifestation of these traits. Traits including PB, SB, FPH, PPP, SPP, SW, BY, and Yield exhibited both high heritability and a considerable percentage of Genetic Advance (% mean). This indicates that these traits are predominantly influenced by additive gene effects, making them amenable to improvement through selective breeding. Therefore, it is imperative to take into account both genetic variability and heritability when evaluating the potential for enhancement through selection.

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