

Morphological Evaluation of Chickpea (*Cicer arietinum* L.) Genotypes Based on DUS Characteristics and Character Association among Seed Yield Characters

ABSTRACT

Twenty-one genotypes of chickpea were used in the experiment, which was carried out by using a Randomized Block Design with three replications at the Department of Genetics and Plant breeding, Sam Higginbottom University of Agriculture, Technology and Sciences, Naini Allahabad, U. P during the rabi season of 2021-22. The present investigation was carried out to morphologically characterization and classify chickpea genotypes on the basis of DUS descriptors suggested by PPV& FRA. The observations were recorded on five randomly selected plants from each replication for 12 different quantitative traits. Analysis of variance showed significant differences for all the 12 characters viz., Days to 50 % Flowering, Days to Maturity, pod initiation, Plant Height, Number of Primary Branches, Number of Secondary Branches, number of pods per plant, Number of effective pods per plant, Number of seeds per plant, Biological Yield, Harvest Index, economic Yield Per Plant, Seed Index. The results of the analysis of variance showed that the majority of the qualities were significantly variable. Among twenty-one genotypes, CG-297 recorded high seed yield per plant followed by CG-255, CG-288, CG-210 and CG-214. All these genotypes recorded high seed yield as compare to check PUSA-362. High Genotypic Coefficient of Variation and Phenotypic Coefficient of Variation was observed for seed yield, seed index, harvest index, number of pods per plant, number of effective pods per plant. High heritability coupled with high genetic advance as percent of mean was observed for seed yield, seed index, harvest index, biological yield, number of pods per plant and number of effective pods per plant. The correlation studies revealed that seed yield per plant was positively and significantly correlated with pod initiation, plant height, number of pods per plant, number of effective pods per plant, biological yield, harvest index. The path analysis indicated that harvest index was observed as maximum positive direct effect on seed yield per plant and thus, may be considered as useful traits for yield improvement of chickpea.

Keywords: chickpea, DUS, genetic variability, heritability, genetic advance, correlation, path analysis.

Introduction

Pulses are the most essential vegetarian diet constituents because they include a larger percentage of protein and fat than grains. These are important in diets because they are high

in energy-producing minerals and vitamins. Because they are abundant in protein and several essential amino acids, particularly lysine, they are referred to as "poor man's meat" and "rich man's vegetable." They are also nutritious feed for livestock. They complement the bulk of vegetarians' cereal-heavy diet.

Chickpea, a self-pollinated, true diploid ($2n = 2x = 16$) cool-season food legume crop, has been identified in Middle Eastern archaeological sites spanning from 7500 to 6800 BC. The majority of its cultivation is in semi-arid locations, with southwest Asia and the Mediterranean region recognized as primary origin regions, and Ethiopia as secondary origin region. The chickpea is said to have originated in Anatolia, Turkey. Chickpeas are frequently farmed throughout the dry season in subtropical, semi-arid, and warm temperate areas.

The two most well-known chickpea cultivars are Kabuli and desi. The desi varieties are grown predominantly in Ethiopia and India, whereas the Kabuli varieties are grown primarily in the Mediterranean region, which encompasses Southern Europe, Western Asia, and Northern Africa. Desi chickpeas are grown mostly in South Asia, Africa, and Mexico, and are characterized by their small size, angular shape, and darker colour. Desi chickpeas are used more frequently than Kabuli chickpeas to create splits or Dal. Chickpeas have 59.8 percent carbohydrates, 4.8 percent oil, 3% ash, 0.2% calcium, and 0.3% phosphorus, as well as 20.8% protein, 5.6% fat, 2.7% minerals, and 1.2% fibre.

In other words, Kabuli chickpeas are grown in temperate regions, whereas desi chickpeas are grown in semiarid tropical climates (**Malhotra *et al.*, 1987; Muehlbauer and Singh, 1987**). While Kabuli chickpeas have owl- or ram-shaped beige-colored seeds, white flowers, smooth seed surfaces, and anthocyanin pigmentation on stem or other plant parts, Desi chickpeas have flowers of varying colours, angular to round seeds with dark seed coats, and anthocyanin pigmentation on stem or other plant parts.

Varietal characterization and identification are now more important than ever, according to the Protection of Plant Varieties and Farmer's Rights (PPV & FR) Act, 2001, which was enacted after India became a WTO signatory. Breeders, the seed industry, seed production and certification groups, seed testing labs (STLs), and farmers should all pay attention. Because over 4000 different crop varieties have been made available through the ICAR and SAU systems, together with exact information to discern one variation from another, varietal identification has become critically important for inclusion in varietal lists.

South Western Asia is the most likely origin. Bengal gramme is grown on 150.04 million hectares worldwide, yielding 158.71 million tonnes at a productivity of 1057.8 kg/ha (FAO STAT, 2021). In 2021-2022, India accounted for 86% of global Bengal gramme production, with 137.50 lakh tonnes planted on 102.65 lakh hectares at a productivity of 1447 kg/hectare (agricoop.nic.in). In

terms of Bengal gramme production, Madhya Pradesh leads all other states, followed by Maharashtra (23.05 lakh tonnes), Rajasthan (21.87 lakh tonnes), Uttar Pradesh (7.83 lakh tonnes), and Karnataka (6.55 lakh tonnes). India is the world's largest grain producer, with 36.96 lakh tonnes produced.

Genetic crop development is dependent on utilising the phenotypic variety present in the gene pool by providing helpful information in parent selection and their subsequent application through plant breeding procedures. Plant breeding procedures in recent years have restricted the genetic foundation of cultivated chickpea. Characterization of newly generated genotypes for economic features, on the other hand, will aid in the development of improved cultivars.

Correlation coefficient studies aid in identifying interrelationships between various plant properties. Path coefficients are typical partial regression coefficients that assess the direct influence of one variable on another by splitting the correlation coefficient into direct and indirect effect components.

OBJECTIVES:

1. To characterize genotypes on the basis of morphological traits.
2. To estimate genetic variability parameters for yield and its attributing characters among chickpea germplasm.
3. To study phenotypic and genotypic correlation between quantitative traits and seed yield.
4. To assess direct and indirect effects of yield attributing traits on seed yield.

MATERIALS AND METHODS

The genetic material for this study consisted of 21 diverse genotypes of chickpea from different geographical origin that were sown in the Randomized block design with 3 replications for the "MORPHOLOGICAL EVALUATION OF CHICKPEA (*Cicer arietinum* L.) GENOTYPES BASED ON DUS CHARACTERISTICS AND CHARACTER ASSOCIATION AMONG SEED YIELD CHARACTERS" was conducted at the Experimental Farm of the Department Genetics and PlantBreeding, Naini Agricultural Institute, Sam Higginbottom University of Agriculture, Technology andSciences,Prayagraj,UttarPradeshduring **Rabi, 2021-22.**

EXPERIMENTAL MATERIAL

The experimental material for the current study consists of chickpea, 21 genotypes received from the Department of Genetics and Plant Breeding, and the experiment will be carried out in Randomized Block Design with three replications at the Experimental Farm of the Department of Genetics and Plant Breeding, Naini Agricultural Institute, Sam Higginbottom

University of Agriculture, Technology and Sciences, Prayagraj U.P. during 2021-22.

Fiverandomlyselectedcompetitiveplantsofeachsegregatingpopulationineachreplication were used to record on both qualitative and quantitative characters.

List1 experimentalmaterialusedinthepresentinvestigation

Sl. No	ENTRYNAME	Sl. No	ENTRYNAME
1	CG - 15	12	CG - 255
2	CG - 15	13	CG - 262
3	CG - 62	14	CG - 268
4	CG - 65	15	CG - 273
5	CG - 81	16	CG - 288
6	CG - 210	17	CG - 294
7	CG - 211	18	CG - 296
8	CG - 214	19	CG - 297
9	CG - 221	20	CG - 300
10	CG - 239	21	PUSA - 362 (Check)
11	CG - 254		

Qualitativetraits:

The observations were recorded on the following 13 morphological characteristics (Table : 1) of 21 chickpea genotypes to assess the genetic evaluation as per the guidelines for the conduct of test for Distinctiveness, Uniformity and Stability (DUS) on chickpea (*Cicer arietinum* L.) approved by the Protection of Plant Varieties and Farmers' Rights Authority (PPVFR) in 2007, Government of India.

Quantitative traits:

Data is recorded for the 12 characters viz., Days to 50 % Flowering, Days to Maturity, pod initiation, Plant Height, Number of Primary Branches, Number of Secondary Branches, number of pods per plant, Number of effective pods per plant, Number of seeds per plant, Biological Yield, Harvest Index, economic Yield Per Plant, Seed Index.

The F- test was used to examine the differences between germplasm using an analysis of variance. It was done to divide total variation into variation owing to treatments and replications using the **Panse and Sukhatme approach (1967)**. This also makes it easier to segment total variance into phenotypic, genotypic, and environmental variants. The entire variance was separated into three components: replications, germplasm, and error, and the significance of 'F' was assessed.

In the present study of investigation, the data were analyzed in **WINDOSTAT 9.3**

ver. This software tool was used to find out for correlation and path analysis.

STATISTICAL ANALYSIS

1. Analysis of Variance (**Fisher, 1935**)
2. Co-efficient of Variation (**Burton and De vane, 1952**)
 - a. Genotypic Co-efficient of Variation (**GCV**)
 - b. Phenotypic Co-efficient of Variation (**PCV**)
3. Heritability broad sense (**Burton and De vane, 1953**)
4. Genetic Advance (**Johnson et al., 1955**)
5. Correlation Co-efficient Analysis (**Al Jibouriet al., 1958**)
6. Path coefficient analysis (**Dewey and Lu, 1959**)

RESULTS AND DISCUSSION

The analysis of variation values for 12 biometrical traits was presented in table-2. The mean sum of squares due to the genotypes were significant for all the characters studied at both level of significance 1% and 5%, suggesting the existence of high genetic variability among the genotypes for all the traits. This indicates that there is sample for selection of genotypes from the present gene pool for yield and its component traits.

The mean performance of seed index varied from 9.96 to 26.89g with a grand mean value of 15.06g. The genotype with high test weight was regarded as the best genotype for seed index was observed in the genotype G-T 262(26.89g) followed by CG-294(24.45g), CG-288(19.67g), and CG-239(18.70g). The low seed index was observed in CG-297(9.96g) followed by CG-255(10.31g), CG-221(10.43g) and CG-273(10.58g).

Genetic variability: In the present investigation from (table- 3); High GCV (>20%) is observed for seed yield (39.599), number of effective pods per plant (36.978), harvest index (35.088), seed index (31.518) and number of pods per plant (30.614). GCV was found moderate (10-20%) for biological yield (13.901), plant height (11.969) and number of secondary branches (10.303). Low (<10%) for number of primary branches (5.276), days to 50% flowering (4.223), pod initiation (4.097) and days to maturity (0.882). High PCV (>20%) is observed for seed yield (40.903), number of effective pods per plant (38.362), harvest index (36.504), number of pods per plant (32.432) and seed index (32.206). PCV was found moderate (10-20%) for biological yield (16.366), plant height (13.194) and

number of secondary branches (13.049). Low(<10%) for number of primary branches (8.696), pod initiation (7.069), days to 50% flowering (7.005) and days to maturity (1.861).

Heritability: In the present study, high heritability values were recorded (table- 3) for almost all the characters. The estimates of heritability ranged from 22.301% (days to maturity) to 95.776% (seed index). High heritability (>60%) was recorded for seed index (95.776%) followed by seed yield (93.726%), number of effective pods per plant (92.915%), harvest index (92.392%), number of pods per plant (89.104%), plant height (82.302), biological yield (72.143%), number of secondary branches (62.34%). However, moderate heritability from 30 - 60% was recorded for number of primary branches (36.815%), days to 50% flowering (36.343%) and pod initiation (33.59%). Low heritability (< 30%) found in days to maturity (22.301%). The high heritability values of the considered traits in the present study indicated that those were less influenced by the environment and thus help in effective selection of the traits based on the phenotypic expression by adopting simple selection method and suggested the scope of genetic improvement.

Genetic advance as a percent of mean: It ranged from 0.858% (days to maturity) to 78.973% (seed yield) from (table- 3). High genetic advance as a percent of mean was observed for seed yield (78.973), number of effective pods per plant (73.427), harvest index (69.477), seed index (63.542), number of pods per plant (59.53), plant height (22.369). While moderate genetic advance as a percent of mean was observed for number of secondary branches (16.758). Low genetic advance as a percent of mean was observed for number of primary branches (6.595), days to 50% flowering (5.244), pod initiation (4.892) and days to maturity (0.858).

Genotypic Correlation Coefficient

In the present investigation (table 4) seed yield per plant showed positive and significant correlation with pod initiation (0.506**), plant height (0.4685**), number of pods per plant (0.822**), number of effective pods per plant (0.852**), biological yield (0.517**) and harvest index (0.918**). The correlation showed negative and significant for days to maturity (-0.450**). The correlation showed positive and non-significant association with number of primary branches (0.053). The correlation showed negative and non-significant for days to 50% flowering (-0.193), number of secondary branches (-0.054) and seed index (-0.168).

Phenotypic Correlation Coefficient

In the present investigation (table 4) seed yield per plant showed positive significant association with plant height (0.417**), number

of pods per plant (0.795**), number of effective pods per plant (0.833**), biological yield (0.515**) and harvest index (0.905**). Showed positive and non-significant association with pod initiation (0.204), number of primary branches (0.090), number of secondary branches (0.009). Negative and non-significance is observed for days to 50% flowering (-0.179), days to maturity (-0.197) and seed index (-0.178).

Genotypic Path coefficient analysis

In the present investigation (table-5) positive direct effect was showed by days to 50% flowering (0.0831), days to maturity (0.0182), number of primary branches (0.0046), number of effective pods per plant (0.0701), biological yield (0.5015), harvest index (0.8989) and seed index (0.0142). Negative direct effect was showed by pod initiation (-0.1353), plant height (-0.0260), number of secondary branches (-0.0392) and number of pods per plant (-0.0240).

Phenotypic Path coefficient analysis

In the present investigation (table-5) positive direct effect was showed by pods initiation (0.0174), plant height (0.0437), number of secondary branches (0.0018) and number of pods per plant (0.1731), number of effective pods per plant (0.0120), biological yield (0.2588) and with harvest index (0.7097). Negative direct effect was shown by days to 50% flowering (-0.0373), days to maturity (-0.0374), primary branches per plant (-0.0085) and with harvest index (-0.0369).

CONCLUSION

From the present investigation it is concluded that among 21 chickpea genotypes, based on the mean performance CG-297 (10.65g) and CG- 255 (8.36g) were found to be superior in seed yield per plant over the check variety PUSA-362 (6.77g). The morphological characterization will be relevant for subsequent DUS (Distinctness, Uniformity, and Stability (DUS) Testing evaluation. DUS tests are performed to determine that a new variety is Distinct from current varieties, that its traits are Uniform, and that the variety is Stable, with stable phenotypic characteristics from generation to generation. On the basis of Analysis of variance significant difference was recorded for all the seed yield and its components indicating presence of large amount of variability in the genotypes. The magnitude of GCV and PCV recorded high for seed yield (39.599 and 40.903). Correlation coefficient analysis revealed that seed yield per plant exhibited positive and significant association with number of pods per plant, number of effective pods per plant, biological yield and harvest index at both genotypic and phenotypic levels. Path coefficient analysis

revealed that character's plant height, number of pods per plant, effective pods per plant, seed index, biological yield and harvest index have positive direct effect on seed yield per plant at genotypic and phenotypic levels.

Table-1 Guidelines for DUS test by PPV&FRA, 2007 for 13 morphological DUS traits on chickpea

SN	Characteristics	States	Observationstage
1.	Anthocyanin pigmentation onstem	Absent/Present.	Beforeflowering
2.	Plantgrowthhabit	Erect (0-15° from vertical)/ Semi-erect (16-60° from vertical)/ Spreading(61-80° from vertical).	At50%flowering
3.	Foliagecolour	Lightgreen/Mediumgreen/Darkgreen/Greenishpurple.	
4.	Leafletsizel(Length)	Small(<10mm)/Medium(10-15mm)/ Large(>15mm).	
5.	Numberofflowers/ peduncle	Single/Twin.	
6.	Flowercolour	White/Pink/Blue.	
7.	Leaf pattern	Pinnate	
8.	Pedunclelength	Short(<5mm)/Medium(5-10mm)/Long(>10mm).	
9.	Podsize	Small(<15mm)/Medium(15-20mm)/ Large(>20 mm).	Harvestmaturity
10.	Seedcolour	Beige(<i>Kabuli</i>)/Creamybeige/Green/yellow/Orangebrown/Darkbrown/ Greyblack.	30daysafterharvest
11.	Seedshape	Pea-shaped/Owl'shead/Angular.	
12.	No. of seeds per pod	One/Two/Three	
13.	Seedtype	<i>Desi/Kabuli</i> .	

Table 1a: Classification of 21 chickpea genotypes on the basis of anthocyanin pigmentation on stem.

STEM ANTHOCYANIN COLOURATION	CATEGORY
ABSENT	CG-62, CG-65, CG-210, CG-254, CG-268, CG-273, CG-296, CG-297, PUSA 362(Check)
PRESENT	CG-15, CG-18, CG-81, CG-211, CG-214, CG-221, CG-239, CG-255, CG-262, CG-288, CG-294, CG-300

Table 1b: Classification of 21 chickpea genotypes on the basis of plant growth habit

PLANT GROWTH HABIT	Category
ERECT	CG-15, CG-18, CG-65, CG-81, CG-214, CG-239, CG-254, CG-255, CG-262, CG-296
SEMI-ERECT	CG-62, CG-211, CG-221, CG-268, CG-273, CG-288, CG-294, CG-297, CG-300, PUSA 362(Check)
SPREADING	CG-210

Table 1c: Classification of 21 chickpea genotypes on the basis of foliage colour

PLANT COLOUR OF FOLIAGE	CATEGORY
-------------------------	----------

DARK GREEN	CG-15, CG-18, CG-211, CG-239, CG-288, CG-294, CG-300
MEDIUM GREEN	CG-62, CG-65, CG-81, CG-210, CG-214, CG-221, CG-254, CG-255, CG-262, CG-268, CG-273, CG-296, CG-297, PUSA 362(Check)

Table 1d: Classification of 21 chickpea genotypes on the basis of leaflet size

LEAFLET SIZE	CATEGORY
LARGE	CG-62, CG-254, CG-268, CG-288, CG-294
MEDIUM	CG-15, CG-18, CG-65, CG-210, CG-211, CG-214, CG-255, CG-296, PUSA 362(Check)
SMALL	CG-81, CG-221, CG-239, CG-262, CG-273, CG-297, CG-300

Table 1e: Classification of 21 chickpea genotypes on the basis of Leaf pattern

LEAF PATTERN	CATEGORY
PINNATE	CG-15, CG-18, CG-62, CG-65, CG-81, CG-210, CG-211, CG-214, CG-221, CG-239, CG-254, CG-255, CG-262, CG-268, CG-273, CG-288, CG-294, CG-296, CG-297, CG-300, PUSA 362(Check)

Table 1f: Classification of 21 chickpea genotypes on the basis of number of flowers per peduncle.

FLOWER. NO.PER PEDUNCLE	CATEGORY
DOUBLE	CG-81, CG-255, CG-294
SINGLE	CG-15, CG-18, CG-62, CG-65, CG-210, CG-211, CG-214, CG-221, CG-239, CG-254, CG-262, CG-268, CG-273, CG-288, CG-296, CG-297, CG-300, PUSA 362(Check)

Table 1g: Classification of 21 chickpea genotypes on the basis of flower colour

FLOWER COLOUR	CATEGORY
PURPLE	CG-15, CG-18, CG-62, CG-65, CG-81, CG-210, CG-211, CG-214, CG-221, CG-239, CG-254, CG-255, CG-262, CG-273, CG-288, CG-294, CG-296, CG-297, CG-300, PUSA 362(Check)
WHITE	CG-268

Table 1h: Classification of 21 chickpea genotypes on the basis of peduncle length

PEDUNCLE LENGTH	CATEGORY
LONG	CG-62, CG-15, CG-288
MEDIUM	CG-65, CG-81, CG-210, CG-211, CG-214, CG-239, CG-254, CG-255, CG-262, CG-268, CG-273, CG-294, CG-296, CG-297, CG-300, CG-18, PUSA 362(Check)
SMALL	CG-221

Table 1i: Classification of 21 chickpea genotypes on the basis of pod size

POD SIZE	CATEGORY
LONG	CG-15, CG-62, CG-81, CG-239, CG-268, CG-288
MEDIUM	CG-18, CG-65, CG-210, CG-211, CG-214, CG-254, CG-255, CG-262, CG-273, CG-294, CG-296, CG-297, CG-300, PUSA 362(Check)
SMALL	CG-221

Table 1j: Classification of 21 chickpea genotypes on the basis of seed colour

SEED COLOUR	CATEGORY
BEIGE	CG-268
BLACK	CG-81, CG-211
BROWN	CG-300, CG-62, CG-65, CG-214, CG-221, CG-239, CG-255, CG-262, CG-296, CG-297, CG-273
DARK BROWN	CG-18, CG-294
GREEN-BROWN	CG-288
LIGHT BROWN	CG-210, CG-254
REDDISH-BROWN	CG-15
YELLOWISH BROWN	PUSA 362(Check)

Table 1k: Classification of 21 chickpea genotypes on the basis of seed shape

SEED SHAPE	CATEGORY
ANGULAR	CG-15, CG-18, CG-62, CG-65, CG-81, CG-210, CG-211, CG-214, CG-221, CG-239, CG-255, CG-262, CG-288, CG-294, CG-297, CG-300, CG-273, PUSA 362(Check)
OWL-HEAD	CG-268
ROUND	CG-254, CG-296

Table 1l: Classification of 21 chickpea genotypes on the basis of seed type

SEED TYPE	CATEGORY
DESI	CG-15, CG-18, CG-62, CG-65, CG-81, CG-210, CG-211, CG-214, CG-221, CG-239, CG-254, CG-255, CG-262, CG-273, CG-288, CG-294, CG-296, CG-297, CG-300, PUSA 362(Check)
KABULI	CG-268

Table 1m: Classification of 21 chickpea genotypes on the basis of Number of seeds per pod

NUMBER OF SEEDS PER POD	CATEGORY
THREE	CG-81, CG-239, CG-300
TWO	CG-15, CG-18, CG-62, CG-65, CG-210, CG-211, CG-214, CG-221, CG-255, CG-262, CG-273, CG-288, CG-296, CG-297
ONE	CG-254, CG-268, CG-294, PUSA 362(Check)

Table 2: Analysis of Variances for 12 quantitative traits among chickpea genotypes

Sl.no.	source	mean sum of squares (mss)		
		replication	treatment	error
		degrees of freedom	2	20
1	Days to 50% flowering	32.190	55.133**	20.324
2	No. of days to maturity	5.7620	6.505*	3.495
3	Pod initiation	41.6480	60.482**	24.025
4	Plant height	7.510	56.046**	3.749
5	No. of Primary branches	0.0330	0.045**	0.016
6	No. of Secondary branches	0.0670	0.433**	0.073
7	Number of pods per plant	11.4730	168.446**	6.597
8	Number of effective pods per plant	9.4940	199.125**	4.936
9	Biological yield	2.7990	13.038**	1.487
10	Harvest index	30.5220	534.298**	14.273
11	Seed index	0.3690	68.619**	0.994
12	Seed yield	0.6990	13.914**	0.304

Table 3: Genetic parameters for 12 quantitative characters in chickpea genotypes

Sl. No.	Characters	GCV	PCV	h^2 (Broad Sense)	Genetic Advance	Gen. Adv as % of Mean
1	Days to 50% flowering	4.223	7.005	36.343	4.23	5.244
2	No. of Days to maturity	0.882	1.867	22.301	0.974	0.858
3	Pod initiation	4.097	7.069	33.59	4.162	4.892
4	Plant height	11.969	13.194	82.302	7.803	22.369
5	No. of Primary Branches	5.276	8.696	36.815	0.122	6.595
6	No. of Secondary Branches	10.303	13.049	62.34	0.564	16.758
7	Number of pods per plant	30.614	32.432	89.104	14.283	59.53
8	Number of effective pods per plant	36.978	38.362	92.915	15.976	73.427
9	Biological yield	13.901	16.366	72.143	3.433	24.322
10	Harvest Index	35.088	36.504	92.392	26.07	69.477
11	Seed Index	31.518	32.206	95.776	9.572	63.542
12	Seed yield	39.599	40.903	93.726	4.248	78.973

GCV: Genotypic Coefficient of Variation, **PCV:** Phenotypic Coefficient of Variation, **h^2 :** Heritability, **GA% of Mean:** Genetic Advance at percent of mean

DF50: Days to 50% Flowering, **DM:** Days to Maturity, **PI:** Pod Initiation, **PH:** Plant Height, **NPP:** Number of Primary Branches, **NSB:** Number of Secondary Branches, **NPPP:** Number of Pods per Plant, **EPPP:** Effective Pods Per Plant, **BY:** Biological Yield, **HI:** Harvest Index, **SI:** Seed Index, **SY:** Seed Yield, **P:** Phenotypic, **G:** Genotypic

UNDER PEER REVIEW

Table 5: Path Coefficient Analysis

Traits		DF50	DM	PI	PH	NPB	NSB	NPPP	EPPP	BY	HI	SI	SY
DF50	G	0.0831	0.0507	0.0096	-0.0305	0.0148	0.0383	-0.0193	-0.0184	-0.0325	-0.0052	-0.0130	-0.1937
	P	-0.0373	-0.0057	-0.0022	0.0083	0.0019	-0.0054	0.0053	0.0052	0.0096	0.0020	0.0025	-0.1798
DM	G	0.0111	0.0182	-0.0008	0.0030	-0.0114	-0.0157	-0.0068	-0.0067	-0.0106	-0.0048	-0.0092	-0.450**
	P	-0.0057	-0.0374	0.0009	-0.0035	0.0057	0.0093	0.0071	0.0082	0.0073	0.0042	0.0069	-0.1975
PI	G	-0.0157	0.0062	-0.1353	-0.0299	-0.0493	-0.0289	-0.0446	-0.0611	-0.0633	-0.0586	0.0222	0.506**
	P	0.0010	-0.0004	0.0174	0.0025	-0.0022	0.0018	0.0021	0.0040	0.0023	0.0029	-0.0021	0.2041
PH	G	0.0095	-0.0043	-0.0057	-0.0260	0.0092	0.0119	-0.0048	-0.0058	-0.0095	-0.0100	0.0121	0.468**
	P	-0.0098	0.0041	0.0062	0.0437	-0.0045	-0.0090	0.0065	0.0087	0.0145	0.0145	-0.0186	0.417**
NPB	G	0.0008	-0.0029	0.0017	-0.0016	0.0046	0.0028	0.0008	0.0006	0.0011	-0.0001	0.0009	0.0536
	P	0.0004	0.0013	0.0011	0.0009	-0.0085	-0.0045	-0.0009	-0.0008	-0.0017	-0.0004	-0.0011	0.0907
NSB	G	-0.0180	0.0339	-0.0084	0.0179	-0.0241	-0.0392	0.0011	0.0000	-0.0040	0.0035	-0.0152	-0.0540
	P	0.0003	-0.0004	0.0002	-0.0004	0.0009	0.0018	0.0000	0.0000	0.0003	-0.0001	0.0005	0.0097
NPPP	G	0.0056	0.0089	-0.0079	-0.0044	-0.0041	0.0007	-0.0240	-0.0237	-0.0116	-0.0162	0.0007	0.822**
	P	-0.0247	-0.0327	0.0207	0.0259	0.0186	0.0014	0.1731	0.1689	0.0822	0.1135	-0.0085	0.795**
EPPP	G	-0.0156	-0.0258	0.0316	0.0156	0.0093	0.0000	0.0695	0.0701	0.0370	0.0497	-0.0017	0.857**
	P	-0.0017	-0.0026	0.0028	0.0024	0.0011	0.0003	0.0118	0.0120	0.0062	0.0084	-0.0005	0.833**
BY	G	-0.1964	-0.2925	0.2345	0.1842	0.1193	0.0513	0.2425	0.2652	0.5015	0.0622	-0.0894	0.517**
	P	-0.0662	-0.0506	0.0342	0.0860	0.0517	0.0511	0.1229	0.1324	0.2588	0.0469	-0.0497	0.515**
HI	G	-0.0559	-0.2349	0.3892	0.3461	-0.0176	-0.0806	0.6078	0.6374	0.1114	0.8989	-0.0897	0.918**
	P	-0.0386	-0.0798	0.1183	0.2354	0.0309	-0.0266	0.4656	0.4926	0.1287	0.7097	-0.0711	0.905**
SI	G	-0.0022	-0.0072	-0.0023	-0.0066	0.0029	0.0055	-0.0004	-0.0003	-0.0025	-0.0014	0.0142	-0.1681
	P	0.0025	0.0068	0.0045	0.0157	-0.0049	-0.0105	0.0018	0.0016	0.0071	0.0037	-0.0369	-0.1786
SY	G	-0.1937	-0.450**	0.506**	0.468**	0.0536	-0.0540	0.822**	0.857**	0.517**	0.918**	-0.1681	1.0000
	P	-0.1798	-0.1975	0.2041	0.417**	0.0907	0.0097	0.795**	0.833**	0.515**	0.905**	-0.1786	1.0000

DF50: Days to 50% Flowering, **DM:** Days to Maturity, **PI:** Pod Initiation, **PH:** Plant Height, **NPP:** Number of Primary Branches, **NSB:** Number of Secondary Branches, **NPPP:** Number of Pods per Plant, **EPPP:** Effective Pods Per Plant, **BY:** Biological Yield, **HI:** Harvest Index, **SI:** Seed Index, **SY:** Seed Yield, **P:** Phenotypic, **G:** Genotypic



Pic 1 Plant Growth Habit

Pic 2 Flower Colour



Pic 3 Seed Colour

Pic 4 Seed Types

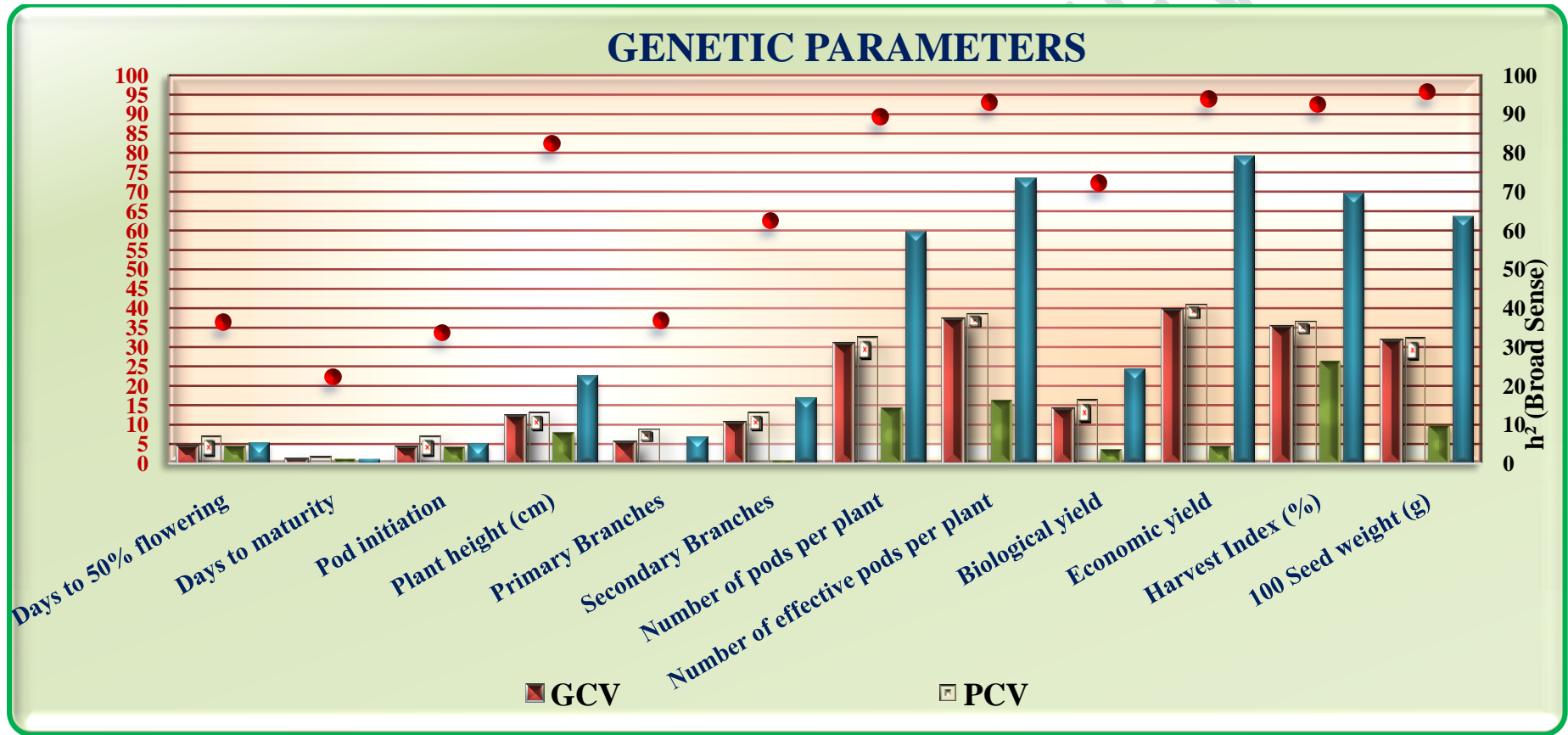


Fig 1: Histogram depicting GCV, PCV, Genetic advance and h^2 for 12 quantitative characters of 21 chickpea genotypes

UNDER PEER REVIEW

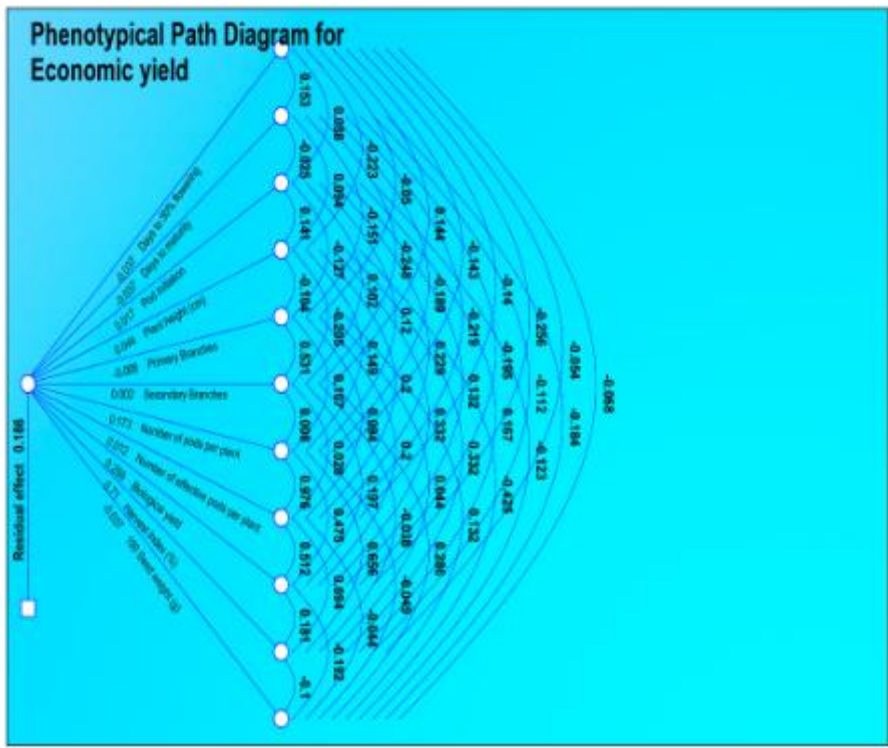


Fig 2: Phenotypic Path Diagrams for Seed Yield

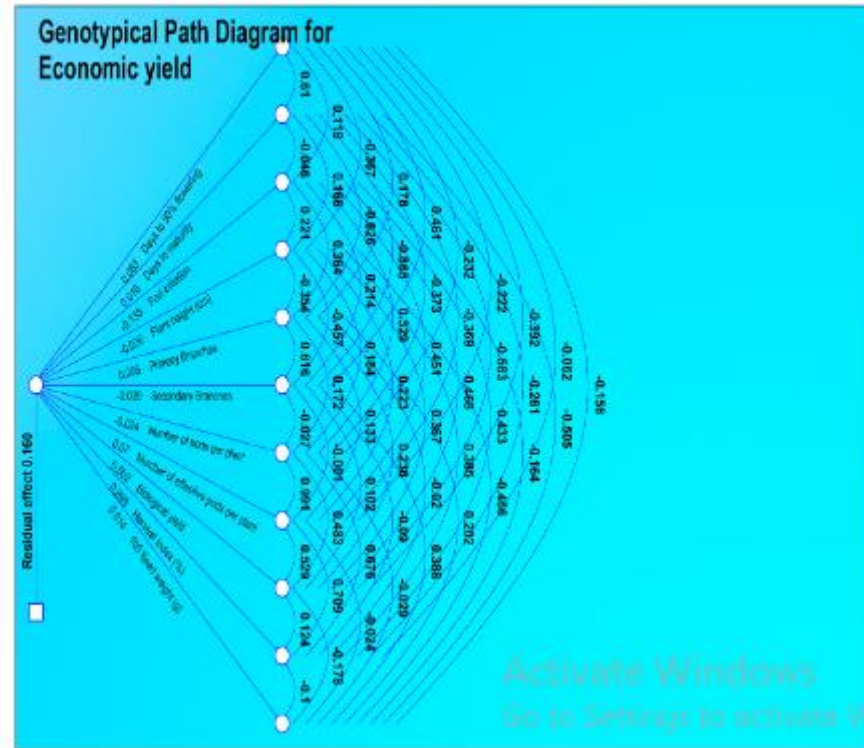


Fig 3: Genotypic Path Diagrams for Seed Yield

References

1. **Al-Jibouri, H.A., Miller, P.A. and Robinson, H.F. (1958).** Genotypic and environmental variances in upland cotton cross of interspecific origin. *Agronomy Journal*, **50**:633-637.
2. **Burton, G.W. (1952).** Quantitative Inheritance of Grasses. *Proceedings of 6th International Grassland congress*, **1**:277-283.
3. **Burton, G.W. and Devane. (1953).** Estimation of Heritability in Tall Fescue (*Festuca arundinaceae*) from replicated clonal material. *Agronomy Journal*, **45**:478-481.
4. **Dewey D. R. and Lu K. H. (1959).** A correlation and path coefficient analysis of components of crested wheat grass seed production. *Agronomy Journal*, **51**:515-518.
5. **Durdane, M. (2021).** Investigation of the Morphological Characteristics of Chickpea (*Cicer arietinum* L.) Cultivars Cultivated under Irrigated and Non-Irrigated Conditions Sown in Winter and Early Spring. *Turkish Journal of Range and Forage Science*, 2022, **3(2)**: 75-83.
6. **FAOSTAT. (2021).** Food and Agriculture Organization of the United Nations Statistical Database.
7. **Fisher, R.A. (1918).** The correlation between relative on the supposition of Mendelian Inheritance. *Earth and Environmental Science Transactions of The Royal Society of Edinburgh*, **52**: 399-403.
8. **Fisher, R.A., Yates, F. (1967).** Statistical tables for biological, Agricultural and Medical Research, Congress Group Limited, London.
9. **Johnson, H.W., Robinson, H.F and Comstock, R.E. (1955).** Estimates of genetic and environmental variability in soybean. *Agronomy Journal*, **47 (7)**: 314-318.
10. **Johnson, P.L., Sharma, R.N. and Nanda, H.C. (2016).** Characters association in chickpea (*Cicer arietinum* L.) under rice-based cropping system. *Progressive Research an International Journal*, **11(9)**:5891-5894.
11. **Malhotra RS, Pundir RPS, Slinkard AE (1987).** Genetic resources of chickpea. In: Saxena MC, Singh KB (eds) *The chickpea*. CAB International Cambrian News Ltd, Aberystwyth, pp 67–81.
12. **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.
13. **Tiwari, A., Babbar, A. and Pal, N. (2016).** Genetic variability, correlation and path analysis in yield and yield components in chickpea (*Cicer arietinum* L.) genotypes under late sown condition. *International Journal of Agricultural Sciences*, **54(8)**:2884-2886.
14. **Vijayalaxmi, N.V.S., Kumar, J. and T.N. Rao. (2000).** Variability and correlation studies in

UNDER PEER REVIEW