Morphological Evaluation of Chickpea (*Cicer arietinum* L.) Genotypes Based on DUSCharacteristics 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~~O~~o~~bservations 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

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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.

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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 climes **(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 torecordon 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:

Theobservationswererecordedonthefollowing13morphologicalcharacteristics(Table : 1) of 21 chickpea genotypes to assess the genetic evaluation as per the guidelines for the conduct oftestforDistinctiveness,UniformityandStability(DUS)onchickpea(*Cicerarietinum*L.)approved by the Protection of Plant Varieties and Farmers' Rights Authority (PPVFRA) in 2007,GovernmentofIndia.

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 Jibouri*et 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. Themean sum of squares due to the genotypes were significant for all the characters studied at bothlevel of significance 1% and 5%, suggesting the existence of high genetic variability among thegenotypes for all the traits. This indicates that there is sample for selection of genotypes from thepresentgenepoolforyieldanditscomponenttraits.

The mean performance of seed index varied from 9.96 to 26.89g with a grand meanvalue of 15.06g. The genotype with high test weight was regarded as the best genotypefor seed index was observedin the genotype G-T 262(26.89g) followed by CG-294(24.45g),CG-288(19.67g),and CG-239(18.70g).Thelow seed indexwasobservedinCG-297(9.96g)followedbyCG- 255(10.31g), CG-221(10.43g)andCG-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). HighPCV (>20%) isobservedfor 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.Theestimatesofheritabilityrangedfrom22.301%(daystomaturity)to95.776%(seed index). High heritability (>60%) was recordedfor 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%). Thehigh heritability values of the considered traits in the present study indicated that those were lessinfluenced bytheenvironment andthushelp ineffectiveselectionofthetraitsbasedonthe phenotypic expression by adopting simple selection method and suggested the scope ofgeneticimprovement.

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 apercent of mean was observed for number of secondary branches (16.758). Low genetic advance aspercentmean 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

Inthepresentinvestigation (table 4) seedyieldperplantshowedpositiveandsignificantcorrelation 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**).Thecorrelation 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

Inthepresentinvestigation (table 4) seedyieldperplantshowedpositivesignificantassociation with plant height (0.417**), number

of pods per plant (0.795**), number of effectivepodsperplant(0.833**),biologicalyield(0.515**)andharvestindex(0.905**).Showed positiveand non-significantassociationwith pod initiation (0.204), number of primary branches (0.090), number of secondary branches (0.009). Negative andnon-significance is observed for days to 50% flowering (-0.179), days to maturity (-0.197) and seed index (-0.178).

GenotypicPathcoefficientanalysis

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 effectwas showed by pod initiation (-0.1353), plant height (-0.0260), number of secondary branches (-0.0392) and number of pods per plant (-0.0240).

PhenotypicPathcoefficientanalysis

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 withharvest index (0.7097). Negative direct effect was shown by days to 50% flowering (-0.0373), days to maturity (-0.0374),primarybranchesperplant(-0.0085)and with harvest index (-0.0369).

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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 (0-15º from vertical)/ Semi-erect (16-60º from vertical)/ Spreading(61-80º from vertical).	At50%flowering
3.	Foliagecolour	Lightgreen/Mediumgreen/Darkgreen/Greenishpurple.	
4.	Leafletsize(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).	Poddevelopment
9.	Podsize	Small(<15mm)/Medium(15-20mm)/ Large(>20 mm).	Harvestmaturity
10.	Seedcolour	Beige(*Kabuli*)/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	*Desi*/*Kabuli*.	

Table 1a: Classification of 21 chickpea genotypeson thebasisofanthocyanin pigmentationon 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: Classificationof 21 chickpeagenotypesonthebasisofplantgrowthhabit

PLANT GROWTHHABIT	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)
SPREAING	CG-210

Table 1c: Classificationsof 21 chickpeagenotypesonthebasisoffoliagecolour

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: Classificationsof 21 chickpeagenotypesonthe basisofleafletsize

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: Classificationof 21 chickpeagenotypesonthebasisofLeafpattern

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: Classificationof21chickpeagenotypesonthebasisofnumberofflowersper 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: Classificationof 21 chickpeagenotypesonthebasisofflowercolour

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: Classificationof 21 chickpeagenotypesonthe basisofpedunclelength

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: Classificationof 21 chickpeagenotypesonthebasisofpod 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: Classificationof 21 chickpeagenotypesonthe basisofseedcolour

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 YELLOWISH BROWN	CG-15 PUSA 362(Check)

Table 1k: Classificationof 21 chickpeagenotypesonthebasisofseedshape

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: Classificationof 21 chickpeagenotypesonthe basisofseedtype

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: Classificationof 21 chickpeagenotypesonthebasisofNumber ofseedsperpod

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: AnalysisofVariancesfor12quantitativetraitsamongchickpea genotypes

Sl.no.	source	mean sum of squares (mss)		
		replication	treatment	error
	degrees of freedom	2	20	40
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: Geneticparametersfor12quantitativecharactersinchickpeagenotypes

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

Table4:Correlation Coefficient Analysis

Traits		DF50	DM	PI	PH	NPB	NSB	NPPP	EPPP	BY	HI	SI	SY
DF50	G	1	0.610**	0.1159	-0.367*	0.1778	0.461**	-0.2320	-0.2220	-0.392*	-0.0621	-0.1565	-0.1937
	P		0.1531	0.0584	0.2232	-0.0503	0.1438	-0.1427	-0.1398	-0.256*	-0.0543	-0.0682	-0.1798
DM	G		1	-0.046	0.1665	-0.626**	-0.865**	-0.373*	-0.369*	0.583**	-0.261*	-0.505**	-0.450**
	P		1	-0.0253	0.0945	-0.1513	-0.2480	-0.1891	-0.2189	-0.1953	-0.1124	-0.1841	-0.1975
PI	G			1	0.2210	0.364*	0.2135	0.330*	0.451**	0.468**	0.433**	-0.1640	0.506**
	P			1	0.1408	-0.1265	0.1024	0.1197	0.2293	0.1322	0.1667	-0.1232	0.2041
PH	G				1	-0.354*	0.457**	0.1842	0.2227	0.367*	0.385*	0.466**	0.468**
	P				1	-0.1040	-0.2048	0.1494	0.1999	0.332*	0.332*	-0.425**	0.417**
NPB	G					1	0.616**	0.1719	0.1332	0.2379	-0.0196	0.2016	0.0536
	P					1	0.531**	0.1074	0.0941	0.1999	0.0435	0.1319	0.0907
NSB	G						1	-0.0272	-0.0007	0.1022	-0.0897	0.389*	-0.0540
	P						1	0.0083	0.0283	0.1973	-0.0375	0.286*	0.0097
NPPP	G							1	0.991**	0.483**	0.676**	-0.0292	0.822**
	P							1	0.976**	0.475**	0.656**	-0.0493	0.795**
EPPP	G								1	0.529**	0.709**	-0.0237	0.857**
	P								1	0.512**	0.694**	-0.0435	0.833**
BY	G									1	0.1239	-0.1783	0.517**
	P									1	0.1813	-0.1919	0.515**
HI	G										1	-0.0998	0.918**
	P										1	-0.1002	0.905**
SI	G											1	-0.1681
	P											1	-0.1786
SY	G												1
	P												1

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

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

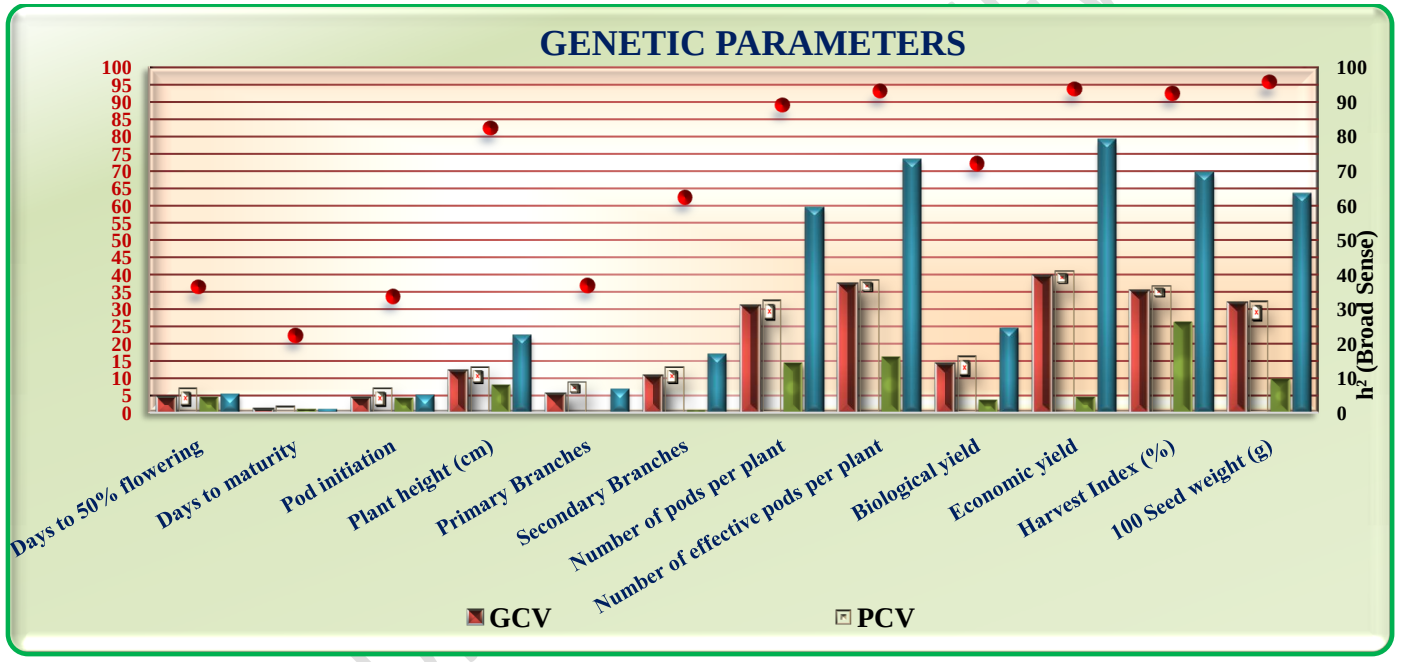

Fig 1: HistogramdepictingGCV,PCV,Geneticadvanceandh^{2}for12quantitativecharactersof 21chickpeagenotypes

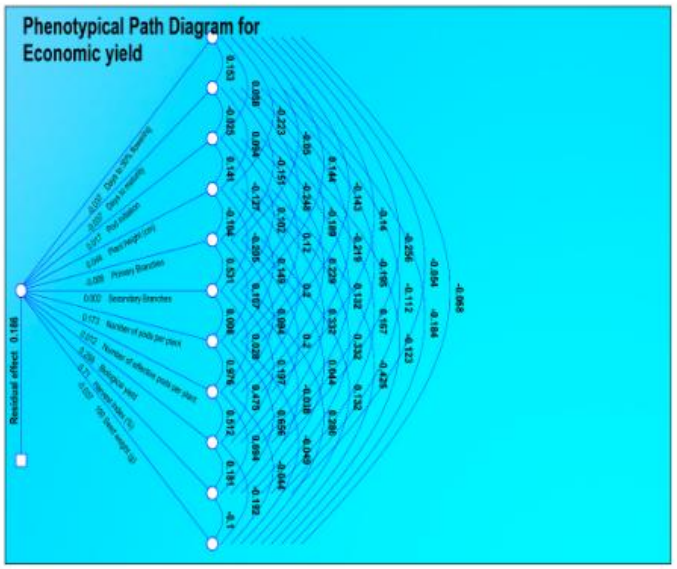

Fig 2: PhenotypicPathDiagramsforSeedYield

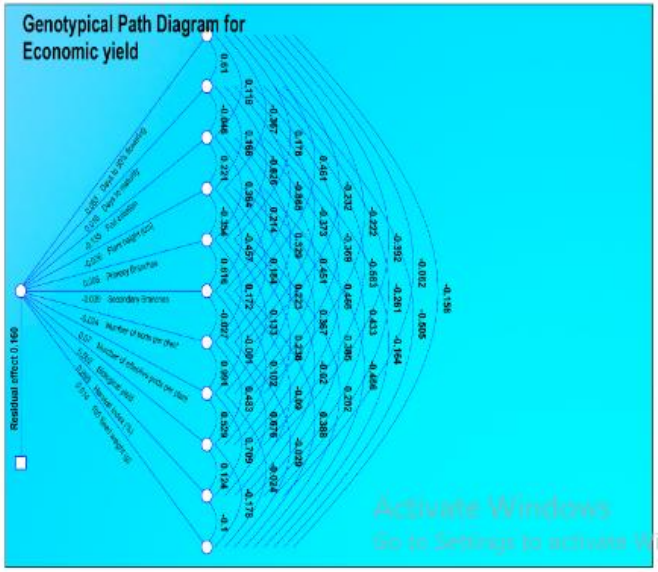

Fig 3: GenotypicPathDiagramsforSeedYield

References

1. **Al-Jibouri, H.A., Miller, P.A. and Robinson, H.F. (1958).** Genotypic and environmentalvariancesinuplandcottoncrossofinterspecificorigin.*AgronomyJournal,* **50**:633-637.
2. **Burton, G.W. (1952).** Quantitative Inheritance of Grasses. *Proceedings of6th International Grassland congress*, **1**:277-283.
3. **Burton, G.W. and Devane. (1953).**Estimation of Heritability in Tall Fescue*(Festuca arundinaceae*)fromreplicatedclonalmaterial.*AgronomyJournal*,**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.andNanda,H.C.(2016).**Charactersassociationinchickpea (*Cicerarietinum* L.) under rice-based cropping system. *Progressive Research an InternationalJournal*,**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 inyield and yield components in chickpea (*Cicer arietinum* L.) genotypes under late sowncondition.*International Journal ofAgricultural Sciences*, **54(8):**2884-2886.
14. **Vijayalaxmi, N.V.S., Kumar, J. and T.N. Rao. (2000).** Variability and correlation studies in

Desi,KabuliandIntermediateChickpeas.*Legume Research*,**23(4):**232-236.