Research Article

Genetic Divergence and Heritability Studies for Yield and Yield Attributes in Various Accessions of Desi Chickpea (*Cicer arietinum* L.)

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Abstract | Genetic variability and heritability studies were carried out during 2017-2018 for earliness, phonological and yield related parameters in desi *Cicer arietinum* L. genotypes at Agriculture Research Institute, D. I. Khan, Pakistan. Sixteen chickpea genotypes including 14 accessions along with 2 check varieties (Bhakkar-2011 and Bittle-2016) were grown and evaluated according to (RCB) design in three blocks. High variation were noted in the chickpea germplasms in days to germination, days to 50% flowering, seeds per pod, 1st branches plant^{-1}, 2ndry branches plant^{-1}, plant height, hundred grain weight and grain yield plant^{-1}. Overall, chickpea accessions CH30/12, CH10/12, CH44/12, CH14/12, and CH11/12 performed well, and recorded with maximum values for grains pod^{-1}, hundred seed weight along with other contributing parameters. Values for phenotypic found greater than gcv which depicted primary presence of environment in the performance of chickpea genotypes for the said parameters. Overall, the gcv and pcv were low to moderate for majority of the parameters. Highest amount of gcv and pcv were recorded for seed yield per plant (30.48 and 32.00%) and secondary branches per plant (20.47 and 24.29%), respectively. High broad sense heritability and genetic gain values were also noted in seed yield plant^{-1} and 2ndry branches plant^{-1} ranging from 71 to 91% and 36.00 to 60.00%, respectively. Therefore, the above promising accessions have greater genetic variability and sufficient information in further breeding programs to introduce ideotype chickpea genotypes.

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Introduction

Chickpea is a diploid species having 16 chromosomes and belongs to the family Fabaceae/Leguminoseae. Southwest world regions are designated for 1st and Ethiopia as 2ndry regions of variation for *Cicer arietinum* L. (Vavilov, 1926), and later its migrated to Indian continent and so on to the remaining countries of the earth (Bouhadida *et al*., 2015). *Cicer arietinum* L. is an arid and semi-arid areas grown crop in 59 countries (Varshney *et al*., 2013; Rasool *et al*., 2015). Among essential food legumes, the chickpea (*Cicer arietinum* L.) is ranked 2nd from beans (*Phaseolus vulgaris* L.) in the era of yield. *Cicer arietinum* L. ranked 3rd important cultivated legume crop in the world after soybean and dry bean (Srivastava *et al*., 2017; Mohan and Thiyagarajan, 2019). Depending upon the grain shape and texture,

the *Cicer arietinum* L. is placed in 2 categories i.e. desi and kabuli. Worldwide eighty percent of chickpea yield is gained by desi genotypes.

In world pulses production, the chickpea contribution is about 12% in which more than 70% production is made by the Asian countries. However, the highest percentage is noted for *Cicer arietinum* L. yield in India i.e. 70% of total world yiled (Aswathi *et al*., 2019). The remaining *Cicer arietinum* L. yield countries are Australia (6%), Pakistan (5%), Turkey (4%), Myanmar (4%), Ethiopia (3.5%), Iran (2%), Mexico (2%), Tanzania (1%), and Malawi (0.5%). In Pakistan during 2018-19, the *Cicer arietinum* L. was sown on 944000 hectares soil with having yield of 438000 tons which shows 35.6% increased production from the previous year 2017-18 (ESP, 2016-17). It requires fewer inputs as compared to cereals and considered as less labor-intensive crop. It also have positive activities in soil up gradation by utilizing the natural air nitrogen. *Cicer arietinum* L. can meet most of its nitrogen requirement by fixing up nitrogen from air about 140 Kilo gram Nitrogen per hectare .

Chickpea is a cheap and important source of protein for those people who cannot afford animal protein or who are largely vegetarian (Gul *et al*., 2013; Hama, 2019). Furthermore, chickpea is also good source of minerals (calcium, phosphorus, magnesium, zinc and iron), unsaturated fatty acids, fiber and β-carotene which are considered good for health (Rasool *et al*., 2015; Kousar *et al*., 2019). Chickpea contain an average of 22% protein, 63% carbohydrate, 8% crude fiber 4.5% fat and 2.7% ash (Hirdyani, 2014). The normal use of chickpea maintains a good health by controlling fatty acids in human beings. Chickpea leaves and dried stalks are also a good source of proteins for animal feed (Deb and Khaleque, 2009).

In KP Province Pakistan, *Cicer arietinum* L. is largely sown on arid era of Lakki Marwat, Bannu, Karak, Malakand, Tehsil Kulachi and Dera Ismail Khan. Accordingly, a huge era of Thal (90%) of Punjab is also noted for *Cicer arietinum* L. The need of pulses has direct proportion to population growth. To occupy need of human beings, it is necessary to introduce the cultivars by increasing the yield of *Cicer arietinum* L. through different breeding programs (Ali *et al*., 2018; Shengu *et al*., 2018).

To occupy overwhelming demand of increasing growth rate, the breeders are trying to enhance the heredity potential of chickpea genotypes. Heritability can better explain that variation noted in genotypes raised due to different genetic composition and their interaction with environment (Saleem *et al*., 2002a, b). Genetic gain also provides a prediction of acceptable improvement for new induction by selections. Hence, researchers have highlighted the utility of gene compositions related to quantitative parameters for identification and the correlated interaction of different parameters to yield (Parshuram *et al*., 2003).

In chickpea, the major limitations in attaining optimum grain yield are deficiency of wide heredity variation in sowing *Cicer arietinum* L. germplasm with both type of stresses (Aswathi *et al*., 2019). The success of crop enhancement program related to heredity variation present in the germplasms where heritability estimates are taken to investigate the degree of variation found in the germplasms (Babbar *et al*., 2015; Ali *et al*., 2018). Heritability along with genetic gain provides genetic improvement through intensive selection (Chopdar *et al*., 2017; Langat *et al*., 2019). Therefore, the present research work was designed to investigate the genetic variability, heritability and genetic gain among the chickpea germplasm for earliness, morphological and seed yield traits (Aswathi *et al*., 2019).

Materials and Methods

Plant material and experimental design

Breeding material comprises 18 chickpea genotypes which were procured from the Agriculture Research Institute, Dera Ismail Khan, Khyber Pakhtunkhwa, Pakistan, and the studies were also carried out during 2017-18 at the same station. Sixteen chickpea accessions and 2 check varieties i.e., Bhakkar-2011 and Bittle-2016 were grown and evaluated in RCB design with three blocks. Every accession has 5 meters long row along with 15 and 30 cm distance within plant to plant and row to row positively. Recommended cultural practices required for the chickpea crop were applied from seed bed preparation to harvesting of the crop for eliminating the field variations.

Traits measurement and statistical analyses

Parameters were noted for the traits i.e., days to germination, days to fifty percent flowering, plant height (cm), 1st branches plant^{-1}, 2ndry branches

plant^{-1}, seeds pod^{-1}, hundred grain weight (g) and grain yield plant^{-1} (g). Accession average and ANOVA for all traits were analysed for RCB design according to the methods used by. GC variance and PC variance were analysed according to Singh and Chaudhry (1985). Heritability (broad sense) and genetic gain were calculated according to Burton and Devane (1953).

Results and Discussion

Analysis of variance with respect to earliness, morphological and seed yield related parameters indicated that mean squares due to genotypes were highly significant ($p \leq 0.01$) for all the concerned traits (Table 1). Thus, it indicating the access genetic variation in various accessions and check genotypes of chickpea for the traits studied. Heredity variation was observed in various populations of chickpea for earliness, morphological and grain yield related traits (Shengu *et al.*, 2018; Langat *et al.*, 2019). Analysis of variance revealed significant differences among the chickpea genotypes for plant height, secondary branches plant^{-1}, grains plant^{-1}, hundred grain weight and harvest index (Kousar *et al.*, 2019; Mohan and Thiyagarajan, 2019).

Table 1: *Mean squares for various traits in chickpea germplasm.*

Traits	Replications (df = 2)	Genotypes (df = 17)	Error (df = 34)	CV%
Days to germination	1.55**	1.68**	0.457	5.18
Days to 50% flowering	5.24**	13.60**	1.574	1.28
Plant height	245.13**	32.83**	32.34	7.56
Primary branches plant^{-1}	0.287**	0.285**	0.176	16.34
Secondary branches plant^{-1}	1.50**	6.84**	0.82	13.09
Seed pods^{-1}	0.16**	0.10**	0.04	12.64
100-seed weight	2.16**	22.39**	4.36	7.15
Seed yield plant^{-1}	0.22**	18.16**	0.58	9.65

Genetic variability in chickpea germplasm

The minimum and at par days to germination (12 days) were recorded in chickpea accessions i.e., CH10/12 and CH30/12 (Table 2). However, these promising genotypes were found alike with seven other accessions ranging from 12.33 to 13.00 days. The highest and same number of days to germination (14.00 days) were recorded in chickpea genotypes CH32/12 and CH40/12. In comparison, these genotypes were found at par with five other accessions ranged from 13.33 to 13.66 days to germinations. Other genotypes enunciated medium number of days to germination. Chickpea genotypes revealed greater genetic variability by having significant differences for days to germination, days to fifty percent flowering, primary branches plant^{-1}, grains pod^{-1} and seed yield (Nizama *et al.*, 2013; Dev *et al.*, 2017).

In chickpea germplasm, the less and same no. of days to fifty percent flowering (94.33) recorded for accession CH32/12 and check genotype Bhakkar-2011, followed by three other accessions i.e., CH19/12 (96.00 days), CH27/12 (96.00 days) and CH30/12 (94.33 days) (Table 2). Genotype CH03/12 showed the highest days to fifty percent flowering (102.33) which were at par with genotype CH33/12 (101.00 days) followed by CH11/12 (100.00 days). Remaining genotypes exhibited moderate days to fifty percent flowering. Past studies revealed greater genetic variability in the chickpea germplasms for days to fifty percent flowering, days to 75% for maturity, plant height, grains pod^{-1} and grain yield (Langat *et al.*, 2019).

About plant stature, the maximum plant height was attained by genotype CH32/12 (84.33) which was at par with other 9 germplasms varied from 73.00 to 78.66 cm (Table 2). However, the minimum plant height was observed in eight accessions ranging from 70.00 to 74.66 cm. All other accessions and check genotypes revealed medium values for plant height. Past studies on genetic variability for quantitative traits including plant stature in desi chickpea genotypes revealed significant variations for all the traits (Aswathi *et al.*, 2019; Hama, 2019).

Highest no. of 1st branches plant^{-1} was enunciated to accession CH33/12 (3.13) and that promising genotype was found at par with two other genotypes i.e., CH03/12 and CH44/12 having same number of primary branches per plant (2.93) (Table 2). However, the minimum and same number of primary branches per plant (2.13) were noted in two genotypes CH30/12 and CH32/12. Other chickpea accessions revealed medium number of first branches plant^{-1}. *Cicer arietinum* L. accessions with 3 check varieties BG-256, K-850 and L-550 revealed wide variation for different parameters including number of 1st branches, hundred grain weight (g) and grain yield, and suggested for enhancing the yield in chickpea

genotypes by using the said parameters.

Table 2: *Mean performance of chickpea genotypes for various traits.*

Chickpea accessions	Days to germination	Days to 50% flowering	Plant height (cm)	Primary branches plant^{-1}
CH03/12	13.33	102.33	78.33	2.93
CH08/12	12.66	98.67	72.00	2.60
CH09/12	12.33	98.33	71.33	2.73
CH10/12	12.00	97.67	76.66	2.40
CH11/12	13.33	100.00	75.66	2.46
CH12/12	13.00	98.33	78.66	2.73
CH13/12	13.66	96.67	76.33	2.80
CH14/12	13.00	98.67	75.66	2.33
CH19/12	13.33	96.00	75.66	2.33
CH23/12	13.00	97.00	73.00	2.33
CH27/12	12.66	96.00	77.00	2.40
CH30/12	12.00	95.33	73.66	2.13
CH32/12	14.00	94.33	84.33	2.13
CH33/12	12.66	101.00	75.00	3.13
CH40/12	14.00	98.00	70.00	2.20
CH44/12	13.00	98.67	73.33	2.93
Check genotypes				
Bhakkar-2011	13.66	94.33	72.00	2.86
Bittle-2016	13.33	97.33	74.66	2.86
$LSD_{0.05}$	1.12	2.09	9.43	0.69

The highest and at par no. of 2^{ndry} branches plant^{-1} (9.00) were noted for two accessions i.e., CH03/12 and CH12/12 and check genotype Bittle-2016 (Table 3). The least number of secondary branches per plant were recorded in check genotype Bhakkar-2011 (4.07), and it was found at par with two other accessions CH23/12 and CH27/12 with same no. of 2^{ndry} branches plant^{-1} (5.00). Past findings revealed that data on chickpea genotypes for morphological traits, seed yield and yield contributing parameters showed that average performance for various parameters were large showing the presence of genetic variation (Parshuram *et al.*, 2003; Shengu *et al.*, 2018).

Maximum number of seeds per pod were achieved in accession CH44/12 (2.00), and the said promising genotype was found same in performance with five other chickpea accessions CH13/12 (1.93), CH23/12 (1.86), CH14/12 (1.80), CH10/12 (1.80), and CH08/12 (1.80) (Table 3). The minimum number of seeds per pod were attained in four accessions i.e., CH12/12, CH27/12, CH32/12, and CH33/12 ranging from 1.40 to 1.53. Other chickpea germplasms revealed moderate no. of grains pod^{-1}. Past findings suggested that the *Cicer arietinum* L. accessions viz., ICCV-14808, Mariye and ICCV-92069 with promising mean values for seeds per plant, pods per plant and grain yield were focused as parental genotypes for future research to introduce unique chickpea varieties. Heredity variability was depicted in newly introduced *Cicer arietinum* L. varieties for authenticated to both variability's for all noted parameters (Mohan and Thiyagarajan, 2019).

Table 3: *Mean performance of chickpea genotypes for various traits.*

Chickpea accessions	Secondary branches plant^{-1}	Seeds pods^{-1}	100-seed weight (g)	Seed yield plant^{-1} (g)
CH03/12	9.00	1.66	32.00	4.00
CH08/12	7.00	1.80	26.33	6.33
CH09/12	8.00	1.40	28.00	5.80
CH10/12	6.66	1.80	31.00	11.00
CH11/12	7.00	1.60	33.33	10.33
CH12/12	9.00	1.53	30.00	9.33
CH13/12	7.66	1.93	33.00	9.00
CH14/12	6.5	1.80	33.33	7.73
CH19/12	4.80	1.60	29.00	8.07
CH23/12	5.00	1.86	28.66	8.00
CH27/12	5.00	1.40	28.33	5.73
CH30/12	7.60	1.66	27.00	12.27
CH32/12	7.00	1.53	29.66	9.00
CH33/12	8.33	1.40	23.33	6.13
CH40/12	5.80	1.66	28.00	3.73
CH44/12	7.20	2.00	28.00	8.00
Check genotypes				
Bhakkar-2011	4.07	1.40	31.00	6.73
Bittle-2016	9.00	1.73	26.00	11.80
$LSD_{0.05}$	1.50	0.34	3.46	1.27

The large size seeds with highest hundred grain weight (33.33 g) was recorded in two accessions CH11/12 and CH14/12 (Table 3). However, these promising genotypes were found at par in performance with two other chickpea accessions i.e., CH13/12 (33.00 g) and CH03/12 (32.00 g). The smaller seeds and less 100-seed weight was recorded in chickpea accession CH33/12 (23.00 g). Other chickpea accessions showed the seeds with medium size. Highly significant differences were recorded among the chickpea genotypes and check cultivars for pods per

plant, seeds per pod, 100-seed weight and grain yield, indicating the presence of greater genetic variability (Langat *et al*., 2019).

On other hand grain yield plant^{-1}, maximum seeds in weight were produced by chickpea accession CH30/12 (12.27 g) and check genotype Bittle-2016 (11.80 g) (Table 3). However, these two genotypes were found at par with one other genotype i.e., CH10/12 (11.00 g) in grain yield plant^{-1}. Minimum and at par grain yield plant^{-1} was exhibited by four accessions i.e., CH09/12 (5.80 g), CH27/12 (5.73 g), CH33/12 (6.13 g), and CH08/12 (6.33 g) and check genotype Bhakkar-2011 (6.73). The remaining accessions revealed moderate values for grain yield per plant. Past findings on genetic variability in desi chickpea genotypes enunciated significant differences for quantitative traits including seed yield and yield contributing traits (Shengu *et al*., 2018; Aswathi *et al*., 2019; Langat *et al*., 2019).

GCV and PCV

CVs were analysd at genotypic (GCV) and phenotypic (PCV) levels as categorized by Burton (1952) i.e., low (<10%), moderate (10-20%) and high (>20%). The genotypic, phenotypic, environmental variance, GCV, PCV, broad sense heritability and genetic gain in 18 chickpea accessions are provided in Table 4. Genotypic coefficient of variation values were low to high in magnitude for all the parameters ranging from 0.53 to 30.48%. However, in earlier studies, the highest values for genotypic (36.11%) and pcv (36.70%) noted to pods per plant, seeds per pod, seed index and grain yield in *Cicer arietinum* L. germplasms (Langat *et al*., 2019). Low values of GCV were recorded for traits i.e., plant height (0.53%), days to fifty percent flowering (2.04%), days to germination (3.40%), first branches per plant (7.45%), 100-seed weight (8.38%), and seeds per pod (9.00%). However, greater GCV noted for grain yield plant^{-1} (30.48%), related to secondary branches plant^{-1} (20.47%). High genotypic and phenotypic coefficient of variations were found for 100-seed weight and plant height recorded with high heritability and genetic advance in chickpea (Langat *et al*., 2019; Mohan and Thiyagarajan, 2019). Lowest values of GCV and PCV obtained for days to flowering and maturity in *Cicer arietinum* L. genotypes. Past studies reported low values due to GCV and PCV for earliness, morphological and yield related traits in chickpea (Thakur and Sirohi, 2008). Likewise, Thakur and Sirohi (2008) and Srivastava *et al*. (2017) reported moderate to high values for GCV and PCV in hundred grain weight, seeds per pod and grain yield plant^{-1}.

In the said studies, the magnitude for PC of variation were low to high ranging from 2.41 to 32.00% for all the parameters. The low values of PCV were noted for days to fifty percent flowering (2.41%), days to germination (6.19%) and plant height (8.00%). However, moderate values of phenotypic coefficient of variation were recorded for first branches plant^{-1} (18.00%), grains pod^{-1} (15%) and hundred grains weight (11.02%). Higher values of PCV were recorded in 2^{ndry} branches plant^{-1} (24.29%) and grain yield plant^{-1} (32.00%). Past studies revealed that decrease magnitude of gcv were recorded for majority of traits in chickpea genotypes (Gul *et al*., 2013). Greater degree of GC and PC variations were noted in seed yield followed by 100-grain weight, 2^{ndry} branches, pods plant^{-1} and grains plant^{-1} in chickpea (Aswathi *et al*., 2019). Overall, the PCV values were higher than GCV for all the traits noted. Past observations also revealed that PCV were noted to be greater than GCV for all parameters (Shengu *et al*., 2018).

Heritability (broad sense)

For improvement in plant genome, the important investigation needed to researcher is the greater hereditary variability of accession for various parameters for result best orientation. Therefore the variation is an outcome for many factors (genetic, epigenetic and environmental, Aswathi *et al*., 2019). Studies involving heritability estimates stands the researcher to got excess and effective selection response, if variability showed by population is greater due to additive genetic variance. In this study, broad sense heritability was estimated, which involves all types of gene expressions, additive as well as non-additive effects. Heritability estimates in broad sense were calculated and categorized as high (>70%), moderate (50-70%) and low (<50%) as suggested by Robinson (1966). High broad sense heritability values were recorded for seed yield plant^{-1} (91%), days to 50% flowering (72%), and secondary branches plant^{-1} (71%) (Table 4). High heritability along with a high estimate of genetic advance (expressed as percent of mean) were exhibited for secondary branches, pods per plant, seeds per plant, hundred seed weight and seed yield in chickpea populations (Shengu *et al*., 2018; Aswathi *et al*., 2019; Langat *et al*., 2019). Moderate heritability was observed

Table 4: *Genetic parameters for various traits in chickpea germplasm.*

Traits	Variances			Coefficients of variability		Broad sense heritability (%)	Genetic gain (%)
	Genotypic	Environmental	Phenotypic	GCV (%)	PCV (%)		
Days to germination	0.20	0.45	0.20	3.40	6.19	31	4.00
Days to 50 % flowering	4.01	1.57	5.58	2.04	2.41	72	4.00
Plant height	0.16	32.34	32.50	0.53	8.00	50	0.07
Primary branches plant^{-1}	0.03	0.17	0.21	7.45	18.00	18	6.46
Secondary branches plant^{-1}	2.00	0.82	2.83	20.47	24.29	71	36.00
Seeds pod^{-1}	0.02	0.04	0.06	9.00	15.00	33	11.00
100-seed weight	6.01	4.36	10.37	8.38	11.02	58	14.00
Seed yield plant^{-1}	5.86	0.58	6.44	30.48	32.00	91	60.00

for 100-seed weight (58%), and plant height (50%). Low heritability values were recorded for primary branches per plant (18%), days to germination (31%), and seeds per pod (33%). Low heritability values were noted for days to germination, days to 50% flowering, primary branches per plant and seeds per pod in chickpea (Nizama *et al*., 2013; Dev *et al*., 2017). Moderate to high heritability values were observed for yield related traits and seed yield which suggested effective improvement through the selection based on these traits in chickpea (Sewak *et al*., 2012). Past studies also revealed moderate to high heritability values for morphological and yield related traits in chickpea genotypes (Babbar *et al*., 2015). In present study, the findings about genetic parameters for seeds per pod, 100-seed weight and seed yield per plant were parallel with the earlier findings of Nizama *et al*. (2013) in chickpea genotypes.

Genetic gain

Genetic gain (as percentage of population mean) was recorded and categorized as high (>20%), moderate (10-20%) and low (<10%). Higher percentages of genetic gain were observed for seed yield per plant (60.00%), secondary branches per plant (36.00%), while moderate for 100-seed weight (14.00%) and seeds per pod (11.00%) (Table 4). However, low values of genetic gain were recorded for plant height, days to germination, days to 50% flowering, and primary branches per plant ranging from 0.07 to 6.46%. High estimates of heritability and genetic gain were observed for secondary branches per plant and seed yield per plant. Results further authenticated the predominance of additive gene action for controlling these parameters. Therefore, selection based on phenotypic performance would be more effective for the improvement of these traits in chickpea (Aswathi *et al*., 2019). Gradually increasing variability and genetic advance were observed for no. of 1st branches, hundred grain weight and maturation days which suggested the said parameters are meaningful for yield improvement (Sewak *et al*., 2012). High heritability and genetic gain were recorded for seed yield and yield contributing traits in *Cicer arietinum* L. germplasms (Parshuram *et al*., 2003; Langat *et al*., 2019; Mohan and Thiyagarajan, 2019). Past studies also revealed that majority of the traits were controlled by both additive and non-additive gene action and suggested improvement in these traits through simple selection because of high heritability and additive gene effects (Langat *et al*., 2019).

Conclusions and Recommendations

Higher values of environmental variation as compared to genotypic and phenotypic variations depicts the effects of environments in present findings. Values due to genotypic and phenotypic coefficient of variations were low to moderate for majority of the traits. Highest estimates of genotypic and phenotypic coefficient of variation, broad sense heritability and genetic gain were recorded for seed yield and secondary branches. The accessions CH30/12, CH10/12, CH44/12, CH14/12 and CH11/12 performed well and having sufficient room for further improvement in seed yield and yield contributing traits in chickpea.

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Novelty Statement

This is a novel approach to monitor the genetic variability and heritability studies were carried out for earliness in desi chickpea (*Cicer arietinum* L.). Therefor have highly significant differences effects were observed among the chickpea genotypes for various parameters. The values for phenotypic were higher than genotypic coefficient of variance which depicted primary role of environment in the performance of chickpea genotypes.

Author's Contribution

Muhammad Mohibullah: Conducted the research.
Mehran and Sundas Batool: Helped in article writing.
Muhammad Amin: Helped in field work.
Zakiullah, Muhammad Ilyas, Irfanullah, Abdur Rehman and Sardar Ali: Helped in data analysis.

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