Genetic Variability of Yield, and Yield Components in Chickpea (*Cicer arietinum* L.)

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Abstract

To determination genetic diversity of 25 chickpea genotypes, and estimating the genetic parameters such as phenotype and genotype variance, phenotypic and genotypic coefficient of variation and heritability, a field experiment was arranged in a randomized complete block design with four replications during two seasons of 2012-2013 and 2013-2014. Analysis of variance indicated that there were significant genotypic differences for seed yield, number of days to flowering, number of days to maturity, flowering period, canopy height, number of pods per plant, biological yield and harvest index. Seed yield ranged from 168.3 kg ha^{-1} (L13) to 618.52 kg ha^{-1} (L10) in the first year and 248.86 kg ha^{-1} (L22) to 945.66 kg ha^{-1} (L2) in the second year. The phenotypic coefficient of variation (PCV) was higher than the genotypic coefficient of variation (GCV) for seed yield, days to flowering, flowering period, canopy height, number of pods per plant, biological yield and harvest index, indicated the influence of environment upon these traits. Heritability of canopy height, days to flowering and days to maturitywas greater than the heritability of the other traits. This finding indicated the above characters can be used as genetic parameters for improvement and selection of high yielding genotypes. Seed yield in chickpea can be improved by selecting for a genotype having moderate days to flowering and days to maturity as well as higher number of pods per plant and plant height.

Keywords: coefficient of variation, heritability, genetic diversity, selection

Introduction

Chickpea (*Cicer arietinum* L.) is an important source of vegetable protein in the world. It is the most common cool season food legume based on the basis of occupied areas in the world. The Asian region contributes 70% to the total world's production (FAO, 2013).The region located between north-west of Iran and south-eastern Turkey and the adjoining areas of Syria has been proposed to be the Vavilovian center of origin for the cultivated chickpea (Van der Maesen 1987). Tanno and Willcox (2006) indicated the wild progenitor of chickpea, is found in a limited area of southeast Turkey, at a considerable distance from Tell el-Kerkh. Talebi et al. (2008) based on DNA markers suggested that there are three centers of diversity for chickpea: Pakistan-Afghanistan, Iran-Turkey and Syria-Lebanon. India and Ethiopia, which were previously considered as a secondary center of diversity for chickpea, showed lower diversity than the above regions. Ladizinsky (1976) stated that chickpea was domesticated in south eastern Turkey.

Diverse genetic backgrounds among parental lines provide the allelic variation necessary to create favorable new gene combinations, and the probability of producing unique genotypes

increases in proportion to the number of genes by which the parents differ (Talebi et al., 2007). Analysis of genetic diversity in germplasm collections can make easy reliable classification of genotypes and identification of subsets of core accessions with possible utility for specific breeding purposes (Mohammadi and Prasanna, 2003). Genetic variability is a prerequisite for any breeding program, which provides opportunity to a plant breeder for selecting maximum yielding genotypes (Yücel et al., 2006). Heritability connected to genetic advance has a more important role to play in determining the effectiveness of selection of a trait (Berwal and Khairwal, 1997). The overall performance of a genotype may alter according to changes in environment and the higher values of heritability leads to the simpler the selection process and greater the response to selection (Soomro et al., 2008).

Many workers, however, expressed genetic apprehension about total reliance on chickpea yield components. Yucel et al. (2006) indicated that genotypic variance in chickpea was the highest for 1000 seed weight, followed by seed number per plant. Broad-sense heritabilities ranged from 5.47% (days to flowering) to 51.66% (seed number per plant). Malik et al. (2010) studied twenty chickpea genotypes and revealed significant differences between genotypes for yield and its components. Maximum variation was recorded for pods per plant followed by secondary branches per plant, biological yield, seed yield and harvest index. Mushtaq et al. (2013) indicated maximum heritability for days to flowering, days to maturity, number of pods per plant, plant height, 100-grains weight and grain yield. Farshadfar et al. (2013) indicated hundred seed weight, number of pod per plant, number of seed per pod and seed yield exhibited high genotype and environment effects. Genotype by environment (GE) interactions was highly significant for hundred seed weight and number of pod per plant but non-significant for seed yield and number of seed per pod. Ali et al. (2009) studied twenty chickpea genotypes and indicated significant differences for yield and yield components among genotypes. Farshadfar and Farshadfar, (2008) studied 360 chickpea landraces and lines and indicated among the morphological characters, numbers of branches and pod numbers had higher variation, while leaflet had minimum variation. Among the phonological traits the flowering period and flowering time had highest and lowest variability, respectively. Sallem et al. (2002) studied 20 chickpea elite genotypes and indicated the genotypes had highly significant differences for days to flowering, days to maturity, plant height, number of primary branches per plant, number of secondary branches per plant, total weight of plant (g), number of pods per plant, number of seeds per pod, 100-seed weight and seed yield per plant. Vural and Karasa (2007) studied 11 chickpea genotypes in two years and indicated there were significant effects of genotypes and year for plant height, number of main branch, number of pods per plant, number of seeds per plant, 1000 seed weight, harvest index and seed yield. Ali et al. (2011a) indicated the greatest genotypic variances corresponded to proteins followed by the fats and 100-seed weight, whereas the lowest figures were identified for plant height and number of seeds per pod. Ali et al. (2011b) showed phenotypic variance was greater than genotypic variance for the number of pods per plant, whereas it was the lowest for biomass per plant, indicating the influence of environmental effect. Genotypic coefficients of variations were relatively greater in fats, number of seeds per pod and grain yield per plant than in other traits, while these coefficients were smaller in 100-seed weight and proteins. The highest values of heritability were found for 100-seed weight, number of pods per plant and number of seeds per pod. Talebi and Rokhzadi (2013) studied 40 chickpea landrace accessions and showed high significant differences for yield and yield components.

The objective of present study is determination of the variability of traits and estimating the genetic parameters such as phenotype and genotype variance, phenotypic and genotypic coefficient of variation and heritability of chickpea genotypes.

Materials and Methods

Field Experiments

Twenty five chickpea genotypes (Table 1) were grown under dryland condition. The field experiment was arranged in a randomized complete block design (RCBD) with four replications, using

30 × 10 cm spacing, in four-row plots of four m length at Brojerd Agricultural Research Station (west of Iran) during two seasons of 2012-2013 and 2013-2014. The size of plot was 1.2 × 4 m rows (4.8 m^2). Plants were fertilized with nitrogen at the rate of 35 kg ha^{-1} Urea and phosphorus at the rate of 70 kg ha^{-1} Triple Super Phosphate. All recommended agronomic practices were followed to raise good crop. Two-hand weddings were done.

In harvest season plants were collected by hand and seed and biological yield was recorded on plot basis and then was converted to kg ha^{-1}. The other traits including days to flowering (DF), days to maturity (DM), flowering period (FP), canopy height (CH), canopy width (CW) and number of pods per plant (NPP) were studied in every years.

Statistical Analysis

The phenotype (σ_p^2),genotype (σ_g^2) and genotype× environment (σ_{gy}^2) variances were estimated as follows:

$$\sigma_g^2 = \frac{(\mathrm{MSg} - \mathrm{MSgy})}{\mathrm{ry}},$$

$$\sigma_{gy}^2 = \frac{(\mathrm{MSgy} - \mathrm{MSe})}{\mathrm{r}} \text{ and}$$

$$\sigma_p^2 = \sigma_g^2 + \sigma_{gy}^2 / y + \sigma_e^2 lry$$

Where r: number of replications; σ^2_e: error or environmental variance; MSg, MSgy and MSe: genotype, genotype × environment and error and mean squares, respectively.

Table 1 Name, origin, status and main characters of chickpea genotypes

Entry number	Name/cross	Status	Days to maturity	Seed yield	Origin
1	215171	Breeding line	Moderate	High	Iran
2	215296	Breeding line	Moderate	High	Iran
3	215551	Breeding line	Moderate	High	Iran
4	215618	Breeding line	Low	Moderate	Iran
5	215654	Breeding line	High	Moderate	Iran
6	215664	Breeding line	High	Moderate	Iran
7	215671	Breeding line	High	Low	Iran
8	215686	Breeding line	Moderate	Moderate	Iran
9	215767	Breeding line	Moderate	Moderate	Iran
10	215843	Breeding line	Moderate	High	Iran
11	215940	Breeding line	Moderate	High	Iran
12	215941	Breeding line	Moderate	Moderate	Iran
13	215995	Breeding line	Moderate	Low	Iran
14	216001	Breeding line	Moderate	Moderate	Iran
15	216066	Breeding line	Moderate	Low	Iran
16	216084	Breeding line	Moderate	High	Iran
17	216324	Breeding line	Low	Moderate	Iran
18	216325	Breeding line	Moderate	Moderate	Iran
19	216364	Breeding line	Moderate	Low	Iran
20	216368	Breeding line	Moderate	Moderate	Iran
21	215685-1	Breeding line	Moderate	Low	Iran
22	215685-2	Breeding line	Moderate	Low	Iran
23	Arman	Introduced cultivar	High	Low	Iran
24	Azad	Introduced cultivar	High	Moderate	Iran
25	Hashem	Introduced cultivar	High	Low	Iran

Phenotypic (PCV) and genotypic (GCV) coefficients of variation were calculated based on the following formula:

Phenotypic coefficient of variation (PCV)

$$= \frac{\sqrt{\sigma_p^2}}{\bar{X}} \times 100$$

Genotypic coefficient of variation (GCV)

$$= \frac{\sqrt{\sigma_g^2}}{\bar{X}} \times 100$$

Where $\bar{X}$ = Grand mean

Broad sense heritability (h^2) was estimated according to the following formulas:

$$h^2 = \frac{\sigma_g^2}{\sigma_{ph}^2}$$

The analysis of variance was conducted by SAS (SAS, 2004). Genetic, environmental and genotype × environmental variances for all of the traits were also estimated from the 25 experimental genotypes using the PROG VARCOMP option in SAS.

Results and Discussion

Analysis of Variances

Combined analysis of variance indicated that the interaction effects of genotype and year were significant for seed yield (SY), days to flowering (DF), days to maturity (DM), flowering period (FP), biological yield (BY) and harvest index (HI). There were also significant differences between years for SY, DF, DM, FP, CH, CW, NPP, BY and HI. The effects of genotype were significant for SY, DF, DM, FP, CH, NPP, BY and HI. The coefficient of variation (CV) was varied from 3.2 (flowering period) to 27.8 (number of pods per plant) (Table 2). High significant differences between yield and yield components of genotypes which exhibiting genotypic diversity and variability were supported by previous chickpea researchers (Yucel et al., 2006; Malik et al., 2010; Farshadfar et al., 2013; Ali et al., 2009; Sallem et al., 2002; Karasa, 2007; Talebi and Rokhzadi, 2013). Similar results were also reported in several earlier studies that showed significant variation in days to flowering and maturity in chickpea (Atta et al., 2008; Saleem et al., 2008).

Mean Performance of Genotypes

Genotype × year interaction effects was significant for SY, DF, DM, FP, BY and HI, therefore mean comparison of studied traits carried out in two years separately and do not explain main effects of genotype or year. Mean comparison of studied traits in first and second year were presented in Tables 3 and 4, respectively.

From Table 3, it is evident that the measurement values in the studied traits show variations among the 25 genotypes. Days to flowering were varied from 49 (L1 and L2) to 59 (L7 and Arman). The average days taken to flowering were 52.6. The range of days to maturity was varied from 81.5 to 90 with 87.59 as average. The higher and lover values of flowering period were for L4 and L22, respectively. Range of seed yield was 168.3 kg ha^{-1} (L13) to 618.52 kg ha^{-1} (L10). The mean of seed yield over to all of the genotypes was 343.1 kg ha^{-1}. The values for biological yield ranged from 1510.14 kg ha^{-1} (L2) to 3624.86 kg ha^{-1} (Azad). The values for harvest index also indicated range from 5.86 % (Azad) to 29.25 (L2). The average value of harvest index over all of the studied genotypes was 13.64 %.

From Table 4 it is obvious that large variation exists among the 25 genotypes in terms of seed yield, yield components and growth in second year. Days to flowering varied from 34 (L1) to 53.75 (L17) and 46.94 as average. The range of days to maturity was 79 (L4) to 100 (Hashem). The range of flowering period was 33 (L18) to 39.5 (Hashem). The highest seed yield (945.66 kg ha^{-1}) was obtained in L2 and lowest value of seed yield produced by L22 (248.86 kg ha^{-1}). The average of seed yield per hectare in this data set was 516.44 kg. The highest and lowest values of biological yield were obtained in L1 (3205 kg ha^{-1}) and Arman, respectively. The average value of biological yield was 1427.27 kg ha^{-1}. Harvest index ranged from 17.74 (Hashem) to 64.01 (Line 4).

Table 2 Combined analysis of variance for the studied trails.

S.O.V	df	MS								
		Seed yield	Days to flowering	Days to maturity	Flowering period	Canopy height	Canopy width	Pod (No. plant^{-1})	Biological yield	Harvest index
Year	1	1502289.24**	1601.78**	886.20**	1346.80**	1965.64**	4541.04**	16128.08**	82373130.48**	30884.57**
Year (Replication)	6	8326.06	45.3	12.27	1.29	39.58	7.65	553.47	117863.73	128.215
Genotype	24	104484.32**	127.52**	72.34**	14.51**	43.62**	8..26	103.83**	671930.02**	442.35**
Genotype*Year	24	92762.31**	58.62**	29.75**	9.12**	13.89	11.15	63.88	904414.61**	369.38**
Error(2)	144	3467.04	16.12	7..92	1..32	11.62	14.30	44.16	103210.8	49.66
CV		13.70	8.06	3.20	3.47	13.46	13.51	37.78	15.72	27.03

**significant at the 0.01 probability level

Table 3 Mean comparison of studied traits in first year

G	Flowering period	Days to maturity	Days to flowering	Seed yield	Biological yield	HI
				(---------- kg ha^{-1}----------)		(%)
1	49.00	83.00	29.00	545.74	2544.44	21.73
2	49.50	84.00	29.75	440.74	1510.14	29.25
3	51.75	85.75	31.00	430.56	2879.31	15.10
4	52.00	82.00	28.00	248.80	1714.17	14.70
5	53.00	84.75	30.50	368.80	2953.47	12.50
6	51.50	84.50	32.00	274.81	2676.67	10.42
7	59.00	90.00	30.25	320.18	3275.28	9.85
8	51.50	84.75	30.50	559.17	3465.83	16.15
9	57.00	90.00	31.50	336.30	3610.14	9.41
10	54.00	86.50	29.75	618.52	2271.94	27.19
11	50.50	84.75	30.00	359.35	2234.17	16.24
12	50.50	84.75	28.75	380.28	2880.97	13.16
13	51.00	85.00	29.75	186.30	2917.08	6.46
14	56.50	88.25	29.25	477.50	2466.11	19.21
15	51.50	85.25	32.00	231.02	3064.17	7.58
16	49.50	83.00	29.00	351.67	2734.44	12.97
17	49.25	81.50	29.75	215.09	2365.56	9.41
18	51.50	84.75	29.25	303.98	1577.92	19.39
19	50.50	84.75	30.25	263.70	2674.72	10.05
20	54.00	86.50	29.75	344.81	2366.25	14.72
21	53.25	88.25	32.75	233.71	2502.92	9.38
22	51.25	85.00	33.00	240.09	2624.03	9.22
23	59.00	90.00	31.25	294.06	2632.78	11.27
24	53.50	87.75	32.00	212.22	3624.86	5.86
25	55.00	90.00	32.50	340.19	3546.67	9.89
Range	49–59	81.5–90	28–33	186.3–618.52	1510.14–3624.86	5.86–29.25
Mean	52.6	85.79	30.46	343.10	2684.56	13.64
LSD 5%	5.08	5.47	1.97	68.30	428.05	3.05

LSD5%: Least significant differences at 5% probability level.

The interaction effects of year and genotype was not significant for canopy height, canopy width and number of pods per plant, therefore we compared the means of the genotypes for canopy height and number of pods per plant over two years. Genotype means do not compared for canopy width, because of not significant effect of genotype for this trait. Non-significant difference between genotypes for canopy width was due to low genetic effect and large environmental effect. Furthermore, the non-

Table 4 Mean comparison of studied traits in second year

G	Flowering period	Days to maturity	Days to flowering	Seed yield	Biological yield	HI
				(---------- kg ha^{-1}----------)		(%)
1	34.00	88.75	34.25	593.54	3205.00	31.94
2	35.25	87.25	33.50	945.66	2007.00	47.71
3	35.50	92.00	34.50	686.70	1367.50	50.62
4	43.00	79.00	33.75	767.16	1317.50	64.01
5	41.25	97.50	35.25	614.99	1440.00	50.22
6	48.75	97.75	34.50	534.88	1360.00	40.20
7	52.25	93.75	37.25	301.53	1717.50	17.96
8	51.00	90.00	34.00	255.30	1417.50	18.59
9	51.00	89.75	38.50	543.00	1452.50	38.29
10	50.50	88.00	34.25	418.71	1355.90	43.68
11	37.25	90.75	34.25	756.19	1442.50	55.67
12	53.00	88.50	39.00	612.67	1332.50	54.25
13	50.75	88.75	34.50	509.65	1115.00	46.68
14	50.75	88.75	35.25	490.25	1135.00	44.87
15	51.25	89.00	34.00	307.39	1202.50	26.39
16	40.00	89.00	35.00	691.55	1406.25	50.56
17	53.75	81.50	39.00	672.31	1175.00	59.16
18	44.25	88.00	33.00	678.73	1465.00	48.86
19	48.50	91.50	34.75	408.26	1182.50	35.11
20	49.75	88.75	38.00	371.72	1195.00	31.46
21	50.50	88.75	38.25	275.51	1275.00	21.62
22	48.50	90.50	34.25	248.86	1227.50	20.14
23	52.75	90.25	35.25	347.19	1040.00	33.58
24	48.50	92.25	37.50	601.98	1060.00	58.36
25	51.50	100.00	39.50	277.29	1787.50	17.74
Range	34–53.75	79–100	33–39.5	248.86–945.66	1040–3205	17.74–64.01
Mean	46.94	90.00	35.65	516.44	1427.27	40.31
LSD 5%	6.17	1.22	1.16	95.45	476.36	13.71

LSD5%: Least significant differences at 5% probability level.

significant difference of genotype × year interaction for some traits indicated that the performance of the genotypes with respect to these traits was consistent across growing seasons. Range of canopy height was 21.68 cm (L3) to 33.11 cm (Hashem) and average canopy height was 25.33 cm. Range of number of pods per plant was from 11.33 (L20) to 24.44 (2). The average numbers of pod per plant were 17.42 (Table 5).

Genotypic and Phenotypic Variances and Coefficient of Variation and Heritability

Genotypic and phenotypic variances and coefficient of variation and heritability of various traits are given in the Table 6. Data indicated that the extent of phenotypic and genotypic variances varied from trait to another. Phenotypic variance was greater than genotypic variance for all of the studied traits, indicating the influence of environmental effect. High value of phenotypic coefficient of variation (PCV) was recorded for number of pods per plant, seed yield and harvest index. Genotypic coefficient of variation (GCV) was relatively high in number of pods per plant and harvest index. Days to maturity and canopy width indicated very low differences between genotypic and phenotypic coefficient of variation, suggesting less environmental influence on the expression of traits and genotypes influenced more in the expression of these traits. These findings are in good agreement with those reported by Joshi (1972), Mohamed et al. (2015) and Naveed et al. (2015) in case of chickpea. If the value of PCV is greater than GCV, it means that the apparent distinction is due to both genotypes and environment. Nevertheless, the magnitude of PVC was higher than GVC for seed

Table 5 Means of canopy height and number of pods per plant for 25 chickpea genotypes evaluated for two growing seasons.

G	Canopy height (cm)	Pod (No. plant^{-1})
1	25.00	24.16
2	25.20	24.44
3	21.68	19.34
4	25.45	13.90
5	24.95	23.88
6	26.13	14.65
7	28.23	17.94
8	26.44	19.75
9	25.55	15.66
10	25.36	21.13
11	23.28	16.51
12	24.04	16.80
13	26.68	17.44
14	22.00	21.33
15	23.43	12.34
16	24.63	15.56
17	23.03	17.69
18	24.10	18.31
19	25.10	19.63
20	24.63	11.33
21	23.45	15.60
22	26.85	14.56
23	27.53	12.28
24	27.38	16.06
25	33.11	15.35
Min	21.68	11.33
Max	33.11	24.44
Mean	25.33	17.42
LSD5%	3.37	6.58

LSD5%: Least significant differences at 5% probability level.

yield, days to flowering, flowering period, canopy height, number of pods per plant, biological yield and harvest index indicated the influence of environment upon these traits. Similar results have been reported by Kanouni et al. (2012), Güler et al. (2001) and Arshad et al. (2002).

In the present study, the characters including canopy height as well as days to flowering and maturity had the highest broad sense heritability (h^2) (0.68, 0.54 and 0.59, respectively). The lowest value of heritability was obtained for seed yield and harvest index. A moderate heritability was also obtained for flowering period (0.37) and number of pods per plant (0.38). The highest value of broad sense heritability for canopy height, days to flowering and days to maturity suggested that the environmental factors had a small effect on the inheritance of these traits. These high estimates of heritability for the traits under consideration indicated that a reasonable proportion of the total variability was due to genetic causes. Improvement of these traits that have greater heritability, via direct selection, could be limited to the lines used in the present study. The above results indicate that high yielding genotypes may be selected on the bases of those parameters. Estimate of heritability also give some idea about the gene action involved in the expression of various polygenic traits. This suggests that crop improvement, in terms of these traits, may be possible by simple selection, given that high heritability coupled with high genotypic variation reveals the presence of additive gene effects. Canopy height, days to flowering and days to maturity, which indicates that the heritability is due to additive gene action and the selection based

Table 6 Estimation of genetic parameters

Parameters	Genotypic variance	Phenotypic variance	Phenotypic coefficient of variation	Genotypic coefficient of variation	Broad sense heritability
Days to flowering	8.61	15.94	8.02	5.90	0.54
Days to maturity	5.32	9.04	3.42	2.62	0.59
Flowering period	0.67	1.81	4.07	2.48	0.37
Canopy height	3.72	5.45	9.22	7.61	0.68
Pod (No. plant^{-1})	4.99	12.98	20.68	12.83	0.38
Seed yield	1465.30	13060.58	26.59	8.91	0.11
Harvest index	9.12	55.29	27.57	11.20	0.16

on these characters may be effective. The magnitude of heritability was affected by the type of genetic material and yield level of environment due to the fact that the canopy height, days to flowering and maturity are created by the effects of genes and environment. High estimates of heritability indicated that selection based on mean would be successful in improving these traits. The lowest value of h^2 for seed yield and harvest index, indicating the influences of environment to seed yield. The present of high heritability for these characters was confirmed to those observed by Ali et al., (2011b) and Joshi (1972) in chickpea. In agreement with the results of this work, Mushtaq et al. (2013) indicated maximum heritability for days to flowering, days to maturity, number of pods per plant, plant height. Ali et al., (2011b) indicated high value of heritability for number of pods per plant. Zali et al. (2011) indicated high values of heritability for number of days to maturity, number of days to flowering and plant height, indicating that these traits are controlled mainly by additive genes and that selection of such traits may be effective for improving seed yield. Kanouni et al. (2012) indicated PCV was highest for number of pods per plant and heritability of days to maturity and days to flowering was greater than the heritability of the other traits. Unlike to results of this experiment, Yucel et al. (2006) indicated the lower value of broad-sense heritability for days to flowering and high one for seed number per plant. Khan et al. (2011) and Saleem et al. (2008) found similar results and observed high heritability values in chickpea for days to flowering, plant height and 100-seed weight.

A plot was draw of the first and second principal components and indicated in Figure 1 to show the best genotype according to seed yield of the 25 chickpea genotypes for each of years. Since PC2 scores also play a significant role (19%) in explaining the genotype × environment interaction, the PC1 scores were plotted against the IPCA 2 scores to further explore adaptation. This view of the plot exhibits the best genotype(s) in each environment (Yan and Hunt, 2002). The best genotypes with respect to first year were G19. The genotypes containing G12 and G3 were the best for second year. A further understanding was obtained by plotting the PC scores for individual observations in relation to the axes of PC1 and PC2. The ordination of the genotypes on axes 1 and 2 has two hidden observations. Further, scattering of experimental materials in all the four segments of plot suggested the existence of considerable genetic assortment among the genotypes. Genotype 2, with high yield (945.66 kg ha^{-1}) in second year and moderate yield (440.74 kg ha^{-1}) in first year, was the most distinct from the others and origin of plat. Accessions in close proximity to each other and origin had small or no valuable variability while those distant from the origin had useful diversity for the characters being investigated and can be introgressed in already cultivated chickpea cultivars or newly developed genotypes with a view of expanding its genetic base.

Conclusions

The high and moderate values of heritability for canopy height, days to flowering, days to maturity and number of seeds per pod indicates that these characters can be used as genetic parameters for improvement and selection of high yielding genotypes. Days to flowering, days to maturity, flowering period, canopy height and number of pods per plant might be considered as an important selection criteria. In this study seed yield ranged from 168.3 kg ha^{-1} (L13) to 618.52 kg ha^{-1} (L10) in the first year and 248.86 kg ha^{-1} (L22) to 945.66 kg ha^{-1} (L2) in the second year. It can be concluded that seed yield in chickpea can be improved by selecting for an genotype having moderate days to flowering and days to maturity as well as higher number of pods per plant and plant height.

References

Ali, Q., M. Ahsan, M.H.N. Tahir, M. Waseem, J. Farooq, M. Elahi and M. Sadique. 2011a. Genetic variability for grain yield and quality traits in chickpea (*Cicer arietinum* L.). Inter. J. Agro. Vet. Med. Sci. 5: 201-208.

Ali, Q., M. Ahsan, I. Khaliq, M. Elahi, M. Shahbaz, W. Ahmed and M. Naees. 2011b. Estimation of genetic association of yield and quality traits in chickpea (*Cicer arietinum*L.). Inter. Res. J. Plant Sci. 2: 166-169.

Ali, M.A., N.N. Nawa1, A. Abbas, M. Zulkiffal and M. Sajjad. 2009. Evaluation of selection criteria in *Cicer*

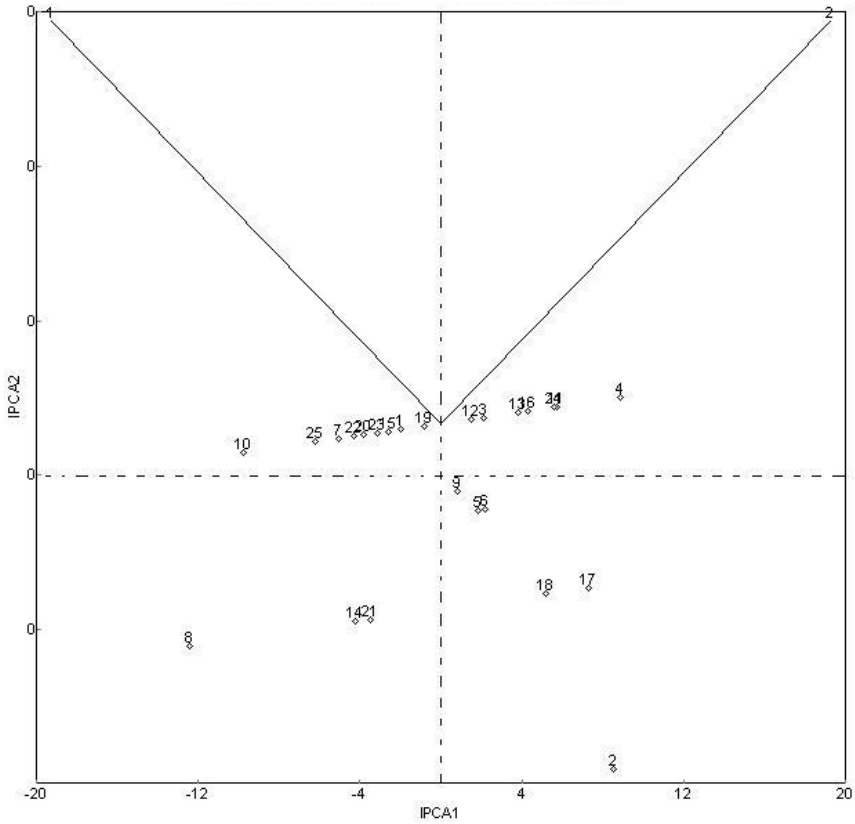

Figure 1 Plot of the first and second principal components to show best genotype according to seed yield of the 25 chickpea genotypes for each of yields.

arietinum L. using correlation coefficients and path analysis. Aus. J. Crop Sci. 3: 65-70.

Arshad, M., A. Bakhsh, M. Bashir and M. Haqqani. 2002. Determining the heritability and relationship between yield and yield components in chickpea (*Cicer arietinum* L.). Pak. J. Bot. 34: 237-245.

Atta, B.M., M.A. Haq and T.M.Shah. 2008. Variation and inter-relationships of quantitative traits in chickpea (*Cicer arietinum* L.). Pak. J. Bot. 40: 637-647.

Berwal, K.K. and I.S. Khairwal. 1997. Genetic divergence in pearl millet. Inter. Sorghum Millet News. 38: 103-106.

FAO. 2013. FAOSTAT. Food and Agriculture Organization of the United Nations. Website http://faostat.fao.org/default.aspx.

Farshadfar, M. and E. Farshadfar. 2008. Genetic variability and path Analysis of chickpea (*Cicer arientinum*L.) landraces and lines. J. Appl. Sci. 8: 3951-3956.

Farshadfar, E., E. Mahtabi, M.M. Jowkar. 2013. Evaluation of genotype × environment interaction in chickpea genotypes using path analysis. Inter. J. Adv. Biol. Biom. Res. 1: 583-593.

Güler, M., M.S. Adak and H. Ulukan. 2001. Determining relationships among yield and some yield components using path coefficient analysis in chickpea (*Cicer arietinum* L.). Eur. J. Argon. 14: 161-166.

Johnson, P.L., S. Sai, H.C. Nanda and R.N. Sharma (2015). Variability and stability analysis for seed yield and its components in chickpea (*Cicer arietinum* L.). J. Food Sci. Agric. Tech. 1: 152-156.

Joshi, S.N. 1972. Variability and association of some yield components in gram (*Cicer arietinum* L.). Indian J. Agric. Sci. 42: 397-399.

Khan, R, T. Farhatullah and H. Khan. 2011. Dissection of genetic variability and heritability estimates of chickpea germplasm for various morphological markers and quantitative traits. Sarhad J. Agric. 27: 67-72.

Kanouni, H., M.R. Shahab, M. Imtiaz and M. Khalili. 2012. Genetic variation in drought tolerance in chickpea (Cicer arietinum L.) genotypes. Crop Breed. J. 2(2): 133-138.

Ladizinsky, G. and A. Adler. 1976. Genetic relationships among the annual species of Cicer L. Theor. Appl. Genet. 48: 197-203.

Malik, S.R., A. Bakhsh, M.A. Asif, U. Iqbal and S.M. Iqbal. 2010. Assessment of genetic variability and interrelationship among some agronomic traits in Chickpea. Inter. J. Agric. Biol. 12: 81-85.

Mohamed A.A., I.S.A. Tahir and A.M.A. Elhashimi 2015. Assessment of genetic variability and yield stability in chickpea (*Cicer arietinum* L.) cultivars in River Nile State, Sudan. J. Plant Breed. Crop Sci. 7: 219-224.

Mohammadi, S.A. and B.M. Prasanna. 2003. Analysis of genetic diversity in crop plants-salient statistical tools and considerations. Crop Sci. 43: 1235-1248.

Mushtaq, M.A., M.M. Bajwa and M. Saleem. 2013. Estimation of genetic variability and path analysis of grain yield and its components in chickpea (*Cicer arietinum* L.). Inter. J. Sci. Engineer. Res. 4: 1-4.

Naveed, M., M. Shafiq, C.M. Rafiq and M.A. Zahid. 2015. Genetic diversity in new chickpea accessions for'fusarium'wilt resistance, canopy temperature and yield components under drought milieus. Austr. J. Crop Sci. 9: 538-544.

SAS Institute. 2004. SAS/STAT User's Guide. SAS institute Inc., Cary, NC, USA.

Saleem, M., M. Arshad and M. Ahsan. 2008. Genetic variability and interrelationship for grain yield and its various components in chickpea (*Cicer arietinum* L.). J. Agric. Res. 46: 109-116.

Sallem, M., M.H.N. Tahir, R. Kabir, M. Javid and K. Shahzad. 2002. Interrelationships and Path Analysis of Yield Attributes in Chick Pea (*Cicer arietinum* L.). Inter. J. Agric. Biol. 4: 404-406.

Soomro, Z.A., A.S. Larik, M.B. Kumbhar, N.U. Khan and N.A. Panhwar. 2008. Correlation and path analysis in hybrid cotton. Sabrao J. Breed and Genet. 40: 49-56.

Talebi, R. and A. Rokhzadi. 2013. Genetic diversity and interrelationships between agronomic traits in landrace chickpea accessions collected from 'Kurdistan' province, north-west of Iran. Inter. J. Agric. Crop Sci. 5: 2203-2209.

Talebi, R., A.M. Naji, F. Fayaz. 2008. Geographical patterns of genetic diversity in cultivated chickpea (*Cicer arietinum* L.) characterized by amplified fragment length polymorphism. Plant Soil Environ. 54: 447-452.

Talebi, R., F. Fayaz, N.A. Jelodar. 2007. Correlation and path coefficient analysis of yield and yield components of chickpea (*Cicer arietinum* L) under dry land condition in the west of Iran. Asian J. Plant Sci. 6: 1151-1154.

Tanno, K. and G. Willcox. 2006. The origins of cultivation of *Cicer arietinum* L. and *Viciafaba* L.: early finds from Tell el-Kerkh, north-west Syria, late 10th millennium B.P. Veget. Hist. Archaeobot. 15: 197-204.

Van Der Maesen, L.J.G. 1987. Origin, history and taxonomy of chickpea, pp. 11-34. In M.C. Saxena and K. Singh, eds. The Chickpea. CAB Inter, Wallingford

Vural, H. and A. Karasa. 2007. Agronomical characteristics of some chickpea ecotypes (*Cicer arietinum* L.) growth in turkey. World J. Agric. Sci. 3: 440-443.

Yücel, Ö.D., A.E. Anlarsal and C. Yücel. 2006. Genetic variability, correlation and path analysis of yield, and yield components in chickpea (*Cicer arietinum* L.). Turk. J. Agric. Forest. 30: 183-188.

Yucel, O.D., A.E. Anlarsal and C. Yucel. 2006. Genetic Variability, Correlation and Path Analysis of Yield, and Yield Components in Chickpea (*Cicer arietinum* L.). Turk J. Agric. For. 30: 183-188.

Zali, H., E. Farshadfar and S.H. Sabaghpour. 2011. Genetic variability and interrelationships among agronomic traits in chickpea (*Cicer arietinum* L.) genotypes. Crop Breed. J. 1: 127-132.

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