UDC 575.630
https://doi.org/10.2298/GENSR1701273A
Original scientific paper

CORRELATION AND PATH ANALYSIS FOR GRAIN YIELD AND YIELD COMPONENTS IN CHICKPEA (*Cicer arietinum* L.)

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Astereki H., P. Sharifi, M. Pouresmael (2017): *Correlation and path analysis for grain yield and yield components in chickpea (Cicer arietinum L.).*- Genetika, Vol 49, No. 1, 273 - 284.

Chickpea is the second most important pulse crop in the world after dry bean. The aim of this study was to estimate the correlation coefficients and path analysis between seed yield, morphological traits and yield components. Twenty five chickpea genotypes, including advanced lines and commercial varieties, were grown under dryland condition at Brojerd Agricultural Research Station (west of Iran) during two seasons (2012-2013 and 2013-2014). The field experiment was arranged in a randomized complete block design (RCBD) with four replications. Combined analysis of variance revealed that the studied genotypes differed significantly in seed yield, days to flowering, days to maturity, flowering period, canopy height, number of pods per plant, biological yield and harvest index. The correlation coefficients indicated that there were significant and positive correlations between seed yield and number of pods per plant and harvest index in two years. Path analysis indicated that days to flowering, days to maturity, canopy height and width, number of pods per plant and flowering period directly and indirectly affected seed yield. Therefore, this study suggested that chickpea improvement program could be based on these traits, especially number of pods per plant and canopy height, according to positive direct effect on seed yield over two years, as selection criteria.

Key words: breeding, chickpea, correlation, path analysis, seed yield

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INTRODUCTION

Chickpea (*Cicer arietinum* L.) is the second most important pulse crop in the world after dry bean. It is also the important pulse in Iran (FAO, 2013). Chickpea is an important source of human food and animal feed and helps to improve soil fertility, particularly in drylands (YUCEL *et al.*, 2006). The rotation of chickpea and cereal can break the disease and pest cycle, and increase the productivity of the entire rotation (JODHA and SUBBA RAO, 1987). Yield is a multidimensional trait that encompasses several different properties and is affected by numerous factors (FILIPOVIC *et al.*, 2014). Yield is a complex character associated with many interrelated components (CIFTCI *et al.*, 2004). The application of relevant breeding criteria is very important in the process of breeding and selection of superior genotypes (FILIPOVIC *et al.*, 2014). Knowing the interdependence of morpho-physiological characteristics with yield is of utmost importance in order for their breeding programs to be successful (HLADNI *et al.*, 2015).

Genetic variation among traits is important for breeding and in selecting desirable types. Simple correlation analysis, which shows relationships among independent traits and the degree of linear relation between these traits, cannot provide detailed and actual knowledge in the relation between dependent variable and predictor variables. However, path analysis, which is developed by WRIGHT (1921) as a statistical tool, was employed in the most of causation relationships. Path analysis is needed to clarify relationships between traits deeply because correlation coefficients describe relationships in a simple manner (CIFTCI *et al.*, 2004). This method enables the studying complex relationships between traits and is used to organize the effect and present the causal relationships between the predictor variables and response variables (SAMONTE *et al.*, 2006). Selections based only on simple correlation coefficients without taking into account the interactions among yield and yield components may mislead the breeders to reach their main breeding purposes (GARCI´A DEL MORAL *et al.*, 2003). Path coefficient analysis measures the inter-association among yield components for their direct and indirect effects on grain yield by correlation. The investigation of direct and indirect effects of various characters on yield is major importance to increase the yielding capacity of crops. Path analysis provides the basis for success in breeding programs and increases grain yield more efficiently (SINGH and CHAUDHARY, 1979).

Some of researchers studied relationships between seed yield and yield components in chickpea by correlation and path analysis. CIFTCI *et al.* (2004) indicated positive and significant relationships between seed yield and plant height, number of pods per plant, biological yield and harvest index. The strong direct effects of biological yield, harvest index and number of seeds per plant were obtained on seed yield. YUCEL *et al.* (2006) determined positive and significant relationships between seed yield and plant height and number of pods per plant. The path coefficient analysis revealed that plant height, number of pods per plant, 1,000 seed weight and harvest index exhibited high positive direct effects on seed yield, as a dependent variable. MALIK *et al.* (2010) studied twenty chickpea genotypes and indicated highly significant and positive correlation of seed yield with biological yield and number of pods per plant. ARSHAD *et al.* (2004) reported that seed yield was correlated positively and significantly with plant height, number of pods per plant, 100 seed weight and biological yield. GULER *et al.* (2001) stated that the direct effects of the number of pods per plant and number of seeds per plant were positive and significant on chickpea seed yield. HASSAN *et al.* (2005) indicated chickpea seed yield had the highest positive and significant correlation with number of pods per plant followed by number of seed per plant and 100 seed weight. Path coefficient analysis showed maximum direct and positive influence of number of seeds per plant on seed yield followed by 100 seed weight. YUCEL and ANLARSAL

(2010) indicated positive and significant relationships among seed yield and harvest index and number of seeds per plant. The path coefficients analysis revealed that harvest index had the greatest direct effect on seed yield. MUSHTAQ *et al.* (2013) revealed chickpea seed yield was positively correlated with plant height and number of pods per plant. Path analysis showed that days to flowering had maximum direct effect on seed yield followed by total weight of plant, 100 grains weight and plant height. FARSHADFAR *et al.* (2013) indicated the contributions of number of seeds per pod, hundred seed weight and number of pods per plant on seed yield. ALI *et al.* (2009) revealed chickpea seed yield had significant genotypic and phenotypic relationship with number of pods per plant, number of seeds per plant, number of seeds per pod and biological yield. The path analysis confirmed that biological yield followed by number of seeds per pod and 100 seed weight had the maximum positive direct effect on seed yield. MALIK *et al.* (2014) indicated days to flowering and maturity, plant height, number of pods per plant, biological yield and harvest index had positive significant correlation with seed yield. FARSHADFAR and FARSHADFAR (2008) indicated the highest correlation coefficient between seed yield and number of pods per plant. Path analysis revealed that number of pods per plant, number of seeds per pod and 100 seed weight had highest direct effect on seed yield. SALLEM *et al.* (2002) indicated seed yield was correlated positively and significantly with days to flowering, number of pods per plant and 100 seed weight both at the genotypic and phenotypic levels. Number of pods per plant had maximum positive direct effect on seed yield. GHORBANI *et al.* (2013) indicated the highest direct effect of seed yield by biological yield and the highest indirect effect by seed number per plant due to biological yield. ALI *et al.* (2011) and ALI and AHSAN (2011) indicated positive and highly significant genotypic and phenotypic correlation of seed yield with 100 seed weight, number of pods per plant, number of seeds per pod, plant height and biomass per plant. TALEBI and ROKHZADI (2013) studied 40 landraces of chickpea and showed seed yield is highly correlated with number of pods per plant, number of seeds per plant and biomass. Path analysis indicated that 100 seed weight and number of pods per plant had most direct positive effects on seed yield. ALIPOOR YAMCHI *et al.* (2013) studied 64 Kabuli chickpea genotypes and showed that seed yield per plant had significant and positive correlation with seed and pod weight, biological yield, number of pods per plant, 100 seed weight, number of seeds per plant.

The objective of this research was to determine direct and indirect effects of some morphological and yield components on seed yield and estimating correlation coefficients between seed yield and the other studied traits in chickpea genotypes.

MATERIALS AND METHODS

Field experiments

Twenty-five chickpea (*Cicer arietinum* L.) 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 4-m length at Brojerd Agricultural Research Station (west of Iran) during two seasons (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} Super Phosphate Triple. All recommended agronomic practices were followed in order to raise good crop. Two-hand weddings were done.

The following statistical model was adopted for experimental design:
$$Y_{ijkl} = \mu + E_i + R(E)_{j(i)} + G_k + GE_{ik} + e_{ijk}$$

Where, μ: general mean; E_i: effect of i^{th} environment (i = 1, 2); $R(E)_{j(i)}$: effect of j^{th} block within the i^{th} environment (j = 1, 2, 3); G_k: effect of k^{th} genotype (I = 1, 2,………..25); GE_{ik}: effect of the interaction of the k^{th} genotype with the i^{th} environment; e_{ijk}: experimental error.

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.

Table 1. Name and origin of chickpea genotypes

Entry number	Name/cross No.	Origin
1	215171	Iran
2	215296	Iran
3	215551	Iran
4	215618	Iran
5	215654	Iran
6	215664	Iran
7	215671	Iran
8	215686	Iran
9	215767	Iran
10	215843	Iran
11	215940	Iran
12	215941	Iran
13	215995	Iran
14	216001	Iran
15	216066	Iran
16	216084	Iran
17	216324	Iran
18	216325	Iran
19	216364	Iran
20	216368	Iran
21	215685-1	Iran
22	215685-2	Iran
23	Arman	Iran
24	AZad	Iran
24	Hashem	Iran

Statistical analysis

The analysis of variance and computation of correlation coefficients between each pair of the traits was conducted by SPSS (Ver. 17.0). Path analysis was carried out by path analysis software

(MAJIDI, 2011). Correlation and path analyses were done on mean of four replications of data in every year. In path analysis, seed yield used as dependent variable and the other studied traits was as predictor variables. The level of multi-collinearity in each path components was measured from two common measures, namely the tolerance and its inverse the variance inflation factor (VIF) as suggested by HAIR *et al.* (1995). Thus, very small tolerance values (much below 0.1) or large variance inflation factor (above 10) indicate a high collinearity. Path coefficient analysis was performed to divide the correlation coefficient between seed yield and the agronomic traits (r_{iy}) into direct (p_{iy}) and indirect effects ($r_{ij}p_{jy}$) according the following equation: $r_{iy} = p_{iy} + r_{ij}p_{jy}$

Path analysis technique allowed the evaluation of the direct causal effect or path coefficient (p_{iy}) of a cause (i) on an effect (y i.e. seed yield) and indirect effect of that cause through another causal variable (j). A single direct effect (unidirectional pathway) is quantitatively equal to p_{iy}, while an indirect effect is expressed as $p_{jy}r_{ij}$ of various agronomic traits on seed yield. r_{ij} is correlation between i and j and $r_{ij}p_{jy}$ is the indirect effect of trait i on Y *via* j. For example, in the equation $r_{1y} = p_{1y} + r_{12}p_{2y}$, p_{1y} is the direct effect of trait 1 on response variable (Y) (the path coefficient), while $r_{12}p_{2y}$ is the indirect effect of trait 1 on Y *via* trait 2 (GARCI´A DEL MORAL *et al.*, 2003). Similar definitions apply to all of the causal effect relations. Partial coefficient of determination (analogues to R^2 of linear regression) was calculated from the path coefficients for all the predictor variables.

RESULTS

Analysis of variance

Combined analysis of variance indicated that there were significant differences between years for seed yield (SY), days to flowering (DF), days to maturity (DM), flowering period (FP), canopy height (CH), canopy width (CW), number of pods per plant (NPP), biological yield (BY) and harvest index (HI). The effects of genotype were significant for SY, DF, DM, FP, CH, NPP, BY and HI. The interaction effects of genotype and year were significant for SY, DF, DM, FP, BY and HI. The coefficient of variation (CV) varied from 3.2 (flowering period) to 27.78 (number of pods per plant) (Table 2).

Table 2. Combined analysis of variance for seed yield

S.O.V	df	Mean Squares								
		SY	DF	DM	FP	CH	CW	NPP	BY	HI
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

S.O.V: source of variation, df: Degree of fredome, SY: Seed yield, DF: days to flowering, DM: days to maturity, FP: flowering period, CH: canopy height, CW: canopy width, NPP: number of pods per plant, BY: biological yield and HI: harvest index.

**significant at the 0.01 probability level

Correlation Analyses

The correlation matrix of yield and the other agronomic traits in the chickpea over two years is shown in Table 3. It revealed that there were significant and positive correlations between seed yield and number of pods per plant and harvest index in two years. There were negative correlations between seed yield and days to maturity, flowering period, canopy height and biological yield in first year. The correlation coefficient of seed yield with days to flowering, days to maturity, flowering period and canopy height and width were also negative in the second year. The other positive correlation coefficient in the first year were obtained between DF/DM, DF/CH, DM/FP, DM/CH, DM/BY, FP/CH, FP/BY, CH/BY, CW/NPP and NPP/HI. There were also positive and significant correlations between DF/FP, DM/CH and CH/CW in second year (Table 3).

Table 3. Simple correlation coefficients (r) for seed yield and the other morphological traits in chickpea genotypes (above the diagonal for first year and below the diagonal for second year)

Traits	SY	DF	DM	FP	CH	CW	NPP	BY	HI
SY	1	.005	-.005	-.345	-.146	.357	.701**	-.070	.788**
DF	-.675**	1	.888**	.274	.440*	-.193	-.366	.361	-.187
DM	-.351	.033	1	.509**	.409*	-.174	-.296	.507**	-.238
FP	-.253	.526**	.149	1	.400*	-.121	-.270	.509**	-.514**
CH	-.254	.215	.430*	.269	1	-.070	-.355	.488*	-.367
CW	-.097	-.011	.379	.316	.405*	1	.456*	.062	.235
NPP	.276*	-.288	.106	-.180	-.031	-.076	1	-.259	.690**
BY	.159	-.525**	.024	-.142	.174	-.012	.278	1	-.621**
HI	.851**	-.351	-.423*	-.131	-.341	-.198	.136	-.167	1

*significant at the 0.05 probability level

**significant at the 0.01 probability level

SY: Seed yield, DF: days to flowering, DM: days to maturity, FP: flowering period, CH: canopy height, CW: canopy width, NPP: number of pods per plant, BY: biological yield and HI: harvest index.

Path and Regression analysis

First year

The results of stepwise regression based on seed yield, as a dependent variable, indicated that number of pods per plant, days to flowering and flowering period included in the model as predictors in the first year:

SY= -48.62+30**NPP+14.1*DF-20FP

This equation indicated that regression coefficients of number of pods per plant and days to flowering were significant on seed yield. The results of path analysis for data set of first year, when all of the predictor variables were as the first-order variables, presented in Table 4. Based on tolerance and inflation factor values and besides the magnitude of direct effect, the traits including day to flowering, days to maturity, canopy height and width and number of pods per plant had positive direct effects on seed yield. It indicated that these traits are main contributors towards seed yield. These traits explained 36% of the total variation for seed yield, which means the most of variation in seed yield, was not explained by the traits included in the model. The overall effect of a trait on a dependent trait is equal to the sum of the corresponding direct path (effect) between the two traits and all of the indirect effects leading from the trait to the dependent trait (KOZAK *et al.*, 2007). The indirect effects of DF on seed yield were positive *via* DM and CH. Flowering period had negative direct effect on seed yield, while indirectly and positively influenced seed yield by DF, DM and CH. The highest value of path coefficient (direct effect) was depended to number of pods per plant. This predictor variable had also positive indirect effect on seed yield *via* FP and CW. When the results of correlation and path coefficient analysis were examined, it was observed that DM and CH recorded a positive direct effect on seed yield, but they had negatively correlated with seed yield. The reason for this is the negative indirect effect of DM and CH *via* FP, CW and NPP.

Table 4. Direct (under line numbers) and indirect effects of predictor variables on seed yield of chickpea genotypes in first year

Traits	DF	DM	FP	CH	CW	NPP	Overall effects
DF	0.075	0.067	0.02	0.03	-0.015	-0.03	0.005
DM	0.25	0.29	0.15	0.12	-0.05	-0.09	-0.005
FP	-0.09	-0.18	-0.35	-0.14	0.04	0.09	-0.34
CH	0.047	0.04	0.04	0.11	-0.008	-0.04	-0.15
CW	-0.01	-0.009	-0.006	-0.003	0.05	0.02	0.36
NPP	-0.26	-0.22	-0.19	-0.26	0.34	0.73	0.70
	R^2=0.36				$\sqrt{1-R^2}$ =0.60		

SY: Seed yield, DF: days to flowering, DM: days to maturity, FP: flowering period, CH: canopy height, CW: canopy width, NPP: number of pods per plant.

Second year

In the second year, days to flowering and maturity included in the stepwise regression model, when seed yield were as dependent variable:

SY= 2748-20.3**DF-14.2*DM

This equation indicated that days to flowering and maturity had significant negative effect on seed yield. In second year data set, flowering period, canopy height and number of pods per plant had positive direct effect on seed yield, whereas days to flowering, days to maturity and canopy width had negative direct effect on seed yield (Table 5). These traits explained 52% of the total variation for seed yield. The highest and positive values of direct effect were revealed by flowering period on seed yield (0.23). The indirect effects of DF were positive on seed yield via FP, CH and CW. Number of pods per plant had positive indirect effect on seed yield *via* day to flowering and canopy width. The indirect effects of CW were positive on seed yield by DF, FP and CH. The direct effect of day to maturity was negative, but the indirect effect of it was positive on seed yield by FP, CH and NPP. Regarding to the results of correlation and path coefficient analysis, FP had a positive direct effect on seed yield, but they had a negative indirect effect on seed yield *via* DF, DM, CW and NPP. Indirect effect of flowering period on seed yield by DF, DM, CW and NPP lead to negative correlation between seed yield and flowering period. Canopy height had a positive direct effect and negative indirect effects on seed yield by DF, DM, CW and NPP (Table 5).

Table 5. Direct (under line numbers) and indirect effects of predictor variables on seed yield of pea genotypes in second year

Traits	DF	DM	FP	CH	CW	NPP	Overall effects
DF	-0. 75	-0.02	-0.39	-0.16	0.008	0.22	-0.68
DM	-0.01	-0.37	-0.06	-0.16	-0.14	-0.04	-0.35
FP	0.12	0.03	0.23	0.06	0.07	-0.04	-0.25
CH	0.005	0.01	0.006	0.02	0.009	-0.0007	-0.25
CW	0.0003	-0.01	-0.01	-0.014	-0.035	0.002	-0.10
NPP	-0.04	0.01	-0.02	-0.004	-0.01	0.14	0.28
	Adjusted R^2=0.38				$\sqrt{1-R^2}$ =0.62		

SY: Seed yield, DF: days to flowering, DM: days to maturity, FP: flowering period, CH: canopy height, CW: canopy width, NPP: number of pods per plant.

DISCUSSION

The estimation of genetic variability is prerequisite for breeding programs aimed at crop improvement. In plant breeding, selection is aimed at improving some desirable traits. Analysis of variance in this work indicated significant effects of genotype for seed yield and yield components, indicating genetic diversity between genotypes. The significant effect of genotype × year interactions for yield and yield components indicated that genotypes had different performances over the year, therefore correlation and path analysis surveyed separately in any of years. Higher values of variances for SY, DF, DM, FP, CH, NPP, BY and HI in different chickpea collections were also reported by MALIK *et al.* (2014), GHAFOOR *et al.* (2003), MALIK *et al.* (2010) and KHAN *et al.* (2011) indicating the importance of these traits in yield improvement. The quantitative traits indicated significant variability and had high variance could be exploited either by direct selection for traits or through inclusion of selected genotypes as parents with desired traits in crossing program for genetic enhancement (TALEBI *et al.*, 2008). The utility of correlation for qualifying the degree of relationship between traits in a genetically diverse population at genotypic level (BELLO *et al.*, 2006) was used as an effective tool for making meaningful progress in crop improvement. Hence the analysis of yield components and their relative contribution towards yield would give better chance for selection for high yielding genotypes.

The correlation coefficients indicated that there were significant and positive correlations between seed yield and number of pods per plant and harvest index over two years. Similarly, CIFTCI *et al.* (2004), YUCEL *et al.* (2006), MALIK *et al.* (2010), ARSHAD *et al.*, (2004), GULER *et al.* (2001), HASSAN *et al.* (2005), YUCEL and ANLARSAL (2010), MUSHTAQ *et al.* (2013) and FARSHADFAR *et al.* (2013) showed positive and significant relationships between seed yield and plant height, number of pods per plant, biological yield and harvest index. The main purpose of breeders is to attain an increase in chickpea yield. To this end, emphasis should be given to the development of chickpea lines with higher number of pods per plant, plant height and harvest index to improve seed yield. Determination the major contributor towards seed yield is difficult from correlation alone, because of presence of significant correlations between yield components.

The path coefficient analysis provides more effective information and selection should be done according to these aggregate data. In this manner, the correlation coefficients were partitioned into direct (path) and indirect effects by using seed yield as a dependent variable in every year. In the first year, day to flowering, days to maturity, canopy height and width and number of pods per plant had the positive direct effects of seed yield. The highest value of path coefficients was obtained for number of pods per plant followed by day to maturity and canopy height. The indirect effects of day to flowering were also positive on seed yield by day to maturity and canopy height. CIFTCI *et al.* (2004) stated number of seeds per plant can be proposed as primary selection criteria for chickpea breeding. YUCEL *et al.* (2006) demonstrated the highest direct and indirect effects of plant height and number of pods per plant on seed yield by path analysis. In the second data set, flowering period, canopy height and number of pods per plant had the positive direct effect on seed yield. MALIK *et al.* (2014) indicated days to flowering and maturity, plant height, number of pods per plant, biological yield and harvest index had positive significant correlation with seed yield. In this data set, the highest and positive direct effect was revealed by flowering period on seed yield. The indirect effects of day to flowering were positive on seed yield by flowering period, canopy height and width. MUSHTAQ *et al.* (2013) using path coefficient analysis indicated that days to flowering had maximum direct effect on seed yield followed by total weight of plant and plant height. Therefore, the traits including canopy height and number of pods per plant had positive and direct effect on seed yield over two seasons. These results are also in accordance to those of ALIPOOR YAMCHI *et al.* (2013), TALEBI and ROKHZADI (2013), ALI *et al.* (2011), ALI and AHSAN (2011), SALEEM *et al.* (2002), and FARSHADFAR and FARSHADFAR (2008) who distinguished plant height and number of pods per plant as predictor variable via direct effect on seed yield. Residual effect (60% and 62%, in the first and second year, respectively) indicates that there were many other factors than these included in the present study, affecting seed yield. The results of present study suggested that the selection of genotypes with shorter flowering and maturity, highest number of pods per plant and canopy height contribute to increasing seed yield with an indirect effect *via* these traits.

CONCLUSIONS

In conclusion, seed yield, days to flowering, days to maturity, flowering period, canopy height, number of pods per plant, biological yield and harvest index indicate highly significant differences for genotypes from the variance analysis. This suggests that the traits should be considered in improvement programs. Number of pods per plant had the highest correlation coefficient and direct effect on seed yield. Hence, number of pods per plant should be seen as a major determiner of final seed yield. Therefore, for breeding program of chickpea the number of pods per plant and canopy height can be good selection criterion for improving seed yield in chickpea.

Received July 03th, 2016
Accepted January 16th, 2017

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KORELACIJE I PATH ANALIZA PRINOSA ZRNA I KOMPONENTI PRINOSA KOD LEBLEBIJE (*Cicer arietinum* L.)

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Izvod

Leblebije su druga najznačajnija mahunarka u svetu, posle pasulja. Cilj ovog proučavanja bio je da se izračunaju korelacioni koeficijenti i path analiza između prinosa zrna, morfoloških osobina i komponenti prinosa. Dvadeset pet genotipova, uključujući elitne linije i komercijalne sorte, gajeno je u uslovima suvog ratarenja u zapadnom Iranu (Brojerd poljoprivredna stanica) tokom dve sezone (2012/13 i 2013/14). Ogled je bio postavljen po RCBD dizajnu u četiri ponavljanja. Kombinovana analiza varijanse pokazala je da se proučavani genotipovi značajno razlikuju u prinosu zrna, broju dana do cvetanja, broju dana do pune zrelosti, visini useva, broju mahuna po biljci, biološkom prinosu i žetvenom indeksu. Značajne pozitivne korelacije bile su između prinosa zrna i broja mahuna po biljci i žetvenog indeksa u obe godine. Path analiza je pokazala da broj dana do cvetanja i pune zrelosti, visina i širina biljke, broj mahuna po biljci i vreme cvetanja utiču direktno i indirektno na prinos zrna. Rezultati ukazuju da poboljšanje programa oplemenjivanja leblebija može biti zasnovano na ovim svojstvima, posebno na broju mahuna po biljci i visini biljke, na osnovu dobijenog pozitivnog direktnog efekta na prinos zrna, tokom obe godine.

Primljeno 03. VII 2016.
Odobreno 16. I. 2017.