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The interrelationships of chickpea (*Cicera rietinum* L.) kernel yield and its components under rainfed conditions

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ABSTRACT-Chickpea (*Cicer arietinum* L.) is a native crop of Asia which is grown worldwide including Iran. In this study, different selection criteria including correlation, regression and path analysis were used to improve yield. The experimental design was split plot with RCBD replicated four times in which three sowing dates (5 January, 4 February, and 5 March) were used in main plots and four genotypes; two semi bush types and early mature cultivars(ILC_{482} and $Flip_{84-42}$) and two stand types and late mature ones (Hashem and Arman), were allocated to subplots. Results showed that $Flip_{84-42}$ variety and 5 January sowing date had the highest amount of kernel yield, pod number per plant, kernel number per pod, 100 kernel weight, biological yield, and days to flowering. There was a positive correlation between the kernel yield and pod number per plant ($r=0.57^{**}$, $p\leq0.05$), kernel number per pod ($r=0.51^{**}$, $p\leq0.05$), biological yield ($r=0.39^{*}$, $p\leq0.05$), plant height ($r=0.31^{*}$, $p\leq0.05$), branch number ($r=0.22^{*}$, $p\leq0.05$), leaf area index ($r=0.59^{**}$, $p\leq0.05$), and first pod height ($r=0.58^{**}$, $p\leq0.05$). Regression analysis also showed that yield was determined by biological yield, leaf area index and days to flowering. Results of path analysis revealed that biological yield had the greatest direct effect on kernel yield ($p=0.61^{**}$, $p\leq0.05$). This character was followed by number of pods per plant ($p=0.31^{*}$, $p\leq0.05$) and leaf area index ($p=0.35^{*}$, $p\leq0.05$). Results of this study indicated $Flip_{84-42}$ and5 January are the best variety and sowing date to cultivate chickpea in Badjgah region under dryland condition. In addition, it can be concluded that rainfed chickpea breeders should pay attention to the traits such as biological yield, leaf area index and days to flowering when selecting high-yielding genotypes.

INTRODUCTION

Chickpea (*Cicer arietinum* L.), a native crop of southwest Asia, is among the first crops to be cultivated by human. Its wild relatives are still found in Afghanistan, Iran and Ethiopia (Oelke et al., 1991). This crop has been grown in Iran. The leading countries in pea production include Russia, China, India, Canada, and the United States. In Iran, rainfed chickpea is mostly produced in Kermanshah, Lorestan, Azerbaijan and Fars provinces where the area under cultivation in 2010 was estimated to be over 409000 ha with 218000 ton production (Anonymous, 2011). Sowing date affects yield through affecting response to day length and temperature. Inappropriate planting date causes the vegetative and reproductive growth period of the plant to encounter unsuitable conditions of day length or temperature. Reduction of growth period or confronting the critical plant growth stages with the adverse conditions of temperature can reduce growth and yield components and even cause the plant death (Khajehpour, 2000). Yield loss in chickpea can vary between 30% and 60% depending on genotype, sowing time, location, and climatic conditions during sowing season. Some chickpea genotypes have capacity to tolerate drought and in that case sowing time can be delayed. However, too early or late sowing causes drastic yield reduction and net profit compared with timely sowing (Dixitet al., 1993).

Traditionally, plant breeders have optimized yield mainly by empirical selection with little attention to the physiological processes involved in yield increase (Singh and Singh, 2004). More recently, strategies to optimize yield in pea have focused on the physiological mechanisms involved in the seed setting and fruit filling (Ranjan et al., 2006). However, selection of high yielding cultivars via specific traits requires knowledge of not only final yield but also various compensating mechanisms among yield components which result from genotypic, environmental and management factors. Grain yield of pea is a quantitative trait which is affected by many genetic and environmental factors (Ceyhan and Avci, 2005).Since grain yield is a complex trait, indirect selection through correlated, less complex and easier measurable traits would be an advisable strategy to increase it. Efficiency of indirect selection depends on the magnitude of correlations between yield and target yield components (Bhatti et al., 2005).In agriculture, correlation coefficients in general show associations among characteristics. It is not sufficient to describe this relationship when the causal association among characteristics is needed (Toker and Cagirgan, 2004). If there is genetic correlation between two traits, direct selection of one of them will cause change in the other. When more than two variables are involved, the correlations per se do not give the complete picture of their interrelationships (Fakorede and Opeke, 1985). The path analysis has been used by plant breeders to assist in identifying traits that are useful as selection criteria to improve crop yield because it identifies the causes, measures the relative importance of the association, and is used to determine the amount of direct and indirect effect of the causal components on the effect component (Dewey and Lu, 1959). (Kosev and Mikic, 2012) assessed the relationships between seed yield components in spring-sown field pea. They reported that the strongest and direct positive effect on pea seed yield was found in branch length (17.70), 1000-seed weight (5.92) and number of seeds per pod (4.93). The highest positive indirect contribution was in branch length to number of seeds per pod (2214.8), number of fertile nodes per plant (1258.0) and number of seeds per plant (708.70).

Because of the importance of this crop in dryland fields of Fars province and to gain more knowledge about affecting traits in grain yield determination, this study was conducted to evaluate selection criteria in pea breeding programs by means of correlation, multiple regression and path coefficient analysis.

MATERIALS AND METHODS

To evaluate the interrelationships between kernel yield and its components in rainfed chickpea, a field experiment was conducted in 2009 and 2010 growing seasons at Experimental Station, College of Agriculture, Shiraz University, Shiraz, Iran, located at Badjgah. Two field trials were conducted on a silt loam soil at Badjgah (longitude: 52º, 46' and latitude 29º, 50'). The experimental design was split plot with randomized complete block replicated four times in which three sowing dates (5 January, 4 February, and 5 March) in main plots. Four genotypes, two semi bush types and early mature cultivars(ILC$_{482}$ and Flip$_{84-42}$) and two stand types and late mature cultivars (Hashem and Arman), were allocated to subplots. ILC$_{482}$ and Flip$_{84-42}$ originated from ICARDA, plant height for these two cultivars is around 30 to 35 cm. Hashem and Arman are taller than ILC$_{482}$ and Flip$_{84-42}$ (35 to 45 cm) and have late maturity habit. All of them are temperate and white seeded. Seeds were obtained from Dryland Agricultural Research Institute of Sararoud, Kermanshah, Iran. Each plot was 5 m wide and 6 m long and crop density was 40 plant m^{-2}. Soil preparation included chisel plowing and disking. Fertilizers applied as urea (120 kg ha^{-1}, which was used in two phases: 1/2 with plowing and 1/2 in stem elongation period) and triple super phosphate (50 kg ha^{-1} with plowing). Treflan herbicide was used as pre-planting to control weeds (2 liter ha^{-1}).

Monthly minimum and maximum air temperatures (degrees Celsius) and rainfall (mm) were recorded by permanent weather stations located about 200 m from the experimental site (Table 1). Harvesting was performed, as hand-done on June 10, 2009 and June 12, 2010, when the pods turned light yellow and grains were semi-hard. The grains were dried to 15% moisture content and re-weighed. Yield, yield components and some morphological characteristics were recorded at plant physiological maturity

Table 1. Some weather parameters during two years at the experimental site.

Month	2009 T_{max} (ºC)	2010 T_{min}(ºC)	Rainfall (mm)	T_{max} (ºC)	T_{min}(ºC)	Rainfall (mm)
January	14.7	-4.0	27.0	11.4	-3.1	-3.1
February	14.2	0.2	75.0	11.7	-0.5	-0.5
March	19.9	1.3	46.5	18.1	1.0	1.0
April	20.1	4.4	18.5	24.3	4.9	4.9
May	30.2	9.0	0.0	28.8	8.8	8.8
June	32.3	11.7	0.0	35.1	12.6	12.6

Hundred-kernel weights (HKW), pod number (PN), kernel number per pod (KNPP), branch number (BN) (first branch, second branch and third branch), leaf area index (LAI), length of the internodes (LI), plant height (H), harvest index (HI), biological yield (BY), days to flowering (DF), and kernel yield (KY) were measured at the dry seed stage. In both years, yield components were measured from a 2m^2 harvest area from the central four rows of each plot at maturity. Kernel yield was measured using 5 m^2 samples randomly cut from each plot. Leaf area index was measured using leaf area meter (Delta-T Devices, England).

Because of non-significant differences between years, data were combined and subjected to analysis of variance. Mean comparisons were made by LSD test at 0.05 significant level. The simple phenotypic correlation coefficient among all the observed components was first calculated by the SAS software; (25) and then, they were separated into direct and indirect effects via path coefficient analysis as suggested by (Dofing and Knight, 1992; Rodriguez et al., 2001). Stepwise multiple regression analysis was carried out using SAS software.

RESULTS AND DISCUSSION

Kernel yield and its components as affected by sowing date and cultivar

Chickpea varieties showed significant differences for PNP, KNPP and KY, but the difference was not significant for HKW (between ILC_{482} and $Flip_{84-42}$; Arman and Hashem), BN, FPH and DF (Table 2). The highest number of PNP and KNPP were observed in $Flip_{84-42}$, which were statistically different from other cultivars. The highest HKW was observed in $Flip_{84-42}$ which was statistically at par with ILC_{482} and the lowest one was observed in Arman and Hashem, which might be due to genotypic variation. The highest KY was found in $Flip_{84-42}$, which was statistically different from the other cultivars. This was because of higher PNP and also the number of KNPP for the cultivar $Flip_{84-42}$. Therefore, the highest seed yield per hectare was found in $Flip_{84-42}$. The lowest seed yield per hectare was found in Arman, which was statistically different from the other cultivars. Similar results were observed for H, LAI and BY in all chickpea varieties (Table 2).

Sowing time of chickpea varieties showed significant differences in all of measured characteristics (Table 2). The highest PNP was obtained from 5 January sowing date (20.1) which was statistically different from other sowing dates. So, variation in sowing time beyond optimum was found to decrease the number of PNP. Such result was also reported earlier by scientists. The highest KNPP was observed in January, 5 sowing date (1.1), which was statistically different from that of the 4th of February and the 5th of March, but the lowest number of KNPP was found in March, 5 sowing date (0.7). Due to reduced rainfall amount from March onwards, gradual depletion of soil moisture may have affected the growth of chickpea plants; as a result, a declining trend of PNP and also KNPP were observed. The 100-seed weight was not influenced by the variation on the 5th of January (34.8 g) and the 4th of February (34.1 g), which is supported by Fallah (2008).

Table 2. The effect of variety, sowing date and their interactions on some rainfed chickpea characteristics (two years combined data).

	Treatment	KY (kg ha^{-1})	PNP	KNPP	HKW (g)	BY (kg ha^{-1})	H (cm)	BN	LAI	FPH (cm)	DF (day)
Variety (V)	V1	510.8 b	15.5 b	0.97 b	33.4 a	1290.8 a	32.9 c	6.6 a	4.7 a	17.9 b	44.4 a
	V2	216.2 d	13.2 d	0.89 c	33.1 b	1118.5 c	37.0 b	4.9 c	3.2 c	20.0 a	37.0 b
	V3	228.8 c	13.6 c	0.89 c	33.1 b	1145.9 b	36.7 a	5.0 c	2.9 d	19.5 a	37.4 b
	V4	538.9 a	16.3 a	1.03 a	33.6 a	1293.6 a	33.7 b	6.1 b	4.4 b	17.7 b	43.1 a
Sowing date (D)	D1	546.3 a	20.1 a	1.1 a	34.8 a	1382.2 a	37.9 a	6.8 a	4.6 a	22.5 a	48.8 a
	D2	378.5 b	14.3 b	1.0 b	34.1 a	1262.1 b	36.1 b	5.8 b	3.8 b	18.9 b	40.3 b
	D3	196.2 c	9.5 c	0.7 c	31.0 b	992.2 c	31.3 c	4.4 c	3.0 c	14.8 c	32.3 c
V×D	V1D1	732.9 b	21.1 b	1.17 b	34.9 a	1474.5 a	35.4 d	7.7 a	5.56 a	19.6 d	53.3 a
	V1D2	532.7 c	15.5 f	1.04 de	34.4 b	1371.0 b	33.3 e	6.5 bc	4.77 ab	16.3 f	44.3 b
	V1D3	266.8 f	10.0 j	0.72 h	31.2 c	1027.3 f	30.3 g	5.5 de	3.8 bcd	13.3 g	35.7 c
	V2D1	732.9 b	18.7 d	1.05 d	34.5 d	1276.9 d	40.4 a	6.2 c	3.9 bcd	23.4 a	45.0 b
	V2D2	215.5 g	12.6 h	1.03 e	33.8 cd	1131.3 e	37.4 c	5.1 e	3.16 def	21.4 c	37.7 c
	V2D3	106.7 i	8.2 l	0.61 j	31.0 c	947.3 g	36.4 cd	3.6 f	2.53 ef	18.3 e	28.3 d
	V3D1	326.4 d	19.2 c	1.04 de	34.8 c	1323.7 c	39.4 ab	6.1 cd	3.7 bcd	23.1 ab	46.3 b
	V3D2	219.6 g	13.0 g	0.99 f	34.0 d	1155.3 e	38.4 bc	5.3 e	2.83 def	22.1 bc	36.3 c
	V3D3	129.3 h	8.6 k	0.63 i	30.5 c	958.7 f	35.4 d	3.6 f	2.23 f	17.7 e	29.7 d
	V4D1	788.0 a	21.5 a	1.3 a	35.2 a	1454.0 a	33.3 e	7.1 ab	5.16 a	20.2 d	50.7 a
	V4D2	546.1 c	16.0 e	1.07 c	34.3 d	1391.3 b	32.3 f	6.1 cd	4.53 abc	15.7 f	43.0 b
	V4D3	282.2 e	11.4 i	0.75 g	31.4 c	1035.7 f	29.3 h	5.0 e	3.5 cde	13.9 g	35.7 c

- V1: ILC_{482}, V2: Arman, V3: Hashem, V4: $Flip_{84-42}$; D1: 5-Jan, D2: 4-Feb, D3: 5-Mar
- KY: Kernel yield, PNP: Pod number per plant, KNPP: Kernel number per plant, KWG: 100 kernel weight, BY: Biological yield, H: Plant height, BN: Branch number, LAI: Leaf area index, FPH: First pod height and DF: Days to flowering.
- There is no significant difference between numbers with similar letters in each column.

The 100-seed weight is an inherent conservative character, which was not usually affected by environmental changes unless the change was extreme. Sowing dates affect KY significantly so that the highest and the lowest amount of KY were found in January, 5 (546.3 kg ha^{-1}) and March, 5 sowing dates (196.2 kg ha^{-1}), respectively. As soil moisture decreases with time, the available soil moisture becomes lower which affects yield contributing characters and subsequently kernel yield per hectare (Fallah, 2008).

The interaction between variety and sowing date showed significant differences in all measured characteristics (Table 2). The highest PNP (21.5) was recorded from V4D1 ($Flip_{84-42}$ in January, 5) which was statistically different from all the others over treatments. The lowest PNP (8.2) was found inV2D3 (Arman in March, 5), which indicates that under delayed sowing conditions all the varieties showed poor pod formation. The highest KY (788 kg ha^{-1}) was recorded in V4D1 ($Flip_{84\text{-}42}$ in January, 5) treatment. Mansur et al. (2010) reported that earlier sown chickpea cultivars (October) produced 56% increased yield compared to sowing at later dates. The highest biological yield (1474.5 $kgha^{-1}$) was recorded from V1D1 (ILC_{482} in January, 5) which was statistically similar to V4D1 (1454.0 $kgha^{-1}$) which was statistically significant over the rest of the combinations. The interaction between variety and sowing date showed significant differences on Plant height (H), branch number (BN), leaf area index (LAI), final pod height (FPH) and days to flowering (DF). (Kobraeeet al., 2010) concluded that early planting chickpea produced the highest plant height, distance of first pod from the earth surface, number of sub branch, number of pods per plant, number of seeds per plant, 100-seed weight, grain yield, biological yield and harvest index.

The highest and the lowest H were recorded from V2D1 (Arman in January, 5) (40.4 cm) and V4D3 ($Flip_{84\text{-}42}$ in March, 5) (29.3cm), respectively. The highest BN, LAI and DF were recorded from V1D1 (ILC_{482} in January, 5) which were similar to V4D1 ($Flip_{84\text{-}42}$ in January, 5). Maximum amount of FPH was recorded from V2D1 (Arman in January, 5) treatment (23.4 cm) which did not differ significantly from V3D1 (Hashem in January, 5) (23.1 cm).

Relationship between yield and its components

Correlation coefficient and path analysis

Simple correlation coefficients between the kernel yield and other variables are given in Table 3. Kernel yield was positively and highly correlated with PN ($r = 0.57^{**}$), KNPP ($r = 0.51^{**}$), BY ($r = 0.39^{*}$), H ($r = 0.31^{*}$), BN ($r = 0.22^{*}$), and LAI ($r = 0.59^{**}$), but it was negatively correlated with DF ($r = –0.12^{*}$). Days to flowering showed negative correlation with all other traits except H and LAI. These results were consistent with the findings of (Çakmakçiet al., 2003) who observed positive and significant correlations between seed yield and biological yield ($r = 0.81^{**}$), harvest index ($r = 0.42^{**}$), plant height ($r = 0.30^{*}$), seed number per plant ($r = 0.49^{**}$), pod number per plant (r = 0.42**) in common vetch (*Vicia sativa*). Similar results have been reported by other researchers (Çakmakçiand Açikgöz, 1994; Büyükburç and Iptas, 2001; Yücel, 2004). Correlation coefficient analyses usually show relationships among independent traits and the degree of linear relation between these characters. Consequently, these interrelationships with regard to sign and magnitude were found to be different when path analysis was performed (Çakmakçi and Açikgöz, 1994).

The relationships determined by path analysis are shown in Table 3. BY had the greatest direct effect on KY ($p= 0.61^{**}$) which was followed by PN ($p = 0.36^{*}$) and LAI ($p = 0.35^{*}$), respectively. H ($p = -0.47^{*}$) showed high negative direct effect on kernel yield. The number of pods per plant had the highest moderate indirect positive effects on kernel yield via biological yield ($p = 0.51^{*}$), while 100 kernel weight had the highest moderate indirect negative effects on kernel yield via number of kernels per pod ($p = -0.31^{*}$) (Table 4). Similar observations were reported by (Akdag and Sehirali, 1992; Ermanet al., 1997; Cinsoy and Yaman, 1998) for chickpea and (Cokkizgin and Colkesen, 2007) for pea which confirmed our results.

In such situations, the indirect causal factors must be considered simultaneously (Singh and Chaudhary, 1977). These results indicated that correlation coefficient analysis should not be considered as the only method to determine the relationship between traits in plant breeding studies; instead both correlation and path coefficient analyses should be used together.

Table 3. Correlation coefficients among characters in rainfed chickpea (average of two years).

	KY	PNP	KNPP	HKW	BY	PH	BN	LAI	FPH	DF
KY	1.00	0.57^{**}	0.51^{**}	0.19^{ns}	0.35^{**}	0.31^{**}	0.22^{*}	0.59^{**}	0.58^{**}	-0.12^{*}
PNP		1.00	0.77^{**}	-0.22^{ns}	0.10^{ns}	0.68^{**}	0.42^{ns}	0.17^{ns}	0.22^{**}	-0.13^{ns}
KNPP			1.00	-0.37^{**}	0.12^{ns}	0.59^{**}	-0.34^{*}	0.24^{ns}	0.31^{**}	-0.21^{ns}
HKW				1.00	0.14^{ns}	-0.36^{**}	-0.17^{*}	0.46^{**}	0.42^{**}	-0.14^{ns}
BY					1.00	0.04^{ns}	0.48^{**}	0.22^{*}	-0.32^{**}	-0.18^{ns}
H						1.00	0.31^{ns}	0.11^{ns}	0.24^{**}	0.04^{ns}
BN							1.00	-0.17^{ns}	-0.21^{*}	-0.09^{ns}
LAI								1.00	0.10^{ns}	0.12^{ns}
FPH									1.00	-0.15^{ns}
DF										1.00

- KY: Kernel yield, PNP: Pod number per plant, KNPP: Kernel number per plant, KWG: 100 kernel weight, BY: Biological yield, H: Plant height, BN: Branch number, LAI: Leaf area index, FPH: First pod height and DF: Days to flowering.

$^{*}p< 0.05$, $^{**}p < 0.01$, ns: Non-significant.

Raseie et al. (2011) reported that grains per pod, pods per plant and harvest index have a positive and high correlation with the grain yield.

The results of the path analysis revealed that the most direct and positive effect on grain yield was related to harvest index while the most indirect and positive effect was related to pods per plant through harvest index. As a result, harvest index can have an important influence on yield.

These results also indicated that correlation coefficient and path analysis were not always in agreement and the magnitude of the correlation coefficients was low. For example, correlation coefficients between kernel yield, plant height and days to flowering were 0.31 and -0.12, respectively whereas path coefficients of the relations were –0.47 and 0.15, respectively. If the correlation coefficient is positive, but the direct effect is negative or negligible, the indirect effects seem to be the reason for the correlation.

In such situations, the indirect causal factors must be considered simultaneously (Singh and Chaudhary, 1977). These results indicated that correlation coefficient analysis should not be considered as the only method to determine the relationship between traits in plant breeding studies; instead both correlation and path coefficient analyses should be used together.

Table 4. Path coefficients for seed yield of rainfed chickpea genotypes**.**

Character	Direct effect	Indirect effect									Total effect
		PH	FPH	BN	PNP	KNPP	BY	HKW	LAI	DF	
H	-0.47**		-0.29*	0.06	0.00	0.02	0.05	0.03	0.00	0.00	0.31**
FPH	0.23*	0.18*		-0.13	-0.01	-0.06	-0.04	-0.06	-0.04	0.03	0.58**
BN	0.07	-0.05	-0.03		-0.01	0.01	0.02	0.01	0.12	0.12	0.22*
PNP	0.36*	0.00	-0.01	0.05		-0.22	0.51**	0.13	-0.22*	-0.17*	0.57**
KNPP	0.27*	-0.13	-0.01	0.05	-0.08		0.02	-0.31*	-0.01	-0.08	0.51**
BY	0.61**	-0.04	-0.04	0.21*	0.10	0.05		-0.12	0.13	-0.03	0.35**
HKW	0.18*	-0.07	-0.11	0.09	0.08	-0.31	0.05		-0.11	-0.12	0.19ns
LAI	0.35*	0.00	-0.10	-0.05	0.12	0.25*	0.22*	0.17*		0.21*	0.59**
DF	0.15*	0.00	-0.03	-0.00	0.11	-0.00	-0.01	-0.02	0.23*		-0.12*

- FPH: First pod height, PNP: Pod number per plant, KNPP: Kernel number per plant, HKG: 100 kernel weight, BY: Biological yield, H: Plant height, BN: Branch number, LAI: Leaf area index, and DF: Days to flowering. *p< 0.05, ** p < 0.01.

Stepwise regression

The stepwise regression variance analysis showed that the model was significant to perform stepwise regression analysis for yield (Table 5). The parameter estimated showed that BY, LAI and DF determined yield during these two years. Thus, yield could be increased directly through BY, LAI and DF but indirectly through H because leaf area is one of the most essential physiological determinants of plant growth is the efficiency of the leaves with which the intercepted light energy is used in the production of new dry matter (Uzun and Celik, 1999).Moreover, leaf area is an indicator of photosynthetic capacity and growth rate of a plant and its measurement is of value in studies of plant competition for light and nutrients. Leaf area is a good indicator of yield potential because this trait is positively correlated but influenced in opposite way by the number of seeds which is an important yield component.

Table 5. Summary of stepwise multiple regression analysis of kernel yield and yield components in rainfed chickpea.

Traits	Estimate	Standard error	t-value
Intercept	28.90		
BY	0.451	0.16	2.90**
LAI	0.278	0.08	1.45*
DF	0.210	0.11	1.89*

- BY: Biological yield, LAI: Leaf area index, and DF: Days to flowering. *p< 0.05, ** p < 0.01.

CONCLUSIONS

Based on the results of this study, $Flip_{84\text{-}42}$ is the best variety to cultivate in Badjgah region under dryland condition. In addition, plants sown on the 5th of January had the highest kernel yield compared to those cultivated on the 4th of February and the 5th of March. The results of the present study give a better knowledge on kernel yield components in rainfed chickpea. Collecting data on the mutual relationships among individual kernel yield components and their effects on kernel yield remains crucial for their optimization and development of improved dry pea genotypes with high quality and stable yields. Based on the trait association and the path coefficients for yield and its components, it can be concluded that rainfed chickpea breeders should pay attention to the traits such as biological yield, leaf area index and days to flowering when selecting high-yielding genotypes.

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روابط بین عملکرد دانه و اجزای آن درنخود (*Cicerarietinum* L.)تحت شرایط دیم

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واژه های کلیدی:
عملکرد بیولوژیک
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چکیده- نخود یکی از گیاهان بومی آسیاست که در جهان و از جمله ایران کشت می شود. راهکار-های گوناگونی برای بهبود عملکرد این گیاه به کار برده شده است. بدین منظور، در این آزمایش معیارهای مختلف انتخاب شامل همبستگی، رگرسیون و تجزیه مسیر مورد استفاده قرار گرفتند. چهار ژنوتیپ نخود (ILC_{482}، $Flip_{84-42}$،هاشم و آرمان) در سه تاریخ کشت (۱۵ دی، ۱۵ بهمن و ۱۴ اسفند) در سال‌های ۱۳۸۸ و ۱۳۸۹ در مزرعه تحقیقاتی دانشکده کشاورزی دانشگاه شیراز کشت شدند. در انتهای دوره رشد ویژگی‌های وزن صد دانه، تعداد نیام، تعداد دانه در نیام، تعداد ساقه جانبی، شاخص سطح برگ، طول میان گره‌ها، ارتفاع گیاه، شاخص برداشت، عملکرد بیولوژیک، تعداد روز تا گلدهی و عملکرد دانه این گیاهان اندازه‌گیری شدند. نتایج نشان داد که همبستگی مثبتی بین عملکرد دانه با تعداد نیام در بوته، تعداد دانه در نیام، عملکرد بیولوژیک، ارتفاع گیاه، تعداد ساقه جانبی و شاخص سطح برگ وجود دارد. همچنین تجزیه ضرائب رگرسیون نشان داد که عملکرد دانه بوسیله‌-ی اجزایی همچون عملکرد بیولوژیک، شاخص سطح برگ و تعداد روز تا گلدهی تعیین می‌شود. نتایج تجزیه مسیر نیز روشن ساخت که عملکرد بیولوژیک بیشترینتاثیر مستقیم را بر عملکرد دانه داشته و پس از آن تعداد نیام در گیاه و شاخص سطح برگ بیشترین تاثیر را بر عملکرد دانه داشته اند.