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DETERMINATION OF DIRECT AND INDIRECT RELATIONS BETWEEN SOME YIELD CHARACTERS OF RED LENTIL CULTIVARS

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Abstract

This study was conducted in 2013 and 2014 by using 10 red lentil cultivars registered by the research institutes, universities and private sector in the ecological conditions of Central Anatolia Region to determine the agronomic characters having direct and indirect impacts on yield. For this aim; the differences were determined by applying variance analysis on the attained data and the groups were compared with Duncan Multiple Range Test. In addition; path analysis in which the direct and indirect impacts were determined with correlation analysis between the examined characters. Results showed that Evirgen and Cagil lentil cultivars were distinguished amoung the studied cultivars in terms of the characters affecting yield. As results; plant height, first pod plant height, number of pods and yield per plant had direct positive impact on yield.

Key words: Lentil, Character, Yield, Correlation, Path analysis.

Introduction

Lentil (*Lens culinaris* Medik), an edible legume plant is grown successfully in the dry areas of the world. It has a special place for the dry areas due to its resistance to dry conditions (Hamdi & Erskine, 1996). A significant part of lentil cultivars produced in our country is grown in dry areas, especially in Central Anatolia and Southeastern Anatolia. They have been important protein and vitamin source of human nutrition (Bicer, 2014). Lentil is also very valuable as animal feedstuff with its qualified straw as well as its grain yield (Bicer & Sakar, 2011). Furthermore; it has a soil-protective property due to its on-the-soil habitus and root structure in addition to human and animal nutrition. It also comes to the forefront due to its earliness against the seasonal changes in drought (Harris *et al*., 1987; Loss & Siddique, 1994). Although the lentil is ranked number fifth among the edible grain legumes with 4.33 million ha cultivation area and 4.98 million tonnes production in the world, it takes place second after chickpea in Turkey with 281 thousand ha cultivation area and 417 thousand tonnes production. While the world yield average has been 115 kg da^{-1} for lentil, this value has reached to 148 kg da^{-1} as a result of the successful breeding studies especially recently in Turkey (Anonymous, 2015). Turkey has also been seriously affected by the climate change experienced lately. For this reason; it is necessary to increase the studies on the lentil plants due to the danger of drought that is felt deeply day by day (Christensen *et al*., 2007). Slim *et al*. (1993) explained that the variation observed in the seed yield of lentil grown under dry conditions stems from the difference seen in especially the flowering period. It has been well known that the biotic and abiotic factors are affective on seed yield (Lichtenhaler, 1996). Lentil has got very high tolerance to different environmental conditions. Therefore; it is successfully grown under all kinds of conditions. However; there could be serious changes in the reactions they give depending on the conditions of the environment in which they are grown. One of the most important factors affecting the development of lentil is earliness. For this reason, the earliness is important for plantation and harvesting in dry climate conditions.

Berger *et al*. (2004) expressed that the lentil cultivars of the Mediterranean region are generally the late cultivars. As generally observed in the edible grain legumes, the yield is under the impact of many factors (Usha & Dubey, 2010). Correlation and path analyses conducted in the studies of plant breeding have been used in the assessment of the properties such as yield and quality in the plant breeding. They have been also used in the determination of the direct and indirect impacts on these properties (Hiltbrunner *et al*., 2007). The determination of indirect impacts will lead us while working on the characters. The factors affect the yield directly or indirectly. While the direct impacts are determined with the correlation test, path analysis was used for the indirect impacts (Karadavut, 2009). These relations may have positive and negative direction. The direct or indirect impacts may also be existent (Kakde *et al*., 2005). In the study conducted by Ghafoor *et al*. (1990), it was found that there was a positive and direct relation between harvesting index and biological yield. Ciftci *et al*. (2004) reported a direct correlation between the biological yield, harvest index, number of seeds per plant and seed yield.

Kumar *et al*. (2004) expressed that there were positive relations between yield and plant height, harvest index, 100-seed weight. While Kakde *et al*. (2005) determined a high positive correlation between the seed yield per plant and harvesting index. They, also, found out that a negative relation between number of pods per plant and harvesting index. Bicer & Sakar (2008) detected that the number of pods per plant and biological yield had a positive and direct impact on yield. Younis *et al*. (2008) revealed that flowering time, plant height, biological yield and 100-seed weight had a positive and a linear relation on the yield. The aim of this study was to determine the direct and indirect impacts of the characters of the red lentil cultivars affecting between yield and yield characters as well as the relations.

Materials and Methods

This study was conducted in the province of Kirsehir within the borders of Central Anatolia Region, possessing dry climate conditions. This study was carried out in 2013 and 2014 vegetation years and in the Research and Application Trial Field taking place in Bagbasi campus of Ahi Evran University. According to soil analysis for trial field, pH in the soil was 7.72, loamy structure, 1.75 % organic substance content, sufficient K (1.44 Me/100 g) and insufficient P content (2.16 ppm). There was an extreme continental climate in Kirsehir placed in Central Anatolia Region (Fig. 1). Annual precipitation amount was 379 mm in average. The climate data during the study in 2013-2014 are given in Table 1. When Table 1 is examined, it is seen that there is a similarity between the values for two years in terms of monthly temperature and total precipitation amount. In 2013, the amount of precipitation has taken twice as much as that of 2014. It has taken precipitation four times as much as those of long years. In terms of relative humidity value that there was a similarity between the relative humidity values in two years 2013 and 2014.

Ten red lentil cultivars (Sakar, Evirgen, Ciftci, Kafkas, Ozbek, Altintoprak, Cagil, Firat 87, Seyran 96 and Yerli Kirmizi) were used as plant materials registered by different institutions and organizations in our country. Some features of red lentil cultivars used in the current study are given in Table 2.

The study has been established in randomized blocks trial design with 4 replications. The seeds were planted by hand and by opening the grooves with marker and with the in row distance of 20 cm between the plantations. Parcels were arranged as 5 x 1.2=6 m². One each row at both sides out of 6 rows forming the parcel and the plants taking place within 50 cm from the row heads were taken out of the observation. DAP ($NH_4 2.HPO_4$) fertilizer was given to each parcel on condition that 2.5 kg pure nitrogen and 5 kg pure phosphorus will correspond as equal together with the plantation. Lentil is cultivated in arid or semi arid fields in Turkey. For this reason; no irrigation was applied in the trial. However, weed control was done by removing weeds from the parcel two times in total (before flowering). The plant height, first pod plant height, number of pods, number of grains, 1000 seed weight, yield and biological yield per plant were recorded for 10 plant cultivars randomly selected from each parcel. Their average values were calculated per lentil cultivar.

The data were analyzed by ANOVA. LSD test ($p>0.05$) was used to determine which genotypes were different each other with respect to the studied parameters. Correlation analysis was conducted for the linear relations between the variables while path analysis was conducted for the indirect impacts (Duzgunes *et al*., 1987). These data processes were done by MINITAB 14 V package program.

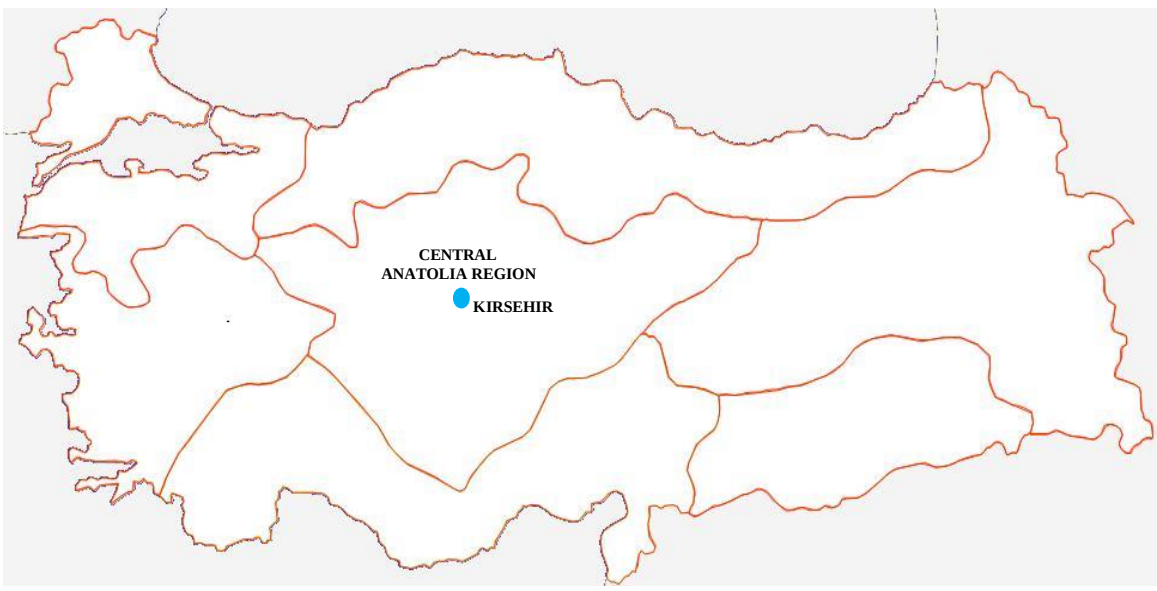

Fig. 1. Central anatolia region map.

Results and Discussion

The values of the average of both years regarding the plant height, first pod plant height, number of pods per plant and the number of seeds per plant values are given in Table 3. As plant height is an important criterion affecting yield; the highest plant height was attained from Sakar cultivars with 31.1 cm, Seyran 96 cultivar followed it with 30.8 cm. The lowest plant height was observed in Ozbek cultivar with 25.3 cm and very important differences were seen among the cultivars. Ölmez (2011) observed that the average plant height was 28.3 cm and plant height changes between 41.00-48.17 cm. Colkesen *et al*. (2014) showed that plant heights of red lentil genotypes were 66.00 and 78.63 cm for two years. The differences were significant due to the fact that the attained results were obtained in a region dominated by the irregular precipitation. This result was expected due to the changed climate conditions.

Table 1. Climate data for Kırsehir province*.

Months	Average temperature (ºC)			Total rainfall (mm)			Average relative humidity (%)		
	2013	2014	Long years	2013	2014	Long years	2013	2014	Long years
March	7.2	7.4	6.3	14.2	52.2	9.3	63	64.3	67.5
April	12	13.2	11.4	45.1	20.2	7.7	62.8	54.9	59.7
May	19.3	16.9	16.2	15.1	46.6	10.7	44.7	59.5	56.2
June	21.4	20.8	20.6	1	36	13.9	42	51.6	50.9
July	24.1	27.6	24.8	6.6	13	2.9	37.1	33.6	38.4
Average	16.8	17.2	15.9				52.5	52.8	54.5
Total				82	168	44.5			

*Kırsehir provincial meteorology directorate

Table 2. Some characteristics of red lentil varieties.

Cultivar name	Characteristics	Registrant ınstitution
Sakar	It has a semi-upright form. It has 25-45 cm plant height. The first pod height is 15-21 cm, the number of pods per plant is 20-34, and 1000-seed weight is 39-41g.	Dicle University Faculty of Agriculture
Evirgen	It has an upright form. It has 22-38 cm plant height. The first pod height is 11-19 cm, the number of pods per plant is 19-30, and 1000-seed weight is 27.3-38.4 g.	Mersin Commodity Exchange
Ciftci	It has an upright form. It has 22-30 cm plant height. The first pod height is 11-15 cm, the number of pods per plant is 22-32, and 1000-seed weight is 36.7 g.	Field Crops Central Research Institute
Kafkas	It has a semi-upright form. It has 22-31 cm plant height. The first pod height is 11-14 cm, the number of pods per plant is 20-31, and 1000-seed weight is 36.5 g.	
Ozbek	It has an upright form. It has 23-38 cm plant height. The first pod height is 10-12 cm, the number of pods per plant is 21-34, and 1000-seed weight is 35.2g.	
Altintoprak	It has an upright form. It has 22-31 cm plant height. The first pod height is 11-15 cm, the number of pods per plant is 19-34, and 1000-seed weight is 32-40 g.	GAP International Agricultural Research and Training Center
Cagil	It has an upright form. It has 26-33 cm plant height. The first pod height is 12-16 cm, the number of pods per plant is 21-32, and 1000-seed weight is 31-40 g.	
Firat 87	It has a semi-upright form. It has 40-50 cm plant height. The first pod height is 16-20 cm, the number of pods per plant is 22-35, and 1000-seed weight is 35-40 g.	
Seyran 96	It has an upright form. It has 35-40 cm plant height. The first pod height is 13-17 cm, the number of pods per plant is 20-30, and 1000-seed weight is 30-36 g.	
Yerli Kirmizi	It has a semi-upright form. It has 25-30 cm plant height. The first pod height is 13-16 cm, the number of pods per plant is 19-30, and 1000-seed weight is 33 g.	

Table 3. The mean of plant height, first pod plant height, number of pods and number of seeds per lentil cultivar.

Cultivars	plant height (cm)	the first pod height (cm)	number of pods per plant (number/plant)	number of seeds per plant (number/plant)
Evirgen	30.4 ± 1.8 a	22.3 ± 2.0 a	13.0 ± 5.4 a	18.9 ± 9.0 a
AltinToprak	26.3 ± 3.6 b	19.5 ± 2.8 ab	10.5 ± 2.8 ab	11.1 ± 2.0 b
Cagil	28.4 ± 2.7 ab	20.4 ± 2.9 ab	12.3 ± 6.6 a	15.4 ± 9.7 ab
Yerli Kirmizi	30.0 ± 1.9 a	22.1 ± 2.2 a	6.3 ± 2.9 bc	9.3 ± 5.4 bc
Seyran 96	30.8 ± 5.2 a	22.2 ± 4.4 a	12.3 ± 4.2 a	17.5 ± 7.1 a
Sakar	31.1 ± 6.8 a	22.4 ± 4.9 a	10.4 ± 5.6 ab	11.5 ± 7.1 b
Ciftci	25.9 ± 2.9 b	18.6 ± 3.4 b	7.1 ± 3.2 b	11.7 ± 6.0 b
Firat 87	26.5 ± 3.2 b	19.3 ± 2.1 b	6.1 ± 2.1 c	7.2 ± 2.5 bc
Ozbek	25.3 ± 2.3 b	18.8 ± 2.6 b	8.8 ± 1.6 b	10.8 ± 2.7 b
Kafkas	28.3 ± 4.2 ab	19.4 ± 2.1 b	8.5 ± 2.1 b	8.4 ± 2.7 bc
Mean	28.3	20.5	9.53	12.28

The cultivars whose first pod plant height is high are preferred for the machine harvesting to be able to be made more comfortably. The pod heights of lentil cultivars were between 18.6 and 22.4 cm. The average value was 20.5 cm. The highest first pod plant height was obtained from Sakar cultivars with 22.4 cm, the cultivars of Evirgen and Seyran 96 follows it with respectively 22.3 cm and 22.2 cm. The lowest first pod height was observed in Ciftci cultivar (18.6 cm). It was well understood that the cultivars do not show a great variation in terms of the first pod height. Kacar & Azkan (1997) showed that the first pod plant height of the examined materials was between 13.5-16.5 cm. Bozdemir (2007) explained that the first pod plant height changed between 14.4-20.1 cm. Generally, the dry conditions are dominant in Central Anatolia. As the plants under dry conditions cannot grow taller, the first pod plant height is also low. The low values in the first pod height were obtained in our study.

It was foud out that the variation in number of pods per plant was the most important components affecting the yield. While the number of pods per plant changed between 6.1 and 13. It was determined as 9.5 on averages. While the cultivars of Evirgen (13 number) and Seyran 96 (12.3 number) were prominent in terms of the number of pods per plant. Firat 87 cultivar was the last one with its value of the number of pods per plant as 6.1. Yerli Kirmizi, Ciftci, Kafkas and Ozbek cultivars were recorded as the cultivars having low values in terms of the number of pods per plant after Firat 87 cultivar. In the study conducted by Toklu *et al*. (2007), it was observed that the number of pods changes between 6.0 and 42.2. Imani & Moosavi (2012) have detected that the number of pods per plant changes between 8.37 and 27.29. This study covered the fully dry and irrigation less climate conditions. The attained results were lower when compared to the values attained from the other studies conducted under arable conditions. However; Evirgen genotype having 13 pods could be focused in the current study.

The number of seeds per plant has always a positive relation with the yield all the time as seen in our study. The number of seeds per plant values changed between 7.2-18.9. While Evirgen (18.9 number), Seyran 96 (17.5 number) and Cagil (15.4 number) cultivars were prominent in terms of the number of seeds per plant; Firat 87 (7.2 number), Kafkas (8.4 number) and Yerli Kirmizi (9.3 number) lentil cultivars showed lower values. Almost half of 10 red lentil cultivars were below than 12.2. This variation might be attributed to the genetic structures of the cultivars and their reactions to environment. Erman *et al*. (2005) explained that the number of seeds per plant changed between 12.8 and 54.3. Cokkizgin *et al*. (2005) showed the number of seeds per plant values changed between 43 and 69.2 and the examined properties were strictly related to the precipitation although the difference between the cultivars in terms of the number of seeds per plant was not found statistically significant. In the event that the amount of precipitation increases or irrigation opportunities exist, an increase occurs in the number of seeds per plant. However; the seasonal distribution of the precipitation and the time of irrigation are efficient in this issue. In this study; although the amount of precipitation seems high in the growing season. However, the irregularity in the distribution of precipitation caused decrease in the number of seeds per plant.

The values of 1000-seed weight, seed yield per plant, biological yield and yield properties attained from the lentil cultivars for two years are given in Table 4. Seed weight values 1000 seeds changed between 27.6-32.8 g according to the average data of both years. While Sakar cultivar was the prominent with 32.8 g 1000-seed weight, followed by Firat 87 (31.4 g) and Altin Toprak (30.8 g) cultivars. Ozbek cultivar showed the lowest value 27.5 g among all the cultivars. The mean of 1000-seed weight value was 29.39 g in 10 red lentil cultivars. Bicer & Sakar (2004) detected that 1000-seed weight changed between 29.01-41.2 g with mean value 35.25 g. Demirhan (2006) found out that 1000-seed weights of the cultivars wer between 26.25-65.5 g with the highest value in Meyveci 2001 cultivar and the lowest value in Kirmizi-51 cultivar. 1000-seed weight is an important indicator of yield. Drought to be experienced just in the seed filling stage directly affects the 1000-seed weight. It makes us think that the experience of drought in the seed filling period may caused the 1000-seed weight values which were lower than the values of other researchers.

Table 4. The mean of 1000-seed weight, seed yield, biological yield and yield per lentil cultivar.

Cultivars	1000-seed weight (g)	Seed yield per plant (g)	Biological yield (g)	Yield (kg da^{-1})
Evirgen	27.6 ± 2.3 c	0.5±0.2 a	2.9 ± 1.1	142.6 ± 13.5 a
Altin Toprak	30.8 ± 2.3 b	0.3±0.0 ab	2.5 ± 0.7	138.3 ± 27.6 a
Cagil	28.6 ± 3.1 bc	0.4±0.3 ab	2.9 ± 0.7	134.4 ± 18.0 a
Yerli Kirmizi	29.1 ± 2.9 b	0.2±0.1 b	2.5 ± 0.6	118.1 ± 9.5 b
Seyran 96	28.4 ± 3.6 c	0.5±0.2 a	2.7 ± 0.7	115.0 ± 2.5 b
Sakar	32.8 ± 3.1 a	0.4 ± 0.1 ab	2.5 ± 0.7	111.6 ± 14.3 b
Ciftci	28.9 ± 2.3 bc	0.3 ± 0.1 ab	3.9 ± 6.1	109.6 ± 19.2 b
Firat 87	31.4 ± 2.4 b	0.2 ± 0.0 b	2.6 ± 0.7	97.6 ± 15.3 bc
Ozbek	27.5 ± 3.3 c	0.3 ± 0.0 ab	2.8 ± 0.7	90.7 ± 3.8 c
Kafkas	28.8 ± 2.8 bc	0.2 ± 0.1 b	2.5 ± 0.7	59.3 ± 18.0 d
Mean	29.39	0.33	2.78	111.72

When the values of seed yield per plant examined, it was seen that the cultivars had very low values. The seed yield values changed between 0.2-0.5 g. To increase the yield per plant, it is necessary to focus on especially the genotypes whose seed yield per plant is high to be included in the arable system. Evirgen and Seyran 96 reached high values of seed yield per plant (0.5 g). Six of the cultivars were below than average. There is no doubt that not only the values of seed yield per plant all alone but also the factors affecting the yield per plant directly or indirectly should be determined and studies should be conducted in the issue of improving them. Cokkizgin (2008) reported that the seed yield per plant changed between 0.682-1.645 g. Their study was conducted by using 9 lentil cultivars and grew them as wintery in Van. It was found in another study that the highest seed yield was obtained from Flip 86-29 L line (Bildirici & Ciftci, 2001). Seed yield is directly related to the number of seeds and seed filling. In our study; the seed yield per plant was quite low due to the insufficiency of seed filling.

It was observed that there was no statistical difference among the cultivars in terms of biological yield accepted indicator of plant development (Table 4). The cultivars gave 2.5-3.9 g biological yield, in average 2.78 g yield led the most important components in the breeding studies. In this study; yield values were between 59.3 and 142.6 g, showing that the cultivars under different environmental conditions in developmental period reacted differently. Kafkas cultivar yielded 59.3 g, indicating that this cultivar could have not completed its development or interacted with the environment in negative way. Evirgen and Cagil cultivars gave significant yields 142.6 and 134.4 g, respectively. It is remarkable that Evirgen cultivar was in the first ranks in terms of all the properties, except for 1000-seed weight. Kaplan (2015) reported that the seed yield averages of lentil cultivars changed as 74.6-122.0 kg da^{-1}. Firat 87 had 74.6 kg seed yield da^{-1} while Ciftci had 122 kg seed yield da^{-1}. Turk & Koc (2003) determined that the red lentil cultivars yielded as 60.6-86.3 kg da^{-1}.

The correlation coefficients between 8 properties are given in Table 5. When Table 5 was examined, a significant relation (r=0.298*) was observed between plant height and yield. It shows that yield will increase as plant height increases. Positive and very important relations were observed between the yield and the first pod plant height (r=0.743**). The number of pods per plant and biological yield had positive relation with yield (r=0.288*, r=0.281*). Very significant relations were detected between plant height and the first pod plant height (r=0.208**) and number of seeds (r=0.294**), between the number of seeds and the number of pods (r=0.882**), and between the seed yield and the number of pods per plant (r=0.871**). In this study reverse to positive important relations, the negative insignificant relations were also detected between the plant height and the number of pods (r=-0.010) and yield per plant (r=-0.086).

The study conducted by Solanki (2006) on lentil in India demonstrated a positive correlation between seed yield and number of pods by using 72 eco-geographic genotypes.

Verma *et al*. (2004) found out a significant positive correlation between seed yield and harvest index, seed weight and number of seeds per plant under arable conditions. They expressed that number of seeds per plant showed negative correlation with seed yield. Encan (2004) conducted a study with 100 number convolute lentil lines and 4 control cultivars in 2003 in summer. He detected that the highest correlation values among 1000-seed weight and seed yield (r=0.839**), number of pods and number of seeds (r=0.849**), plant height and the first pod plant height (r=0.705**) and 1000-seed weight and plant height (r=0.622**). Younis *et al*. (2008) reported that there were significant relations between seed yield and plant height, biological yield and 1000-seed weight. Karadavut (2009) recorded that there were significant relations between yield and biological yield ($r=0.833^{**}$), harvest index (r=0.687**). Vir & Gupta (2002) mentioned that there were positive significant relations between seed yield and the number of pods with seeds per plant. Bildirici & Ciftci (2001) detected that there were significant relations between seed yield and plant height (r=0.338**), number of pods per plant (r=0.419**), between number of seeds (r=0.239*) and seed yield per plant (r=0.301*). These correlations might be related to growth and development of plants. Growth parameters develop in a way that follows one another depending on time. For this reason; every negative or positive factor affects the physiological and morphological structure of the plant. This causes difference between plants depending on the climate.

The direct and indirect impacts of the characters affecting yield and yield are shown in Table 6. When Table 6 is examined, it is seen that the impact of plant height on the yield was in negative direction (-0.214), and its direct impact on yield was 24.16%. The plant height made the actual impact upon the first pod height about 28.4%. However; the plant height had a decreasing impact on yield, number of pods (7.18%) and yield per plant (8.13%).

Earliness is an important issue for the producers to harvest and reach to market earlier (Denton *et al*., 2014). Aydogan *et al*. (2005) considered Firat 87 and Seyran 96 cultivars as late cultivars beause of lateness and deficiencies in yield. In the present study, Firat 87 cultivar had late properties and showed serious decreases in yield, while the decrease had lower level in Seyran 96 cultivar. Some researchers specified that the early cultivars are seriously affected from the last spring frosts and, consequently, decreases yield (Nayyar, 2005). The number of pods, the number of seeds and yield per plant are directly affected by climate conditions. Spreading of the precipitation along the pod bonding period makes a serious increasing effect on the yield (Bejiga *et al*., 1995). In this study; it was observed that these properties decreased in the development periods due to the precipitation was insufficient thus caused development negatively. The plant development is affected by the presence precipitation in the development periods. Precipitation is the most important factors affecting the yield and yield-effective characters in arid and semi arid areas (Silim *et al*., 1993). In this study; it was seen that the reactions of cultivars against the irregular distribution of precipitation decreased yield with its decreasing impacts. It was also seen that Firat 87, Kafkas and Ozbek cultivars were prominent in this issue.

Table 5. Relations between yield and yield components.

Properties	Plant height	The first pod height	Number of pods per plant	Number of seeds per plant	1000-seed weight	Seed yield per plant	Biological yield	Yield
Plant height	-							
The first pod height	0.208**	-						
Number of pods per plant	-0.010	0.162*	-					
The number of seeds per plant	0.294**	0.113	0.882**	-				
1000-seed weight	0.032	0.046	-0.021	-0.135	-			
Seed yield per plant	-0.086	0.127	0.871**	0.552**	0.145	-		
Biological yield	0.006	0.165*	0.693**	0.668**	0.063	0.685**	-	
Yield	0.298*	0.743**	0.288*	0.117	0.052	0.139	0.281*	-

Table 6. Effects of direct and indirect factors on yield.

Direct impact	Indirect effect	P	Impact ratio (%)	r
		-0.214	24.16	
	The first pod height	0.436	28.44	
	Number of pods per plant	-0.032	7.18	
Plant height	Number of seeds per plant	0.234	13.66	0.298*
	1000-seed weight	0.068	14.29	
	Yield per plant	-0.122	8.13	
	Biological yield	-0.072	5.90	
		0.333	32.43	
	Plant height	0.234	21.65	
	Number of pods per plant	0.215	19.21	
First pod plant height	Number of seeds per plant	-0.043	4.13	0.743**
	1000-seed weight	-0.067	6.28	
	Yield per plant	-0.094	6.88	
	Biological yield	0.165	9.42	
		0.267	36.12	
	Plant height	-0.162	8.91	
	The first pod height	-0.142	2.63	
Number of pods per plant	Number of seeds per plant	0.102	13.82	0.288*
	1000-seed weight	-0.158	17.49	
	Yield per plant	0.147	12.00	
	Biological yield	0.208	9.57	
		0.349	43.88	
	Plant height	-0.047	12.56	
	The first pod height	-0.118	9.36	
Number of seeds per plant	Number of pods per plant	0.151	14.27	0.117
	1000-seed weight	0.122	9.33	
	Yield per plant	-0.080	4.32	
	Biological yield	-0.155	6.28	
		0.433	27.11	
	Plant height	-0.127	12.37	
	The first pod height	-0.211	9.64	
1000-seed weight	Number of pods per plant	0.376	18.22	0.052
	Number of seeds per plant	-0.133	17.18	
	Yield per plant	-0.201	10.02	
	Biological yield	-0.085	4.46	
		0.328	29.11	
	Plant height	-0.322	6.54	
	The first pod height	-0.058	16.24	
Seed yield per plant	Number of pods per plant	0.254	11.48	0.139
	Number of seeds per plant	-0.108	22.08	
	1000-seed weight	0.207	9.14	
	Biological yield	-0.162	5.41	
		0.633	42.18	
	Plant height	-0.311	8.15	
	The first pod height	-0.209	9.47	
Biological yield	Number of pods per plant	0.261	14.01	0.281*
	Number of seeds per plant	-0.247	11.26	
	1000-seed weight	0.222	8.24	
	Yield per plant	0.132	6.69	

The first pod height had a direct positive effect on the yield about 32.43%. Its indirect effects were between 21.65-19.21% on the yield. While the number of pods per plant had direct effect on the yield about 36.12%, it affected indirectly on 1000-seed weight about 17.49%. The indirect effect of number of pods on the number of seeds was about 13.82%. While its indirect effect on the yield had become positive on the number of pods per plant about 14.27%. It had negative effect on plant height about 12.56% whereas 1000-seed weight had direct positive effect on the yield about 27.11%. 1000 seed weight had the highest indirect effect on the number of pods about 18.22%. However; it had negative indirect effect on the number of seeds by 17.18%. Indirect effects of 1000-seed weight, except for the property of the number of pods, decreased the yield. While the yield per plant had direct positive effect on yield about 29.11%. On the contrary, it caused to decreasing effects on yield about 16.24% on the first pod height and the number of seeds per plant about 22.08%. Babagil (2013) was of the opinion that the number of pods, the first pod plant height and 1000-seed weight in chickpea had positive and direct effects on yield and plant height. The number of seeds per pod had negative and direct impacts on yield. In this study; the first pod plant height and number of pods had significant direct impact. However; the impact of 1000-seed weight was positive but insignificant. The first pod height was under the influence of the genetic and environmental factors affecting the yield (Fehr, 1987). Aycicek & Babagil (2013) expressed that the plant height and number of seeds per pod had positive and direct impact on the yield.

In this study; the positive contribution of the number of pods per plant was 43.88% on the yield which was so high. However; the number of pods per plant showed a yield-decreasing impact on the yield by the value -0.162 and 12.56% upon the plant height and by the value -0.118 and 9.36% upon the first pod height. The attained results have similarities with the findings of Kakde *et al*. (2005) and Karadavut (2009). Biological yield had a direct and positive impact on the yield by 42.18% as the second best after the number of seeds per plant. While biological impact had the highest positive impact upon the number of pods per plant by 14.01%. Its yield-decreasing indirect impact was 11.26% on the number of seeds per plant. The cultivars in general give nearly same amount of biological yield. The legume plants spend high amounts of energy for the formation of the seed. Therefore; the biological yield decreases (Mc Kenzie & Hil, 1995). Biological yield is an important parameter in the determination of developmental performances of plants. At the same time; the plants good at biological yield cover the ground and save water in the soil. In this study; the biological yield values are in line with the findings of Surek *et al*. (2011), but lower than the values given by Bicer & Sakar (2007). The most important reason for this situation was the precipitation taken during the breeding period.

Conclusion

Ten different registered cultivars were used in this study. The yield and yield-affecting characters of these cultivars were determined. It was observed that Evirgen and Cagil cultivars were better than other cultivars in terms of the yield and yield-affecting characters. It was seen that the impact of the climate factors on the attained results was significantly high. The insufficient precipitation in the first development and pod bonding period affected growth and development negatively. The serious fluctuations in the yield for both years caused to the occurrence of serious variations in the values belonging to some characters. The plant height, the first pod plant height, number of pods per plant and seed yield per plant was direct and positively efficient characters affecting yield in terms of the direct and indirect impacts. The prioritized considerations of these characters specified in the breeding studies will be important for success in genetical improvement.

Refrences

Anonymous. 2015. http://faostat.fao.org/site/336/ Desktop.aspx ?PageID=336.

Aycicek, M. and G.E. Babagil. 2013. Correlations and path analysis of yield and some yield components in chickpea. *J. Food, Agric. & Envir.*, 11(3&4): 748-749.

Aydogan, A., V. Karagul and C. Bozdemir. 2005. Adaptation to middle anatolian conditions of winter lentil cultivars. *GAP Fourth Agriculture Congress*, 820-825.

Babagil, G.E. 2013. Assessment of effectiveness degrees of the factors affecting the yield of some chickpea (*Cicer arietinum*) genotypes by path analysis. *Indian J. Agric. Sci*., 83(11): 93-96.

Bejiga, G., T. Tsegaye and A. Tullu. 1995. Stability of seed yield of lentil varieties (*Lens culinaris* Medik.) grown in the Ethiopian highlands. *Crop Res*., 9(3): 337-343.

Berger, J.D., N.C. Turner, K.H.M. Siddique, E.J. Knights, R.B. Brinsmead, I. Mock, C. Edmondson and T.N. Khan. 2004. Genotype by environment studies across Australia reveal the importance of phenology for chickpea (*Cicer arietinum* L.) improvement. *Aust. J. Agric. Res*., 55(10): 1071-1084.

Bicer, B.T. 2014. Some agronomic studies in chickpea (*Cicer arietinum* L.) and lentil (*Lens culinaris* Medik). *J. Turk. Agri. & Natural Sci*., 1(1): 42-51.

Bicer, B.T. and D. Sakar. 2004. Evaluation of some lentil genotypes at different locations in Turkey. *Int. J. Agri. & Biol*., 6(2): 317-320.

Bicer, B.T. and D. Sakar. 2007. Comparision of exotic lentil lines to native cultivars for agronomic and morphologic traits. *J. Agri. Sci*., 13(3): 279-284.

Bicer, B.T. and D. Sakar. 2008. Heritability and path analysis of some economical characteristics in lentil. *J. Central Europ. Agri*., 9(1):191-196.

Bicer, B.T. and D. Sakar. 2011. The evaluation for yield and its components In the lentil (*Lens culinaris* Medik.) lines. *University of Harran. J. Agri. Faculity*, 15 (3): 21-27.

Bildirici, N. and V. Ciftci. 2001. A research on determination of relations between grain yield and yield components of high effective winter lentil varieties under Van ecological conditions. *University of Cukurova, J. Agri. Faculity*, 16(1): 67-72.

Bozdemir, C. 2007. Determination of performance of spring green lentil lines in Ankara ecology. Institute of Science of Selcuk University Master's Thesis, Konya, 113 p.

Christensen, J.H., B. Hewitson, A. Busuloc, A. Chen, X. Gao, I. Held, R. Jones, R.K. Kolli, W.T. Kwon, R. Laprise, V. Rueda Magana, L. Mearns, C.G. Menendez, J. Raisenen, A. Rinke, A. Sarr and P. Whetton. 2007. In: (Eds.): Solomon, S., D. Qin, M. Manning, Z. Chen, M. Marquis, K.B. Averyt, M. Tignor, H.L. Miller. Climate Change 2007: The Physical Science Basis. Contribution of working group I to the fourth assessment report of the intergovernmental panel on climate change. Cambridge University Press, Cambridge, UK and New York, USA.

Ciftci, V., N. Togay, Y. Togay and Y. Dogan. 2004. Determining relationships among yield and yield components using path coefficient analysis in (*Cicer arietinum* L.). *Asian J. Plant Sci*., 3(5): 632-635.

Cokkızgın, A. 2008. A research on determination of botanical and agronomic properties of local genotypes of some lentils (*Lens culinaris* Medik.) selected from south and southeastern anatolian regions in Turkey. Institute of Science of Adana University Master's Thesis, Adana.

Cokkızgın, A., M. Colkesen, K. Kayhan and M. Aygan. 2005. A research on yield and yield components in different winter lentil (*Lens culinaris* Medic.) cultivars under Kahramanmaras conditions. *University of Akdeniz, J. Agri. Faculity*, 18 (2): 285-290.

Colkesen, M., L. İdikut, G. Zulkadir, A. Cokkizgin, U. Girgel and O.A. Boylu. 2014. Determination of yield and yield components of various winter lentil genotypes (*Lens culinaris* Medik.) in Kahramanmaras conditions. *Turk. J. Agric. & Natural Sci*, Special Issue: 1: 1247-1253.

Demirhan, M.H. 2006. Determine of agricultural and plant properties of some winter lentil cultivars grown Siirt ecological conditions. Institute of Science of Centennial University Master's Thesis, Van.

Denton, O.A., K.O. Oyekale, A.S. Ojo, A.G.M. Nwokocha and O.E. Akinboye. 2014. Evaluation of 14 accessions of amaranthus cruentus for production of early vegetative yield. *J. Adv. Agri*., 5(3): 748-752.

Duzgunes, O., T. Kesici, O. Kavuncu and F. Gurbuz. 1987. Research and trial methods. *J. Agri. Faculty of Ankara University*, 381 p.

Encan, G. 2004. Research of yield and its yield components in some lentil lines. Institute of Science of Ankara University Master's Thesis, Ankara, 50 p.

Erman, M., H. Demirhan and M. Tuncturk. 2005. Determination of important agricultural and plant characteristics of some lentil varieties growing in winter in Siirt ecological conditions. *Turkey Fifth Field Crops Congress*, 1: 237-240.

Fehr, W.R. 1987. Genotyp x Enviroment Interaction. Principles of Cultivar Development, Vol: I. Theory and Tecnique (Ed.): Fehr, W.R. Macmillan Publishing Company, New York, 247-260.

Ghafoor, A., M. Zubair and B.A. Malik. 1990. Path analysis is mash (*Vigna mungo* L.). *Pak. J. Bot*., 22(2): 160-167.

Hamdi, A. and W. Erskine. 1996. Reaction of wild species of the genus Lens to drought. *Euphytica*, 91: 173-179.

Harris, H.C., W. Goebel and P.J. Cooper. 1987. Crop genotype environment interaction. In: (Eds.: Srivastava, J.P., E. Porceddu, E. Acevedo & S. Varma. Drought tolerance in winter cereals. pp. 37-54.

Hiltbrunner, J., B. Streit and M. Liedgens. 2007. Are graining densities an opportunity to increase grain yield of winter wheat in a living mulch of white clover? *Field Crops Res*., 102: 163-171.

Imani, A.A. and S.S. Moosavi. 2012. An evaluation on seed yield and yield components in various lentil genotypes under rain fed and irrigated Conditions. *World App. Sci. J*., 20(10): 1423-1425.

Kacar, O. and N. Azkan. 1997. A research on the determination of lentil varieties that can be grown in bursa ecological conditions. *Turkey Second Field Crops Congress*, 598-600.

Kakde, S.S., R.N. Sharma, A.S. Khilkre and B.M. Lambade. 2005. Correlation and path analysis studies (Lens culinaris L.). *J. Soils & Crops*, 15(1): 67-71.

Kaplan, G. 2015. Determination of yield and some yield components of the registered lentil (*Lens culinaris* Medik.) cultivars of Turkey. Institute of Science of Centennial University Master's Thesis, Van.

Karadavut, U. 2009. Path analysis for yield and yield components in Lentil (*Lens culinaris* Medik.). *Turk. J. Field Crops*, 14 (2): 97-104.

Kumar, R., S.K. Sharma, A. Sharma and S. Sharma. 2004. Path coefficient analysis of yield components in lentil (*Lens culinaris* Medik.). *Legume Res*., 27(4): 305-307.

Lichtenhaler, H.K. 1996. Vegetation stress: an introduction to the stress concept in plants. *J. Plant Physiol.*, 148: 4-14.

Loss, S.P. and K.H.M. Siddique. 1994. Morphological and physiological traits associated with wheat yield increases in mediterranean environments. *Adv. Agron*., 52: 229-276.

McKenzie, B.A. and G.D. Hill. 1995. Growth and yield of two chickpea (*Cicer arietinum* L.) varieties in Canterbury, New Zealand. *New Zealand J. Crop & Hort. Sci*., 23(4): 467-474.

Nayyar, H. 2005. Putrescine increases floral retention, pod set and seed yield in cold stressed chikpea. *J. Agron. & Crop Sci*., 191: 340-345.

Olmez, Z.T.A. 2011. *A study on yield and yield components of different lentil (Lens culinaris Medik) cultivars under Adiyaman conditions*. Institute of Sutcu Imam University Master's Thesis, Kahramanmaras.

Silim, S.N., M.C. Saxena and W. Erksine. 1993. Adaptation of lentil to the mediteranean environment: II. Response to moisture supply. *Exp. Agric*., 29: 21-28.

Solanki, I.S. 2006. Comparison of correlations and path coefficients under different environments in lentil (*Lens culinaris* Medik.). *Crop Improvement*, 33(1): 70-73.

Surek, D., E. Karakurt, K. Meyveci, A.S. Yururer, M. Karacam, B. Ozdemir and M. Avci. 2011. Determination of suitable seed rate on summer lentil cultivar Meyveci-2001. *J. Field Crops Central Res. Inst.*, 20(1): 22-28.

Toklu, F., A.E. Anlarsal, D. Sakar, T. Bicer, D. Mart and T. Karakoy. 2007. "Morphological and genetic characterization of local red lentil (*Lens culinaris* Medik) populations collected from southeastern anatolia region." TUBITAK, Project Number: 104O473.

Turk, Z. and M. Koc. 2003. A study on the determination of the factors limiting the yield and yield components of red lentil (*Lens culinaris* Medic.) In Ceylanpınar ecological conditions. *Turkey Fifth Field Crops Congress*, 2: 421-423.

Usha, M. and S.C. Dubey. 2010. Effect of environmental variables on development of fusarium wilt in chickpea (*Cicer arietinum*) cultivars. *Ind. J. Agri. Sci.*, 80(3): 231-234.

Verma, A.K., R.N. Matho and A. Bhattacharya. 2004. Path analysis in lentil (*Lens culinaris* Medik). *J. Res., Birsa Agricultural University*, 16(1): 135-138.

Vir, O. and V.P. Grupta. 2002. Analysis of relationships of yield factors in *Macrosperma* x *microsperma* derivatives of lentil. *Legume Research*, 25(1): 15-20.

Younis, N., M. Hanif, S. Sadiq, G. Abbas, M.J. Asghar and M.A. Haq. 2008. Estimation of genetic parameters and path analysis in lentil. *Pak. J. Agr. Sci*., 45(3): 44-48.

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