DOI: https://doi.org/10.55302/JAFES18723127go

DETERMINATION OF YIELD AND YIELD CHARACTERISTICS OF SOME EARLIER RED LENTIL LINES (*LENS CULINARIS* MEDIC.) IN F7 AND F8 LEVEL

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Abstract

Lentil is one of the most important crops all over the world. Lentil seeds contain high protein, vitamin and essential elements for human healthy. Lentil is produced wide area in Southeastern Anatolia Region of Turkey. This study was aimed to breeding of high yield red lentil varieties to Southeastern Anatolia region of Turkey. Study was conducted in 2011-2012 and 2012-2013 growing seasons under Sanliurfa conditions. Experiment was established to randomize complete block design with 4 replicates. In the study 6 earlier red lentil lines in F7 and F8 level which are obtained from ICARDA and 2 standard varieties were used as a crop material. Statistically differences were found among the tested lines and standard varieties. Flowering period, plant height, first pod height, thousand kernel weight and grain yield were significant at 0.01 levels. According to average of years; the highest grain yield obtained from line 2 (160.14 kg/da), whereas the lowest grain yield was found at line 5 (124.04 kg/da). Some better lines than others were selected in considering to flowering period, plant height, thousand kernel weight and grain yield values.

Keywords: Red lentil, earlier red lentil lines, Southeastern Anatolia, grain yield.

Introduction

Lentil (*Lens culinaris* Medic**.**) is an important food source for millions of people all over the world. Lentil belongs to the plant family Leguminosae, it has the ability to fix nitrogen from the air through a symbiotic relationship with bacteria housed in root nodules. At the same time, lentil is incredibly high in protein. In addition, lentil is a good source of vitamins A and B, fiber, potassium, and iron, making it a favorite for people on meat-free diets. In addition, stem and straw of lentil has high quality. It is very important to feed the animal. Moreover, lentil can be grown in rotation with cereal crops.

Red lentil is generally grown in semi-arid regions without irrigation such as Southern Eastern Anatolia region of Turkey. Red lentil is grown in the large areas in Turkey, especially Southern Eastern Anatolia region. Red lentil has 2 354 743 decar sowing area, 345 000 tones production and 147 kg/decar average yield in Turkey. Sanliurfa province which is located in the Southeastern Anatolia Region has the most sowing area and production in Turkey. Sanliurfa province has 1 02 032 decar sowing area, 96 086 ton production and 94 kg/decar average yield (Anonymous, 1997).

Main breeding aims are higher yields, resistance to disease, and suitability for mechanical harvesting, improving seed quality, earliness and resistance to lodge in Southeastern Anatolia Region. Some researchers' results which made in red lentil are given below. Bicer and Sakar (2008) reported that red lentil grain yield ranged from 776.8 kg/ha (FLIP 96-47L) to 3242.3 kg/ha (FLIP 2004-49L) in Diyarbakir conditions. Gupta et al. (1996) conducted a characterization study with 414 lentil lines in India. Researchers reported that the numbers of flowering days ranged from 87 to 143 days, the average weight of 100 kernels were 2.26 g, and the average length of the plant was 28.7 cm. Yılmaz et al. (1996) emphases that the highest yield was obtained from a winter-resistant Red 51 variety as 145.1 kg/da in Van ecological conditions. Aydogan et al. (2008) conducted a study to determine grain yield and some yield components of green and red lentils. They reported that the highest and the lowest average yields were 176.2 kg/da and 105.3 kg/da in winter red small sized lentil and spring green large sized lentil, respectively. Oktem and Oktem (2016) conducted a study in

2009-2010 and 2010-2011 growing seasons under Sanliurfa conditions. Researchers reported that genotypes were significant about days to flowering, plant height, first pod height, thousand kernel weight, biological yield and grain yield. Also Oktem (2016) conducted a research was to determine high yield red lentil varieties in 2013-2014 and 2014-2015 growing seasons under Sanliurfa conditions. It was reported that flowering period, plant height, thousand kernel weight and grain yield were found significant at 0.01 level and the highest grain yield was obtained from Sakar variety (186.16 kg/da) while the lowest grain yield was found at Yerli Kırmızı variety (72.82 kg/da). Nazir et al. (2014) conducted an experiment to evaluate performance of newly developed candidate lines of lentil (Lens culinaris) in Pakistan during 2011-12. Researchers reported that plant height varied from 29.67 to 38.67 cm.

This study was to aim developing of high yieldly and earliness red lentil varieties to Southeastern Anatolia Region of Turkey.

Material and methods

This study was conducted in 2011/12 and 2012/13 growing seasons under Sanliurfa conditions. Soil samples were taken from 0 to 20 cm soil layer a day prior to seedling; air dried, passed through a 2.00 mm sieve, and analyzed (Jones 1984). The soil of research field was clay, slightly alkaline, high in lime content, and very low in salt content. Soil properties and climatic data were given in Table 1 and Table 2, respectively.

In the study 6 earlier red lentil lines in F7 and F8 level which are obtained from ICARDA (International Center for Agricultural Research in the Dry Areas) collection and 2 standard varieties, which were Yerli Kırmızı (YK) and Fırat-87 (F-87) were used as a crop material.

Table 1. Some chemical properties of research area soil in 2011/12 and 2012/13

Year	Deep (cm)	EC (dS/m)	$CaCO_3$ (%)	pH	P_2O_5 (kg/da)	K_2O (kg/da)	Org. Mat. (%)
2011-12	0-20	62	25.8	7.86	1.05	118.5	0.93
2012-13	0-20	58	27.3	7.63	2.69	137.1	2.01

Table 2. Some meteorological parameters belong to the growth period of lentil†.

Year	Parameters	1	2	3	4	5	6	10	11	12
2011	Max. Temp. (^{0}C)	14.6	17.8	25.2	28.5	34.9	38.9	32.7	21.4	16
	Min. Temp. (^{0}C)	0.3	-0.9	2.3	4.3	11.3	17.7	8.8	-0.4	0.8
	Av. Temp. (^{0}C)	7.3	7.6	12.3	15.4	21.3	28.3	19.3	9.4	7.4
	Humidity (%)	62.9	64.7	46.1	59.9	46.6	30.3	53.7	53.7	57.4
	Rainfall (mm)	58	28.2	42	133.7	39.2	4.6	12.3	62.1	47.1
2012	Max. Temp. (^{0}C)	14.8	16.2	21.3	32.6	33.2	42.2	37	26.9	18.3
	Min. Temp. (^{0}C)	-4.3	-1.9	-1.7	6.6	13	17.6	11.6	7.1	1.7
	Av. Temp. (^{0}C)	5.5	5.8	9.7	19.3	22.4	30.6	21	14.9	8.3
	Humidity (%)	81	57	47.3	42.4	40.8	21.2	48.5	65.6	73
	Rainfall (mm)	170.9	95.8	35.8	23.3	42.3	5.8	35.2	68.4	142.8
2013	Max. Temp. (^{0}C)	16.4	19.5	24.9	34.3	36.4	41.5	32	27	16.9
	Min. Temp. (^{0}C)	-3	2.9	0.8	7.8	11.7	17.3	10.8	5.7	-2.5
	Av. Temp. (^{0}C)	6.8	9.3	12.9	18.4	22.9	29	19.3	14.8	6.1
	Humidity (%)	69.5	73.6		44.9	43.4	24	36.0	57.5	54.6
	Rainfall (mm)	86.8	107.2	12.1	18	56.2	-	-	19.5	76.7

1.January, 2.February, 3.March, 4.April, 5.May, 6.June, 10.October, 11.November, 12.December

†Data collected from the Sanliurfa Meteorological Station (Anonymous, 2014).

Experiment was established to randomize complete block design with 4 replicates. Each parcel was arranged in 6 rows. Plots were 5 m X 0.2 m dimensions. Research area was ploughed firstly (18-20

cm depth) and cultivated (10-12 cm depth) then prepared for planting with a single pass of a disk-harrow. Seeding was made by trial drill and 350 kernel/m^2 seed was used. At sowing, 60 kg ha^{-1} of pure N and P, as a 20-20-0 composed fertilizer was applied to each plot. Planting dates were 01.11.2011 and 03.12.2012, respectively. Plants were harvested in May at both years. All tested characteristics were measured on randomly selected 10 plants in the center of each plot. An analysis of variance was performed to evaluate statistically differences between results. Means of the data obtained from research were compared using Duncan test at P≤0.05.

Results and discussion

Variance analyses were performed separately for each year and combined of years for all traits. Variance analyses of plant height, first pod height, days to flowering, biological yield and grain yield in 2011-2012, 2012-2013 and combined analyses were given in Table 3.

Table 3. Variance analyses of plant height (cm), first pod height (cm), days to flowering (day), 1000 kernel weight (g) and grain yield (kg/da) in 2011-2012, 2012-2013 and combined analyses

2011-2012 Growing season						
		Mean Squares				
Source of Variation	**SD**	**Plant height**	**First pod height**	**Days to flowering**	**1000 kernel weight**	**Grain Yield**
Replication	3	0.979	6.701	8.531	2.214	83.475
Variety	8	56.839**	10.966*	85.281**	215.426**	2051.45**
Error	21	1.7049	4.718	3.7217	2.030	112.87
Total	31					
CV		3.59	11.55	1.51	3.64	6.38
2012-2013 Growing season						
		Mean Squares				
Source of Variation	**SD**	**Plant height**	**First pod height**	**Days to flowering**	**1000 kernel weight**	**Grain Yield**
Replication	3	7.551	2.227	12.583	0.733	259.651
Variety	8	17.473*	17.309*	56.50**	196.08**	1322.20*
Error	21	7.6765	5.7154	2.0357	1.331	307.74
Total	31					
CV		10.03	12.03	1.37	2.67	14.70
Combined Analyses						
		Mean Squares				
Source of Variation	**SD**	**Plant height**	**First pod height**	**Days to flowering**	**1000 kernel weight**	**Grain Yield**
Year (Y)	1	1235.82**	18.24	9096.391**	275.5738**	35430.2**
Replication	3	6.08	0.56	19.1823	2.1195	97.808
Variety (V)	7	51.47**	10.46*	6.9092**	395.01**	1209.64**
Y X V	7	22.80*	17.82*	0.2844	16.497**	2164.0**
Error	45	4.5413	5.0245	2.816	1.624	212.64
Total	63					
CV		6.66	11.6	1.44	3.09	10.21

* ,** indicates statically significant at 0.05 and 0.01 respectively

Plant height (cm)

According to results of variance analysis; plant height was found statistically significant in both trait years (Table 3). In combined analyses, year, variety and year X variety were statistically significant. Plant height values ranged from 31.7 to 42.4 cm in first year and 25.0 to 30.3 cm in second year (Table 4). The highest plant height values were obtained from Fırat-87 in first year. Yerli Kırmızı and line 1 gave the highest plant height in second year. According to both years of average, the highest plant height values were obtained from standard verities (Fırat-87 and Yerli Kırmızı). But it was

observed that Fırat-87 and Yerli Kırmızı standard varieties had more lodging than others. Hanlan et al. (2006) explained that tall lentil plants have more lodging tendency. Plant height values of lines were smaller than standard verities in both years. Some results were explained by some researchers. Oktem (2016) explained that the highest plant height value was obtained from Seyran-96 (45.1 cm), while the lowest plant height value was seen at the Kafkas variety (37.3 cm) in Sanliurfa condition. Bicer and Sakar (2007) reported that local verities had higher plant height than ICARDA lines in Diyarbakir conditions. Nazir et al. (2014) reported that plant height varied from 29.67 to 38.67 cm.

Table 4. Plant height and first pod height values and Duncan groups

Lines /	Plant height (cm)			First pod height (cm)		
Varieties	2011-12**	2012-13*	Average**	2011-12*	2012-13*	Average*
Line 1	34.1 de	30.3 a†	32.2 bc	19.9 ab	22.4 ab	21.15 a
Line 2	37.9 b	28.9 ab	33.4 ab	19.3 ab	21.8 ab	20.55 a
Line 3	35.6 cd	27.3 b	31.45cd	19.9 ab	17.9 c	18.90 ab
Line 4	36.1 bc	27.8 ab	31.95bc	16.0 c	22.7 a	19.35 ab
Line 5	31.7 f	26.0 b	28.85d	16.8 bc	19.1 bc	17.95 b
Line 6	32.8 ef	25.0 b	28.9d	18.2 a-c	17.8 c	18.00 b
YK	40.8 a	30.3 a	35.5 a	19.8 ab	18.1 c	18.95 ab
F-87	42.4 a	27.4 ab	34.9a	20.7 a	19.3 abc	20.00 ab
Average	36.425	27.875	32.15	18.83	19.89	19.36
LSD	1.92	3.516	2.15	3.19	3.516	2.26

†: There is no statistical difference among values annotated with the same letter at P<0.05 according to the Duncan test.
*, ** : indicates statistical significant at 0.05 and 0.01 level, respectively.

First pod height (cm)

As can be seen from Table 3, first pod height values were statically significant in both years (P<0.05). In combined analysis; year, variety and year X variety were statically significant (P <0.05).
The highest value was obtained from F-87 variety (20.7 cm) in first growing season while the highest value was obtained from Line 4 (22.7 cm) in second growing season (Table 4). According to two years average; first pod height ranged from 17.95 cm to 21.15 cm. Line 1 and Line 2 of first pod height values were higher than standard verities and other lines. First pod height is important characteristics for machine harvesting. Aydogan et al. (2002) reported that the first pod height must be at least 12 cm for machine harvesting. Our results were in accord with some researchers results.

Table 5. Plant height and first pod height values and Duncan groups

Lines /	Days to flowering (day)			1000 seed weight (g)		
Varieties	2011-12**	2012-13**	Average**	2011-12**	2012-13**	Average
Line 1	123.0 d	100.8 c	111.9 d	46.5 ab	55.3 a	50.9 a
Line 2	126.0 bc	102.3 bc	114.15 c	47.4 a	48.0 b	47.7 b
Line 3	126.5 bc	101.0 c	113.75 cd	26.2 e	32.5 e	29.35 g
Line 4	124.5 cd	103.3 b	113.9 c	39.0 c	43.1 c	41.05 d
Line 5	128.5 b	103.5 b	116 b	31.8 d	38.4 d	35.1 f
Line 6	126.0 bc	102.8 bc	114.4 bc	44.8 b	47.5 b	46.15 c
YK	135.0 a†	109.5 a	122.25 a	38.0 c	39.0 d	38.5 e
F-87	135.3 a	110.8 a	123.05 a	39.4 c	42.6 c	41 d
Ave.	128.1	104.25	116.175	39.1	43.3	41.2
LSD	2.84	2.174	1.69	2.10	1.697	1.28

†: There is no statistical difference among values annotated with the same letter at P<0.05 according to the Duncan test.
*, ** : indicates statistical significant at 0.05 and 0.01 level, respectively.

Bicer and Sakar (2007) reported that some pod height of Icarda lines were between 9.67 and 14.67 cm. Erman et al. (2005) stated that first pod height ranged from 10.0 to16.0 cm. Oktem and Oktem (2016) reported that first pod height values ranged from 27.6 cm and 13.7 cm at small red lentil varieties in Sanliurfa conditions.

Days to flowering (day)

According to variance analyses days to flowering was significant in both year (P<0.01). In combined analyses, year and variety were significant at P<0.01 level (Table 3). Days to flowering were between 123.0 day (line 1) and 135.3 day (F.87) in first year, whereas 100.8 day (Line1) and 110.8 day (F-87) in second year (Table 4). According to average of years; days to flowering values changed from 123.05 day (Fırat-87) to 111.9 day (line 1). Earlier lines had earlier flowering period than standard verities. Some researchers' findings were good agreement with our findings about days to flowering period. Turk and Atikyılmaz (1999) reported that the lines from ICARDA were earlier than Yerli Kırmızı and Fırat-87. Aydoğan et al. (2005) reported that Fırat-87 variety had late maturation and late flowering period. Nazir et al. (2014) explained that days to flowering ranged from 80.67 to 114.67 days.

1000 Kernel weight (g)

According to result of variance analyses; 1000 kernel weight value was found statistically significant in first year (P<0.01) and second year (P<0.05), respectively. In combined analyses, year, varieties and year X varieties were significant (P<0.01). Thousand kernel weight values varied between 26.2 g (Line3) and 47.4 g (Line2) in first year while 32.5 g (Line 3) and 55.3 g (Line 1) in second trait year (Table 5). According to both years of average, the highest 1000 kernel weight value found at line 1 (50.9 g). 1000 kernel weight value of second year was higher than first year value due to rainfall of 2011-2012 growing period higher than 2012-2013 growing period. Erksine and Ashkar (1993) stated that the environment have a significant impact on thousand grain weight. Nleya et al. (2000) emphasize that location and variety effects 1000 kernel weight value.

Grain yield (kg/da)

According to variance analysis results, grain yield was statistically significant in both years (P<0.01). In combined analyses; year, varieties and year X varieties were found statistically significant at 0.01 level (Table 3). It can be seen from Figure 1 that grain yield values ranged from 128.06 kg/da (Line1) to 190.28 kg/da (Line 2) in first year while varied from 101.6 (Yerli Kırmızı) to 156.7 kg/da (Line 1). According to years of average, the highest grain yield value was obtained from line 2 (160.1 kg/da) whereas the lowest grain yield was found at Line 5 (124 kg/da). Similar findings reported by some researchers. Yılmaz et al. (1996) stated that the highest grain yield was obtained from winter-resistant Red 51 variety (145.1 kg/da). Oktem and Oktem (2016) reported that small red lentil genotypes were significant about days to flowering, plant height, first pod height, thousand kernel weight, biological yield and grain yield. They obtained from the highest grain yield line 1 (228 kg/da), whereas the lowest grain yield was found at Yerli Kırmızı standard variety (138.9 kg/da) in Sanliurfa conditions. Sakar and Biçer (2003), conducted a with 1 line and 4 lentils varities that the highest grain yield obtain from in Seyran 96. (232.5 kg / da) in Diyarbakır condition.

First year grain yield values were higher than second year values. Rainfall was regularly in the first year especially in the pod binding period. But second year rainfall were insufficient and irregular. Reason of low yields in 2012-2013 growing seasons can be explain as insufficient and irregular rainfall during pod binding period (Table 1). Erksine and Ashkar (1993) reported that variation about 80% on grain yield stemmed from seasonal raining. Silim et al. (1993) emphasized that rainfall effects grain yield especially in pod binding period. If raining is regular in pod binding period, grain yield will be high.

Table 6. Grain yield values and Duncan groups

Lines / Varieties	Grain Yield (kg/da)		
	2011-2012**	2012-2013*	Average**
Line 1	128.06 d	156.7 a	142.4 b
Line 2	190.28 a†	130.0 b	160.1 a
Line 3	179.44 ab	128.0 b	153.7 ab
Line 4	182.50 ab	113.8 bc	148.2 ab
Line 5	141.39 cd	106.7 bc	124.0 d
Line 6	172.50 b	107.7 bc	140.1 bc
YK	153.33 c	101.6 c	127.5 cd
F-87	183.33 ab	110.0 bc	146.7 ab
Average	166.4	119.3	142.8
LSD		25.797	14.685

†: There is no statistical difference among values annotated with the same letter at P<0.05 according to the Duncan test.

*, ** : indicates statistical significances at 0.05 and 0.01 level, respectively.

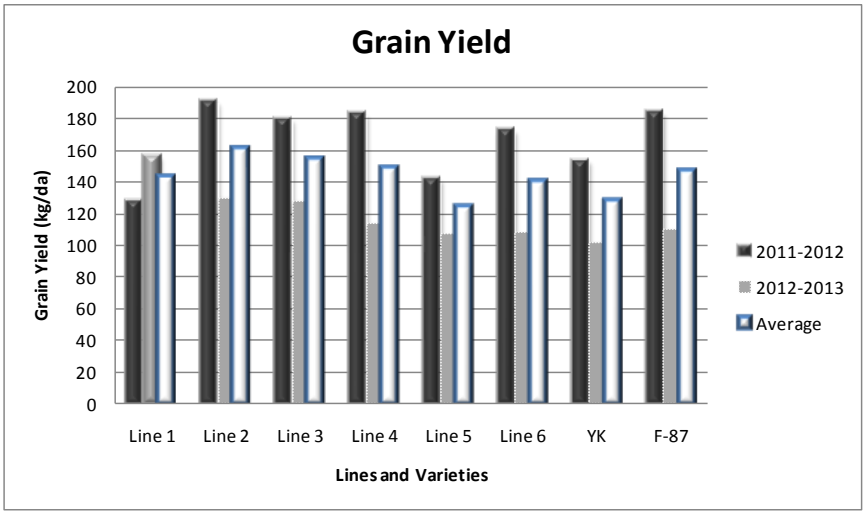

Figure 1. The grain yield values obtained from lines and varieties

Conclusions

According to two years research results; considering to flowering period, plant height, thousand kernel weight and grain yield; line 1, line 2, line 3, line 4 were found better than others.

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