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Agricultural Performances of Some Safflower (*Carthamus tinctorius* L.) Lines Developed by Single Plant Selection Method

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ABSTRACT

This study was carried out to determine seed and oil yield with their components of some safflower lines and varieties under Eskisehir ecological conditions. This research was conducted at the experimental fields of Transitional Zone Agricultural Research Institute (TZARI), during 2010, 2011 and 2012. Both twenty-one safflower lines and four varieties (Yenice, Dincer, Remzibey and Balci) originating from TZARI-Eskisehir were evaluated in this research. The lines used in this study are developed by using single plant selection method. Three years data were collected and analyzed according to randomized block design with three replications. Means of seed yield, number of head per plant, head diameter, 1000 seed weight, oil content, oil yield were found 1330.3-1990.9 and 1210.1 kg ha^{-1}, 11.2-12.3 and 9.6 number plant^{-1}, 2.28-2.42 and 2.54 cm, 41.6-45.7 and 44.1 g, 36.1-36.6 and 35.6%, 470.9-730.0 and 430.0 kg ha^{-1} in 2010, 2011 and 2012, respectively. According to all years and combined analysis results of this study, lines GE-ES-YA-36-36, GE-ES-YA-36-7 in terms of seed yield, lines GE-ES-YA-36-30, GE-ES-YA-36-25, GE-ES-YA-36-26, GE-ES-YA-36-27 in terms of oil content and lines GE-ES-YA-36-36, GE-ES-YA-36-7, GE-ES-YA-36-4 terms of oil yield were listed at the highest statistical group. As a result of this study, it was decided that these lines could be candidate varieties with regard to these different characteristics.

Keywords: Safflower; Selection; Lines; Seed yield; Oil yield

Tek Bitki Seleksiyonu Islahı ile Geliştirilmiş Bazı Aspir (*Carthamus tinctorius* L.) Hatlarının Tarımsal Performansları

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ÖZET

Bu çalışma, Eskişehir ekolojik koşulları altında, bazı aspir hat ve çeşitlere ait tane ve yağ verimleri ile komponenetlerinin belirlenmesi amacı ile yürütülmüştür. Araştırma, 2010, 2011 ve 2012 yıllarında, Geçit Kuşağı Tarımsal Araştırma

Enstitüsü (GKTAE) deneme tarlalarında gerçekleştirilmiştir. Çalışmada, GKTAE-Eskişehir tarafından geliştirilmiş 21 adet hat ve 4 standart çeşit (Yenice, Dincer, Remzibey ve Balcı) kullanılmıştır. Çalışmada kullanılan hatlar tek bitki seleksiyon ıslahı yöntemi ile elde edilmiştir. 3 yıla ait veriler, tesadüf blokları deneme desenine uygun olarak analiz edilmiştir. Araştırmada, ortalama tane verimi, bitkide tabla sayısı, tabla çapı, 1000 tane ağırlığı, yağ oranı, yağ verimi değerleri 2010, 2011 ve 2012 yıllarında sırasıyla, 1330.3-1990.9 ve 1210.1 kg ha^{-1}, 11.2-12.3 ve 9.6 adet $bitki^{-1}$, 2.28-2.42 ve 2.54 cm, 41.6-45.7 ve 44.1 g, 36.1-36.6 ve 35.6%, 470.9-730.0 ve 430.0 kg ha^{-1} olarak bulunmuştur. Yıllara ve birleştirilmiş analiz sonuçlarına göre; tane verimi bakımından GE-ES-YA-36-36, GE-ES-YA-36-7, yağ oranı bakımından GE-ES-YA-36-30, GE- ES-YA-36-25, GE- ES-YA-36-26, GE-ES-YA-36-27, yağ verimi bakımından ise; GE-ES-YA-36-36, GE-ES-YA-36-7, GE-ES-YA-36-4 hatları istatistiki olarak ilk grupta yer almıştır. Çalışma sonuçlara göre, bu hatların belirlenen farklı özellikler bakımından aday çeşit olabileceği sonucuna varılmıştır.

Anahtar Kelimeler: Aspir; Seleksiyon; Hat; Tane verimi; Yağ verimi

1. Introduction

Turkey is undergoing an increasing loss of foreign exchange for many years due to the ongoing oil deficit in every year. To solve this problem, it is necessary to add other oilseed crop in production, beside of the increase yield of existing oilseed crops. Safflower has capable of wide adaptation, high drought resistance and can grow in arid areas (Omidi et al 2012; El-Lattief 2012). Safflower oil is of great importance as well as important for human nutrition as a raw material for biodiesel (Bergman & Charles 2008; Mündel 2008; Sujatha 2008; Uher 2008). Taken into consideration cultivation requests of safflower, it can be cultivating easily. It is a suitable plant applied to fallow and wheat cultivating systems in Turkey (Kose et al 2011).

In our country, although safflower production area was about 2,000 ha in 1970's, it gradually decreases about 30-40 ha at the beginning of the 2000's (TSI 2014). This situation has negative effect of the safflower breeding programs in Turkey. In last year, recognizing the importance of the safflower cause to increase production and breeding researches. According to data, in Turkey, safflower harvested area was 29,259 ha, production quantity is 45,000 tons and yield 1,530 kg ha^{-1}, which was above the world yield average (FAO 2014).

Breeding program, in accordance with the different objectives, is designed for developing new varieties and is used different breeding method. Selection is one of the oldest breeding procedures and is the basis of all crop improvement. Essentially, selection is a process, either natural or artificial, by which individual plants or groups of plants are sorted out from mixed population (Poehlman 1978). Nowadays, single plant selection method is mostly used in safflower breeding program (Fernandez Martinez et al 1986). In this method single plants are selected according to the morphological and quality parameters from population until obtaining breeding objectives.

This study aimed to estimate the performances of 21 safflower lines, which are used in this study are developed by using single plant selection method as compared to varieties for releasing new safflower varieties.

2. Material and Methods

Field trials were performed in 2010, 2011 and 2012 by using 21 safflower lines and 4 varieties (Yenice, Dincer, Remzibey and Balci) developed by Transitional Zone Agricultural Research Institute (39° 45'' 57' N, 30° 24'' 5' E) in Turkey.

These lines derived from 4 different population P-010, P-029, P-101, P-201 originated from Turkey, Balikesir; China, Qinghai; Turkey, Eskisehir; Turkey Isparta, respectively. The efficiency of a selection program mainly depends on the degree of genetic variation and heritability of a trait (Falconer & Mackay 1981; Shinwari et al 2014). A significant level of phenotypic variation was noticed among the population for most of the characters. Lines were developed by using single plant selection method their characteristic and origin are given in Table 1. This method is regarded as the most effective for varietal development in safflower (Singh & Nimbkar 2007). According to the method, individual plants of each genotype were selected in terms of some morphological and agronomic parameters (flower colour, spines, earliness, plant height, head number per plant and number of seed per head) correlated to seed yield and oil content (Khidir 1974; Patil et al 1994; Malleshappa et al 2003; Alizadeh 2005; Omidi et al 2012; Rudolphi et al 2012). Each year selected single plants replanted next year as a new generation. When the selection reached S_7, the plots were harvested in bulk and genotype evaluated screening nursery especially seed yield, oil content and oil yield. Material selection was ended in S_8.

Experimental location has typically a steppe climate with temperature differences between day and night and dries in summer, relatively rainy winter. The weather conditions during the experimental period are presented in Table 2. Soil is clayey and neutral in reaction. It is poor in organic matter and reach in available potassium and phosphorus content. Trials were set up in randomized complete block design with three replications; 80 kg ha^{-1} nitrogen and 60 kg ha^{-1} phosphorus were applied at seeding. Plots were 5 m long, with 45 cm between rows and 5-10 cm between plants within rows after thinning. A length of 45 cm on both sides of the

Table 1- Some morphological characteristics of the genotypes

Genotype	*Line/Variety*	*Flower colour*	*Spines*	*Genotype*	*Line/Variety*	*Flower colour*	*Spines*
GE-36-2	Line	Yellow	Spiny	GE-36-25	Line	Yellow-Orange	Spiny
GE-36-3	Line	Yellow-Orange	Spiny	GE-36-26	Line	Yellow-Orange	Spiny
GE-36-4	Line	Yellow-Orange	Spiny	GE-36-27	Line	Yellow	Spiny
GE-36-6	Line	Yellow	Spiny	GE-36-28	Line	Yellow-Orange	Spiny
GE-36-7	Line	Yellow	Spiny	GE-36-29	Line	Yellow	Spiny
GE-36-8	Line	Yellow	Spiny	GE-36-30	Line	Yellow-Orange	Spiny
GE-36-9	Line	Yellow-Orange	Spiny	GE-36-34	Line	Yellow-Orange	Spiny
GE-36-10	Line	Yellow	Spiny	GE-36-36	Line	Yellow-Orange	Spiny
GE 36-11	Line	Yellow-Orange	Spiny	BALCI	Variety	Yellow	Spiny
GE-36-12	Line	Yellow	Spiny	REMZİBEY	Variety	Yellow-Orange	Spiny
GE-36-13	Line	Yellow-Orange	Spiny	DİNÇER	Variety	Orange-Red	Spineless
GE-36-14	Line	Yellow-Orange	Spiny	YENİCE	Variety	Red	Spineless
GE-36-17	Line	Yellow	Spiny				

Table 2- Monthly and growing season mean temperature, rainfall and relative humidity in 2010, 2011 and 2012

Month	*Mean temperature (°C)*				*Rainfall (mm)*				*Relative humidity (%)*			
	Long term	*2010*	*2011*	*2012*	*Long term*	*2010*	*2011*	*2012*	*Long term*	*2010*	*2011*	*2012*
March	4.9	5.9	3.7	1.5	33.4	32.6	20.0	56.4	82.3	85.5	88.0	87.7
April	10.4	9.2	7.2	12.0	35.2	23.9	56.9	22.1	85.6	84.3	91.0	72.6
May	14.9	15.2	0.5	14.4	43.3	20.7	145.8	80.9	75.9	70.4	87.7	83.3
June	18.9	18.1	16.6	20.0	28.6	79	9.4	0	80.4	82.8	84.6	71.6
July	21.5	22	21.6	22.8	13.5	7.4	8.5	5.5	69.2	75.4	70.8	68.1
August	21.1	24.4	20.0	20.8	6.4	0.9	0	3.5	71.2	66.2	73.5	65.1
Mean	15.3	15.8	11.6	15.3	-	-	-	-	77.4	77.4	82.6	74.7
Total	-	-	-	-	160.4	164.5	240.6	168.4	-	-	-	-

rows in each plot was left as border effects. Date of planting is made in the month of March every three years. The trial was performed under natural conditions without irrigation. During growing season weeds were controlled by hand. Plants were harvested in August.

Samples of each plot were obtained to determine seed yield (kg ha^{-1}), number of heads per plant (number), head diameter (cm), 1000 seed weight (g), oil content (%) and oil yield per hectare (kg ha^{-1}). Oil content of genotype was determined by using Soxhlet apparatus. Oil yield was calculated by multiplying oil content and the seed yield of each plot. Analysis of variance (ANOVA) was performed with the statistical package JMP 5.0.1 (SAS 1989-2002). Statistically significant differences among the mean values were determined with the least significant difference (LSD) test at the 0.05 level.

3. Result and Discussion

In this study, significant differences were determined between the genotypes for all the traits investigated in three years of the study and according to the three-year combined analysis, which implied genetic variation existed for these traits. The analysis demonstrated that significant difference existed between the years expect for head diameter. Year x genotype interaction was found important for all the traits investigated (Table 3, 4 and 5). It is because that there was some environmental factor in

Table 3- Mean values and statistics group of seed yield and number of head per plant studied some safflower lines and varieties in 2010, 2011, 2012 and 2010-2012

Genotype§	*Seed yield (kg ha^{-1})*				*Number of head per plant*			
	2010	*2011*	*2012*	*2010-12*	*2010*	*2011*	*2012*	*2010-12*
GE-ES-YA-2	1390.0 a-f	1841.7 c-g	1180.5 c-f	1470.2 f-ı	11.2 b-f	10.8 f-j	9.6 b-g	10.5 d-ı
GE-ES-YA-3	1330.9 a-f	1682.6 d-g	1260.5 cd	1420.9 g-j	10.7 c-f	11.4 d-ı	10.6 a-d	10.9 c-g
GE-ES-YA-4	1490.8 a-c	1920.8 b-g	1560.7 ab	1660.2 b-f	11.0 b-f	12.9 a-f	11.2 ab	11.7 b-d
GE-ES-YA-6	1450.2 a-d	1723.1 d-g	1600.0 a	1590.2 c-g	12.0 a-c	11.9 b-h	11.7 a	11.9 a-c
GE-ES-YA-7	1530.9 ab	2327.6 a-c	1630.0 a	1830.2 ab	11.4 b-e	13.4 a-f	10.0 b-f	11.6 b-d
GE-ES-YA-8	1280.1 c-g	2117.7 b-d	1130.7 c-f	1510.2 d-h	10.5 c-f	14.2 a-c	9.4 d-h	11.4 b-e
GE-ES-YA-9	1300.2 c-g	1728.0 d-g	1020.0 d-g	1350.0 h-k	11.0 b-f	11.7 c-h	7.9 h	10.2 e-ı
GE-ES-YA-10	1410.1 a-e	1893.1 b-g	1240.3 c-e	1510.6 d-h	12.1 a-c	10.8 e-j	8.2 g-h	10.4 e-ı
GE-ES-YA-11	1360.0 a-f	2042.8 b-e	1000.0 e-g	1460.8 f-ı	10.6 c-f	12.8 a-g	8.9 e-h	10.8 c-h
GE-ES-YA-12	1440.0 a-d	2658.6 a	1280.0 cd	1790.3 a-c	12.6 ab	14.8 a	9.3 d-h	12.2 ab
GE-ES-YA-13	1370.3 a-f	2403.0 ab	1020.5 d-g	1600.1 c-g	13.2 a	14.4 ab	9.2 d-h	12.3 ab
GE-ES-YA-14	1400.4 a-e	2388.3 ab	1270.3 cd	1680.9 b-e	13.2 a	14.9 a	11.0 a-c	13.0 a
GE-ES-YA-17	1180.1 fg	2034.8 b-e	960.7 fg	1390.4 g-j	9.7 fg	12.6 a-g	8.5 f-h	10.3 e-ı
GE-ES-YA-25	730.2 h	2081.5 b-d	850.7 g	1220.3 jk	8.7 g	12.6 a-g	8.9 e-h	10.1 f-ı
GE-ES-YA-26	1080.7 g	1405.1 g	980.0 fg	1150.8 k	9.9 e-g	10.2 g-j	8.2 g-h	9.4 ı
GE-ES-YA-27	1260.1 d-g	1536.8 e-g	1070.3 c-g	1290.0 ı-k	10.2 d-g	9.7 h-j	9.6 b-g	9.8 g-ı
GE-ES-YA-28	1500.0 a-c	2333.6 a-c	1320.0 bc	1710.8 b-d	10.9 c-f	14.3 a-c	9.9 b-f	11.7 b-d
GE-ES-YA-29	1300.3 c-g	1817.0 c-g	1300.7 bc	1470.6 f-ı	11.8 a-d	13.7 a-d	9.4 d-h	11.6 b-d
GE-ES-YA-30	1320.1 b-f	1935.4 b-f	1240.7 c-e	1500.1 e-h	11.0 b-f	13.5 a-e	8.7 e-h	11.1 b-f
GE-ES-YA-34	1290.0 c-g	2029.6 b-e	1140.4 c-f	1480.8 e-ı	10.3 d-g	8.3 j	10.2 a-e	9.6 h-ı
GE-ES-YA-36	1560.0 a	2683.9 a	1740.0 a	1990.5 a	12.0 a-c	13.1 a-f	10.3 a-e	11.8 bc
YENİCE	1210.7 e-g	1446.7 f-g	1110.7 c-g	1260.0 jk	10.9 b-f	8.9 ıj	9.9 b-f	9.9 f-ı
DİNÇER	1400.4 a-f	2031.9 b-e	1090.7 c-g	1510.1 e-h	11.9 a-d	13.8 a-d	10.3 a-e	12.0 a-c
REMZİBEY	1340.2 a-f	1793.3 d-g	1000.0 e-g	1370.8 h-j	11.6 a-d	11.8 b-h	9.4 c- h	11.0 c-g
BALCI	1340.0 a-f	2113.3 b-d	1200.7 c-f	1550.3 d-h	11.1 b-f	11.7 c-h	9.8 b-g	10.9 cg
Mean	1330.3	1990.9	1210.1	1510.4	11.2	12.3	9.6	11.0
Genotype	**	**	**	**	*	**	*	**
Year				**				*
Genotype x Year				**				**

§, means in the same column followed by the same letters were not significantly different at 0.05 level using LSD test; * and **, significant at the 5 and 1% level, respectively

Table 4- Mean values and statistics group of head diameter and 1000 seed weight studied some safflower lines and varieties in 2010, 2011, 2012 and 2010-2012

Genotype§	*Head diameter (cm)*				*1000 seed weight (g)*			
	2010	*2011*	*2012*	*2010-12*	*2010*	*2011*	*2012*	*2010-12*
GE-ES-YA-2	2.33 b-g	2.17 gh	2.63 a-d	2.38 c-g	42.8 d-ı	47.5 a-d	44.5 c-f	45.0 c-ı
GE-ES-YA-3	2.60 ab	2.17 gh	2.27 e-g	2.34 e-g	41.7 f-j	45.0 b-f	43.4 d-f	43.4 g-j
GE-ES-YA-4	2.33 b-g	2.45 b-f	2.87 ab	2.55 bc	39.8 h-k	43.8 e-h	39.5 ıj	41.0 kl
GE-ES-YA-6	2.13 f-ı	2.38 d-g	2.20 g	2.24 g	43.2 c-h	46.5 a-e	47.9 ab	45.9 c-e
GE-ES-YA-7	2.10 g-ı	2.40 c-g	2.23 fg	2.24 g	47.8 ab	47.6 a-d	48.4 a	47.9 ab
GE-ES-YA-8	2.30 c-h	2.40 c-g	2.63 a-d	2.44 c-f	42.2 e-j	45.7 a-f	44.5 c-f	44.1 e-j
GE-ES-YA-9	2.20 e-ı	2.40 c-g	2.70 a-c	2.43 c-f	39.3 ı-k	44.6 c-f	44.2 d-f	42.7 jk
GE-ES-YA-10	2.62 a	2.80 a	2.90 a	2.77 a	39.0 jk	48.6 ab	47.3 a-c	45.0 c-h
GE-ES-YA-11	2.10 g-ı	2.57 a-d	2.33 d-g	2.33 e-g	45.3 a-e	49.1 a	45.8 a-e	46.7 a-c
GE-ES-YA-12	2.40 a-f	2.27 e-h	2.70 a-c	2.46 c-e	43.5 c-g	47.6 a-d	47.4 a-c	46.2 b-d
GE-ES-YA-13	2.03 hı	2.40 c-g	2.27 e-g	2.23 g	46.5 a-c	45.2 b-f	45.6 a-e	45.8 c-f
GE-ES-YA-14	2.13 f-ı	2.10 h	2.47 c-g	2.23 g	46.4 a-d	47.9 a-c	45.9 a-d	46.7 a-c
GE-ES-YA-17	2.17 e-ı	2.50 b-e	2.57 b-e	2.41 c-g	41.1 f-k	45.9 a-e	44.6 c-f	43.9 f-j
GE-ES-YA-25	2.10 g-ı	2.20 f-h	2. 53 c-f	2.27 fg	34.4 lm	44.1 d-g	42.7 e-h	40.4 l
GE-ES-YA-26	2.20 e-ı	2.53 b-d	2.49 c-g	2.41 c-g	41.3 f-k	42.2 f-h	39.7 h-j	41.1 kl
GE-ES-YA-27	2.19 e-ı	2.27 e-h	2.53 c-g	2.33 e-g	42.3 e-j	46.2 a-e	45.3 b-f	44.6 d-j
GE-ES-YA-28	2.23 d-ı	2.50 b-e	2.43 c-g	2.39 c-g	40.0 g-k	45.8 a-f	45.9 a-d	43.9 e-j
GE-ES-YA-29	2.21 e-ı	2.27 e-h	2.60 a-d	2.36 d-g	39.3 ı-k	40.8 gh	40.2 g-j	40.1 l
GE-ES-YA-30	2.40 a-f	2.40 c-g	2.50 c-g	2.43 c-f	32.5 m	40.2 h	35.7 k	36.2 m
GE-ES-YA-34	2.53 a-c	2.53 b-d	2.90 a	2.66 ab	39.1 jk	43.6 e-h	38.8 jk	40.5 l
GE-ES-YA-36	2.00 ı	2.70 ab	2.33 d-g	2.34 e-g	48.0 a	48.9 a	48.3 ab	48.4 a
YENİCE	2.30 c-h	2.63 a-c	2.67 a-c	2.53 b-d	38.0 kl	48.2 a-c	42.9 d-g	43.0 ı-k
DİNÇER	2.42 a-e	2.50 b-e	2.50 c-g	2.47 b-e	44.2 b-f	45.90 a-e	45.3 a-f	45.1 c-g
REMZİBEY	2.50 a-d	2.43 c-f	2.50 c-g	2.48 b-e	41.2 f-k	45.67 a-f	42.3 f-ı	43.1 h-j
BALCI	2.40 a-f	2.53 b-d	2.70 a-c	2.54 bc	40.6 g-k	44.80 c-f	45.7 a-e	43.7 g-j
Mean	2.28	2.42	2.54	2.41	41.6	45.7	44.1	43.8
Genotype	**	**	**	**	**	**	**	**
Year				ns				*
Genotype x Year				*				*

§, means in the same column followed by the same letters were not significantly different at 0.05 level using LSD test; * and **, significant at the 5 and 1% level, respectively; ns, not significant

year effect which was responsible for differences in cultivar responses to this trait. Means of seed yield, number of head per plant, head diameter, 1000 seed weight, oil content, oil yield were found 1330.3-1990.9 and 1210.1 kg ha^{-1}, 11.2-12.3 and 9.6 number $plant^{-1}$, 2.28-2.42 and 2.54 cm, 41.6- 45.7 and 44.1 g, 36.1-36.6 and 35.6%, 470.9-730.0 and 430.0 kg ha^{-1} in 2010, 2011 and 2012, respectively (Table 3, 4 and 5).

3.1. Seed yield

To increase seed yield is one of the main aim in breeding research of field crops and it is also important to determine high yielding genotype in safflower. Environmental condition is as important as genotype on grain yield, therefore breeders want to tested performance lines and varieties developed in different years and location.

When the results examined, mean of seed yield were found 1330.3 kg ha^{-1} in 2010, 1990.9 kg ha^{-1} in 2011, 1210.1 kg ha^{-1} in 2012 (Table 3). It was determined that the second year had higher seed yield than the others. The reason is that experimental location took high rainfall, especially, during the early stages of development in 2011 (Table 2**).** It was emphasized that seed yield was significantly affected water supply and rain, particularly during early stage of safflower (Agasimani et al 1997; Uslu et al 2002).

Considering grain yield mean values, the highest seed yield was obtained from line GE-36-36 all years of the study and three-year averages and this line gave 1560.0 kg ha^{-1}, 2683.9 kg ha^{-1}and 1740.0 kg ha^{-1} seed yield in 2010, 2011 and 2012, respectively. Based on the average of the combined values of three years, GE-ES-YA-36-36 (1990.5 kg ha^{-1}), GE-ES-YA-36-7 (1830.2 kg ha^{-1}), GE-ES-YA-36-12 (1790.3 kg ha^{-1}) belonged to the same group, with respect to seed yield (Table 3). To consider of this trial value of the varieties; Balci reached 1550.3 kg ha^{-1} and Dincer (1510.1 kg ha^{-1}), Remzibey (1370.8 kg ha^{-1}) and Yenice (126.0 kg ha^{-1}) followed. When the result examined, large number of lines passed the varieties in terms of seed yield. Genotype and ecological factors are two major factors, which are influential on seed yield. Beside of this seed yield was the most affected trait from the environment (Camas & Esendal 2006). The evaluation of seed yield values demonstrated that variations existed between the lines and varieties. These variations were considered may have been from the reactions of the different cultivars and lines to different ecological conditions. It was reported that, seed yield varied 1164.0-2810.0 kg ha^{-1} Bergman et al (1989); 920.0-1050.0 kg ha^{-1} Muralidharudu & Nagaraj (1990); 1030.0-1250.0 kg ha^{-1} Bayraktar (1995); 1300.0-2700.0 kg ha^{-1} Reinbrecht et al (2005); 1330.0-2394.0 kg ha^{-1} Koutroubas & Papadoska (2005); 1107.5-1823.8 kg ha^{-1} Camas et al (2007); 1706.0-3111.0 kg ha^{-1} Kizil et al (2008); 971.0-1585.0 kg ha^{-1} Beyyavas et al (2011) and 1602.0-2167.0 kg ha^{-1} Zarei et al (2011). In this research differences and similarities between the results of the previous researches referred above and also in this trial might be concerned with genetic diversity of the genotypes, different ecological condition and agronomic application.

3.2. Yield components

In breeding programs, new varieties developed are selected by using various yield components are used to determine seed yield (Omidi et al 2012). Although the number of head per plant affected by environmental conditions, it is important trait influence the yield (Consentino et al 1997; Omidi Tabrizi 2000; Beyyavas et al 2011). Weiss (2000) is reported to obtain high seed yield, well-developed 12 to 14 heads per plant are sufficient. In this research, number of heads per plant ranged between 8.7 and 13.2 in first year, 8.3 and 14.9 in second year, 7.9 and 11.7 in third year of the study (Table 3). The three-year averages, number of heads per plant ranged between 9.4 number plant^{-1} (GE-ES-YA-36-26) and 13.0 number plant^{-1} (GE-ES-YA-36-14). Dajue & Mündel (1996) emphasize that number of heads per plant is very strongly linked to yield in safflower. Chaudhary (1990) showed that number of heads per plant could be used determined to high seed yielding varieties with 50 safflower lines. The highest number of heads per plant had been obtained by the researchers were Cazzato et al (2001), 30.0 number plant^{-1}; Beyyavas et al (2011), 19.5 number plant^{-1} and Ada (2013) 23.7 number plant^{-1} in their research. The investigated result in this trial showed differences between previous data. This is the result of different environmental condition and agronomic application. Zarei et al (2011) reported that number of head per plant greatly affected from environmental conditions particularly plant density.

The result of variances analysis examined there is no significant difference existed between the years for head diameter. These result showed that head diameter is not effect different year condition whereas significantly varied with genotypes. According to the Table 4 average of the combined values of three years, head diameter of the lines and the varieties ranged between 2.23 cm (GE-ES-

YA-36-13) and 2.77 cm (GE-ES-YA-36-10). Ashri et al (1976) were reported that head diameter can vary considerably without affecting seed yield; studied on safflower germplasm collection consisted of 900 lines.

When the results examined, 1000 seed weight of genotype ranged between 32.5-48.0 g in 2010, 40.2 and 49.1 g in 2011, 35.7 and 48.4 g in 2012 (Table 4). The genotypes investigated in this study, displayed significant variation. This diversity was considered to reaction of genotypes to different ecological conditions in this study. Beyyavas et al (2011) reported that genetic structure and ecological factors are two major factors, which are influential on 1000 seed weight. Acharya et al (1994) reported that 1000-seed weight had positively effect on seed yield and also indicated the influence of this character was greater than the other characters in

Table 5- Mean values and statistics group of oil content and oil yield studied some safflower lines and varieties in 2010, 2011, 2012 and 2010-2012

	Oil content (%)				*Oil yield (kg ha^{-1})*			
Genotype§	*2010*	*2011*	*2012*	*2010-12*	*2010*	*2011*	*2012*	*2010-12*
GE-ES-YA-2	37.0 ef	36.6 d-h	37.3 d-f	37.0 cd	510.4 a-e	670.4 b-h	440.4 c-g	540.4 c-ı
GE-ES-YA-3	36.4 e-h	37. 3 b-g	35.4 hı	36.4 d-f	480.6 b-f	620.6 e-ı	440.8 b-g	520.0 e-j
GE-ES-YA-4	38.6 a-d	39.9 a-b	37.3 d-f	38.6 a	570.8 a	760.7 a-g	580.4 a	640.3 ab
GE-ES-YA-6	35.1 hı	36.4 d-ı	33.8 k-m	35.1 gh	500.9 a-e	620.6 e-ı	540.0 ab	550.9 c-g
GE-ES-YA-7	35.9 f-h	36.5 d-h	35.2 ı	35.9 e-g	550.2 ab	840.8 a-c	570.4 a	650.8 a
GE-ES-YA-8	37.4 b-e	38.3 a-d	36.6 fg	37.4 b-c	470.9 b-f	810.2 a-e	410.6 c-k	560.9 b-f
GE-ES-YA-9	35.4 g-ı	36.1 d-j	34.8 ıj	35.4 fg	460.1 c-g	620.4 e-ı	350.5 g-k	480.0 h-j
GE-ES-YA-10	35.8 f-h	35.0 f-j	36.6 fg	35.8 e-g	500.6 a-e	660.3 c-h	450.6 b-e	540.2 c-ı
GE-ES-YA-11	37.4 c-e	38.6 a-d	36.1 gh	37.4 b-d	500.8 a-e	790.0 a-f	360.1 f-k	550.3 c-h
GE-ES-YA-12	34.1 ı-k	34. 0 h-k	34.2 jk	34.1 hı	490.2 b-f	900.5 a	430.8 c-h	610.1 a-d
GE-ES-YA-13	34.2 ıj	34.7 g-j	33.7k-m	34.2 hı	470.0 c-f	830.4 a-d	340.6 h-k	550.0 c-ı
GE-ES-YA-14	32.8 kl	34.2 h-k	31.4 o	32.8 j	460.0 c-g	810.9 a-e	400.0 c-k	560.0 c-g
GE-ES-YA-17	38.8 ab	40.3 a	37.3 d-f	38.8 a	450.8 c-g	820.2 a-e	360.0 f-k	540.7 c-ı
GE-ES-YA-25	39.2 a	40.4 a	38.0 a-c	39.2 a	280.8 h	830. 9 a-d	320.5 jk	480.4 g-j
GE-ES-YA-26	39.2 a	39.9 a-c	38.5 a	39.2 a	420.5 fg	550.9 hı	370.7 d-k	450.4 jk
GE-ES-YA-27	38.4 a-d	37.8 a-e	39.0 a	38.4 ab	480.4 b-f	580.0 g-ı	410.8 c-j	490.4 f-j
GE-ES-YA-28	35.7 f-h	37.3 c-g	34.1 j-l	35.7 e-g	530.5 a-c	870.2 ab	450.1 b-f	610.9 a-c
GE-ES-YA-29	36.5 e-g	35.4 e-j	37.6 c-e	36.5 c-e	470.4 b-f	640.0 d-h	490.1 a-c	530.5 c-ı
GE-ES-YA-30	39.3 a	40.3 a	38.3 ab	39.3 a	520.0 a-d	770.9 a-g	470.8 bc	590.2 a-e
GE-ES-YA-34	37.3 de	37.6 b-f	37.0 ef	37.3 cd	480.2 b-f	760.3 a-g	420.4 c-ı	550.6 c-h
GE-ES-YA-36	33.6 jk	33.8 ı-k	33.3 l-m	33.6 ıj	520.4 a-c	900.3 a	570.9 a	660.9 a
YENİCE	31.5 lm	30.0 l	33.0 mn	31.5 k	380.3 g	430.4 ı	360.8 e-k	390.5 k
DİNÇER	31.2 m	32.1 kl	30.3 p	31.2 k	430.8 e-g	650.2 c-h	330.2 ı-k	470.4 ıj
REMZİBEY	33.0 jk	33.7 jk	32.2 no	33.0 j	440.2 d-g	600.6 f-ı	320. 2 k	450.7 jk
BALCI	38.7 a-c	38.3 a-d	39.0 a	38.7 a	510.6 a-e	810.1 a-e	470.1 b-d	590.9 a-d
Mean	36.1	36.6	35.6	36.1	470.9	730.0	430.0	540.7
Genotype	**	**	**	**	**	**	**	**
Year				**				**
Genotype x Year				*				**

§, means in the same column followed by the same letters were not significantly different at 0.05 level using LSD test; * and **, significant at the 5 and 1% level, respectively relation to seed yield. According to average of three years, GE-ES-YA-36-36 (48.4 g), GE-ES-YA-36-7 (47.9 g), GE-ES-YA-36-14 and GE-ES-YA-36-11 (46.7 g) belonged to the same statistic group in terms of 1000 seed weight. The first two lines were also included in the first group with the highest seed yield. These results showed that 1000 weight seed was reliable components influencing seed yield.

3.3. Oil content

The value of safflower oil is dramatically increased nowadays, economically, oil content of seed is important for safflower production and considered as the major factors, affecting the success of safflower introduction in new production areas (Vorpsi et al 2010). Therefore, improving seed yield as well as the oil content of safflower has become importance in breeding program. According to this research, oil content of genotype ranged between 31.2% and 39.3% in the first year, 30.0% and 40.4% in the second year, 30.3% and 39.0% in the third year of the study (Table 5). Compared the lines and the varieties, it was observed that oil content of lines increased and most of them exceed the varieties. This situation is the result of selection made in terms of oil content along breeding program and the difference between the lines and varieties is strongly due to the genotype, beside of environmental condition. Consentino et al (1997), Johnson et al (1999), Uysal et al (2006), Zhang & Chen (2005), Koutroubas & Papadoska (2005), Gawand et al (2005), Arslan & Kucuk (2005) and Kose (2013) were reported that oil content varied between 33.4-43.4%; 13-46%; 23.7-26.9%; 23.8-40.3%; 26.7-35.7%; 26.3-28.5%; 31.3-36.3% and 30.6-38.7%, respectively. These results showed some similarity and differences in our results depend on genotype, trial and environmental condition. Hang & Evans (1985) reported that oil content mostly depends on the genotype, beside of this climatic factor and agronomic practices also affected it (Esendal & Tosun 1972; Pascal Villalobos & Alburquerque 1996; Rahamatalla et al 2001). When the combined values examined GE-ES-YA-36-30 (39.3%), GE-ES-YA-36-25 and GE-ES-YA-36-26 (39.2%), GE-ES-YA-36-17 (38.8%), GE-ES-YA-36-4 (38.6%), GE-ES-YA-36-27 (38.4%) had the first statistic group and remarkable in terms of oil content.

3.4. Oil yield

The oil yield calculated on the seed yield and oil content of genotypes, affected by these two factors. When the examined the result, oil yield of genotype ranged between 280.8 and 570.8 kg ha^{-1} in 2010, 430.4 and 900.5 kg ha^{-1} in 2011, 320.2 and 580.4 kg ha^{-1} in 2012 (Table 5). It is clear that highest oil yield obtained in the second year, similar in seed yield. This result revealed that the increase of oil yield was primarily associated with the increase of seed yield. According to average of three years, lines GE-ES-YA-36-36 with 660.9 kg ha^{-1}, GE-ES-YA-36-7 (650.8 kg ha^{-1}), GE-ES-YA-36-4 (640.3 kg ha^{-1}), GE-ES-YA-36-28 (610.9 kg ha^{-1}), GE-ES-YA-36-12 (610.1 kg ha^{-1}) and variety Balci (590.9 kg ha^{-1}) were in the same statistic group, with respect to higher oil yield per hectare. The result from the present study indicated that oil yield of safflower has been affected of genotype oil content, seed yield and ecologic conditions under which the experiments were carried out. For oil yield, the previous studies were recorded such data as 390.6-514.4 kg ha^{-1}, Rajput et al (2007); 322 to 460 kg ha^{-1} Gawand et al (2005) and 416-701 kg ha^{-1} Koutroubas & Papadoska (2005). The finding of the present study is in parallel with the results of other researchers.

4. Conclusions

This study indicated that large number of line had higher performance than varieties in terms of yield, yield components, oil content and oil yield. In this case, the result of selection of lines showed superior performance compared to the varieties since S_5 generation.

Based on all three years and combined analysis results of this study, lines GE-ES-YA-36-36, GE-ES-YA-36-7 in terms of seed yield, lines GE-ES-YA-36-30, GE-ES-YA-36-25, GE-ES-YA-36-26, GE-ES-YA-36-27 in terms of oil content and lines GE-ES-YA-36-36, GE-ES-YA-36-7, GE-ES-YA-36-4 in terms of oil yield were listed at the highest statistical group. Consequently, it was decided that these lines could be candidate varieties with regard to these different characteristics.

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