www.biodicon.com Biological Diversity and Conservation

ISSN 1308-8084 Online; ISSN 1308-5301 Print 9/1 (2016) 172-181

Research article/Araştırma makalesi

Determining of performances on different characteristics in Safflower (*Carthamus tinctorius*) genotypes under organic and conventional production systems

Duran KATAR [*1], Yusuf ARSLAN [2], Recep KODAŞ [2], İlhan SUBAŞI [2], Nimet KATAR [3]

[1] Osmangazi Üniversitesi Ziraat Fakültesi, Eskişehir, Turkey
[2] Tarla Bitkileri Merkez Araştırma Enstitüsü Müdürlüğü, Eskişehir, Turkey
[3] Osmangazi Üniversitesi Fen Bilimleri Enst, Eskişehir, Turkey

Abstract

All over the world, organic farming has begun to attract attention in recent years. There is an increasing demand for crop cultivars specifically adapted for this system of cultivation. The main objective of this study was to determine the performance, stability of different safflower (*Carthamus tinctorius* L.) cultivars to reveal heritability of yield components under conventional and organic farming conditions. Yield components including seed and oil yield were significantly responded to variability in varieties and environmental conditions. Shifa, TAEK and Remzibey in seed yield; TAEK and Shifa in oil content; and Remzibey and Shifa in oil yield seemed to be high yielding and stabile varieties. Yenice was determined as low yielding and instable variety. High heritability in number of branch, 1000 seed weight, oil content, oleic acid content and linoleic acid content assigned that these characters are mostly formed by genotypic performance, whereas having low heritability, plant height, seed yield and oil yield were determined as under genotype x environment interaction.

Key words: safflower, *Carthamus tinctorius*, yield and yield components, stability and heritability

---------- * ----------

Geleneksel ve organik üretim sistemlerinde incelenen unsurlar bakımından farklı Aspir (*Carthamus tinctorius*) çeşitlerindeki farklılıklarının belirlenmesi

Özet

Organik tarım tüm dünyada dikkatleri üzerine çekmeye başlamış olup bu sisteme adapte olan çeşitlere olan talep gittikçe artmaktadır. Bu çalışmada organik ve geleneksel üretim sisteminde farklı aspir (*Carthamus tinctorius* L.) çeşitlerinin incelenen karakterler yönünden farklılıkları, stabiliteleri ve karakterlerin geniş anlamda kalıtım derecesinin belirlenmesi amaçlanmıştır. Araştırma sonuçlarına göre Şifa, TAEK ve Remzibey çeşitleri verim yönünden, TAEK ve Şifa çeşitleri yağ oranı bakımından, Remzibey ve Şifa çeşitleri ise yağ verimi yönünden üstün performanslı ve stabil belirlenmiştir. Yenice çeşidi ise düşük verimli ve stabil olmayan bir çeşit olarak belirlenmiştir. Yan dal sayısı, 1000 tohum ağırlığı, yağ oranı, oleik asit oranı ve linoleik asit oranı yönünden görülen yüksek kalıtım derecesi bu karakterlerin ortaya çıkmasında genotipik performansın etken olduğunu gösterirken; bitki boyu, tohum verimi ve yağ verimi yönünden görülen düşük kalıtım derecesi ise bu unsurların daha çok genotip x çevre interaksiyonundan etkilendiğini ortaya çıkarmıştır.

Anahtar kelimeler: aspir, *Carthamus tinctorius*, verim ve verim unsurları, stabilite ve kalıtım derecesi

1. Introduction

Having main purpose to increase food production and to meet the need of oil consumption; conventional agriculture has been to be based on not only to increase in production but to use intensive chemical fertilizer and pesticide usage. On the other hand, excessive chemical fertilizer application and chemical pesticide usage have posed a

[*] *Corresponding author* / Haberleşmeden sorumlu yazar: Tel.: +9xxxxxxxxxxxxx; Fax.: +9xxxxxxxxxxxxx; E-mail: xxxxxxx

risk for human and animal health and at the same time caused a serious environmental pollution especially in soil, underground water and air (Er and Başalma, 2008; İlbaş, 2009; Kacar and Katkat, 2009; Kara et al., 2014). It has been understood that the conventional agriculture is unsustainable system along with increased awareness of healthy nutrition and environment. Organic farming has recently begun to attract attention quickly all over the world owing to producing risk-free food for human and animal health and being environment-friendly production system (Elfadl et al., 2010). Organic production has become widespread rapidly in many crops including especially fruits, vegetables and cereals. In addition, organic farming system has been used in cultivation of oilseeds crops (Morteza, 2013).

A large proportion of vegetable oils have been produced from sunflower in Turkey (Arıoğlu et al., 2010). Sunflower initially seems not to be suitable crop for organic farming. Since, specific climate requirements, insufficient resistance to diseases and pests and extensive usage of chemical fertilizers in its cultivation makes sunflower an inappropriate crop in terms of organic production (Gruber et al., 2004, Elfadl et al., 2012). Therefore, it is necessary to conduct a research to identify alternative oilseeds crops suitable for organic farming system (Morteza, 2013). Safflower (*Carthamus tinctorius* L.) seems more advantageous than sunflower for production of organic vegetable oil in Turkey as well as all over the world (Elfadl et al., 2010). Safflower has been cultivated since ancient times for its flowers and oilseeds. It is used to obtain natural dyes and to produce edible oil for human consumption and industrial oils, spices and birdfeed (Tonguç et al., 2012). Safflower is a winter-spring growing annual and deep-rooted oilseed crop (Christos and Sioulas, 2008, Geçit et al., 2009). The crop that can tolerate water stress at a certain level is generally regarded as a suitable crop for arid and semi-arid regions (Christos and Sioulas, 2008, Morteza, 2013, Elfadl et al., 2010). Therefore, it should be suitable for cultivation in regions with a warm climate (Elfadl et al., 2010). Due to the fact that, safflower has edible oil with high polyunsaturated fatty acids, its oil has got the increasing market demand in developed countries. (Elfadl et al., 2010). The safflower seed contains approximately 90% unsaturated and 10% saturated fatty acids. Oleic and linoleic-type cultivars have been developed for commercial cultivation, and seeds of commercial cultivars contain 30-50% oil, 15-20% protein, 35-45% husk, 3-4% carbohydrate, and 11-36% crude fiber. Crude fiber is mostly found in the husk, and meal contains around 10% fiber (Tonguç et al., 2012). On the other hand, safflower cultivation under excessive soil moisture and high air humidity conditions is seriously susceptible to diseases (Mündel et al., 2004). Safflower as an oilseed crop is suitable for organic farming systems and it should be introduced to farmers. The main objective of this study was to determine the performance, stability of cultivars to reveal heritability of yield components under conventional and organic farming conditions.

2. Materials and methods

This study was carried out at the experimental fields of Field Crops Central Research Institute in Haymana District of Ankara/Türkiye (32^0 51 E; 39^0 57 N; 860 m above sea level) during crop growing period of 2011 and 2012. The study area selected has been kept out of the agricultural activities since 1985. The properties of the experimental soil were given in Table 1. Soil characteristics in 2011 and 2012 were: clay-loamy, pH 8.06 and 7.19, lime 2.65% and 2.37%, total salt 0.041% and 0.038%, organic matter 1.57% and 1.91%, phosphorus 110,41 kg/ha and 100,23 kg/ha and potassium 2150,23 kg/ha and 2030,14 kg/ha.

Table 1. Physical and chemical characteristics of soil in research area.

Structure	Lime (%)	Total Salt (%)	Plant-Available Phosphorus (P_2O_5,kg/ha)	Plant-Available Potassium (P_2O_5,kg/ha)	pH	Organic Matter (%)
Clay-Loam (2011)	2.65	0.041	110.41	2150.23	8.06	1.57
Clay-Loam (2012)	2.37	0.038	100.23	2030.14	7.19	1.91

Source: Soil Fertilizer and Water Resources Research Institute.

Temperature, rainfall, relative humidity and total and mean values of these meteorological data were presented in Table 2. Total yearly rainfall in long-term period was 402,1 mm, whereas this value was lower in 2011 (396,6 mm) and higher in 2012 (431,3 mm). Annual temperature and humidity drew similar trend. Mean temperature and humidity in 2011 and 2012 were (11.8ºC and 13.2 °C; 63.7% and 63.2%, respectively). Moreover, temperature and humidity in long-term period were 12.0°C and 60.1%, respectively. The plant materials used in this research were five safflower genotypes (Yenice (spiny), Dinçer l5-18-1 (spineless), Remzibey-05(spiny), and Shifa (spineless) and TAEK (spiny). Yenice, Dinçer l5-18-1 and Remzibey-05 were provided by Anatolia Agricultural Research Institute. Shifa cultivar was obtained from Tajikistan. TAEK line was developed at Turkish Atomic Energy Authority. The experimental scheme was a three replication, randomized complete block split-plot, with different cultivation systems (organic and conventional farming systems) in the main plots and different safflower genotypes (Yenice, Dinçer l5-18-1, Remzibey-05, Shifa and TAEK) in the sub-plots. Seeds were sown by hand, with 30 cm row spacing on plots of 6 m^2 harvest area (1.20 m width X 5 m length) on 19 April of 2011 and 20 April of 2012. After intra-row spacing was stabilized at 10 cm by thinning (Kızıl et al., 1999).

Table 2. Rainfall, temperature and humidity in 2010, 2011 and long term years (1975-2010) in Ankara climatic conditions.

Years	January	February	March	April	May	June	July
Total Rainfall (mm)							
2011	41.8	24.3	57.5	50.1	73.1	44.4	10.7
2012	93,3	47,7	42.7	24.8	65.1	1.2	4.6
1975-2010	39.2	33.6	36.1	50.0	49.7	35.1	16.0
Mean Temperature (°C)							
2011	2.3	3.1	5.8	9.8	15.0	19.3	25.0
2012	-0.8	-1.9	3.7	14.7	17.2	23.7	26.6
1975-2010	0.3	2.1	6.2	11.3	16.0	20.2	23.5
Mean Humidity (%)							
2011	79.5	70.2	68.1	66.9	64.6	58.6	47.5
2012	87.3	83.1	69.3	51.9	60.1	41.8	37.4
1975-2010	58.2	59.4	61.2	60.8	60.3	59.1	60.0

Years	August	September	October	November	December	Tot/Mean
Total Rainfall (mm)						
2011	21.1	0.6	62.4	10.9	39.7	396.6
2012	7.4	3.6	18.6	35.9	86.4	431.3
1975-2010	12.4	18.9	32.5	36.0	42.6	402.1
Mean Temperature (°C)						
2011	23.4	19.9	11.0	3.4	3.7	11.8
2012	23.7	22.1	16.8	9.1	4.3	13.2
1975-2010	23.2	18.7	13.0	6.8	2.2	12.0
Mean Humidity (%)						
2011	48.4	45.4	67.7	71.1	76.4	63.7
2012	40.3	36.4	56.8	78.4	85.0	60.6
1975-2010	61.3	63.1	60.7	57.9	59.2	60.1

[1/]Data were taken from Ankara Regional Meteorological Service.

Weed control was made by hand when needed. No irrigation was applied. Commercial fertilizers as 100 kg N and 60 kg P_2O_5 per ha were given in conventional farming system. Moreover, in organic farming system organic liquid fertilizer (DİCO brand) as 3.3 L/1350 L water/ha were applied and no extra commercial fertilizer was dressed. One row and 0.5 m in both sides were removed as side effects in plots. The plants were harvested by hand.

The seed samples were properly ground and the oil extracted with n-hexane in a Soxhlet extractor for 4 h. Recovered crude oils were taken to dry out on a rotator evaporator at 35 ^{0}C. Fatty acids were esterified as methyl esters and analysed by Agilent 6890N Network with equipment with DB-23 capillary column (JW Scientific 122-2362 DB-23; 60.0 m x 250 µm x 0.25 µm) GC and FID detector. Helium was used as carrier gas at a flow rate of 1 mL/min. Injector and detector temperature were 260 ^{0}C and 240 ^{0}C, respectively. Column temperature was kept at 220 ^{0}C for 69 min. Samples of 0.5 uL was injected by hand and in the split mode (20:1). FAMEs were identified by comparison of their retention times with those of reference standards. The content of fatty acids was calculated from corresponding integration data. With split plots in randomized complete block design, analytical data collected with three replications of each treatment were subjected to analysis of variants using SAS statistical software program, and differences between means were compared via the LSD (Least Significant Difference) test (Düzgüneş et al., 1987). Plant height (cm), capitulum yield (g/cap seed yield (t/ha), thousand seed weight (g), oil content (%), oil yield (t/ha), oleic acid content (%) and linoleic acid content (%) were evaluated (Bergman et al., 2001; Singh, 2005; Camaş and Esendal, 2006; Camas et al., 2007; Golkar et al., 2011; Majidi et al., 2011; Omidi et al., 2012); stability of varieties, variances of genotype, year, cultivation type and their interactions; and heritability of yield components (Comstock and Moll, 1963) were determined in the study. Bi-plot analyses (Şahin et al., 2011) were made by Minitab 15.

3. Results

Yield, yield components are formed wherefore genetic performance, applications and environmental environment (Pireivatlou et al., 2011). The anova analysis showing performance of genotypes for yield components in 2010 and 2011 were presented in Table 3. Well-adapted to dry land conditions of world, safflower is promising plant to meet the need of edible oil in the world. Oil quality is tremendously higher due to fatty acid composition. To increase safflower production, it is necessary to develop novel safflower varieties, having high yield and quality. Yield and yield components are under genotype x environment interaction and seed and oil yield are also under the effect of some yield components. It is therefore important to determine importance of yield component, their heritability and the effect of them on seed and oil yield (Bergman et al., 2001; Singh et al., 2004). As seen in Table 3, differences between years in plant height, seed yield and oil yield were found as significant at 1%. Besides, differences between cultivation types was only significant (p<0.01) in plant types. Differences in varieties in plant height, seed yield, 1000 seed weight, oil content, oil yield, oleic acid content and linoleic acid content were determined as significant at 1%. Year × variety interaction in plant height and seed yield; cultivation type × variety interaction in oil content and oil yield were significant (Table 3). Results of yield and yield components on safflower varieties were given in Table 4. Plant height in first year (83,400 cm) was so higher than the second year (68,090 cm). Conventional farming gave higher plant height (72,607 cm) than organic farming (68,090 cm). In varieties, the highest plant heights were taken from Yenice (80,108 cm) and Shifa (78,883 cm). More differences on years in Yenice and Dinçer varieties made Year × Variety interaction significant (p<0.05).

Plant height is milestone criterion in evaluation of yield and yield component, and it is in a large scale affected from environmental conditions and agronomic applications. Water availability significantly causes plant height in safflower (Singh et al., 2004; Majidi et al., 2011). It could be answer enough to explain significant differences in years, cultivation types and varieties in our study. Water deficit is pointed out to lead variations in plant height and seed yield. Water supply plays important role to determine yield and yield component (Ozturk et al., 2008).

Kafka et al. (2000) reported that varietal differences are mostly seen in studies, since plant height is strongly formed by environmental and agronomical differences. Manju and Sreelathakumary (2002) reported that heritability of plant height was 0.39. Phenotypic variance was higher than genotypic variance and low heritability was recorded (0.412) in plant height. This assigns significant differences between factors and greater association between environmental conditions and genetic factors in this study.

No differences occurred in years, cultivation types, varieties; nor did interactions. It is more likely to be the least affected trait over environmental conditions. Nie et al. (1987) found that the number of branches had high heritability. Similarly, heritability was found as 0.820 in our study. Number of branches in safflower is formed both genetically and environmentally and the number of branches and 1000 seed weight contributes the effect to seed yield either directly or indirectly (Singh et al., 2004; Singh, 2005).

Table 3. Results of yield and yield components on cultivation types and safflower varieties in 2011-2012, 2012-2013

Source of Variation	D.F.	F Values			
		Plant Height (cm)	**Number of Branches**	**Seed Yield**	**1000 Seed Weight (g)**
Year	1	883.792**	0.001ns	985.579**	5.021ns
Error1	2				
Cul.Type	1	88.423**	4.305ns	3.923ns	0.018ns
Ye.× Cul. Type	1	166.436**	3.334ns	0.459ns	0.418ns
Error2	4				
Variety	4	30.324**	1.609ns	45.737**	17.379**
Ye.× Var.	4	3.920*	1.884ns	24.897**	0.525ns
Cul. Type× Var.	4	1.219ns	1.180ns	0.823ns	0.294ns
Ye.×Cul.Type×Var.	4	1.401ns	0.147ns	2.934*	0.174ns
Error3	32				
Mean	59				
C.V.(%)		**23.6703**	**13.8208**	**38.5168**	**11.1602**
Source of Variation	**D.F.**	**F Values**			
		Oil Content (%)	**Oil Yield**	**Oleic Acid Content (%)**	**Linoleic Acid Content (%)**
Year	1	0.387ns	1480.835**	3.103ns	2.961ns
Error1	2				
Cul.Type	1	0.534ns	6.686ns	5.668ns	0.433ns
Ye.×Cul. Type	1	19.193*	7.068ns	2.487ns	3.507ns
Error2	4				
Variety	4	5.476**	77.970**	1976.219**	1524.783**
Ye.× Var.	4	0.469ns	36.902**	1.202ns	0.902ns
Cul. Type× Var.	4	3.516*	3.667*	4.264**	6.350**
Ye.×Cul.Type×Var.	4	0.329ns	5.029**	0.230ns	0.605ns
Error3	32				
Mean	59				
C.V.(%)		**6.6757**	**39.2102**	**57.6390**	**10.7636**

D.F.: Degree of Freedom - M.S.: Means of Square - Cul. Type: Cultivation Type - Ye.× Cultivation Type: Year × Cultivation Type, Ye. × Var.: Year × Variety - Cultivation Type × Var.: Cultivation Type × Variety, Ye. × Cultivation Type × Var.: Year × Cultivation Type × Variety - C.V.: Coefficient of Variation, *: Significant at %5, **: Significant at %1

It is well known that safflower is a drought-tolerant crop and the depletion is seen in biomass production and this leads low amounts in plant height, seed and oil yield and thousand seed yield under drought conditions (Majidi et al., 2011; Wachsmann et al., 2003). Water availability plays key role in determining seed and oil yield under drought conditions (Ozturk et al., 2008). Environment has a main factor for some characters which environmental effects are more effective than genotypic variations or genotype x environment interaction (Schuler et al., 1995). Differences in years and varieties and year × variety interaction were determined as significant (p<0.01). Insignificant difference in cultivation type was recorded. Moreover, year × cultivation type × variety interaction was also significant (p<0.05). Seed yield in the first year (1.130 t/ha) was higher than the second year (0.664 t/ha). Shifa (1.134 t/ha) and Remzibey (1.026 t/ha) had the highest seed yield, and the lowest one belonged to Yenice (0.649 t/ha). Insignificant differences between cultivation types in Remzibey, Dinçer varieties in the first year; in Dinçer and TAEK varieties in the second year made year × cultivation type × variety interaction significant. Significant variations in years and varieties, and year x genotype interactions in our study prove that the seed yield is mainly formed genotype x environment interaction. Besides, greater variation in years, low broad sense heritability (0.542) support results of our study. The broad sense heritability in seed yield, plant height, first branch height, number of branch, head diameter, number of seed per head, 1000-seed weight and oil content were found as 0.35, 0.93, 0.99, 0.45, 0.21, 0.69, 0.81 and 0.59, respectively (Camaş and Esendal, 2006).

1000 seed weight is important yield component. In the study differences between years, cultivation types were found to be insignificant (p<0.05). Besides, interaction between yield x cultivation type, year x variety, cultivation type x variety, year x cultivation type x variety were insignificant. Only differences between varieties were significant (p<0.01) (Table 3). Though Shifa (44.598 gr.) had the highest 1000 seed weight, TAEK (35.817 gr) gave the lowest 1000 seed weight. Similar to our findings, significant variations in varieties and no significant effects of years in seed yield were found by Omıdı et al. (2012). Besides, great variations for 1000 seed weight in safflower cultivars versus water deficit were reported by Nabipour et al. (2007), Camas et al. (2007) and Ghamarnia and Sepehri (2010). Broad sense heritability in the study was 0.765. Sandhu et al. (1988) found high heritability (0.810) in 1000 seed weight. This assign that 1000 seed weight is formed mostly by genetic factors. Chauhan ve Singh (1998) stated that environment plays less important role in performance of characters with higher heritability.

Table 4. Results of yield and yield components on safflower varieties in 2010 and 2011

Plant height (cm)							
Years	**Cultivation Type**	**Cultivars**					**Mean**
		Yenice	**Remzibey**	**Dinçer**	**Shifa**	**TAEK**	
First Year	**Conv.Farm**	94.267	72.267	76.600	95.100	74.567	82.560
	Org.Farm.	94.300	74.167	78.333	97.900	76.500	84.240
	Mean	94.283	73.217	77.467	96.500	75.533	**83.400 A**
Second Year	**Conv.Farm**	69.200	62.367	59.733	66.367	55.600	62.653
	Org.Farm.	62.667	42.233	45.567	55.867	53.367	51.940
	Mean	65.933	52.300	52.650	61.117	54.483	**57.297 B**
As means of Years	**Conv.Farm**	81.733	67.317	68.167	80.733	65.083	**72.607 A**
	Org.Farm.	78.483	58.200	61.950	76.883	64.933	**68.090 B**
Grand Mean		**80.108 A**	**62.758 B**	**65.058 B**	**78.808 A**	**65.008 B**	**70.348**
L.S.D.(%): Year: 8.972, Cultivation Type: 2.211, Year x Cultivation Type: 3.127, Variety: 5.894, Year x Variety: 6.205							
Number of branches							
Years	**Cultivation Type**	**Cultivars**					**Mean**
		Yenice	**Remzibey**	**Dinçer**	**Shifa**	**TAEK**	
First Year	**Conv.Farm**	5.533	5.367	5.267	5.000	4.967	5.227
	Org.Farm.	4.500	5.033	4.300	4.633	4.533	4.600
	Mean	5.017	5.200	4.783	4.817	4.750	4.913
Second Year	**Conv.Farm**	4.933	4.933	4.667	4.933	5.233	4.940
	Org.Farm.	4.500	5.100	4.333	4.833	5.733	4.900
	Mean	4.717	5.017	4.500	4.883	5.483	4.920
As means of Years	**Conv.Farm**	5.233	5.150	4.967	4.967	5.100	5.083
	Org.Farm.	4.500	5.067	4.317	4.733	5.133	4.750
Grand Mean		4.867	5.108	4.642	4.850	5.117	**4.917**
Seed yield							
Years	**Cultivation Type**	**Cultivars**					**Mean**
		Yenice	**Remzibey**	**Dinçer**	**Shifa**	**TAEK**	
First Year	**Conv.Farm**	0.840	1.300	0.853	1.527	1.300	1.164
	Org.Farm.	0.697	1.423	0.730	1.487	1.143	1.096
	Mean	0.768	1.362	0.792	1.507	1.222	**1.130 A**
Second Year	**Conv.Farm**	0.590	0.783	0.787	0.897	0.610	0.733
	Org.Farm.	0.470	0.597	0.640	0.627	0.640	0.595
	Mean	0.530	0.690	0.713	0.762	0.625	**0.664 B**
As means of Years	**Conv.Farm**	0.715	1.042	0.820	1.212	0.955	0.949
	Org.Farm.	0.583	1.010	0.685	1.057	0.892	0.845
Grand Mean		**0.649 C**	**1.026 AB**	**0.753 C**	**1.134 A**	**0.923 B**	**0.897**
L.S.D.(%): Year: 0.147, Variety: 0.113, Year x Variety: 0.160, Year x Cultivation Type x Variety: 0.168							
1000 seed weight (g)							
Years	**Cultivation Type**	**Cultivars**					**Mean**
		Yenice	**Remzibey**	**Dinçer**	**Shifa**	**TAEK**	
First Year	**Conv.Farm**	38.043	37.330	41.553	45.377	37.213	39.903
	Org.Farm.	37.557	38.017	42.467	46.800	37.857	40.539

Table 4 *continued*

	Mean	37.800	37.673	42.010	46.088	37.535	40.221
Second Year	**Conv.Farm**	36.637	36.987	41.380	42.593	34.260	38.371
	Org.Farm.	35.483	37.930	38.790	43.623	33.940	37.953
	Mean	36.060	37.458	40.085	43.108	34.100	38.162
As means of Years	**Conv.Farm**	37.340	37.158	41.467	43.985	35.737	39.137
	Org.Farm.	36.520	37.973	40.628	45.212	35.898	39.246
Grand Mean		**36.930 C**	**37.566 C**	**41.047 B**	**44.598 A**	**35.817 C**	**39.192**
L.S.D.(%): Variety: 3.344							
Oil content (%)							
Years	**Cultivation Type**	**Cultivars**					**Mean**
		Yenice	**Remzibey**	**Dinçer**	**Shifa**	**TAEK**	
First Year	**Conv.Farm**	24.700	25.633	26.300	28.233	27.833	26.540
	Org.Farm.	26.467	30.433	28.767	27.933	29.00	28.520
	Mean	25.583	28.033	27.533	28.083	28.417	27.530
Second Year	**Conv.Farm**	27.330	28.187	28.493	29.193	28.953	28.431
	Org.Farm.	25.393	28.887	27.167	27.137	26.503	27.017
	Mean	26.362	28.537	27.830	28.165	27.728	27.724
As means of Years	**Conv.Farm**	26.015	26.910	27.397	28.713	28.393	27.486
	Org.Farm.	25.930	29.660	27.967	27.535	27.752	27.769
Grand Mean		**25.973 B**	**28.285 A**	**27.682 A**	**28.124 A**	**28.073 A**	**27.627**
L.S.D.(%): Year x Cultivation Type: 1.521, Variety: 1.574, Cultivation Type x Variety: 1.657							
Oil yield							
Years	**Cultivation Type**	**Cultivars**					**Mean**
		Yenice	**Remzibey**	**Dinçer**	**Shifa**	**TAEK**	
First Year	**Conv.Farm**	0.210	0.343	0.227	0.433	0.363	0.315
	Org.Farm.	0.187	0.433	0.210	0.420	0.330	0.316
	Mean	0.198	0.388	0.218	0.427	0.347	**0.316 A**
Second Year	**Conv.Farm**	0.167	0.227	0.227	0.267	0.180	0.213
	Org.Farm.	0.123	0.177	0.177	0.177	0.173	0.165
	Mean	0.145	0.202	0.202	0.222	0.177	**0.189 B**
As means of Years	**Conv.Farm**	0.188	0.285	0.227	0.350	0.272	0.264
	Org.Farm.	0.155	0.305	0.193	0.298	0.252	0.241
Grand Mean		**0.172 E**	**0.295 B**	**0.210 D**	**0.324 A**	**0.262 C**	**0.253**
L.S.D.(%): Year: 0.033, Variety: 0.027, Year x Variety: 0.038, Cultivation Type x Variety: 0.029, Year x Cultivation Type x Variety: 0.054							
Oleic acid content (%)							
Years	**Cultivation Type**	**Cultivars**					**Mean**
		Yenice	**Remzibey**	**Dinçer**	**Shifa**	**TAEK**	
First Year	**Conv.Farm**	8.970	31.113	10.953	10.813	10.377	14.445
	Org.Farm.	9.830	30.367	10.273	11.557	10.983	14.602
	Mean	9.400	30.740	10.613	11.185	10.680	14.524
Second Year	**Conv.Farm**	7.900	30.130	10.950	9.500	9.807	13.657
	Org.Farm.	9.853	30.347	10.477	10.580	10.887	14.429
	Mean	8.877	30.238	10.713	10.040	10.347	14.043
As means of Years	**Conv.Farm**	8.435	30.622	10.952	10.157	10.092	14.051
	Org.Farm.	9.842	30.357	10.375	11.068	10.935	14.515
Grand Mean		**9.138 C**	**30.489 A**	**10.663 B**	**10.613 B**	**10.513 B**	**14.283**
L.S.D.(%): Variety: 0.791, Cultivation x Variety: 1.119							
Linoleic acid content (%)							
Years	**Cultivation Type**	**Cultivars**					**Mean**
		Yenice	**Remzibey**	**Dinçer**	**Shifa**	**TAEK**	
First Year	**Conv.Farm**	82.247	59.057	79.510	79.223	79.193	75.846
	Org.Farm.	81.300	60.620	80.817	79.643	78.667	76.209
	Mean	81.773	59.838	80.163	79.433	78.930	76.028
Second Year	**Conv.Farm**	82.367	60.327	79.323	80.190	80.880	76.617
	Org.Farm.	80.967	60.353	80.387	79.073	78.523	75.861
	Mean	81.667	60.340	79.855	79.632	79.702	76.239
As means of Years	**Conv.Farm**	82.307	59.692	79.417	79.707	80.037	76.232
	Org.Farm.	81.133	60.487	80.602	79.358	78.595	76.035
Grand Mean		**81.720 A**	**60.089 C**	**80.009 B**	**79.532 B**	**79.316 B**	**76.133**
L.S.D.(%): Variety: 0.894, Cultivation Type x Variety: 1.265							

Seed oil content seems to range in little limit over the years and applications; is strongly related to the genotype (Hang and Evans, 1985; Beyyavas et al., 2011). In oil content, years and cultivation type didn't create significant differences, nor did interaction between year x variety and year x cultivation type x variety. Differences between varieties (p<0.01) and interactions between year x cultivation type and cultivation type x variety (p<0.05) were found to be significant (Table 3). With similar results TAEK (28.073%) and Shifa (28.124%) had the highest oil content, the lowest belonged to Yenice (25.973%). Safflower (*Carthamus tinctorius* L.) has been cultivated almost for the seed oil and oil content ranges between 30 and 50%. Oil yield therefore comes into mind when oil production is taken into account (Camas et al., 2007). Genotypic and genotype related variations and broad sense heritability (0.785) are almost high; this explains why variations in years and farming applications are insignificant and oil content is shaped by genotypic features of varieties. Seed genetic components, including additive and dominance effects, play an important role in the inheritance of oil content traits (Pai and Kumar, 1991) and broad-sense heritability is reported to be high 0.875 (Hu 1987; Camaş and Esendal, 2006).

The success of safflower introduction and development in a given country or region largely depends on seed oil yield (Malleshappa et al. 2003; Abdolrahmani, 2005). Oil yield is generally taken into consideration when process is made in evaluation of safflower varieties. Besides, it was reported that the seed oil yield of safflower decreased sharply when drought stress was severe (Lovelli et al. 2007). The effect of years and differences between varieties (p<0.01), interactions between year x variety (p<0.01), cultivation type x variety (p<0.05) and year x cultivation type x variety (p<0.01) were determined as significant. Oil yield in the first year (0,316 ton/ha) was higher than that of the second year (0.189 ton/ha).In this character, the highest and the lowest oil yields belonged to Shifa (0.324 ton/ha) and Yenice (0.172 ton/ha), respectively. Year x cultivation type x variety interaction was found to be significant at 1%. Significant differences between cultivation types on Yenice, Remzibey and Dinçer varieties in the first year; such significant differences on Remzibey, Dinçer and Shifa varieties in the second year made this interaction significant. Similar to our findings, Omidi et al. (2012) reported that highly significant effects of the environmental conditions, environment x variety interactions, significant differences between varieties were found on seed yield and seed oil yield (Camas et al., 2007; Beyyavas et al., 2011; Omidi et al., 2012). Significant variations between years and varieties were proved in (Table 3); as a proof of these effects, heritability was 0.666. low heritability of oil yield (0.59) was reported by Camaş and Esendal (2006). The highest variations on fatty acids belong to safflower and this phenomenon causes breeders to search and develop novel varieties having high fatty acid composition (Dajue and Mundel, 1996; Bergman et al., 2001). Level of the fatty acids is essential vegetable oils including safflower for their commercial usages. Oleic and linoleic acid content increase importance and nutritional value of oil use. Effect of years and cultivation types, interactions between year x cultivation type, year x variety and year x cultivation type x variety were insignificant. Moreover, differences between varieties and interaction between cultivation type x variety were significant at 1% in both characters. The highest yield was taken from Remzibey (30.489%) in oleic acid content and from Yenice (81.720%) in linoleic acid content. The lowest ones belonged to Yenice (9.138%) in oleic acid content and Remzibey (60.089%) in linoleic acid content (Table 4). Oleic and linoleic acid levels are reported to be almost 18-20% and 70-70 %, respectively (Dajue, 1993; Velasco and Fernandez-Martinez, 2001). Our results are in accordance with Hamdan et al. (2009) and Velasco and Fernandez-Martinez (2001) who reported that the content of fatty acids in safflower varieties showed significant difference; oleic and linoleic acids were environmentally stable and affected by genotypic potential. Genotypic variances were so higher and broad sense heritability of oleic and linoleic acids in our study were 0.909 and 0.786 (Table 5). It was pointed out that broad sense heritability on oleic and linoleic acids were high indicated that additive genetic variances for these fatty acids were proportionally great (Golkar et al., 2011).

Correlation between yield and yield components were given in Table 4. Significant and positive interactions (p<0.01) between seed yield and plant height, 1000 seed weight and plant height, 1000 seed weight and seed yield, oil yield and plant height, oil yield and seed yield, oil yield and 1000 seed weight, oil yield and oil content, oleic acid content and oil yield (p<0.05) were found.

Table 4. Correlations between yield and yield components in safflower

	Pl.He.	**Num. of Br.**	**Seed.Y.**	**1000 S.W.**	**Oil Co.**	**Oil Y.**	**Oleic A.**
Num. of Br.	0,028ns						
Seed Y.	0,580**	0,120ns					
1000 S.W.	0,350**	-0,098ns	0,369**				
Oil Co.	-0,147ns	-0,062ns	0,238ns	0,139ns			
Oil Y.	0,534**	0,085ns	0,980**	0,371**	0,337**		
Oleic A.	-0,224ns	0,146ns	0,226ns	-0,151ns	0,190ns	0,256*	
Linoleic A.	0,239ns	-0,163ns	-0,238ns	0,152ns	-0,196ns	-0,267*	-0,995**

*:P<0.05,**:p<0.01.

However negative and significant interactions between linoleic acid content and oil yield (p<0.05), linoleic acid content and oleic acid content (p<0.01) occurred. Moreover, rational effects of source of variances by years, cultivation types and varieties in characters and broad sense heritability of characters were given in Table 5. The highest variance was determined from year x cultivation type, year x variety and year x cultivation type x variety in plant height. Similar variances of all effects were determined in the number of branch. In seed yield and 1000 seed weight the higher effects of variances were in year x cultivation type, year x variety, and year x cultivation type x variety.

Table 5. Rational effects of source of variances by years, cultivation types and varieties in characters and broad sense heritability of characters

Characteristic	Var. of Cul.Type	Var. of Ye.× Cul. Type	Genotypic Var.	Var. of Ye.× Var.	Var. of Cul. Type× Var.	Var. of Ye.×Cul. Type×Var.	Phenotypic Var.	Broad Sense Heritability
Plant Height	5,102	185,051	56,196	233,793	63,544	253,351	136,381	0,412
Number of Branch.	0,028	0,049	0,032	0,069	0,083	0,145	0,039	0,820
Seed Yield	0,003	0.057	0,032	0,103	0,034	0,078	0.059	0,542
1000 Seed Weight	0,003	1,132	10,363	11,736	10,543	12,089	13,545	0,765
Oil Content	0,020	0,749	0,724	0,795	1,208	0,845	0,922	0,785
Oil Yield	0,002	0,004	0,003	0,009	0,003	0,009	0,0045	0,666
Oleic Acid Content	0.054	0,135	65,978	66,075	66,176	66,304	72,57	0,909
Linoleic Acid Con.	0.010	0,099	65,067	65,117	65,346	66,304	82,782	0,786

Genotypic variance, variances of year x cultivation type, year x variety and year x cultivation type x variety were dominant in oil content and oil yield. Moreover, in oleic and linoleic acid contents, genotypic variance, variances of year x variety, c.t x variety and year x cultivation type x variety were dominant. Heritability of plant height (0.412), seed yield (0.542) were lower than that of number of branch (0.820), 1000 seed weight (0,765), oil content (0.785), oil yield (0.666), oleic acid content (0.909) and linoleic acid (0.786)content (Table 5). Bi-plot analyses denoting stability performances of varieties for seed yield, oil content and oil yield; showing variety-character behaviors were given in Figure 1. If PC_1>0 with higher values, varieties are so valuable. Varieties are considered as invaluable if PC_2<0. Moreover, PC_2 assign stability performances of varieties are considered as stabile. In case of their PC_2 values are zero or close to zero. Shifa, TAEK and Remzibey in seed yield; TAEK and Shifa in oil content; and Remzibey and Shifa in oil yield seemed to be high yielding and stabile varieties. Yenice was determined as low yielding and instable variety.

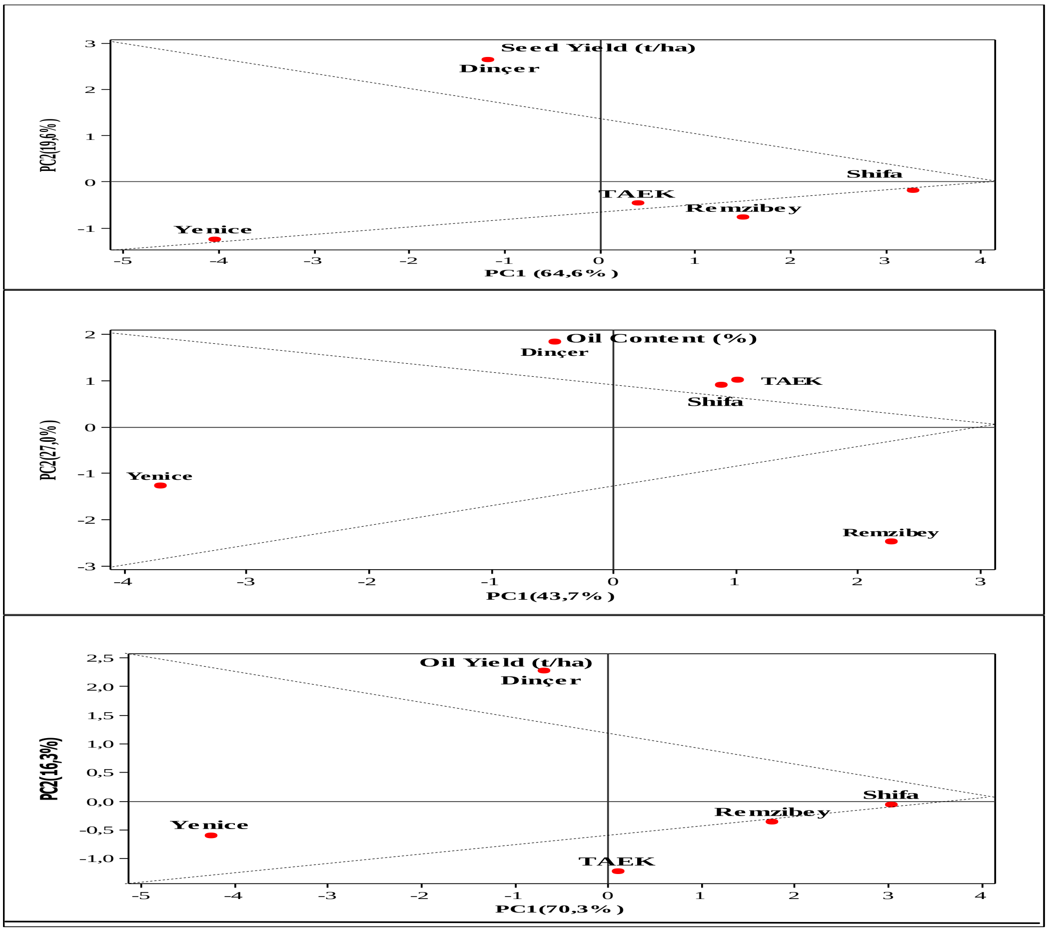

Figure 1. Bi-plot analyses denoting stability performances of varieties for seed yield, oil content and oil yield

Figure 2 well explains relationship between yield components, and varietal performances. Besides, this figure also explains combine effects of variety, farming applications, and environmental effects. TAEK variety, oil content and oil yield contributed mostly to PC_1 (accounted for 98.0% of total variability). The total variability of first component is influenced by Shifa and TAEK and Remzibey varieties. All characters were almost homogenous at Remzibey and Dinçer varieties. Besides Yenice variety was mostly homogenous in all characters.

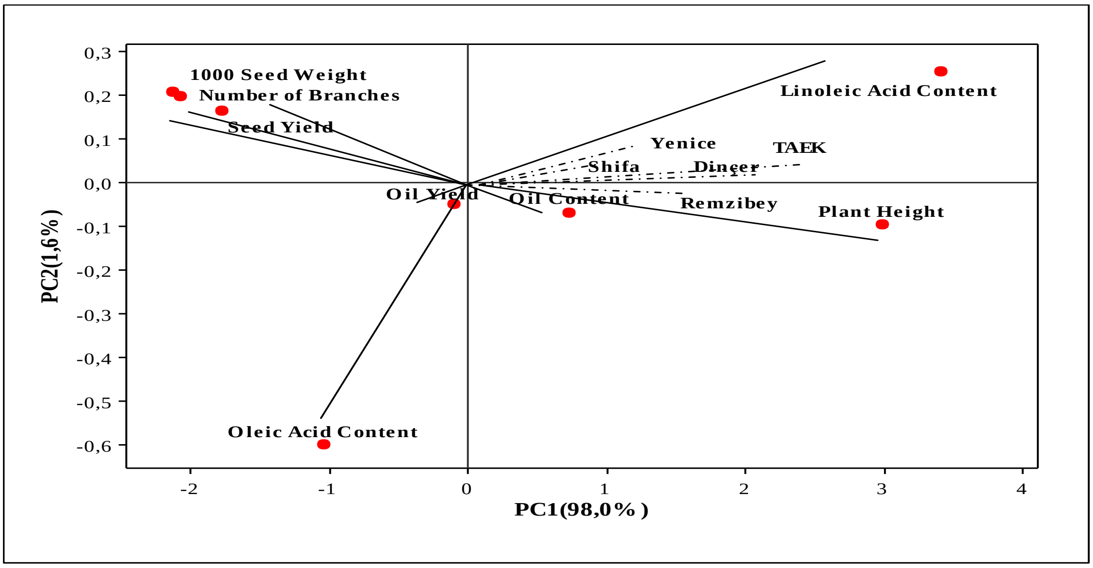

Figure 2. Bi-plot analyses explains relationship between yield components, and varietal performances

4. Conclusions and discussion

In our study, it was concluded that seed and oil yield, yield components were significantly responded to variability in varieties environmental conditions in growth stages. Shifa, TAEK and Remzibey in seed yield; TAEK and Shifa in oil content; and Remzibey and Shifa in oil yield seemed to be high yielding and stabile varieties. Yenice was determined as low yielding and instable variety. High heritability in number of branch, 1000 seed weight, oil content, oleic acid content and linoleic acid content assigned that these characters are mostly formed by genotypic performance, whereas having low heritability, plant height, seed yield and oil yield were determined as under genotype x environment interaction. Determining and developing novel varieties having higher seed and oil yield and its quality should be main target of safflower breeding. Further studies are required to determine the effective techniques and high yielding varieties to increase oil yield and quality in safflower.

References

Abdolrahmani, B., 2005. Effect of plant density on grain and oil yield of safflower cv Arak 2811 in dryland conditions. Seed Plant 20: 417-428.

Arioglu, H.H., Kolsarici, Ö., Göksu, A.T., Güllüoglu, L., Arslan, M., Çaliskan, S., Sögüt, T., Kurt, C. and Arslanoglu, F., 2010. Possibilities to Increase Oil Production. Turkey Agricultural Engineers Association VII. Pub. of Technique Congress I: 361-377. Ankara

Bergman, J.W., Flynn, C.R., Kott, R.W., Hatfield, P.G., Van Wagoner, H., Boles, J.A., 2001. Feedlot performance, carcass composition and muscle and fat conjugated linoleic acid concentrations of lambs fed diets supplemented with high linoleic safflower. In: Bergman JW, Mundel HH (eds). Proceedings of the fifth international safflower conference, Williston, ND, Sidney, MO, USA.

Beyyavas, V., Haliloglu, H., Copur, O., Yilmaz, A., 2011. Determination of seed yield and yield components of some safflower (*Carthamus tinctorius* L.) cultivars, lines and populations under the semi-arid conditions. Afr. J. Biotech. 10:527-534.

Camaş, N., Esendal, E., 2006. Estimates of broad-sense heritability for seed yield and yield components of safflower (*Carthamus tinctorius* L.). Hereditas. Dec; 143:55-7.

Camas, N., Cirak, C., Esendal, E., 2007. Seed yield, oil content and fatty acids composition of safflower (*Carthamus tinctorius* L.) grown in Northern Turkey conditions. J. Fac. Agric. O.M.U. 22: 98-104.

Chauhan, M.P. and Singh, I.S., 1998. Genetic variability, heritability and expected genetic advance for seed yield and other quantitative characters over two years in lentil. LENS News. 25(1/2): 3-6.

Christos, A., Dordas, C.A., Sioulas, C., 2008. Safflower yield, Chlorophyll content, photosynthesis, and water use efficiency response to nitrogen fertilization under rainfed conditions. Industrial Crops and Products. 27: 75-85.

Comstock, R.E. and Moll, R.H., 1963. Genotype x environment interactions. In: Statistical Genetics and Plant Breeding, p.164-196, NAS-NRC Publ. 982.

Dajue, L., Mundel, H.H., 1996. Safflower (*Carthamus tinctorius* L.). IPGRI, Italy.

Dajue, L., 1993. Progress of safflower (*Carthamus tinctorius* L.) research and production in China. In: Third International Safflower Conference, pp 35-46.Beijing, China.

Elfadl, E., Reinbrecht, C., Claupein, W., 2010. Development of near infrared reflectance spectroscopy (NIRS) calibration model for estimation of oil content in a worldwide Safflower germplasm collection. International Journal of Plant Production, 4(4): 259-270.

Er, C. and D. Başalma. 2008. Developments in Organic Agriculture. Nobel Pub. No: 1354, Ankara.

Geçit, H.H., Çiftçi, Y.C., Emeklier, Y., Kincikaraya, S., Adak, M.S., Kolsarici, Ö., Ekiz, H., Altunok, S., Sancak, C., Sevimay, C.S. and Kendir, H., 2009. Field Crops. Ankara University Faculty of Agric., Pub. No: 1569, Text Book: 521, Ankara.

Ghamarnia, H. and Sepehri, S., 2010. Different irrigation regimes affected water use, yield and other yield components of safflower (*Carthamus tinctorius* L.) crop in a semi-arid region of Iran. J. Food Agric. Environ. 8: 590-593.

Golkar P., Arzani A., Rezaei A. M. 2011. Genetic Analysis of Oil Content and Fatty Acid Composition in Safflower (*Carthamus tinctorius* L.). J. Am. Oil Chem. Soc., 88: 975-982.

Gruber, S., Pekrun, C. and Claupein, W., 2004. Seed persistence of oilseed rape: variation in transgenic and conventionally bred cultivars. Journal of Agricultural Science 142: 29-40.

Hamdan, Y.A.S., Pérez-Vich, B., Velasco, L., Fernández-Martínez, J.M., 2009. Inheritance of high oleic acid content in safflower. Euphytica, 168(1): 61-69.

Hang, A.N. and Evans, D.W., 1985. Deficit sprinkler irrigation of sunflower and safflower. Agron. J. 77: 588-592.

Hu, Z.L., 1987. Genetic anlysis on several quality traits in rapeseed (*Brassica napus* L). Oil Crop China, 1: 19-22.

İlbaş, A.İ., 2009. Organic Farming. Principles and National Legislation. Eflatun Pub., Ankara.

Kacar, V. and Katkat, V., 2009. Fertilizers and Fertilization Techniques. Pub. of Nobel Science and Research Center; 46. Ankara.

Kafka, S.R., Kearney, T.M., Knowles, P.D. and Miller, M.D., 2000. Safflower Production in California. http://agric.ucdavis.edu/crops/oilseed/safflower. htm (10.01.2007).

Kara, N. 2014. Yield and Mineral Nutrition Content of Buckwheat (*Fagopyrum esculentum* Moench): The Effect of Harvest Times. SDÜ Journal of Agric. Fac., 9/1: 85-94.

Kizil, S., Tonçer, Ö. and Sögüt, T. 1999. The effect of seed rows on yield and yield components in Safflower *Carthamus tinctorius* L.) in Diyarbakır climatic conditions. Turkey 3th Field Crop Congress, 15-18 November, Adana.

Lovelli, S., Perniola, M., Ferrara, A. and Di Tommaso T., 2007. Yield response factor to water (Ky) and water use efficiency of *Carthamus tinctorius* L. and *Solanum melongena* L. Agric Water Manage. 92: 73-80.

Majidi, M.M., Tavakoli, V., Mirlohi, A.and Sabzalian, M.R., 2011. Wild safflower species (*Carthamus oxyacanthus* Bieb.): A possible source of drought tolerance for arid environments. Aust. J. Crop Sci., 5: 1055-1063.

Malleshappa, S.M., Hiremath, I. and Ravikumar, R.I., 2003. Negative associations between important quantitative traits in safflower (*Carthamus tinctorius* L.). Sesame Safflower Newsletter, 18: 80-83.

Manju, P.R. and Sreelathakumary, I., 2002. Genetic variability, heritability and genetic advance in hot chilli (*Capsicum chinense* Jacq.). J. Trop. Agric., 40: 4-6.

Morteza, A.S., 2013. Study on replacement probability of composted organic manure with chemical fertilizer in Safflower (*Carthamus tinctorius* L) organic farming. International J. f Agric. Crop Sci., 6(199): 1304-1311.

Mündel, H.H., Morrison, R.J., Blackshaw, R.E. and Roth, B., 2004. Safflower production on the Canadian prairies. Agricultural Research Stations. Lethbridge, Canada.

Nabipour, M., Meskarbashee, M. and Yousefpour, Y., 2007. The effect of water deficit on yield and yield components of safflower (*Carthamus tinctorius* L.). Pak. J. Biol. Sci. 10:421-426.

Nie, Z., Shi, X.C., Chen, F.T. and Wang, Y., 1987. Hereditary capacity, progress and correlation of major agro-characters of safflower. Chinese Oil Crops, 2: 18-22.

Omidi, A.H., Khazaei, H., Monneveux, P. and Stoddard, F., 2012. Effect of cultıvar and water regıme on yıeld and yıeld components ın safflower (*Carthamus tinctorius* L.). Turkish J. Field Crops, 17/1/: 10-15.

Ozturk, E., Ozer, H. and Polat, T., 2008. Growth and yield of safflower genotypes grown under irrigated and non-irrigated conditions in a highland environment. Plant Soil Environ., 54: 453-460.

Pai, R. and Kumar, P., 1991. Estimates of gene effects of oil content under normal and late sowing in mustard (*Brassica juncea*). Indian J. Agron. Sci., 61: 918-921.

Pireivatlou, A.S., Masjedlou, B.D. and Aliyev, R.T., 2010. Evaluation of yield potential and stress adaptive trait in wheat genotypes under post anthesis drought stress conditions. African J. of Agricult. Res., 5: 2829-2836.

Şahin, M., Akçacik, A. and Aydoğan, S., 2011. The relationship between grain yield and quality characteristics of some bread wheat genotypes and stability potential, Anadolu, J. of AARI, 21/2: 39-48.

Sandhu, T.S., Gumber, R.K., Bhatia, R.S. and Singh, K., 1988. Evaluation of disease resistant lines of chickpea. Indian J.Pulses Res., 1/2: 159-161.

Schuler, S.F., Bacon, R.K., Finney, P.L. and Gbur, E.E., 1995. Relationship of test weight and kernel properties to milling and baking quality in soft red winter wheat. Crop Sci., 35: 949-953.

Singh, V., 2004. Annual Report of Ad Hoc Project on *"*Biometrical Investigations of Flower Yield and Its Components and Their Maximization in Safflower." Submitted to ICAR, New Delhi.

Singh, V., 2005b. Final Report of Ad Hoc Project on "Identification of Early Plant Growth Male Sterility Marker in Existing GMS Systems and Search for Cytoplasmic Genetic Source of Sterility in Safflower." Submitted to ICAR, New Delhi, 61 pp.

Tonguç, M. and Erbaş, S., 2012. Evaluation of fatty acid compositions and some seed characters of common wild plant species of Turkey. Turk J. Agric. For., 36: 673-679.

Velasco, L. and Fernandez-Martinez, J.M., 2001. Breeding for oil quality in safflower. (ed.Bergman JW, Mündel HH),. Proceedings of the 5th International Safflower Conference. Williston, North Dakota and Sidney, Montana.

Wachsmann, N., Norton, R., Jochinke, D. and Knights, S., 2003. The comparative growth, yield and water use of safflower, Linola™, mustard, canola and wheat in southern Australia. Paper presented at the 11th Australian Agronomy Conference, Geelong, Victoria, 2-6 February.

(Received for publication 02 February 2016; The date of publication 15 April 2016)