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SEED YIELD, OIL CONTENT AND FATTY ACIDS COMPOSITION OF SAFFLOWER (*Carthamus tinctorius* L.) GROWN IN NORTHERN TURKEY CONDITIONS

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ABSTRACT: The introduction of safflower to a regional cropping system requires information concerning its performance under local environmental conditions. Field studies were conducted to investigate the adaptation, seed yield, yield components, oil content and fatty acid compositions of the safflower cultivars, Remzibey, Dinçer and Yenice at five locations in Northern Turkey (Bafra, Ladik, Suluova, Gümüşhacıköy and Osmancık) during the 2004-2005 growing season. Experimental design was a randomized complete block design with three replications. Seed yield, plant height, first branch height, number of branches per plant, head diameter, number of seeds per head, 1000-seed weight, oil content and fatty acid composition were determined as experimental parameters. According to the results, the evaluated parameters varied with cultivars and locations greatly. The cultivar Remzibey produced the highest seed yield (2482 kg ha^{-1}) and oil content (33 %) in the location Gümüşhacıköy. Fatty acids linoleic and oleic acid were main oil components for all cultivars and fatty acid composition varied greatly among locations and cultivars. The results indicate that safflower is well adapted to Northern Turkey conditions and could be introduced as an alternative oil seed plant.
Keywords: *Carthamus tinctorius,* fatty acid, oil content, safflower cultivars, seed yield.

KUZEY TÜRKİYE ŞARTLARINDA YETİŞTİRİLEN ASPİRİN (*Carthamus tinctorius* L.) TOHUM VERİMİ, YAĞ ORANI VE YAĞ ASİT KOMPOZİSYONU

ÖZET: Bölgesel bir ürün yetiştirme sistemine dahil edilebilmesi için aspir bitkisinin performansını ölçmek üzere yöresel çevre şartlarında yürütülen çalışmalara ihtiyaç vardır. Bu gaye ile ülkemizin kuzeyinde yer alan beş lokasyonda (Bafra, Ladik, Suluova, Gümüşhacıköy ve Osmancık) Remzibey, Dinçer ve Yenice aspir çeşitleri 2004-2005 yıllarında yetiştirilerek adaptasyon, tohum verimi, verim komponentleri, yağ oranı ve yağ asit kompozisyonları belirlenmiştir. Denemeler tesadüf blokları deneme desenine gore üç tekrarlamalı olarak tertip edilmiştir. Agronomik gözlemler olarak, tohum verimi, bitki boyu, ilk dal yüksekliği, bitkide dal sayısı, tabla çapı, tablada tohum sayısı, 1000 tohum ağırlığı, yağ oranı ve yağ asit kompozisyonu tespit edilmiştir. Sonuçlara göre, değerlendirilen parametreler çeşide ve lokasyona göre büyük ölçüde değişim göstermiştir. Gümüşhacıköy lokasyonunda yetiştirilen Remzibey çeşidi en yüksek tohum verimi (2482 kg ha^{-1}) ve yağ oranı (% 33) değerlerine ulaşmıştır. Linoleik ve oleik yağ asitleri tüm çeşitler için temel yağ asitleri olarak belirlenmiştir ve yağ asit kompozisyonu çeşitlere ve lokasyonlara göre büyük ölçüde değişim göstermiştir. Bu sonuçlar aspir bitkisinin Kuzey Türkiye şartlarına iyi uyum sağladığına ve bölge için alternatif bir yağlı tohum olabileceğine işaret etmektedir.
Anahtar Kelimeler: *Carthamus tinctorius,* yağ asiti, yağ oranı, aspir çeşitleri, tohum verimi.

1. INTRODUCTION

Safflower (*Carthamus tinctorius* L.) has been grown for centuries, primarily for its colorful petals to use as a food coloring and flavoring agent, for vegetable oils and also for preparing textile dye in the Far East, Central and Northern Asia and European Caucasian (Esendal, 2001). It has also received considerable interest recently as forage (Landau *et al*., 2004, 2005). Vegetable oil is one of the fundamental components in foods and has important functions regarding human health and its nutritional physiology. The demand for vegetable oils for food purposes has entailed a considerable expansion of oilseed crops all over the world (Corleto *et al*., 1997). Particularly, consumers have demanded healthier oils, naturally low in saturated fat such as olive, safflower, canola and sunflower oils.

Safflower has been received a lot of publicity recently, not so much for its colourful petal but because it is hailed as one of the most important sources of vegetable oils. The seeds contain 35-50% oil, 15-20% protein and 35-45% hull fraction (Rahamatalla *et al*., 2001). It has attracted significant interest as an alternative oil seed due to its high adaptability for dry climatic conditions with little precipitation. This plant is considered as a drought tolerant crop which is capable of obtaining moisture from levels not available to the majority of crops (Weiss, 2000). Safflower can also be grown successfully on soil with poor fertility and in areas with relatively low temperatures (Koutroubas and Papakosta, 2005).

The introduction of a new crop to a regional cropping system requires information concerning its

performance under local environmental conditions. In Turkey the planted area for safflower has just reached 265 ha during 2005 (FAO, 2006) and since it has not been systematically cultivated, information on the adaptation, yield and quality characters of this crop is limited. Results from the previous studies have indicated that some commercial safflower cultivars are well adapted to different parts of Turkey (Esendal, 1997; Baydar and Turgut, 1999; Samancı and Özkaynak, 2003; Özel *et al*., 2004; Çamaş and Esendal, 2006). However, further experimental data are required to support these positive results. Thus, the main objective of the present study was to examine the adaptation ability, seed yield, yield components, oil content and fatty acid compositions of three commercial safflower cultivars under Northern Turkey conditions.

2. MATERIAL AND METHODS

2.1. Plant Material

Three safflower cultivars (Remzibey, Dinçer and Yenice), kindly provided by The Anatolian Agricultural Research Institute in Eskişehir, Turkey were used as plant materials. Remzibey is a short and spiny type. Dinçer and Yenice are tall, thick, stemmed and spineless types.

2.2. Experimental Procedures

The experiment was conducted at the locations Bafra (41° 35′ N 35° 56′ E Long., and 15 m sea level), Ladik (40° 56′ N 35° 54′ E and 920 m sea level), Suluova (40° 47′ N 35° 41′ E and 484 m sea level), Gümüşhacıköy (40° 52′ N 35° 14′ E and 785 m sea level), and Osmancık (40° 58′ N 34° 51′ E and 449 m sea level), located in Northern Turkey (Figure 1). Sowings were performed on 8-11 th April, 7-10 th April in 2004 and 2005, respectively. Climatic data for the research areas are given in Table 1. Soil types of Bafra, Suluova and Gümüşhacıköy are clay loam, while Osmancık and Ladik are silty clay loam. The experimental design was a randomized complete block design with three replications. Sowing rates were 15 kg ha^{-1} for all locations and cultivars. Individual plot size was 2 x 5 m= 10 m^2. Row spacing was 50 cm and intrarow spacing was 12-15 cm after decollation. Plants were harvested on 20-27 th September, 22-26 th September in 2004 and 2005, respectively. Samples of each plot were obtained to determine seed yield, plant height, first branch height, number of branches per plant, head diameter, number of seeds per head, 1000-seed weight, oil content and fatty acid compositions.

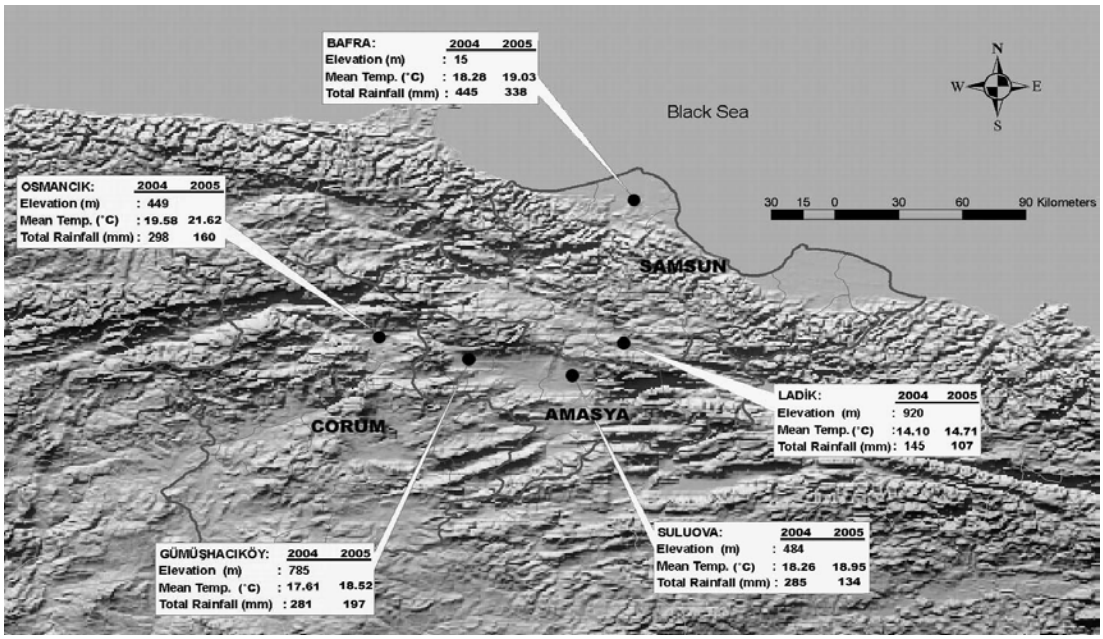

Figure 1. The map showing the experimental areas and some climatic data.

Table 1. Climatic data for the experimental areas

Locations	Total rainfall (mm)			Mean temperature (°C)			Mean humidity (%)		
	Long-period	2004	2005	Long-period	2004	2005	Long-period	2004	2005
Bafra	297	445	338	18.13	18.28	19.03	76.3	75.7	75.2
Ladik	228	145	107	14.22	14.10	14.71	62.5	61.9	61.4
Suluova	165	282	134	18.44	18.26	18.95	66.8	67.1	65.6
G.hacıköy	257	281	197	17.79	17.61	18.52	52.5	51.3	51.2
Osmancık	213	298	160	20.13	19.58	21.62	62.7	63.6	57.5

2.3. Determination of Seed Oil Content and Fatty Composition

The seeds were oven-dried at 40°C for 4 hours, using a ventilated oven, up to a moisture content of about 5%, and were then ground with a Waring blender. Four grams of dried safflower seeds were extracted with petroleum ether for 6 hours in a Soxhlet system (B.chi Universal Extraction System B-811, Germany) according to the AOCS method (AOCS, 1993). The oil extract was evaporated by distillation at a reduced pressure in a rotary evaporator at 40°C until the solvent was totally removed.

The oil was extracted 3 times from a 2 g of air-dried seed sample by homogenization with hexane/isopropanol, 3:2, v/v. The oil sample (50-100 mg) was converted to its fatty acid methyl esters (FAME) as described by Marquard (1987). The methyl esters of the fatty acids (0.5 µl) were analyzed in a Hewlett-Packard 6890 series gas chromatograph (Perkin Elmer Auto System XL, USA) equipped with a flame ionizing detector (FID) and a fused silica capillary column (MN FFAP (50 m x 0.32 mm i.d.; film thickness = 0.25 µm). This was operated under the following conditions: oven temperature program, 120°C for 1 min raised to 240°C at a rate of 6°C min^{-1} and then kept at 240°C for 15 min); injector and detector temperatures, 250 and 260°C, respectively; carrier gas, helium at a flow rate of 40 ml min^{-1}; split ratio, 1/20 ml min^{-1}. Peak identification was performed by comparing the relative retention times with those of a commercial standard mixture of FAME. The contents of palmitic (16:0), stearic (18:0), oleic (18:1), and linoleic (18:2) acids were determined using a computing integrator. The effects of the independent variables on oil content and palmitic, stearic, oleic, and linoleic acid concentrations of the oil were analyzed on a percentage basis.

2.4. Statistical Analyses

The data were objected to analysis of variance (ANOVA) using SAS (1998) program and differences among treatments were tested with LSD test (Level of significance $P<0.05$, 0.01 and 0.001). The means between years were compared with Tukey homogeneity test. Besides, correlation analyses were performed to clarify the relations among parameters evaluated in this study.

3. RESULTS

The means between years were similar according to the Tukey homogeneity test. Therefore, data presented correspond to the means of the two years. Mean values of seed yield, yield and quality components for the safflower cultivars tested are shown in Tables 3 and 4. The results of variance analysis revealed significant differences among the cultivars, locations and C x L interactions for the parameters tested indicating the presence of genetic variability among cultivars as well as the environments and the performance of cultivars being differential over locations (Table 2).

Similar of the locations, the evaluated parameters varied greatly among the cultivars. Cv. Remzibey was found to be superior than the other two cultivars with its higher seed yield (1648 kg ha^{-1}), oil content (28.0 %) and oil yield (480 kg ha^{-1}). However, head diameter (2.34 cm), seed per head (33.06), 1000 seed weight (41.8 g), palmitic (11.0 %) and stearic (2.8 %) acid contents of cv. Dinçer and linoleic acid content (75.6 %) of cv. Yenice were higher than those of cv. Remzibey (Table 4).

Apart from, the significant location and cultivar effects, values for the parameters evaluated were affected significantly by cultivar x location (C x L) interaction (Table 2). In terms of this interaction, the cultivar Remzibey grown in the location Gümüşhacıköy produced the highest seed yield (2482 kg ha^{-1}), oil content (33 %) and oil yield (821 kg ha^{-1}) followed by the same cultivar grown in Suluova (1819 kg ha^{-1}) and Ladik (30.0 %) and cv. Yenice grown in Gümüşhacıköy (492 kg ha^{-1}), respectively. Effect of the same interaction on fatty acid composition was also found to be significant. Palmitic and stearic acid contents of Dinçer cultivar grown in Gümüşhacıköy were the highest (11.8 and 3.1 %, respectively) while cv. Remzibey grown in Osmancık and cv. Yenice grown in Gümüşhacıköy produced the highest oleic (31.4 %) and linoleic (77.5 %) acids (Table 3).

Among the locations, Gümüşhacıköy produced the highest values for all parameters tested. Seed yield, 1000 seed weight, oil content and oil yield were 1987 kg ha^{-1}, 43.6 g, 29.4 % and 592 kg ha^{-1} for the location, respectively. Palmitic (9.2 %), stearic (2.8 %) and linoleic (72.9 %) acid contents of oil of Gümüşhacıköy grown safflower plants were also found to be highest. Those higher values mentioned above were followed by the locations Suluova and Osmancık (Table 4).

Based on the results of correlation analyses on all agronomic traits tested, the relationships between different characters of safflower were identified. The yield correlated with other characters in the following order: oil yield (r: 0.95), oil content (r: 0.51), number of branch per plant (r: 0.49), 1000 seed weight (r: 0.45), number of seed per head (r: 0.44) and head diameter (r: 0.33) (Table 5).

4. DISCUSSION

The success of safflower introduction in new areas will largely depend on the extent of improvement made in yield and oil content (Malleshappa et al., 2003; Abdolrahmani, 2005). Yield varied among cultivars, locations and was affected by C x L interaction significantly in the present study. The seed yield of a cultivar in a given location might vary because of light, water, precipitation, temperature, humidity and nutrient competition (Koutroubas *et al*., 2004). The flowering

Table 2. Results of variance of analysis for mean values of parameters tested

Source of variance	Df	SY	PH	BH	BP	HD	SH	SW	OC	OY	16:0	18:0	18:1	18:2
Year (Y)	1	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	*
Location (L)	4	***	***	***	***	ns	***	***	***	***	***	***	***	***
Y x L	4	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Block (Yx L)	20	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
Cultivar (C)	2	**	***	***	***	***	***	***	***	***	***	***	***	***
Y x C	2	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
L x C	8	***	***	***	***	***	*	*	*	***	***	***	*	*
Y x L x C	8	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns	ns
CV (%)		22.4	5.57	10.90	13.63	6.56	11.80	10.91	12.90	29.1	3.14	5.48	8.54	2.72

Df: degrees of freedom; CV: coefficient of variation; SY: seed yield; PH: plant height; BH: first branch height; BP: number of branch per plant; HD: head diameter; SH:number of seed per head; SW: 1000-seed weight; OC: oil content; OY: oil yield; 16:0 palmitic acid; 18:0 stearic acid; 18:1 oleic acid; 18:2 linoleic acid; ns: not significant. *P < 0.05, **P < 0.01, ***P < 0.001

and pollination of safflower can be severely reduced by rain or excessive dew and high humidity. Plant diseases such as alternaria (*Alternaria carthami*) and bacterial blight can also be more destructive under these conditions and cause major yield reductions (Mündel, 2001; Johnston *et al*., 2002). The lowest seed yield was obtained from the Bafra location having the highest level of rainfall (Table 1). Thus, the significant yield differences observed for all cultivars tested among locations may be attributed to the climatic differences. Previous literature reports cite seed yield of safflower ranging from 1168 to 3325 kg ha^{-1}(Dadashi and Khajehpour, 2004; Eslam, 2004; Özel *et al*., 2004; Kumbhar *et al*., 2004 ; Misra *et al*., 2005 ; Azari and Khajehpour, 2005 ; More *et al*., 2005). Thus, the lowest and highest yields observed in the current study are somewhat similar those found in the preceding works.

Plant height, first branch height, number of branches per plant, head diameter, seeds per head, 1000-seed weight and oil content are the most important morphological characteristics concerning seed yield (Patil, 1998; Gupta and Singh, 1997; Choulwar *et al*., 2005) because of a direct correlation between these characteristics and seed yield as confirmed by results of the correlation analyses in our case (Table 5). Likewise, higher values for the aforesaid yield components were observed for the location Gümüşhacıköy which produced the highest seed yield.

Oil content of seeds is a very important economic trait for safflower cultivars and considered one of the most important factors affecting the success of safflower introduction in new areas (Bassil and Kaffka, 2002). Similar of yield, oil contents were affected significantly by cultivar, location and C x L interaction in the present study. Oil content is known to chance depending on factors like cultivar, soil characteristics and climate (Rahamatalla *et al*., 2001). Oil content of safflower cultivars from different production areas of the word was reported as 23.86-40.33 % (Zhang and Chen, 2005), 26.72-35.78 % (Koutroubas and Papadoska, 2005), 26.3-28.5 % (Gawand *et al*., 2005) and 31.3-36.3 % (Arslan and Küçük, 2005). Evaluating our results of oil content measurements, it can be established that our results are in accordance with those of previous reports. The results have also confirmed the fact that spiny safflower cultivars contain more oil than spineless ones (Weiss, 1971). Considering the significant and positive correlation between yield and oil content, higher oil yield values were observed in the present study. Gawand *et al*. (2005) recorded oil yield among four safflower cultivars which ranged from 322 to 460 kg ha^{-1} and Koutroubas and Papadoska, (2005) observed higher values for twenty-one cultivars (416-701 kg ha^{-1}). As shown in Table 4, our results for oil yield were superior over those reported by other researchers.

Oil quality is a significant concern of consumers, particularly for the contents of oeic and linoleic acids which are proven as healthy sources of oil for human body. Safflower is thought to be one of the highest quality vegetable oils and its oil consists of mainly palmitic, stearic, oleic and linoleic acids (Penumetcha *et al*., 2000; Lee *et al*., 2004). Thus, we performed oil analyses to determine the content of aforesaid fatty acids in the present study. The cultivar Remzibey and Yenice with the highest content of oleic (27.7 %) and linoleic (75.6) acids could be good material for oil quality improvement of safflower. Similar results were reported by Vasishtha *et al*. (1994), Penumetcha *et al*. (2000), Bergman *et al*. (2001) and Arslan and Küçük (2005).

Fatty acid composition for safflower has been determined by a couple of genes (*O/ol*). High linoleic (75-80 %) and low oleic acids (10-15 %) have been determined by the gene pair *OlOl*, while the gene pair

Table 3. Mean values of seed yield, plant height, first branch height, number of branch per plant, head diameter, number of seed per head, 1000-seed weight, oil content, oil yield and fatty acid composition of oil for safflower cultivars tested grown in different cites

Parameters	SY	PH	BH	BP	HD	SH	SW	OC	OY	16:0	18:0	18:1	18:2
Locations						**Cv. Remzibey**							
Bafra	1005ef	81F	24 F	5.4 E	2.2CD	30cd	31gh	25 cf	261FH	8.2 E	2.2 E	29.8a	59.8f
Ladik	1494c	74G	23 F	6.2CE	2.2CD	27de	40cd	30ab	445CD	7.7 FG	2.3DE	26.2b	63.8f
Suluova	1819b	67H	20FG	6.3CE	2.2CD	29ce	37df	26be	479BC	7.8 F	2.3DE	27.8b	62.1f
G. hacıköy	2482a	88EF	18 G	8.2 A	2.1DE	33bc	43bc	33 a	821 A	7.3 G	2.4CD	23.3c	67.0e
Osmancık	1439c	91 E	16 G	7.8AB	2.0 E	25 e	39ce	27bd	396 E	8.2 E	2.2 E	31.4a	58.2g
						Cv. Dinçer							
Bafra	1177de	98 D	32 D	5.9DE	2.1DE	29ce	33fh	21 f	257 H	10.8 C	2.3DE	15.8df	71.1d
Ladik	1148de	77FG	29 D	5.7DE	2.4AB	32 c	40cd	26be	295FG	11.4 B	3.1 A	14.2fg	71.3d
Suluova	1709 b	81 F	29 D	5.7DE	2.3BC	37ab	40cd	25 cf	432DE	11.1BC	2.8 B	14.5 f	71.6d
G. hacıköy	1772 b	99CD	29 D	6.8BC	2.4AB	39a	49 a	26be	462BD	11.8 A	3.1A	10.6 h	74.5bc
Osmancık	1096 e	106BC	31 D	5.3 E	2.5 A	28de	46ab	22 ef	237 H	9.2 D	2.3DE	17.4 d	71.1 d
						Cv. Yenice							
Bafra	913 f	107BC	62B	5.6DE	2.3BC	29ce	30 h	21 f	193 I	7.4 G	2.4D	14.9ef	75.3bc
Ladik	1137 e	97 DE	60B	7.1BC	2.3BC	29ce	30 h	26 e	313 F	8.2 E	2.7 B	12.9 g	76.2ab
Suluova	1221 d	112 B	59B	6.8BC	2.1DE	28db	35eg	24 df	295FG	8.2 E	2.5 C	14.2fg	75.1bc
G. hacıköy	1708 b	138 A	72A	6.6CD	2.5 A	37ab	38de	29 ac	492 B	8.4 E	2.8 B	11.3gh	77.5 a
Osmancık	1759 b	105 C	49C	6.9BC	2.4AB	26de	31gh	25 cf	446CD	7.2 G	2.4CD	16.5de	73.9 c

SY: seed yield (kg ha^{-1}); PH: plant height (cm); BH: first branch height (cm); BP: number of branch per plant; HD: head diameter (cm); SH:number of seed per head; SW: 1000-seed weight (g); OC: oil content (%); OY: oil yield (kg ha^{-1}); 16:0 palmitic acid (%); 18:0 stearic acid (%); 18:1 oleic acid (%); 18:2 linoleic acid (%). Values followed by the same capital and small letters are different at $P<0.05$ and $P<0.001$ levels.

olol has determined low linoleic acid (12-30 %) and high oleic acid (64-83 %) (Baydar, 2000). Based on the results of the present study, it may be speculated that Yenice and Dinçer cultivars are homozygote dominant (*OlOl*) and Remzibey cultivar is heterozygote dominant (*Olol*) in terms of fatty acid composition.

As shown in Table 2, fatty acid composition varied with locations significantly. In general, the locations with high temperatures (Bafra, Osmancık and Suluova) produced high stearic and oleic acids, however low palmitic and linoleic acids. Environmental factors such as soil and climatic ones have played an important role in change of fatty acid composition and temperature is the most important factor affecting fatty acid composition (Baydar and Turgut, 1999). Oleayl-PC desaturaz and linoleayl-PC desaturaz enzymes have converted oleic acid to linoleic and linoleic acid to linolenic acid, respectively. The activities of both enzymes have been decreased by high temperatures resulting in the decrease in linoloic and linolenic acids synthesis and the increase in oleic acid synthesis (Pleines and Friedt, 1989). In the light of these findings, it can be concluded that an increase in temperature promotes a higher synthesis of oleic acid but a lower synthesis of linoleic acid.

5. CONCLUSIONS

Result from the present study indicated that seed yield, yield components, oil content of seed and fatty acid composition of safflower have been affected significantly by the cultivars and growing conditions. In our case, safflower showed generally good adaptation to Northern Turkey conditions. High values for oil content and seed yield observed in the present

Table 4. Mean values of seed yield, plant height, first branch height, number of branch per plant, head diameter, number of seed per head, 1000-seed weight, oil content, oil yield and fatty acid composition of oil for each safflower cultivar and experimental location

	SY	PH	BH	BP	HD	SH	SW	OC	OY	16:0	18:0	18:1	18:2
						Locations							
Bafra	1032d	95.5 c	39.1 a	5.66 c	2.21 b	29.34 b	31.1 c	22.2 c	237 d	8.6 b	2.3 c	20.2b	68.9cd
Ladik	1260c	82.8 e	37.2 ab	6.33 b	2.28 ab	29.51 b	36.8 b	27.2 a	354 c	9.1 a	2.7 a	17.5d	70.6 b
Suluova	1584b	86.6 d	36.2 b	6.27 b	2.19 b	31.23 b	37.2 b	24.9 b	402 b	9.0 a	2.5 b	18.9c	69.6bc
G. hacıköy	1987a	108.7a	39.9 a	7.23 a	2.32 a	36.11 a	43.6 a	29.4 a	592 a	9.2 a	2.8 a	15.1e	72.9 a
Osmancık	1432bc	101.2b	31.9 c	6.67 ab	2.29 ab	26.07 c	38.4 b	24.8 b	360 c	8.2 c	2.3 c	21.9a	67.7 d
						Cultivars							
Remzibey	1648 a	80.4 c	19.9 c	6.78 a	2.14 b	28.59 b	37.8 b	28.0 a	480 a	7.9 b	2.3 c	27.7	62.2 c
Dinçer	1381 b	92.3 b	30.2 b	5.90 b	2.34 a	33.06 a	41.8 a	24.0 b	337 b	11 a	2.8 a	14.5	71.9 b
Yenice	1348 b	112.2a	60.5 a	6.61 a	2.30 a	29.71 b	32.7 c	25.1 b	348 b	7.8 b	2.6 b	13.9	75.6 a

SY: seed yield (kg ha^{-1}); PH: plant height (cm); BH: first branch height (cm); BP: number of branch per plant; HD: head diameter (cm); SH:number of seed per head; SW: 1000-seed weight (g); OC: oil content (%); OY: oil yield (kg ha^{-1}); 16:0 palmitic acid (%); 18:0 stearic acid (%); 18:1 oleic acid (%); 18:2 linoleic acid (%). Values followed by the same letters are different at P<0.001 levels.

Table 5. Correlation coefficients for some plant characteristics in the safflower cultivars tested

	2	3	4	5	6	7	8	9
1	-0.11	-0.18	0.49**	0.33**	0.44**	0.45**	0.51**	0.95**
2		0.71**	0.13	0.07	0.06	-0.04	-0.11	-0.12
3			-0.03	0.19	0.11	-0.23*	-0.16	-0.21*
4				-0.02	0.11	0.17	0.34**	0.51**
5					0.71**	0.47**	0.24*	0.29**
6						0.53**	0.37**	0.44**
7							0.29**	0.39**
8								0.72**
9								-

1: Seed yield, 2: Plant height, 3: First branch height, 4: Number of branch per plant, 5: Head diameter, 6: Number of seed per head, 7: 1000-seed weight, 8: Oil content, 9: Oil yield. *P<0.05; **P<0.01

study encouraged the introduction and cultivation of this plant in Turkey. Among the investigated cultivars, cv. Remzibey is recommended for cultivation in different locations across Northern Turkey since it has significantly high yield performance and oil content. Further studies are currently underway to elucidate the appropriate cultivation requirement of safflower under Northern Turkey conditions.

6. REFERENCES

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