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Research Article

Comparing The Performances of Sunflower Hybrids in Semi-Arid Condition

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Abstract

The study was performed in semi-arid climate and rainfed conditions to compare the yield and yield performance of sixteen sunflower hybrids (Bosfora, Fx 9008, Fx 9009, Fx 9114, Hornet, Lg 5550, Lg 5580, Maximus, Oliva, Reyna, Sanay, Sanbro, Sirena, Tarsan, Transol, and Tunca). The experiment was established with randomized complete block design with three replications at experimental field of Kırşehir Ahi Evran University in 2012 and 2013. During the sunflower growth period, 130 mm of precipitation was recorded in 2012, and this precipitation was normal compared to the long-term anomaly, but 40 mm of precipitation in 2013 was about 70% lower than the long-term. This decrease in precipitation between years had important negative effects on yield and yield components of sunflower cultivars. The decrease in the amount of precipitation between research years caused a significant decrease in the plant height (16.57%), head diameter (18.90%), 1000 seed weight (20.00%), oil yield (29.70%) and seed yield (30.59%). Results showed that seed yield decreases varied from 13% to 50% comparing the years and these changes were attributed to the genetic abilities of the hybrids and limited precipitation in 2013. As a result, the highest seed (3.03 t ha^{-1}) and oil yield (1.40 t ha^{-1}) was obtained from Tarsan cultivar in 2012, while in 2013 the highest seed yield was 1.76 t ha^{-1} (Hornet) and the highest crude oil yield with 0.85 t ha^{-1} was obtained from Transol. Considering the results, for seed and oil yield it is recommended that Tarsan, Transol, Sirena and Hornet hybrid cultivars for similar ecological conditions of arid areas.

Key words: Sunflower, correlation, seed yield, oil yield

Yarı Kurak İklim Koşullarında Hibrid Ayçiçeği Çeşitlerinin Performanslarının Karşılaştırılması

Öz

Yarı kurak iklim koşullarında yürütülen çalışmada kuru kurak koşullarda 16 hibrid ayçiçeği çeşidinin (Bosfora, Fx 9008, Fx 9009, Fx 9114, Hornet, Lg 5550, Lg 5580, Maximus, Oliva, Reyna, Sanay, Sanbro, Sirena, Tarsan, Transol ve Tunca) verim ve verim performanslarının karşılaştırılması amaçlanmıştır. Araştırma tesadüf blokları deneme desenine göre 3 tekerrürlü olarak 2012 ve 2013 yıllarında Kırşehir Ahi Evran Üniversitesi deneme tarlalarında yürütülmüştür. Ayçiçeği büyüme döneminde, 2012 yılında 130 mm yağış kaydedildi ve bu yağış, uzun vadeli anomali ile karşılaştırıldığında normaldi, ancak 2013 yılında 40 mm yağış, uzun vadeden yaklaşık %70 daha düşüktür. Yıllar arasında yağıştaki bu azalmanın ayçiçeği çeşitlerinin verim ve verim bileşenleri üzerinde önemli olumsuz etkileri olmuştur. Yağış miktarındaki azalmaya bağlı olarak çeşitlerin bitki boyu %16.57, tabla çapı %18.90, bin tane ağırlığı %20.00, yağ verimi %29.70 ve tane veriminde %30.59 oranında ortalama azalma gözlenmiştir. Sonuçlar yıllar arasında çeşitlerin tohum veriminde azalmanın %13 ile %50 arasında değiştiğini ve bu değişikliklerin ise 2013 yılında yağış miktarında önemli oranda düşmesine ve çeşitlerin genetik kabiliyetlerine bağlanmıştır. Sonuç olarak, 2012 yılında Tarsan çeşidinden en yüksek tane (3.03 t ha^{-1}) ve yağ verimi (1.40 t ha^{-1}) elde edilirken, 2013 yılında kuraklık stresi altında en yüksek tohum verimi 1.76 t ha^{-1} (Hornet) ve en yüksek ham yağ verimi 0.85 t ha^{-1} ile Transol çeşidinden elde edilmiştir. Sonuçlar değerlendirildiğinde tane ve yağ verimi yönünden Tarsan, Transol, Sirena ve Hornet çeşitlerinin kurak koşullarda benzer ekolojiler için önerilmektedir.

Anahtar Kelimeler: Ayçiçeği, korelasyon, verim, yağ verimi

Introduction

Sunflower (*Helianthus annuus* L.) is one of the most widely cultivated oilseed crops in the world. World sunflower production has reached 47.3 million tons from 26.2 M ha areas in 2016 (FAO, 2017). It is cultivated under temperate zone , which can easily adapt and perform well under a variety of climatic and soil conditions (Canavar, et al., 2010, Demir, 2019). Due to this, sunflower has been successfully produced in Russia, Argentina, Australia, India, Ukraine, Turkey and the United States, and in a wide geography of World. Hybrid sunflowers varieties show greater stability than open pollinated varieties. These hybrid cultivars also exhibit a lower degree of genotype-environment interactions, thus ensuring higher and more stable yields. The cultivation of sunflower hybrids, consequently, allows higher production values by increasing seed yield per unit area (Göksoy, et al., 1999). However, despite the availability of varieties with high yield stability, it is, also, necessary and important to conduct studies on investigating the regional varieties with high seed and oil yield as well as high pest and disease resistance that are well adapted to local environmental conditions (Yılmaz and Kınay, 2015). Sunflower suffers from terminal drought accompanying with high temperature stress since it grows mainly in rain fed areas (Kaya, et al., 2016). Yield and oil content of sunflower is a complex quantitative feature determined as a result of individual or combined effects of genetic and environmental conditions (Balalić, et al., 2016, León, et al., 2003). Seed and oil production depend on the number of grains in head, grain weight and oil content. These yield parameters depend on genetic ability, but can be altered by environmental and cultural conditions (Aguirrezábal, et al., 2015).

Seed yield of the sunflower cultivars is determined by genetic and environmental factors along with interaction between them. Seed yield and yield components are negatively affected by inadequate and irregular rainfall with increased temperature and evaporation. Therefore, the objective of this study was to determine the seed yield and oil content of sunflower hybrid cultivars and to determine which cultivars were most affected from irregular and less precipitation in arid and rainfed conditions.

Materials and Methods

Sixteen oil type sunflower hybrid cultivars (Bosfora, Fx 9008, Fx 9009, Fx 9114, Hornet, Lg 5550, Lg 5580, Maximus, Oliva, Reyna, Sanay, Sanbro, Sirena, Tarsan, Transol, and Tunca) were used to determine seed yield, oil yield of sunflower in 2012 and 2013 at the Research Farm of Ahi Evran University in Kırşehir Province. This experimental field is located at 39.15° Northern latitude and 34.11° Eastern longitude at 1014 meters above sea level. According to soil analysis, experimental soil was salt-free, clayed-loamy textured, low in organic matter and slightly alkaline reaction. It was classified as poor soil in terms of available phosphorus, but rich in potassium (Table 1).

Table 1. The results of soil analysis in trial areas

Texture	pH	EC (mmhos/Cm)	Salinity (%)	Available P_2O_5 (kg ha^{-1})	$CaCo_3$ %	Available K_2O (kg ha^{-1})	Organic matter(%)
Clay-Loam	7.59	0.52	0.02	21.4	27.90	666.2	1.81

Based on soil analysis, all trial parcels were fertilised with 80 kg N ha-1 and 60 kg P ha-1. Seeds were planted to the 6 m to 4.2 m parcels in 6 rows at 70 x 30 cm intervals on the second week of April (15 April 2012 and 18 April 2013). The experiment was carried out with three replications for two years in the randomized blocks design. Data were analysed by using MSTAT-C statistical program (Russell, 1986). LSD test was used to compare the means (Düzgüneş, et al., 1987).

According to the climatic data (as can be seen in Table 2), the relative humidity between April and September (the period the study was conducted) was slightly below the long-term annual average in 2013. Precipitation was 144.1 mm in 2012, which was close to the long-term average precipitation values. On the other hand, precipitation was 101.1 mm in 2013, which was considerably below the long-term average and first year of experiment's values. Temperature values during the cultivation period were above the long-term average for the region.

Table 2. Meteorological data in Kırşehir Province during the period of 1970-2013

Month	Relative Humidity (%)			Precipitation (Mm)			Temperature (°C)		
	1970-2013	2012	2013	1970-2013	2012	2013	1970-2013	2012	2013
April	50.3	63.8	63.2	45.6	20.1	46.2	10.6	13.3	11.9
May	66.5	61.0	50.7	43.9	109.5	15.1	15.3	15.4	18.0
June	47.7	54.3	41.1	34.5	11.9	1.0	19.6	21.6	20.4
July	38.8	48.4	41.2	6.7	1.4	6.6	23.1	25.3	22.7
August	42.0	48.7	39.7	5.0	0.0	0.2	22.8	23.0	23.1
September	39.4	53.2	50.0	11.8	1.2	32.0	18.2	20.6	16.8
Total				147.5	144.1	101.1			
Mean	47.45	54.9	47.65				18.27	19.87	18.82

According to the daily temperature changes from sowing to harvest time, a higher temperature was observed in April 2012, when the compared the same period of 2013. Until the flowering period after emergence, 2013 reached higher temperatures with faster heating (Figure 1).

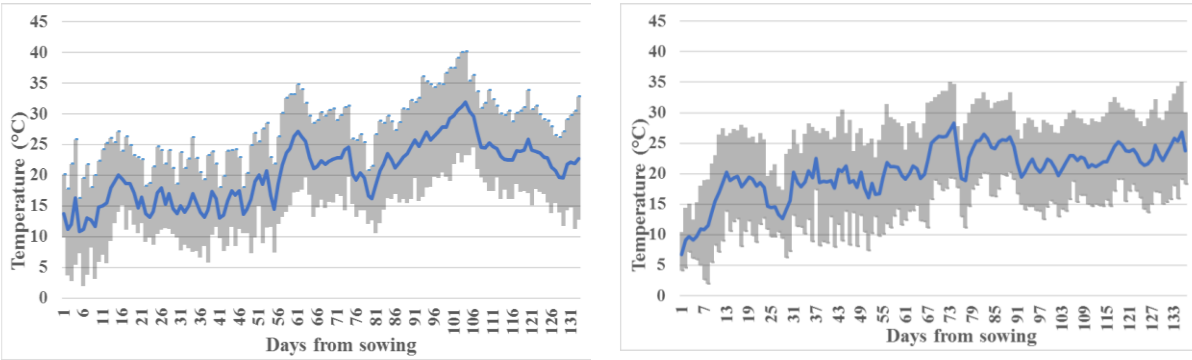

Figure 1. Daily temperature changes from sowing to maturity.

During the flowering and grain filling period, the temperature increases in 2012 was higher than 2013. In terms of the effect of temperature on growth and development in sunflower, in 2012, high temperature in sowing time positively affects early emergence and growth. In 2013, due to the low temperature of sowing time, there was a late emergence and growth.

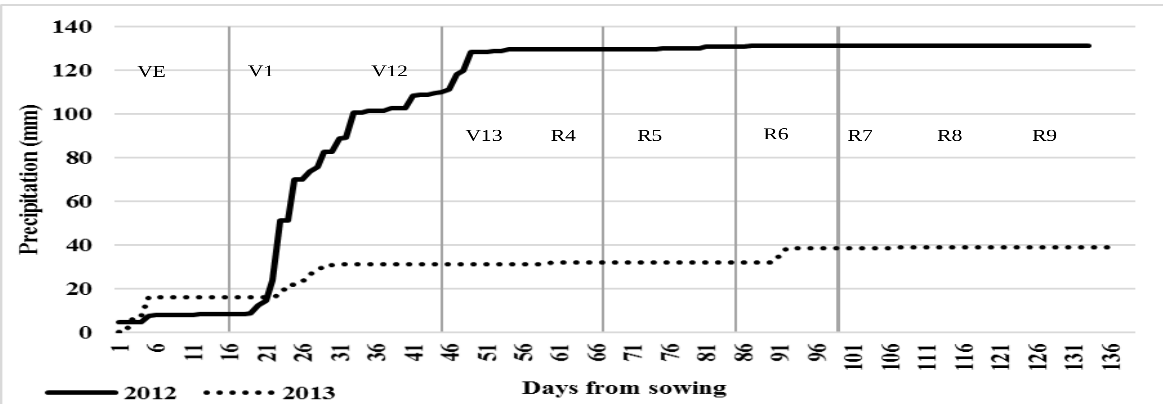

Figure 2. Daily accumulated precipitation with growth phase of sunflower

When the daily precipitation change is analysed, a similar amount of precipitation is obtained from the date of sowing to emergence period of 2012 and 2013 (Figure 2). After emergence time the precipitation was significantly different in terms of amount. This precipitation differences in 2012 were likely more than 110 mm in the period from emergence (VE) to flowering stage (R5) of sunflower when the compared period of 2013 (Schneiter and Miller, 1981). When the compared the total precipitation from sowing to harvest time, 130 mm precipitation was in 2012-

and 40 mm precipitation was in 2013. Even if the precipitation in the growing period of sunflower in 2012 was higher than 2013, the precipitation amount in 2012 was similar to the long-term total precipitation amount. Extremely low precipitation was occurred in 2013. In rainfed agriculture systems of semi-arid climate zone, such as 2013, plant growth and yield significantly affected by drought.

Results and Discussion

The statistical differences between cultivars were found significant with respect to plant height, kernel ratio (2012), seed yield, oil content, and oil yield (P<0.01), head diameter and 1000-seed weight (2012) (P<0.05). However, there weren't any significant differences between cultivars with respect to 1000-seed weight in 2013 (Table 3).

Table 3. Some agronomic traits of sunflower cultivars grown in 2012 and 2013.

Analysis of Variance	***Plant Height (cm)***		***Head diameter (cm)***		***1000 Seed Weight (g)***	
	2012	**2013**	**2012**	**2013**	**2012**	**2013**
MSE	**1,523**	**0,848**	**0,173**	**0,129**	**1,427**	**0,654**
Cultivars	**	**	*	*	*	ns
CV(%)	4.06	4.41	5.54	4.97	4.65	5.37
Cultivars						
Bosfora	141. 20a	109.50a	18.12be	15.21ae	58.85ab	44.28
Fx 9008	126.20cd	104.20ad	17.75ce	14.53bf	54.13bc	41.65
Fx 9009	141.30a	103.70ad	18.06ce	14.78bf	66.54a	45.48
Fx 9114	134.70ab	97.90df	18.62ae	14.04ef	51.45bc	41.96
Hornet	121.90cf	101.90be	20.12a	14.95bf	52.02bc	49.52
Lg 5550	109.20hi	103.60ad	17.22de	15.04be	57.72ab	43.45
Lg 5580	113.00gi	105.00ad	19.10ac	15.46ad	50.63bc	41.93
Maximus	115.00fi	106.00ac	17.81ce	15.12be	39.22ab	39.76
Oliva	124.30ce	100.30ce	19.81ab	14.30df	53.38bc	39.88
Reyna	118.60dg	95.60ef	18.70ad	14.44cf	46.75cd	44.34
Sanay	127.40bc	103.40ad	16.94e	13.80f	49.01bd	38.05
Sanbro	121.70cf	108.40ab	17.47ce	16.36a	57.33ac	42.58
Sirena	117.20eh	108.40ab	18.66ad	15.75ab	54.37bc	44.47
Tarsan	123.90ce	92.47f	18.54ae	14.39df	55.90ac	41.77
Transol	123.30ce	102.60ae	18.33be	15.63ac	52.39bc	42.29
Tunca	108.30i	98.47cf	18.57ae	14.51cf	58.78ab	45.38
Mean	122.96	102.58	18.36	14.89	53.65	42.92
LSD	**2.41**	**4.85**	**2.14**	**2.16**	**0.37**	

*, ** significant at the 0.05 and 0.01 level, respectively. For each main effect, values within columns followed by the same letter are not significant. ns, nonsignificant. MSE: the mean squared error

The average plant height in 2012 was 20.42 cm longer than that of 2013, most likely, due to varying weather (considerably below the long-term average precipitation values in 2013) conditions. Especially since the height of the plant grows up to the flowering period, 130 mm of precipitation is obtained in period of sunflower from emergence to flowering in 2012, while the precipitation for the same period was 33 mm in 2013. About 100 mm lack of precipitation amount in 2013 was very important factor to limit plant height in this year. When the plant heights of cultivars are compared, Bosfora cultivar was higher plant in both years. On the other hand, Tunca (108,30 cm) cultivar in 2012 and Tarsan (92.47 cm) cultivar in 2013 were lower in height (*Table 3*). In rainy condition Bosfora reached 141.20 cm and in dry year of 2012 reached 109.50 cm tall. In terms of plant height mostly effected cultivar was FX 9009 and FX 9114 which have 37.58 and 36.83 cm differences between years. It shows that mostly effected cultivars were not suitable for dry conditions. At the same time, least effected cultivars were LG 5050 and LG 5080, and plant height changes 5.6 and 7.97 cm respectively. These differences in plant height may also be attributed to the genetic potential of hybrids and the other prevailing environmental conditions, especially precipitation and temperature. The plant height of some sunflower hybrids increased with increasing temperature and precipitation. Similar results were obtained by (Qadir, 2006).

The largest head diameter was obtained in 2012 while the smallest one was produced in 2013. Decreased head diameter approximately 6.32 cm low in 2013 was related to weather conditions which were dry cool season on growing period. Head diameters ranged from 13.80 cm (Sanay cultivar in 2013) to 20.12 cm (Hornet cultivar in 2012). Comparing two years head diameter results, Hornet cultivar in 2012 and Sanbro cultivar in 2013 were higher than the others. Sanay cultivar was the smallest in both years (Table 3). The biggest changes in head diameter between years were determined from Hornet and Oliva cultivars about 5.52 and 5.16 cm respectively. This situation shows that, genetic capabilities of these cultivars will perform better in irrigated conditions. In addition, Sanbro and Transol varieties formed sufficient table diameter both in the wet and dry years. The difference in table diameter was 1.12 in Sanbro and 2.7 cm in Transol. In this case, it shows that these varieties will give better performance especially in rain-based agricultural areas. Head diameter of sunflower is a significant property, because it influences the number of flowers, and thus the number of grains per head, which are important preconditions for yield of sunflower hybrids (Balalić, et al., 2016).

Thousand seed weight is one of the major yield contributing attributes (Akcay and Dagdelen, 2016). Thousand seed weight differs based on cultivars and growing conditions. Statistical analysis showed that there was highly significant effect of cultivars on 1000-seed weight in only 2012. When compared the obtained average results, when rainfall was high in 2012, the 1000 seed weight (53,65 g and 42,92 g) was higher than that of 2013 without statistical significance. The lowest value for seed weight in 2012 was determined for Maximus cultivar (39.22 g), while Fx 9009 cultivar had the highest value of 1000-seed weight (66.54 g). In 2013, 1000 seed weight was ranged from 38.05 g for Sanay cultivar to 49.52 g for Hornet cultivar (Table 3) in used cultivars.

Table 4. Some agronomic traits of sunflower cultivars grown in 2012 and 2013.

Analysis of Varians	***Oil content (%)***		***Seed yield (t ha^{-1})***		***Oil yield (t ha^{-1})***	
	2012	2013	2012	2013	2012	2013
MSE	0,289	0,284	0,528	0,255	0,253	0,131
Cultivars	**	**	**	**	**	**
CV(%)	10.35	10.35	10.95	7.15	10.95	7.15
Cultivars						
BOSFORA	45.31d-g	48.86a	2.17c-f	1.67abc	0.98cg	0.81ab
FX 9008	44.37fh	47.67abc	2.14c-g	1.55c-e	0.95dg	0.74bd
FX 9009	45.14d-h	48.49a	2.31bcd	1.28g	1.04bf	0.62eg
FX 9114	46.56b-e	45.69c-e	2.27b-e	1.39e-g	1.06be	0.63eg
HORNET	48.62ab	44.70e	2.31bcd	1.76a	1.12bd	0.78ac
LG 5550	43.05h	48.49a	1.98d-g	1.68ac	0.86g	0.82ab
LG 5580	47.76abc	48.86a	1.79g	1.54ce	0.86g	0.75bd
MAXİMUS	44.52e-h	48.88a	1.91eg	1.57bd	0.85g	0.77ad
OLİVA	48.86a	48.17ab	2.01dg	1.45dg	0.98dg	0.70ce
REYNA	46.76a-d	44.42e	1.98dg	1.33fg	0.93eg	0.59g
SANAY	43.85gh	46.90ad	1.98dg	1.37eg	0.87fg	0.64eg
SANBRO	44.34fgh	45.41de	2.62b	1.32g	1.16bc	0.60fg
SİRENA	47.49abc	45.70ce	2.50bc	1.62ad	1.18b	0.74bd
TARSAN	46.35c-f	46.10be	3.03a	1.54ce	1.40a	0.71ce
TRANSOL	44.99d-h	48.90a	2.25be	1.74ab	1.01bg	0.85a
TUNCA	46.41c-f	45.27de	1.81fg	1.50cf	0.84g	0.68df
Mean	45.9	47.03	2.19	1.52	1.01	0.71
LSD	2.14	2.16	0.37	0.18	0.18	0.09

*, ** significant at the 0.05 and 0.01 level, respectively. Values within columns followed by the same letter are not significant. ns, nonsignificant. MSE: the mean squared error

The oil contents of cultivars were significantly different between studied years 2012 and 2013. Seed oil content was significantly influenced by genotype and environmental conditions. Crude oil rate (45.90%) in 2012 when the weather was rainy and cool was lower than that (47.03%) of 2013 when the weather was less rainy and warmer. The highest oil rate was obtained from Oliva cultivar (48.86%) in the first year and Transol, Maximus, Lg5580, Lg5550 and Fx9009 cultivars (48.90, 48.88, 48.86, 48.49 and 48.49, respectively) in the second year (Table 4). Seed oil content is affected by genotype, environmental conditions and cultural practices (Roche, et al., 2010).

The sunflower seed yield is significantly affected by genotype, environmental conditions and agricultural applications. Owing to the studied sunflower cultivars were subjected to the same agricultural applications, the observed differences in seed yield more likely, would be attributing the genetic differences among cultivars and the different effects of climate on them during growing season. The changes in seed yield could be, mostly, related to the climate condition. Average seed yield of cultivars was 2.19 t ha^{-1}obtained in 2012 with rainy season while poor rainfall season of 2013 was1.52 t ha^{-1}. As seen in Table 4, there were statistically significant differences in seed yield between sixteen sunflower cultivars in each year.

The higher seed yields were obtained from Tarsan cultivar (3.03 t ha^{-1}) in 2012 and from Hornet cultivar (1.76 t ha^{-1}) in 2013. The lower seed yields were obtained from Lg 5580(1.79 t ha^{-1}) in 2012 and Sanbro (1.32 t ha^{-1}) and Fx 9009 cultivars (1.28 t ha^{-1}) in 2013. All cultivars showed different responses to rainy condition and drought condition. The lowest seed yield in the rainy season (2012) was almost more than the highest seed yield in the dry season (2013) (Table 4). These results showed that rainfall was a more important factor than genotypes with regard to seed yield in arid and rainfed conditions. The environmental factors, especially from flowering to seed-filling, affect seed yield dominantly (Ali, et al., 2009). Most affected cultivars in drought season were generally the ones that provide the highest yield in the rainy period. The highest seed yield decrease was occurred Sanbro and Tarsan cultivars with a drop rate of approximately 49.69% and 49.18% respectively (Figure 3). According to two years mean, it is seen that Tarsan and Hornet cultivars had higher seed yield.

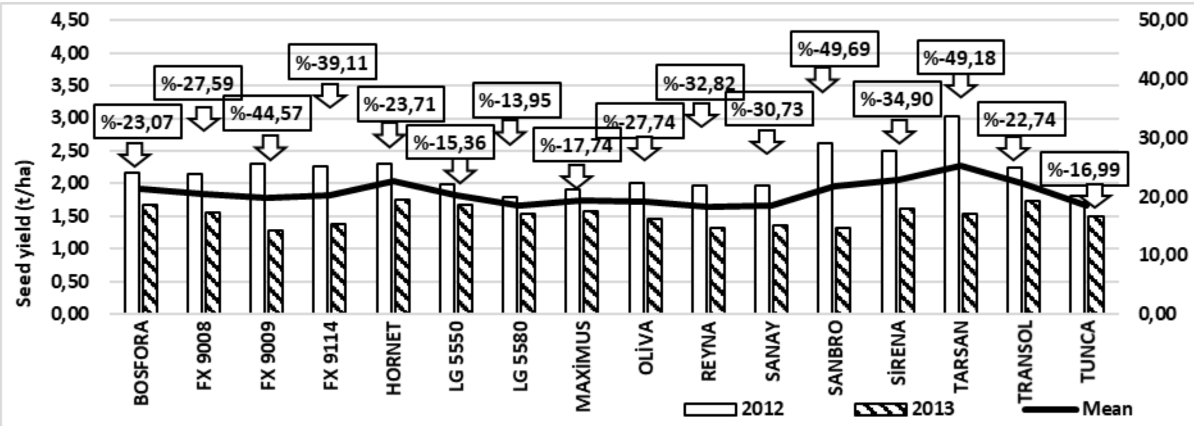

Figure 3. Seed yield changes

The oil yield was significantly different by year and cultivars (Table 3 and 4) as in other yield components. The used cultivars produced more oil yield in 2012 (1.01 t ha^{-1}) than in 2013(0.71 t ha^{-1}). The maximum oil yield was obtained from Tarsan (1.40 t ha^{-1}) in 2012 and Transol (0.85 t ha^{-1}) in 2013 (Table 4). Oil yield was calculated by multiplying the seed yield and oil rate. The higher oil yields were obtained from the cultivars having higher seed yield and oil rate.

According to correlation analysis, highly positive correlations were found between plant height with head diameter, 1000 seed weight, seed yield and oil yield and non-significant relationships were detected with oil rate (Table 5)

Head diameter had a highly positive significant correlation with 1000 seed weight, seed yield and oil yield, and had a non-significant relationship with oil rate. Even though the positive correlations of 1000 seed weight with seed yield and oil yield were exist ($P<0.01$) the negative direct effects of 1000 seed weight on crude oil rate was determined ($P<0.01$, Table 5). Previous studies have similarly reported that the association between seed yield and the 1000-seed weight is positive and significant (Hladni, et al., 2011, Kholghi, et al., 2011). The present seed yield values had positive significant relation with plant height, head diameter and 1000 seed weight. Similar findings were previously reported by (Göksoy and Turan, 2007, Kaya, et al., 2007, Pandya, et al., 2016) for plant height, head diameter and 1000 seed weight. Correlation analysis showed that oil yield was highly correlated (0.983) with seed yield (P<0.01, Table 5). Other researchers (Anandhan, et al., 2010, Mijić, et al., 2009) supported our findings, especially on the strong relationship between seed and oil yield in sunflower.

Table 5. Correlation co-efficients between some traits of sunflower cultivars grown in 2012 and 2013.

	PH	HD	TSW	OC	SY	OY
PH	1					
HD	0.698**	1				
TSW	0.622**	0.543**	1			
OC	-0.161ns	0.011ns	-0.221*	1		
SY	0.696**	0.696**	0.605**	-0.165ns	1	
OY	0.673**	0.714**	0.573**	0.017ns	0.983**	1

PH: Plant Height**, HD:** Head Diameter**, TSW:** 1000 Seed Weight**, OC:**Oil Content**, SY:**Seed Yield**, OY:**Oil Yield
*, ** significant at the 0.05 and 0.01 level, respectively and ns, nonsignificant.

Conclusions

In the present study, seed yield, yield components and relationship between yield components were determined in sixteen sunflower cultivars. Due to the different climate conditions in 2012 (rainy) and in 2013 (drought), yield and yield components were significantly different by year and cultivars. Yield and yield components of sunflower cultivars in rainfed and arid conditions generally showed considerable sensitivity to climate conditions in two years. Therefore, climate condition, especially rainfall during the growing season is very important to take sufficient yield in rainfed conditions. When the yield and yield parameters of cultivars are compared by the years, in 2012, the plant height (16.57%), head diameter (18.90%), 1000 seed weight (20.00%), oil yield (29.70%) and seed yield (30.59%) were higher than those of 2013 due to the rainy season in the first year of study period. Second year (2013) which was drought conditions, kernel ratio (1.99%) and oil content (2.46%) were higher than 2012. According to the correlation test it is concluded that seed yield was dependent upon plant height, head diameter and 1000 seed weight. Oil yield was mostly related (r=0.983**) with seed yield. It is important to consider the relations between these characters for the sufficient seed production and selections of cultivars for arid condition. In conclusion for rainfed similar ecological conditions, Tarsan and Transol cultivars should be suggested for obtaining higher seed and oil yield.

Conflict of Interest Statement: The manuscript's authors declare that, they do not have any conflict of interest.

Researchers' Contribution Rate Statement Summary: The authors declare that, they have contributed equally to the manuscript.

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