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Determination of the Agronomic Performances of Some Oilseed Sunflower (*Helianthus annuus* L.) Hybrids Grown under Erzurum Ecological Conditions

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Abstract: In eastern Anatolia, the sunflower (*Helianthus annuus* L.) has been grown as a confectionary crop for a long time, but oilseed sunflower types have more recently been grown commercially. No information on the performance of oilseed sunflower hybrids for this region is, however, available. Therefore, during the 1998 and 2001 growing seasons, a field experiment was conducted to evaluate the agronomic performances and genotypic differences of some sunflower hybrids under Erzurum conditions. In this study 20 sunflower genotypes were used. The 2-year results showed that the genotypes differed significantly in all the characteristics investigated, except for kernel percentage. Similarly, the year had a significant influence on the agronomic parameters of the genotypes, with the exception of 1000-seed weight. The present study suggests that higher seed yields may be achieved through the use of hybrid genotypes under the region's conditions. Based on these 2 years' data, it can be concluded that P-64A52, Trakya-80, AS-508 and HI with their higher seed and oil yield could be successfully grown under this region's conditions.

Key Words: Sunflower, hybrid, genotype, seed yield, adaptation, genotypic variation

Erzurum Ekolojik Koşullarında Yetiştirilen Bazı Yağlık Ayçiçeği (*Helianthus annuus* L.) Hibridlerinin Agronomik Performanslarının Belirlenmesi

Özet: Ayçiçeği (*Helianthus annuus* L.) uzun zamandan beri Doğu Anadolu Bölgesinde çerezlik bir bitki olarak yetiştirilmektedir. Ancak, yağlık çeşitlerin yetiştirilmesine daha son yıllarda başlanılmıştır. Bununla birlikte, bu yağlık tiplerin, özellikle hibrit olanların bölge koşullarındaki performans durumlarına dair herhangi bir araştırma sonucu bulunmamaktadır. Bu nedenle, 1998 ve 2001 yıllarında, Erzurum sulu koşullarında bazı hibrit ayçiçeği çeşitlerinin performansları ve genotipik farklılıklarını değerlendirmek üzere bir deneme yürütülmüştür. Bu tarla çalışmasından elde edilen iki yıllık sonuçlara göre genotipler tane iç oranı hariç, incelenen tüm özellikler yönünden önemli ölçüde farklılık göstermiştir. Benzer şekilde yıllar agronomik parametreler üzerine 1000 tohum ağırlığı hariç önemli etkide bulunmuştur. Bu çalışma, bölge koşullarında hibrit ayçiçeği çeşitlerin kullanılmasıyla yüksek verim değerlerine ulaşmanın mümkün olduğunu ortaya koymuştur. İki yıllık veriler ışığında, yüksek tohum ve yağ verimine sahip P-64A52, Trakya-80, AS-508 ve HI çeşitlerinin bölge koşullarında başarıyla yetiştirilebileceği söylenebilir.

Anahtar Sözcükler: ayçiçeği, hibrit, çeşit, tohum verimi, adaptasyon, genotipik varyasyon

Introduction

The sunflower (*Helianthus annuus* L.) is the most important oilseed crop in Turkey. Its oil is widely used for food products (salad oil, etc.), as well as for nonfood use. Nationally, most cultivated oilseed sunflower genotypes consist of hybrid types (Atakişi et al., 1994). Hybrid sunflower genotypes have important advantages over open-pollinated types, including greater yield potential, better disease resistance, and a higher degree of self-compatability.

The sunflower is well adapted to different climatic zones in Turkey, including eastern Anatolia, where the climate is characterized by a short growing season and cool temperatures. The existing adverse conditions limit yield and growth in many crops. The sunflower is the only oilseed crop grown commercially in this region, but nearly all sunflower genotypes grown there are non-oilseed types. In recent years, there has been increased interest in oilseed sunflower production among the region's farmers. However, to date, no information on the

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performance of oilseed sunflower hybrids in this area was available.

Successful oilseed-sunflower cropping depends on the yielding ability of genotypes, as well as on the reliability of production systems. Numerous studies have been conducted to evaluate the agronomic performances of commercially available sunflower genotypes in different areas of Turkey (İlisulu and Arslan, 1973; Kara, 1988; Oral and Kara, 1989; Kara, 1991; İlbaş et al., 1996; Gür et al., 1997; Kıllı, 1997; Karaaslan et al., 1999). These studies suggested that genotypes showed wide differences in their agronomic characteristics and seed yield.

Although a large number of sunflower hybrids for production have recently been released, the yield capabilities of these new genotypes have not been studied under eastern Anatolian conditions. Therefore, this study was initiated to evaluate the agronomic performances of some commercially available oilseed sunflower hybrids, and to determine the genotypic variability among the genotypes under Erzurum ecological conditions.

Materials and Methods

A field study was conducted on the farm of the Agricultural Research and Extension Center of Atatürk University in Erzurum (1850 m elevation) during the 1998 and 2001 growing seasons. The Experiments were performed in a loamy soil with 11.6 g kg^{-1} organic matter, pH of 7.2, and available P and K levels of 58.4 and 1745 kg ha^{-1}, respectively. The previous crop was barley in 1998 and 2001. Air temperatures, precipitation, and relative moisture values were collected from a meteorological station about 2 km north of the test site and are presented in Table 1.

The experiment was established as a randomized complete block design with 3 replicates. Twenty oilseed sunflower genotypes (AS-503, AS-506, AS-508, Edirne-87, Trakya-80, Trakya-83, Trakya-129, P-6433, P-64A52, P-6482, XF-466, XF-474, GK-70, HI, Super 25, 8110, 3330, 3312, 3320 and Isostar) were used. The genotypes were hybrids, except for GK-70. The experimental plots were 2.8 m wide and 6 m long and consisted of 4 rows spaced 0.7 m apart. Seeding occurred on 4 May and 7 May during 1998 and 2001, respectively. Three seeds were sown in each hill, and the plots were hand-thinned to 1 plant per hill when the plants were at the 4 to 6-leaf stage. Before sowing, nitrogen fertilizer in the form of ammonium sulfate was broadcast and incorporated at a rate of 100 kg ha^{-1}. All plots received 80 kg P_2O_5 kg ha^{-1} as triplesuperphosphate before sowing (Ülgen and Yurtsever, 1995). Weeds were controlled mechanically and by hand-hoeing. All plots were furrow irrigated regularly to avoid drought stress. A total of 4-5 irrigations each year were applied.

The sunflower genotypes were hand-harvested at the stage of physiological maturation when the back of the head had turned from green to yellow and the bracts were turning brown (in the second week of September in both years). At harvest, 10 plants from each plot were selected for determining plant height, stem diameter, head diameter, 1000 seed weight, test weight, and kernel percentage. Seed oil content (% dry matter) was determined using the Soxhlet method. At maturity, head

Table 1. Monthly and growing season precipitation, temperature, and relative humidity in Erzurum in 1998 and 2001.

Months	Precipitation			Temperature			Relative humidity		
	1998	2001	normal*	1998	2001	normal	1998	2001	normal
	mm			°C			%		
May	98.1	68.7	59.3	10.8	6.3	10.4	71.0	61.3	62.2
June	26.4	7.3	31.7	16.4	15.4	15.3	59.4	48.1	56.6
July	32.7	36.6	23.6	19.2	20.6	19.9	52.9	46.2	49.8
August	9.5	9.2	8.4	19.7	19.9	19.5	45.7	44.1	47.0
September	27.0	3.8	34.4	13.4	14.3	13.8	54.5	42.0	53.3
Total or mean	193.7	125.6	157.4	15.9	15.3	15.8	56.7	48.3	53.8

* Normal refers to the long-term average, a 72-year average.

samples for yield were harvested from the 2 center rows of each plot; they were then dried and threshed mechanically. All data were analyzed by analysis of variance for individual years and combined over the years using the SAS package (SAS Inst., 1990). Means were compared using Duncan's multiple range test at the 0.05 probability level. Correlation coefficients between tested characters were also calculated.

Results and Discussion

Air temperature, rainfall and relative humidity for the experimental site during the study years are presented in Table 1. Long-term average rainfall for this area is 157.4 mm. In general, the environmental conditions in 1998 were more favorable for the growth of sunflowers than those in 2001. The average rainfall for 1998 (193.7 mm) was higher than that observed (125.6 mm) in 2001 (Table 1). The 1998 growing season received rainfall above normal, but rainfall was below normal in 2001. Temperature values were about the same for 1998 and 2001, and over the long term.

In this study, significant year x genotype interactions for days to maturity, head diameter, 1000-seed weights, seed oil content, seed yield and oil yield were observed. Year x genotype interactions for the other characteristics investigated were not significant (Table 2).

Plant growth

As can be seen from Table 2, there were statistically significant differences among sunflower genotypes for maturity. Many studies have confirmed that genetic variation for maturity exists in sunflower genotypes (Kara, 1986; Oral and Kara, 1989; Kara, 1991). Crop maturity varied depending on growing season (Table 3). Apparently, the higher rainfall in 1998 delayed the growth of sunflower plants. The maturity responses of the genotypes also varied with the study year, and this led to significant year x genotype interactions (Table 2).

The plant heights of the sunflower genotypes are presented in Table 3. Oilseed sunflower genotypes differed significantly. The genotypes with the highest plant height were XF-466 (185.6 cm), GK-70 (166.1 cm) and AS-503 (157.9 cm), and those with the lowest plant heights were Super 25 and 3320, with 118.2 cm and 127.9 cm, respectively. Differences observed among the genotypes were probably related to genotypic variation, as reported by Kara (1986) and Oral and Kara (1989).

In the first year of the study, genotypes had greater plant height than in the second year (Table 3), most likely due to higher rainfall (Table 1).

Yield components

The results regarding the yield components of the sunflower genotypes grown under Erzurum conditions are summarized in Tables 2-4. Significant genotype differences between the 2 years for stem diameter occurred (Table 3). The differences between the years were largely caused by weather conditions, particularly rainfall (Table 1). In the first year of the study, the sunflower genotypes produced taller plants than in the second year. High precipitation levels in 1998 resulted in taller plants.

There were marked differences in the stem diameters of the sunflower genotypes (Table 3). Stem diameters ranged from 2.10 (genotype 3320) to 2.90 cm (Trakya 80). Most stem diameter differences can be attributed to genotypic variation, which is in agreement with several other reports (Süzer and Atakişi, 1993; Kıllı, 1997).

Table 2. Analysis of variances for the agronomic traits of some oilseed sunflower genotypes grown in Erzurum during 1998 and 2001.

		Mean squares									
Source of variation	df	Days to maturity	Plant height	Stem diameter	Head diameter	1000-seed weight	Test weight	Kernel percentage	Seed oil content	Seed yield	Oil yield
Year	1	496.13**	40392.02**	13.00**	7.20*	4.45 ns	1.59 ns	29.64*	13.467	7927113.6**	1140038.36**
Genotype	19	39.46**	1105.851*	0.16**	8.20**	327.88**	19.49**	5.28 ns	12.404**	698275.12**	122961.55**
Rep (Year)	4	0.14	494.88 ns	0.07 ns	2.45ns	27.25**	0.37 ns	2.67 ns	2.493 ns	52445.23 *	7845.63 ns
Year x genotype	19	1.09**	604.62 ns	0.04 ns	2.48**	32.62**	3.41 ns	4.95 ns	6.152*	196705.03**	29309.33**
Error	76	0.299	584.44	0.031	1.050	7.414	1.249	4.31	3.456	60276.86	11457.796

*, ** Significant at the 0.05 and 0.01 probability levels, respectively
df = degrees of freedom
ns = not significant

Table 3. The values of days to maturity, plant height, stem diameter and head diameter of some oilseed sunflower genotypes grown in Erzurum as the average of 1998 and 2001.

Genotypes	Days to maturity (day)	Plant height (cm)	Stem diameter (cm)	Head diameter (cm)
AS-503	137.00 a	157.97 abc	2.40 bcd	20.37 b
AS-506	136.67 ab	144.57 bcde	2.30 cde	18.27 ghı
AS-508	136.67 ab	141.13 bcde	2.32 cd	21.70 a
EDİRNE-87	136.33 b	148.70 bcd	2.25 de	19.12 cdefgh
TRAKYA-80	136.17 bc	149.20 bcd	2.90 a	22.25 a
TRAKYA-83	135.67 cd	143.95 bcde	2.32 cd	17.77 ı
TRAKYA-129	135.67 cd	144.47 bcde	2.35 bcd	20.08 bcd
P-6433	135.17 de	145.18 bcde	2.25 de	19.17 cdefg
P-64A52	135.17de	140.80 bcde	2.20 de	20.28 bc
P-6482	134.83 e	147.42 bcd	2.30 cde	18.88 efghı
XF-466	134.67 e	185.57 a	2.32 cd	19.37 bcdefg
XF-474	134.67 e	144.95 bcde	2.40 bcd	19.30 bcdefg
GK-70	134.00 f	166.12 ab	2.27 de	19.58 bcdef
HI	133.33 g	145.22 bcde	2.48 bc	19.98 bcde
SUPER 25	132.83 g	118.18 e	2.27 de	17.95 hı
8110	131.83 h	139.30 bcde	2.48 bc	18.50 fghı
3330	131.50 h	151.57 bcd	2.28 cde	19.48 bcdef
3312	130.17 i	148.85 bcd	3.37 bcd	18.92 defghı
3320	129.50 j	127.98 de	2.10 e	17.90 ı
ISOSTAR	128.16 k	134.75 cde	2.53 b	18.90 efghı
CV (%)	0.41	16.52	7.51	5.29
Mean				
1998	136.03 a	164.64 a	2.68 a	19.63 a
2001	131.97 b	127.95 b	2.03 b	19.14 b

CV = coefficient of variation
Means followed by the same letter(s) are not significantly different at P = 0.05 level

Averaged over the genotypes, head diameter varied with the study year. Plants had a greater head diameter in 1998 than in 2001. Variance analysis in both experimental years showed that the genotypic effect on head diameter was highly significant (Table 2). The greatest head diameter was obtained from Trakya-80 (22.25 cm), followed by AS-508 (21.70 cm) and AS-503 (20.37 cm) (Table 3). This variation in head diameter is largely due to genotypic differences.

Genotype had a strong impact on 1000-seed weight in 1998 and 2001, whereas the effect of the study year was not significant (Table 2). Table 4 shows that genotypes 3312, 3330 and XF-466 had the highest seed weights, with 74.13, 72.92 and 72.33 g, respectively. The lowest 1000-seed weights were observed in P-6433 (48.03 g), and P-6482 (54.72 g). This variation in seed weight most likely resulted from genotype differences (İlisulu and Arslan, 1973; Oral and Kara, 1989; İlbaş et al., 1996; Yılmaz and Bayraktar, 1996).

Test weight was significantly affected by genotype but not by year (Table 2). The highest test weights were obtained from Edirne 87 and Trakya 83. The test weights of the genotypes ranged from 33.87 to 40.63 kg hl^{-1} (Table 4). The genotype responses in this study were probably genotype-dependent.

As seen in Table 2, the kernel percentage was significantly affected by year, ranging from 43.10% (2001) to 44.09% (1998). The kernel percentage in 1998 when higher precipitation occurred was greater than that in 2001 (Table 4). Differences among the genotypes were not significant (Table 2).

Seed oil content

Seed oil content was significantly influenced by genotype, but year had no effect (Table 2). Seed oil content depends on genotype but is also affected by environmental conditions and cultural practices (Harris et al., 1978; Dedio, 1985; Amir and Khalifa, 1991; Esechie

Table 4. The values of 1000-seed weight, test weight, and kernel percentage of some oilseed sunflower genotypes grown in Erzurum as the average of 1998 and 2001.

Genotypes	1000 seed weights (g)	Test weights (kg hl^{-1})	Kernel percentage (%)
AS-503	63.45 efg	36.55 ghi	42.92
AS-506	55.10 h	37.37 efg	42.38
AS-508	63.52 efg	37.62 defg	43.91
EDİRNE-87	54.93 h	40.63 a	41.26
TRAKYA-80	61.93 g	39.20 bc	44.11
TRAKYA-83	68.42 cd	39.73 ab	43.83
TRAKYA-129	56.07 h	37.05 fgh	43.40
P-6433	48.03 i	37.72 defg	44.92
P-64A52	65.07 ef	34.42 kl	43.32
P-6482	54.72 h	34.77 jkl	42.99
XF-466	72.33 ab	33.87 l	42.57
XF-474	63.97 efg	38.45 bcde	43.28
GK-70	69.65 bc	37.52 defg	43.37
HI	55.22 h	38.07 cdef	45.19
SUPER 25	62.17 fg	38.80 bcd	44.50
8110	65.58 de	38.75 bcd	43.53
3330	72.92 a	37.60 defg	44.51
3312	74.13 a	35.40 ıjk	43.83
3320	72.17 ab	35.77 hıj	43.42
ISOSTAR	68.62 dc	38.50 bcde	44.68
CV (%)	4.29	2.99	4.76
Mean			
1998	63.59 ns	37.50 ns	44.09 a
2001	63.21 ns	37.27 ns	43.10 b

ns = not significant
CV = coefficient of variation
Means followed by the same letter(s) are not significantly different at P = 0.05 level

Table 5. The values of seed oil content, seed yield and oil yield of some oilseed sunflower genotypes grown in Erzurum as the average of 1998 and 2001.

Genotypes	Seed oil content (%)	Seed yield (kg ha^{-1})	Oil yield (kg ha^{-1})
AS-503	39.90 cdefg	2746.0 cd	1105.2 cd
AS-506	39.35 defg	2419.8 efg	950.6 fg
AS-508	41.90 abc	2847.7 bc	1188.3 bc
EDİRNE-87	37.85 g	2564.7 def	972.6 efg
TRAKYA-80	42.30 ab	3088.3 ab	1285.5 ab
TRAKYA-83	40.85 abcdef	2758.3 cd	1131.1 cd
TRAKYA-129	38.83 fg	2322.0 fgh	909.1 gh
P-6433	42.58 a	2647.5 cde	1131.1 cd
P-64A52	42.38 ab	3163.2 a	1335.7 a
P-6482	39.37 cdefg	2339.2 fgh	927.4 fgh
XF-466	41.38 abcd	2495.0 def	1032.2 def
XF-474	41.62 abc	2151.8 ghij	895.6 gh
GK-70	42.30 ab	1943.3 j	814.2 h
HI	39.00 efg	2877.0 bc	1123.7 cd
SUPER 25	42.73 a	2020.5 ij	860.7 gh
8110	40.43 bcdef	2748.8 cd	1109.6 cd
3330	41.87 abc	2344.2 fgh	977.6 efg
3312	41.70 abc	2293.5 fghi	948.8 fg
3320	41.62 abc	2118.0 hij	877.4 gh
ISOSTAR	41.07 abcde	2655.0 cde	1092.3 cde
CV (%)	4.54	9.71	10.36
Mean			
1998	40.62 ns	2784.2 a	1130.9 a
2001	41.29 ns	2270.2 b	935.9 b

ns = not significant
CV = coefficient of variation
Means followed by the same letter(s) are not significantly different at P = 0.05 level

et al., 1996). Previous studies reported that seed oil content could vary widely with plant variety and growing conditions (Biberdzic et al., 1998; Stanojevic et al., 1998). The genotype Super 25 (42.73%) had the highest oil concentration, followed by P-6433, Trakya-80 and GK-70, in descending order (Table 5).

Seed yield

The potential yield of sunflower is highly dependent on environmental conditions during the life of the crop (Bange et al., 1997). In the present study, seed yield was substantially influenced by both genotype and year (Table 2). Averaged over the years, the yields of the genotypes varied from 3163.2 to 1943.3 kg ha^{-1}. Genotypes P-64A52, Trakya-80, HI and AS-508 had the highest seed yields. The lowest seed yields were obtained from GK-70 (1943.3 kg ha^{-1}) and Super 25 (2020.5 kg ha^{-1}) (Table 5). It is interesting to note that all of the hybrids yielded more seed than the open-pollinated genotype GK-70, which was included in this study as a standard genotype recommended for the region according to previous study results (Kara, 1991). This result supports the literature reporting that hybrids have a yield advantage over open-pollinated genotypes (Pereira et al., 1999). Again, the seed yields of the genotypes investigated in the present study were comparable to those reported for this region in previous studies (Kara, 1986, 1991). The sunflower genotypes produced higher seed yields in 1998 (2784.2 kg ha^{-1}) than in 2001 (2270.2 kg ha^{-1}). However, the higher yields in 1998 compared to those in 2001 were due to more favorable weather conditions, particulary rainfall. A differential response occurred among the genotypes in 1998 and 2001. This caused a significant year x genotype interaction (Table 2).

Oil yield

The results from this experiment revealed that highly significant differences occurred among the oil yields of the genotypes (Table 2). Similar results were reported by İlbas et al. (1996) and Yılmaz and Bayraktar (1996) working on sunflower genotypes. The effect of year and year x genotype interaction was significant (Table 2). Consequently, the ranking of the oil yield of the genotypes differed with the study year.

Simple correlations among the investigated characters

Table 6 shows the correlation coefficients of seed yield and other yield traits. Seed yield had a significant positive correlation with days to maturity, plant height, stem diameter, head diameter, test weight, seed oil content and oil yield, while 1000-seed weight and kernel percentage had a negative correlation with seed yield.

Conclusion

Genotypic adaptation is especially important in short-season regions, in which sufficient heat units are not always available for a crop to reach maturity. No problem regarding the need of the growth and development of the sunflower genotypes in this region was encountered. The growing season period of the experimental site was favorable for all genotypes. According to the results of the current study, it can be concluded that P-64A52, Trakya-80, AS-508 and HI with their high seed and oil yield can be suggested as the best genotypes under the ecological conditions of Erzurum. However, we see a need for conducting additional genotype performance studies including recently developed sunflower genotypes.

Table 6. Correlation coefficients between the characters calculated from 20 oilseed sunflower genotypes under Erzurum ecological conditions in the average of 1998 and 2001 seasons.

Characters	(10)	(9)	(8)	(7)	(6)	(5)	(4)	(3)	(2)	(1)
1) Days to maturity	0.473**	0.493**	-0.096	-0.233**	0.146	-0.185*	0.270**	0.536**	0.695**	1.000
2) Plant height	0.452**	0.520**	-0.245**	-0.193*	0.051	-0.002	0.265**	0.734**		
(3) Stem diameter	0.544**	0.605**	-0.197*	-0.191*	0.158	0.015	0.332**			
(4) Head diameter	0.457**	0.488**	-0.091	0.013	0.094	-0.028				
(5) 1000-seed weight	-0.053	-0.103	0.200*	-0.042	-0.192*					
(6) Test weight	0.050	0.075	-0.037	0.087						
(7) Kernel percentage	-0.037	-0.094	0.191*							
(8) Seed oil content	0.112	-0.180*								
(9) Seed yield	0.953**									
(10) Oil yield	1.000									

* and ** significant at P = 0.05 and 0.01, respectively.

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