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PERFORMANCE OF SOME OILSEED AND CONFECTIONARY-TYPE SUNFLOWER (*Helianthus annuus* L.) VARIETIES IN THE AEGEAN REGION OF TURKEY

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SUMMARY

Vegetable oils and fats are vital components of the human diet because they are an important source of energy. In 2008, according to the production data, sunflower was grown in Turkey on an area of 577,958 ha and 992,000 metric tons of the seed were harvested (Anonymous, 2010). Because of the gap in vegetable oil production in Turkey, sunflower is one of the alternatives and the leading oilseed crop that can be used to increase the vegetable oil production in the country. Growing sunflower as a crop in the Aegean Region is one of the possibilities to increase the production.

The main objectives of this study were to identify oilseed hybrids and open-pollinated confectionary varieties that could be grown with satisfactory yield performance in the Aegean Region.

The experiments including oilseed and confectionary types of cultivars were conducted separately during the first crop-growing seasons of 2008 and 2009 on the experiment field of the Aegean Agricultural Research Institute in Menemen, Izmir. The experiments were conducted in a randomized complete block design with four replications.

Oilseed hybrids and open-pollinated confectionary sunflower candidate varieties were used in the study as the material.

An adaptation study was undertaken for the characters of seed yield, seed oil content (%), 1000-seed weight, plant height, head diameter, seed length, seed width, hull percentage (%), seed color (white, black, and intermediate), days to flowering, and days to physiological maturity.

The results indicated that statistically significant differences were found among the sunflower varieties for the characters in question.

In the oilseed variety experiments, the highest seed yield (572 kg da^{-1}) and the lowest seed yield (343 kg da^{-1}) were obtained in 2009 from the varieties ETAE-Y-TM-2007-5 and Armada, respectively.

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In the confectionary variety experiments, the highest seed yield (563 kg da^{-1}) and the lowest seed yield (202 kg da^{-1}) were produced in 2009 by the varieties ETAE-D1-2-B2 and ETAE-Ç-P-1-2, respectively.

Key words: **sunflower, *Helianthus annuus* L., breeding, hybrid variety, open-pollinated variety, oilseed variety, confectionary variety, agronomy, adaptation, yield components**

INTRODUCTION

The increasing world population makes it difficult to deal with the provision of food for the human populace in the world. Vegetable oils are an important source of energy. To reduce the oilseed production gap in Turkey, it is possible to grow sunflowers with high yields, oil percentage, and oil quality; consequently, increasing oilseed production will result in increasing vegetable oil quantities and decreasing the import of vegetable oil (Gobbelen *et al.*, 1989; Schneiter, 1997; Tan, 2006; Tan, 2007).

Turkey is one of the leading countries in terms of sunflower production. In 2008, according to the production data, sunflower was grown in Turkey on an area of 577,958 ha and 992,000 metric tons of the seed were harvested with a mean seed yield of 171.63 kg da^{-1} (Anonymous, 2010). However, the amount of oilseed production including sunflower is not sufficient for the consumption; therefore, the amount of the production should be increased. Besides the main production area of Thrace, there are some other potential sunflower production areas in the country such as the Aegean Region and South East Anatolia (Firat, 1992; Tan, 2006; Tan, 2007; Tan, 2008; Tan, 2009a).

Confectionary sunflower production is also not sufficient in Turkey. The main reason is that there is not enough certified seed production with desired quality. Consequently, landraces / local varieties are mainly used for confectionary sunflower production in the country. The landraces or local varieties are not suitable for combine harvesting because of their nonuniformity of plant development in the field (Tan, 2009a; Tan, 2009b).

In the Sunflower Research Project at AARI, oilseed and confectionary types of sunflower germplasm including hybrid and open-pollinated varieties have been developed, and candidate varieties are evaluated in yield trials in the first and second crop production seasons. Variety performance tests and yield trials indicate that sunflower can grow with satisfactory yield performance (500-550 kg da^{-1}) in both the first and second crop production seasons in the Aegean Region of Turkey (Tan, 2009a). The Aegean Region, which has suitable ecological conditions for the first and second crop sunflower productions, should be considered for sunflower production to decrease the vegetable oil gap in Turkey.

The main objectives of this study were to determine which oilseed hybrids and open-pollinated confectionary varieties could be grown with satisfactory yield performance in the Aegean Region.

MATERIAL AND METHODS

This study was conducted to determine the suitable oilseed hybrid and open-pollinated (OP) confectionary types of cultivars for the Menemen-Izmir conditions.

The experiments including oilseed and confectionary types of cultivars were conducted separately in the first crop-growing seasons in 2008 and 2009 on the experiment field of the Aegean Agricultural Research Institute (AARI) in Menemen, Izmir.

An adaptation study was undertaken for the following characters: seed yield (kg da^{-1}), seed oil content (%), 1000-seed weight (g), plant height (cm), head diameter (cm), seed length (mm), seed width (mm), hull percentage (%), seed color (white, black, and intermediate), days to flowering, and days to physiological maturity.

In this study, 14 oilseed hybrids and eight open-pollinated confectionary sunflower candidate varieties developed at in the AARI sunflower breeding program were used as the material in the experiments. Most of the parents of the hybrids and all parents of the OP confectionary types of varieties were developed by using sunflower collections conserved at the National Gene Bank at AARI.

The oilseed hybrids used in the study were; ETAE-Y-TM-2007-1, ETAE-Y-TM-2007-2, ETAE-Y-TM-2007-3, ETAE-Y-TM-2007-4, ETAE-Y-TM-2007-5, ETAE-Y-TM-2007-6, ETAE-Y-TM-2007-7, ETAE-Y-TM-2007-8, ETAE-Y-TM-2007-9, ETAE-Y-TM-2007-10, ETAE-Y-TM-2007-11, ETAE-Y-TM-2007-12, ETAE-Y-TM-2007-13, ETAE-Y-TM-2007-14, The oilseed commercial hybrids Sanay, Armada, Sirena, Tunca, and Alhaja were used as control varieties.

The OP confectionary varieties used in this study were as follows:

Varieties	Seed coat color
ETAE-D1-1-B1	White with a light gray stripe
ETAE-D1-1-B2	White with a light gray stripe
ETAE-D1-1-B3	White with a light gray stripe
ETAE-D1-1-B6	White with a gray stripe
ETAE-D2	Dark brown with a light gray stripe
ETAE-Ç-P-1-2	Black
ETAE-Ç-P-11-1	Black
ETAE-K-1	White with several pale gray stripes

Experiments with the oilseed hybrids and OP confectionary varieties were conducted as a randomized complete block design with four replications.

The oilseed experiment plots consisted of single rows 7.70 m in length spaced 0.7 m apart, while plots with the open-pollinated confectionary varieties consisted of four rows 8.80 m in length spaced 0.7 m apart.

In each row, there were 22 plants spaced at 0.35 cm and 0.40 cm in the oilseed and confectionary experiments, respectively.

Table 1: Oilseed hybrid variety test trial at first crop production time. AARI, Menemen, Izmir (Tan, 2008).

No.	Hybrids	Plant height	Head diameter	Yield*	Yield groups	1000-seed weight	Days to flowering	Days to physiological maturity	Hull percentage	Oil percentage	Uniformity**
		(cm)	(cm)	(kg da^{-1})	(α=0.01)	(g)	Day	Day	(%)	(%)	
1	ETAE-Y-TM-2007-1	138.9	19.75	374	F	79.30	50	106	23.53	41.15	1.8
2	ETAE-Y-TM-2007-2	147.8	20.80	559	AB	78.45	53	104	26.77	46.80	1.5
3	ETAE-Y-TM-2007-3	134.7	18.30	515	AB	51.80	52	104	23.06	45.97	1.3
4	ETAE-Y-TM-2007-4	134.9	19.65	410	DEF	65.20	51	100	22.78	42.00	1.4
5	Sanay (Control-1)	152.9	21.55	557	AB	83.88	56	106	28.83	39.25	1.5
6	ETAE-Y-TM-2007-5	149.3	21.42	565	AB	81.15	55	105	27.76	46.50	1.3
7	ETAE-Y-TM-2007-6	145.4	19.35	480	BCDE	67.77	52	100	21.27	43.03	1.4
8	ETAE-Y-TM-2007-7	149.9	18.30	496	ABCDE	67.20	52	101	21.01	45.28	1.4
9	ETAE-Y-TM-2007-8	145.0	17.90	410	DEF	68.25	50	100	22.17	43.40	1.6
10	ETAE-Y-TM-2007-9	145.9	18.95	517	AB	63.90	53	104	25.05	43.55	1.4
11	ETAE-Y-TM-2007-10	139.6	19.50	409	EF	70.03	53	101	23.59	42.08	1.4
12	Armada (Control-2)	153.9	19.40	360	F	58.98	56	105	23.43	42.10	1.3
13	Sirena (Control-3)	159.6	20.10	569	A	77.57	55	106	20.42	47.17	1.7
14	ETAE-Y-TM-2007-11	158.5	19.25	509	ABC	53.88	54	105	23.28	43.97	1.4
15	ETAE-Y-TM-2007-12	140.3	20.15	497	ABCD	80.75	53	102	22.46	41.28	1.5
16	ETAE-Y-TM-2007-13	156.5	21.45	505	ABC	92.40	56	102	29.33	38.30	1.2
17	ETAE-Y-TM-2007-14	129.5	22.40	424	CDEF	75.93	52	101	24.02	41.38	1.6
18	Tunca (Control-4)	153.4	21.55	569	A	85.75	56	108	21.98	44.75	1.3
19	Alhaja (Control-5)	149.0	22.10	574	A	86.40	56	108	22.41	42.05	1.3
	CV (%)	6.74	6.85	9.53		9.69	2.83	0.41	11.53	2.59	
	LSD (0.05)	14.00	1.951	66.11		10.04	2.141	0.5998	3.900	1.582	
	LSD (0.01)	18.65	2.598	88.05		13.37	2.851	0.7988	5.194	2.107	

* Seed yield, 1000-seed weight, and oils were adjusted to 0% moisture.

**: 1: highly uniform, 2: uniform, 3: heterogeneous, 4: highly heterogeneous.

Table 2: Oilseed hybrid variety test trial at first crop production time. AARI, Menemen, Izmir (Tan, 2009a).

No.	Hybrids	Plant height	Head diameter	Yield*	Yield groups	1000-seed weight	Days to flowering	Days to physiological maturity	Hull percentage	Oil percentage	Uniformity**
		(cm)	(cm)	(kg da^{-1})	(α=0.01)	(g)	Day	Day	(%)	(%)	
1	ETAE-Y-TM-2007-1	181.4	21.1	415	EF	75.82	49	95	21.57	41.50	1.3
2	ETAE-Y-TM-2007-2	187.9	20.5	525	ABCD	70.33	48	96	21.85	46.77	1.3
3	ETAE-Y-TM-2007-3	180.8	20.7	481	BCDE	61.45	50	96	20.45	44.90	1.4
4	ETAE-Y-TM-2007-4	188.1	19.7	510	ABCD	57.20	50	95	22.47	48.17	1.1
5	Sanay (Control-1)	193.3	21.7	571	A	87.48	51	101	27.41	37.73	1.4
6	ETAE-Y-TM-2007-5	183.7	21.5	572	A	72.80	50	96	22.59	44.67	1.1
7	ETAE-Y-TM-2007-6	193.5	20.2	506	ABCD	66.47	50	97	22.18	45.40	1.3
8	ETAE-Y-TM-2007-7	185.2	20.2	553	DE	68.07	48	94	23.21	44.40	1.4
9	ETAE-Y-TM-2007-8	190.4	19.1	493	ABCDE	62.47	49	94	22.31	44.60	1.3
10	ETAE-Y-TM-2007-9	192.3	22.1	493	ABCDE	68.60	50	95	21.57	43.10	1.8
11	ETAE-Y-TM-2007-10	196.9	18.5	509	ABCD	60.68	50	97	22.57	45.13	1.4
12	Armada (Control-2)	182.7	19.2	343	F	70.53	53	100	21.71	42.00	1.4
13	Sirena (Control-3)	207.8	21.4	506	ABCD	84.85	52	99	22.60	44.97	1.3
14	ETAE-Y-TM-2007-11	173.2	20.5	451	DE	65.22	50	95	22.87	45.63	1.4
15	ETAE-Y-TM-2007-12	185.7	19.7	539	ABC	63.25	50	97	23.59	44.77	1.4
16	ETAE-Y-TM-2007-13	189.7	21.3	502	ABCD	85.72	52	98	20.59	45.07	1.6
17	ETAE-Y-TM-2007-14	181.1	21.4	454	CDE	60.78	48	95	21.93	43.83	1.3
18	Tunca (Control-4)	186.1	21.1	489	ABCDE	90.10	53	99	21.71	45.27	1.3
19	Alhaja (Control-5)	177.4	24.4	560	AB	93.35	53	101	22.43	42.13	1.1
	CV (%)	4.08	6.15	9.24		9.23	1.93	1.90	8.25	3.38	
	LSD (0.05)	10.84	1.808	64.64		9.397	1.375	2.612	2.620	2.472	
	LSD (0.01)	14.43	2.408	86.09		12.51	1.831	3.479	3.489	3.315	

* Seed yield, 1000 seed weight, and oils were adjusted to 0% moisture.

**: 1: highly uniform, 2: uniform, 3: heterogeneous, 4: highly heterogeneous.

The experiments were conducted on sandy loam soil. The recommended agronomic crop production practices were followed, irrigation was applied, and the control of weeds by chemical, mechanical, and hand weeding was performed.

The first and second year experiments were planted on April 23, 2008 and May 6, 2009, respectively.

Fifty kg da^{-1} ($N_{10}P_{10}K_0$) of compound fertilizer were applied during the soil preparation. In the experiments, two-time irrigation was applied in both years. The irrigation applications occurred on June 11 and July 17 in 2008 and on June 18 and July 16 in 2009.

Data were obtained on:

Seed yield (kg da^{-1}): The yield was obtained from each of the two middle rows of the four row plots in the OP confectionary variety test. In the oilseed hybrid variety experiment, the yield was obtained from a single row. At harvesting, the 1^{st} and 4^{th} rows and the first and last plant of the middle row were removed as the edge effect in the confectionary variety experiment. The first and last plants of the rows were removed as the edge effect in the oilseed hybrid variety experiment for evaluation. Heads were hand harvested, threshed, and evaluated at 0% moisture.

Days to physiological maturity: Days from planting to R9 stage (Schneiter, and Miller, 1981).

Days to flowering maturity: Days from emergence to 75% of the flowering.

1000 seed weight (g): The weight of 1000 seeds (g) was determined from dried seed (0% moisture) sample.

Oil content (%): Samples of harvested seeds were dried to 0 g kg^{-1} moisture and percent oil was determined by nuclear magnetic resonance (NMR).

Plant height (cm): The height of ten plants was measured at R9 (Schneiter, and Miller, 1981) from ground level to the base of the head (cm).

Head diameter (cm): Head diameter of ten plants was measured at R9 (Schneiter, and Miller, 1981).

Seed size (mm): The length and width of a sample of 10 seeds were measured in mm for in the confectionary yield trial only.

Hull percentage (%): Samples of harvested seed were dried to 0% moisture and the husk was removed and weighed.

Uniformity: At 75% of the flowering stage plants were observed to determine whether or not they were uniform.

Statistical analysis was performed to determine differences among the varieties (Steel, 1980).

RESULTS AND DISCUSSION

According to three-year findings of this research in Menemen conditions, among the oilseed hybrids and OP confectionary varieties statistically significant results (α: 0,05 and 0,01) were obtained for seed yield, flowering date, physiological maturity date, plant height, capsule number per plant, seed number per capsule, and 1000-seed weight.

Oilseed hybrid variety experiments

In the experiments, the highest seed yield (572 kg da^{-1}) and the lowest seed yield (67 kg da^{-1}) were obtained in the 2009 growing season from the varieties ETAE-TM-2007-5 and Armada, respectively.

The fewest number of days to flowering (48) was observed in ETAE-TM-2007-2, ETAE-TM-2007-7 and ETAE-TM-2007-14 in the 2009 growing season, while the highest number (56) was found in Sanay, Armada, ETAE-TM-2007-13, Tunca, and Alhaja in the 2008 growing season.

The fewest days to physiological maturity (94) were recorded in ETAE-TM-2007-7 and ETAE-TM-2007-8 in 2009, while the most (108) were recorded in Tunca and Alhaja in the 2008 growing season.

The highest plant height (207.80 cm) was obtained from Sirena in the 2009 growing season, while the lowest plant height (129.50 cm) was obtained from ETAE-TM-2007-7 in 2008.

The largest head diameter (24.40 cm) was recorded in Alhaja in 2009 and the smallest (17.90) in ETAE-TM-2007-8 in 2008.

The highest 1000-seed weight (93.35 g) was obtained from Alhaja and the lowest (51.80 g) from ETAE-TM-2007-3 in 2009 and 2008, respectively.

The highest oil content (48.14%) was obtained from ETAE-TM-2007-4 and the lowest (37.73%) from Sanay in the 2008 growing season.

The highest hull percentage (29.33%) was found in ETAE-TM-2007-13 and the lowest (20.42%) in Sirena in the 2008 growing season.

OP confectionary variety experiments

In the experiments, the highest seed yield (563 kg da^{-1}) was obtained from ETAE-D1-2-B2 in 2008. The lowest seed yield (202 kg da^{-1}) was obtained from ETAE-Ç-P-1-2 in the 2009 growing season.

The fewest days to flowering (53) were observed in ETAE-D1-1-B6 in the 2009 growing season, while the most (64) were recorded in ETAE-Ç-P-11-1 in 2008.

The fewest days to physiological maturity (100) were recorded in ETAE-D1-1-B6 in 2009. The highest number of days to physiological maturity (107) was observed in ETAE-Ç-P-11-1 in the 2008 growing season.

The highest plant height (255.60 cm) was obtained from ETAE-K-1 in 2009 and the lowest (133.1 cm) from ETAE-D1-1-B6 in 2008.

Table 3: Confectionary type of sunflower variety test trial at first crop production time. AARI, Menemen, Izmir (Tan, 2008).

No.	Variety	Days to flowering	Days to physiological maturity	Yield*	Yield groups	Plant height	Head diameter	1000-seed weight	Seed width	Seed length	Hull percentage
		Day	Day	(kg da^{-1})	(α=0.01)	(cm)	(cm)	(g)	(mm)	(mm)	(%)
1	ETAE-D1-1-B1	56	104	427	B	160.9	22.4	116.4	6.84	20.04	41.87
2	ETAE-D1-1-B2	55	105	563	A	157.5	21.6	123.5	7.23	19.71	41.24
3	ETAE-D1-1-B3	55	103	381	BC	151.6	19.4	115.6	7.33	20.85	43.57
4	ETAE-D1-1-B6	54	102	321	CD	133.1	18.1	102.8	5.79	20.82	37.95
5	ETAE-D2	55	106	392	BC	150.9	21.4	121.4	7.32	20.28	45.32
6	ETAE-Ç-P-1-2	61	104	222	E	149.1	20.5	86.7	5.53	18.51	46.81
7	ETAE-Ç-P-11-1	64	107	277	DE	147.3	19.4	70.8	5.70	19.42	44.01
	CV (%)	1.51	0.62	11.71		4.56	11.82	7.86	5.48	2.24	5.51
	LSD (0.05)	1.283	0.9639	64.43		10.16		12.34	0.534	0.667	3.533
	LSD (0.01)	1.758	1.321	88.50		13.92		16.95	0.733	0.917	4.854

* Seed yield, 1000-seed weight, and oils were adjusted to 0% moisture.

**: 1: highly uniform, 2: uniform, 3: heterogeneous, 4: highly heterogeneous.

Table 4: Confectionary type of sunflower variety test trial at first crop production time. AARI, Menemen, Izmir (Tan, 2009a).

No.	Variety	Days to flowering	Days to physiological maturity	Yield*	Yield groups	Plant height	Head diameter	1000-seed weight	Seed width	Seed length	Hull percentage
		Day	Day	(kg da^{-1})	(α=0.01)	(cm)	(cm)	(g)	(mm)	(mm)	(%)
1	ETAE-D1-1-B1	55	104	338	B	204.6	22.1	130.0	7.92	20.76	41.07
2	ETAE-D1-1-B2	54	104	546	A	211.9	24.4	146.4	8.17	21.14	40.77
3	ETAE-D1-1-B3	55	102	359	B	195.8	23.3	125.8	7.98	20.74	42.75
4	ETAE-D1-1-B6	53	100	224	CD	172.3	20.2	112.8	6.77	22.67	40.32
5	ETAE-D2	54	101	338	B	193.6	23.6	134.4	8.29	21.81	46.33
6	ETAE-Ç-P-1-2	57	104	202	D	166.8	21.0	108.5	6.22	20.16	45.60
7	ETAE-Ç-P-11-1	58	104	331	BC	166.9	19.7	92.18	6.61	20.98	43.37
8	ETAE-K-1	55	105	266	BCD	255.6	22.8	141.9	8.03	23.42	42.68
	CV (%)	2.30	0.67	16.87		4.03	4.91	5.96	5.16	3.63	5.29
	LSD (0.05)	1.864	1.021	80.73		11.62	1.597	10.87	0.5695	1.147	3.331
	LSD (0.01)	2.538	1.390	109.9		15.82	2.175	14.79	0.7754	1.561	4.535

* Seed yield, 1000 seed weight, and oils were adjusted to 0% moisture.

**: 1: highly uniform, 2: uniform, 3: heterogeneous, 4: highly heterogeneous.

The largest head diameter (24.4 cm) was found in ETAE-D1-1-B2 in 2009 and the lowest (18.1 cm) in ETAE-D1-1-B6 in the 2008 growing season.

The highest 1000-seed weight (146.40 g) was obtained from ETAE-D1-1-B2 in 2009 and the lowest (70.80 g) from ETAE-Ç-P-11-1 in the 2008 growing season.

The highest seed length (23.42 mm) was recorded in ETAE-K-1 in the 2009 growing season, while the lowest seed length (20.16 mm) was observed in ETAE-Ç-P-1-2 in 2009.

The highest seed width (8.17 mm) was obtained from ETAE-D1-1-B2 in 2009 and the lowest (6.22 mm) from ETAE-Ç-P-1-2 in the 2009 growing season.

The highest hull percentage (46.81%) was recorded in ETAE-Ç-P-1-2, while the lowest hull percentage (37.95%) was obtained from ETAE-D1-1-B6 in the 2008 growing season.

CONCLUSIONS

Results showed that statistically significant differences were found among the sunflower varieties for the characters in question.

In the oilseed variety experiments; the highest seed yield (572 kg da^{-1}) and the lowest seed yield (343 kg da^{-1}) were obtained in the 2009 growing season from the varieties ETAE-Y-TM-2007-5 and Armada, respectively.

In the confectionary variety experiments, on the other hand, the highest seed yield for (563 kg da^{-1}) and the lowest seed yield (202 kg da^{-1}) were produced in 2009 by the varieties ETAE-D1-2-B2 and ETAE-Ç-P-1-2, respectively.

There were differences found among the sunflower varieties for the characters in question due to years because of differences in planting time and ecological conditions in both years. However, the oilseed hybrid ETAE-TM-2007-5 showed the highest yield performance in 2008 (565 kg da^{-1}) and 2009 (572 kg da^{-1}), and the confectionary OP variety ETAE-D1-2-B2 also had the highest yield performance in 2008 (563 kg da^{-1}) and 2009 (546 kg da^{-1}). Among the rest of the genotypes, the oilseed hybrid ETAE-TM-2007-12 had satisfactory seed yield performance in both years and was found to be tolerant to the existing races of *Orobanche cumana* Wallr. (Tan, 2009a).

Our research results indicated that both the oilseed hybrids and the OP confectionary varieties had the number of days to physiological maturity days that is suitable for both the first and second crop production seasons in the region.

Our findings indicated that the yield performance of the oilseed varieties ranged from 343 to 572 kg da^{-1}. These results are similar to the long-term adaptation results for the Aegean Region (Tan, 2009a). It is very clear that sunflowers with high seed and oil yields per unit area could have an important role in decreasing the oil gap in Turkey.

Planting high-yielding hybrids in the Aegean Region, which has suitable ecological conditions for the first and second crop sunflower productions, may play an important role in decreasing the vegetable oil gap in Turkey. Research results also indicate that candidate confectionary varieties with their desired seed characters and quality will help decrease the seed demand of the farmers.

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