MAS Journal of Applied Sciences Uygulamalı Bilimler Dergisi ISSN: 2757-5675 masjaps.com

OPEN ACCESS

DOI: http://dx.doi.org/10.5281/zenodo.8051748

Araştırma Makalesi / Research Article

Sunflower (*Helianthus annuus* L.) Advanced Breeding Materials in Field Trials in Different Geographical Regions of Turkey

Abdullah ÇİL[1*], Ayşe Nuran ÇİL[1], Vakas ŞAHİN[1], Yılmaz YAŞAR[1]

[1]Eastern Mediterranean Agricultural Research Institute, Adana

*Sorumlu yazar (Corresponding author): abdullah.cil@tarimorman.gov.tr

Geliş Tarihi (Received): 10.02.2023 **Kabul Tarihi (Accepted)**: 28.03.2023

Abstract

A small number of nations produce sunflower on a big scale; including the Turkey (Mediterranean Region, Central Anatolia, Thrace). The recent development of the production is quite impressive in the Eastern part of Europe and in Turkey. Breeders of sunflowers aim to develop genotypes that perform well and are adaptable to a wide range of conditions. Along with seed yield, sunflower seed oil content must be increased to meet industrial requirements. This study was conducted in three locations at two different geographical regions in Turkiye (Thrace and Cukurova Regions), in the 2015 growth season. As a result of the study, plant heights (cm), table diameters (cm), 1000 seed weights (g), seed yields (kg ha^{-1}), seed oil contents (%), seed protein contents (%) and oil yields per ha (kg ha^{-1}) were determined between 112.0-150.6 cm; 15.21-20.09 cm; 54.9-79.9 cm; 3198-4148 kg ha^{-1}; 38.94-42.42%; 15.47-18.69%; and 1287-1631 kg ha^{-1}, respectively. As a conclusion, Genotype no 1, 2, 3 and 4 were found superior in terms of yield in the trials.

Keywords: Sunflower, *Helianthus annuus*, breeding, yield, oil content, multi-location

1. Introduction

One of the few crops with its origins in North America is the sunflower (*Helianthus annuus* L.), which Native American groups in the east central United States was cultivating. The crop is planted all over the world and grows in the majority of temperate areas, with notable production on every continent excluding Antarctica. A major event in sunflower history was the discovery of cytoplasmic male sterility (CMS) in a wild prairie sunflower, *Helianthus petiolaris* Nutt. (Leclercq, 1969), and restorer genes with recessive branching found in wild *H. annuus* populations (Kinman, 1970) and *H. petiolaris* (Leclercq, 1971) that led to the production of commercial hybrids. The hybrid sunflower industry experienced a revolution as a result of higher yields, oil content, uniformity, and improved disease resistance compared to open-pollinated types, which made sunflower a viable crop on a global scale (Seiler et al., 2017). A small number of nations produce sunflower on a big scale, with two thirds of its production being concentrated in Europe, particularly Ukraine, Russia, and the Trakya region of Turkey. The countries Argentina, China, the United States, and the south-eastern region of Africa (South Africa, Tanzania, Uganda, and Zambia) are the other significant sunflower producing nations. India's acreage was high in past, but it declined sharply from 2.35 Mha in 2006 to 0.5 Mha ten years later and 0.28 Mha in 2019. The top ten nations, including Ukraine, the Russian Federation, Argentina, China, Romania, Bulgaria, Turkey, Hungary, France, and the United States, account for 84% of production and 76% of acreage between 2014 and 2018. The European Union would rank third when taken as a whole, behind Russia and Ukraine. With the exception of France, which drops from position 5 to position 9, both global yield and acreage was stable across the two 5-year periods from 2009 to 2018. The recent development of the production is quite impressive in the Eastern part of Europe and in Turkey. The sunflower industry was able to sustain its competitiveness due to ongoing advancements in genetics, cropping techniques, and research with added value, which increased market segmentation (Pilorge, 2020). Breeders of sunflowers aim to develop genotypes that perform well and are adaptable to a wide range of conditions. Although sunflower is a temperate zone crop, changing conditions can have a significant impact on its yield potential. As previously documented by Abd El-Satar et al. (2015), Khomari and Mohammadi (2017) and Sofalian et al. (2019), environmental changes, such as climatic or edaphic conditions, are regarded limiting variables for seed yield and seed oil content. Sunflower seeds contain around 44% oil and 16% proteins and sunflower is both an oil and protein crop. It competes on both vegetable oils market, led by palm oil, and vegetable protein rich products (containing more than 15% proteins) market, driven by soybean (Pilorge, 2020). The sunflower seed oil content must be increased to meet industrial requirements. This is a major breeding goal for sunflowers to enhance the crop's market value and guarantee growers adequate returns (Rauf et al., 2017). Therefore, a key goal of sunflower breeding programmes is to find high-performing genotypes with greater flexibility in terms of seed yield and seed oil content (Abdelsatar et al., 2020). This study was conducted to determine the adaptation, yield and quality of selected sunflower advanced breeding materials under field conditions in different geographical regions of Turkey.

2. Materials and Method

2.1. Materials

Five candidate sunflower oil type test hybrids (DA-VD20-06, DA-VD20-10, ADASUN21, DA-VD20-13, and DA-VD20-21) sourced from the breeding studies of Eastern Mediterranean Agricultural Research Institute (Adana, Turkiye) and five control hybrids from

private sector (Bosfora, LG-5580, Tunca, P64-LL62, and P64-LL134) were used in this study.

2.2. Method

The trials were conducted total in three locations at two different geographical regions in Turkiye, in the 2015 growth season. One location was in Thrace region (North-West of Turkey) where oil type sunflower acreage is highest in Turkey, in a farmer field in Keşan subprovince of Tekirdağ province. Other two locations (Institute's Doğankent location and Ceyhan TIGEM fields) were in Cukurova delta (Eastern Mediterranean region of Turkey) where sunflowers acreage is significantly high in Turkey. Trials were set up in three locations according to the Randomised Complete Blocks Design with four replications. Sowing were completed in March 2015 in Ceyhan and Doğankent and in April 2015 in Keşan locations. The materials were planted on 7.5 m long, 4 rowed, 21 m^2 parcels with 0.7 m interrow distance. Ten hybrids were tested in each location. The soil of the trial site was prepared for sowing by ploughing when soil was at correct humidity, by using disc harrow. Sowing was done with a trial type sawing machine at 0.70 m interrow and 0.30 m intrarow distances. During soil preparation, 500 kg/ha base fertilizer 20-20-0 was applied to the soil as equal to pure form of 100 kg/ha nitrogen (N) and 100 kg/ha phosphorus (P2O5). Potassium was not applied as it is at sufficient levels in soils of Turkey. Starting from two weeks after the emergence of the plants; hand thinning, hand hoeing, machine hoeing was applied to interrows when needed. When the plants at approximately 10-15 cm height middlebreaking was applied. After flowering was completed, the flower tables were insulated with cotton cloth bags to prevent bird damage. Hybrids were harvested when they reached harvest maturity. Harvested plot area was 9.52 m^2 (2 rows x 1.40 x 6.80 m). Harvest dates were July 2015 for Ceyhan and Dogankent and August 2015 for Kesan locations. When the yellow leaves at the edge of the tables were dried, the flowers fell and the grains matured and hardened, the tables were cut and harvested. The observations and measurements and their methods followed in the research are given below:

Table diameter (cm): At the physiological maturity stage (R-6), the table diameters of five randomly selected plants from each genotype were measured and the average was calculated.

Plant height (cm): During the physiological maturity period (R-6), the distance from the root collar of the five plants on the soil surface to the base of the table was measured and the average was calculated.

Thousand grain weight (g): The average of 100 seeds from each plots were counted with four replication, then multiplyed by 10. Evaluations were made at 10% humidity.

Seed yield (kg ha^{-1}): Yield was calculated by weighing and transforming the parcel seed weights into hectare. The moisture content in the grain was determined by the John Dickey moisture measuring device, and the parcel yield was calculating based on 10% seed humidity.

Seed oil ratio (%): 50 g samples obtained from each plot were analyzed by using a Soxalet oil analyzer, after drying seeds in the oven at 105 °C for eight hours, and analyzed at 10% humidity.

Oil yield (kg ha^{-1}): The seed yield obtained and seed oil ratio determined from each plot were rated.

3. Results and Discussion

Statistically significant differences in seed yields (kg ha^{-1}) among genotypes were observed in Adana/Dogankent and Edirne/Kesan locations but not in Adana/Ceyhan location (Table 1).

Table 1. Seed yields (kg ha^{-1}) of sunflower genotypes tested in 2020

Genotype no	Genotype name	Seed yields (kg ha^{-1}) in tested locations						Average seed yields (kg/ha)
		Adana/Ceyhan	Adana/Dogankent		Edirne/Kesan			
1	DA-VD20-06	3957	4926	a-c	3393	a		4092
2	DA-VD20-10	3712	4862	a-c	3125	a-c		3900
3	ADASUN21	3934	5207	a	3304	ab		4148
4	DA-VD20-13	4033	4362	a-d	2946	a-c		3780
5	DA-VD20-21	3205	5064	ab	3095	a-c		3788
6	Bosfora	3379	3257	d	2956	a-c		3198
7	LG-5580	3703	4732	a-c	2768	c		3734
8	Tunca	4186	5014	a-c	2262	d		3820
9	P64-LL62	3531	3765	cd	2708	cd		3335
10	P64-LL134	4467	4502	b-d	2887	a-c		3952
Average		3811	4502		2944			3752
Standart error		118.0	144.8		246.3			169.7
CV (%)		19.76	16.9		5.4			14.02

In Adana/Ceyhan location, seed yields were between 3205-4467 kg ha^{-1}. In Adana/Dogankent location, seed yields were highest at Genotype no 1, 2, 3, 4, 5, 7 (control variety LG-5580) and 8 (control variety Tunca) (between 4362-5208 kg/ha) and lowest at Genotype no 6, 9 and 10 (between 3257-4502 kg ha^{-1}) (Table 1). In Edirne/Kesan location, seed yields were highest at Genotype no 1, 2, 3, 4, 5, 6 (control variety Bosfora) and 10 (control variety P64-LL134) (between 2887-3393 kg ha^{-1}) and lowest at Genotype no 7, 8 and 9 (between 2262-2768 kg ha^{-1}). Seed yields for average of three locations were between 3198-4148 kg ha^{-1} (Table 1). For all genotypes, seed yields were highest in Adana/Dogankent location, medium in Adana/Ceyhan location and lowest in Edirne/Kesan location. Genotype no 1, 2, 3, 4 and 5 were yielded well in Adana/Dogankent and Adana/Ceyhan locations but among these 5 genotypes, Genotype no 4 was the lowest yielding of all genotypes in Adana/Ceyhan location. Due to this result, Genotype no 1, 2, 3 and 4 were found superior in terms of yield in the trials (Table 1).

Table 2. Seed oil contents (%) of sunflower genotypes tested in 2015

Genotype no	Genotype name	Seed oil contents (%) in tested locations						Average seed oil contents (%)	
		Ceyhan		Dogankent		Kesan			
1	DA-VD20-06	40,87	d	35,32	c	41,20	ab	38,94	d
2	DA-VD20-10	42,60	bc	37,30	a-c	43,87	a	41,03	ac
3	ADASUN21	42,18	c	35,59	c	41,73	ab	39,66	cd
4	DA-VD20-13	42,50	bc	37,57	a-c	42,17	ab	40,62	bd
5	DA-VD20-21	43,74	ab	35,62	c	42,30	ab	40,39	bd
6	Bosfora	42,89	bc	37,01	bc	40,73	ab	40,16	bd
7	LG 5580	44,64	a	40,11	a	42,53	ab	42,42	a
8	Tunca	40,82	d	40,06	a	38,97	b	40,04	bd
9	P64 LL62	42,14	c	39,92	ab	39,00	ab	40,48	bd
10	P64 LL134	43,44	ac	38,93	ab	42,97	ab	41,67	ab
Averages		42,58		37,74		41,55		40,54	
Standart error		0,21		0,93		0,57		0,30	
CV(%)		1,90		4,91		5,27		4,70	

In Adana/Ceyhan location, seed oil contents were lowest at genotype no 1 and 8 (control variety Tunca) (40.9% and 40.8, respectively) and highest at genotype no 5, 7 (control variety LG-5580) and 10 (control variety P64-LL134) (between 43.4-44.6%) (Table 2). In Adana/Dogankent location, seed oil contents were between 35.3-40.1% with lower values at genotype no 1, 3 and 5 and higher at genotype no 7 and 8 (control

varieties LG-5580 and P64-LL134) (Table 2). In Edirne/Kesan location, seed oil contents were between 39.0-43.9 with lower value at genotype no 8 (control variety Tunca) and higher value at genotype no 2 (Table 2).

Table 3. Oil yield (kg/ha) results of sunflower genotypes tested in 2015

Genotype No	Genotypes	Oil Yields (kg ha^{-1}) in Tested Locations					Average oil yields (kg ha^{-1})
		Ceyhan	Dogankent		Kesan		
1	DA-VD20-06	1614	1743	ab	1410	a	1589
2	DA-VD20-10	1586	1818	ab	1377	ab	1593
3	ADASUN21	1657	1858	ab	1376	ab	1630
4	DA-VD20-13	1711	1635	ac	1253	a-c	1533
5	DA-VD20-21	1400	1801	ab	1309	ab	1503
6	Bosfora	1445	1205	c	1212	a-c	1287
7	LG 5580	1655	1896	ab	1177	bc	1576
8	Tunca	1707	2008	a	879	d	1531
9	P64 LL62	1490	1494	bc	1057	cd	1347
10	P64 LL134	1941	1491	bc	1239	a-c	1557
Averages		1621.1	169.53		122.87		1515
Standar error		4.98	5.39		12.27		75.5
CV (%)		19.94	11.00		4.4		11.78

In Adana/Ceyhan location, oil yields were between 1400-1941 kg ha^{-1} (Table 3). In Adana/Dogankent location, oil yields were lower (between 1205-1635 kg ha^{-1}) at Genotype no 4, 6, 9 and 10. Oil yields per ha were higher (between 1743-2008 kg ha^{-1}) at the rest of the genotypes in Dogankent location (Table 3). In Edirne/Kesan location, seed yields were lowest at Genotype no 8 (control variety Tunca) and 9 (control variety P64-LL62) (897 and 1057 kg ha^{-1}, respectively) and highest at Genotype no 1, 2, 3, 4, 5, 6, and 10 (between 1212-1410 kg ha^{-1}). Average of three locations oil yields were between 1287-1630 kg ha^{-1} (Table 3). For all genotypes, except Bosfora, oil yields were lowest in Edirne/Kesan location among three location, and highest in Adana/Ceyhan location except genotypes 4, 6 and 10. In the study by Manivannan et al. (2017), hybrid CO_2 was set in a test in India in station, multi-locations, "adaptive research and on farm trials", and "all India coordinated trial". As a result, Hybrid CO_2 recorded 2431 and 2890 kg ha^{-1} of seed production during the kharif and rabi/summer seasons, respectively, in station trials. During the kharif and rabi/summer seasons, it is 16.9 and 10.4 percent higher than Sunbred 275 (2080 and 2619 kg ha^{-1}), and 20.3 and 29.4 percent higher than TCSH 1 (2021 and 2235 kg ha^{-1}). Hybrid CO_2 recorded 1826 and 2198 kg ha^{-1} over the kharif and rabi/summer seasons, respectively, in multi-location studies. During the kharif and rabi/summer seasons, the yield increased by 15.0 and 26.3 percent over Sunbred 275 (1587 and 1741 kg ha^{-1}) and 18.0 and 11.3 percent over TCSH 1 (1548 and 1975 kg ha^{-1}). In "Adaptive Research and On Farm Trials", Hybrid CO2 recorded an average seed yield of 1826 and 1907 kg ha^{-1} during the kharif and rabi/summer seasons, respectively. This is 11.3 and 8.2 percent higher than Sunbred 275 (1640 and 1763 kg ha^{-1}) and 15.4 and 9.8 percent higher than TCSH 1 (1582 and 1737 kg ha^{-1}), respectively. Hybrid CO2 produced 1742 kg/ha yield at the "All India Coordinated Trial" during the Kharif season. In comparison to KBSH 1 (1580 kg ha^{-1}), the seed yield has increased by 10.3%. Compared to the study of Manivannan et al., (2017), in our study yields were very high due to the fitness of hybrids to favorable agro-ecological conditions. When the combined results are analyzed, it can be seen that the plant height was short (112.0 cm) in the P64-LL134 genotype, medium (130.7 cm) in the P64-LL62 genotype, and tall (138.4-150.6 cm) in the rest of the genotypes (Table 4).

Table 4. Combined analysis results of trials of sunflower genotypes tested in 2015

Genotype No	Genotypes	Plant heights (cm)		Table diameters (cm)		1000 seed weights (g)		Seed yields (kg/ha)		Seed oil contents (%)		Seed protein contents (%)		Oil yields (kg/ha)	
1	DA-VD20-06	143.15	ab	18.18	b	65.93	bc	4092	a	38.94	d	16.91	bc	1588	a
2	DA-VD20-10	140.64	ab	17.91	b	64.40	bd	3900	a	41.02	ac	15.47	c	1593	a
3	ADASUN21	138.36	bc	20.09	a	79.89	a	4148	a	39.66	cd	17.61	ab	1631	a
4	DA-VD20-13	143.09	ab	16.88	bc	69.27	b	3781	ab	40.62	bd	17.01	bc	1533	ab
5	DA-VD20-21	145.00	ab	17.88	b	79.02	a	3789	ab	40.39	bd	18.69	a	1504	ab
6	BOSFORA	146.64	ab	16.45	bc	59.53	df	3198	c	40.16	bd	15.60	c	1287	c
7	LG 5580	150.64	a	15.21	c	62.33	ce	3735	ab	42.42	a	16.77	bc	1576	a
8	TUNCA	148.36	ab	16.48	bc	54.87	f	3821	ab	40.04	bd	16.07	bc	1532	ab
9	P64-LL62	130.73	c	16.57	bc	60.91	ce	3335	bc	40.48	bd	16.36	bc	1347	bc
10	P64-LL134	111.98	d	16.48	bc	57.67	ef	3729	ab	41.67	ab	16.59	bc	1558	a
Averages		139.86		17.22		65.38		3752.8		40.54		16.71		1515	
Standart error		3.32		0.45		1.30		110.3		0.30		0.18		48.9	
CV (%)		7.43		12.00		8.94		7.00		4.70		11.13		8	

When the combined results are analyzed, it can be seen that the table diameters was high (20.9 cm) in the ADASUN21 genotype, low (between 15.21-16.88 cm) in Genotype no 4, 6, 7, 8, 9 and 10 and, medium (between 17.88-18.18 cm) in the other genotypes (Table 4). For the combined results, 1000 seed weight was lowest (between 54.9-59.5 cm) in the 6, 8 and 10 genotypes, the highest in the 3 and 5 genotypes (79.9 cm and 79.0 cm, respectively) and intermediate in the rest of the genotypes (Table 4). According to the combined results, seed yields were low in Genotypes 6 and 9 (3198 and 3335 kg/ha, respectively) and high in the rest of the genotypes (between 3729-4148 kg/ha) (Table 4). For the combined results, seed oil contents were high in Genotypes 2, 7 and 10 (between 41.02-42.42%). Rest of the genotypes were in group with low oil contents (between 38.94-40.62%). According to the combined results, protein contents were high in Genotypes 3 and 5 (17.61% and 18.69%, respectively). Rest of the genotypes were in group with low protein contents (between 15.47-17.01%). For the combined results, oil yields were low in Genotypes 6 and 9 (1287 and 1347 kg/ha, respectively). Rest of the genotypes were in group with high oil yields (between 1504-1631 kg/ha). Although Genotype 3 stands out in terms of head diameter and 1000 grain weight, high yield values were not observed at this genotype. This is likely related to the table filling rate, the number of plants per ha (the number of emerged plants and/or the loss of seedlings due to worm damage, etc.). This genotype requires a strict follow in the next trial seasons. Along with this, plant emergence rates is needed to be examined in the laboratory with hot and cold test analysis.

4. Conclusions

As a conclusion, Genotype no 1, 2, 3 and 4 were found superior in terms of yield in the trials.

Declaration of Author Contributions

The authors declare that they have contributed equally to the article. All authors declare that they have seen/read and approved the final version of the article ready for publication.

Declaration of Conflicts of Interest

All authors declare that there is no conflict of interest related to this article.

References

Abdelsatar, M.A., Hassan, T., Attia, M. 2020. Stability some sunflower genotypes across divergent environments. Helia, 43(72): 33-49.

Abd El-Satar, M.A., Fahmy, R.M., Hassan, T. 2015. Selecting high oil yield sunflower genotypes and stable in their salinity tolerance using parametric and non parametric stability statistics. Zagazig J. Agric. Res, 42: 967-82.

Blackman, B.K., Scascitelli, M., Kane, N. C., Luton, H.H., Rasmussen, D.A., Bye, R.A., Rieseberg, L.H. 2011. Sunflower domestication alleles support single domestication center in eastern North America. Proceedings of the National Academy of Sciences, 108(34): 14360-14365.

Khomari, A., Mohammadi, A. 2017. Stability study of yield in sunflower (Helianthus annuus L.) cultivars using AMMI method. Journal of Crop Breeding, 9(23): 117-124.

Kinman, M.L. 1970. New developments in the USDA and state experiment station sunflower breeding programs. In Proc. 4th Int. Sunflower Conf., Memphis, TN. Int. Sunflower Assoc., Toowoomba, Australia (pp. 181-184).

Leclercq, P. 1969. Cytoplasmic male sterility in sunflower. Ann Amelior Plant, 19: 99-106.

Leclercq, P. 1971. La stérilité mâle cytoplasmique du tournesol. 1. Premières études sur la restauration de la fertilité. Ann. Amelior. Plant. 21:45–54.

Manivannan, N., Vindhiyavarman, P., Muralidharan, V., Chandirakala, R., Gopalkrishnan, C., Suganthy, M., Thiyagarajan, K. 2017. Hybrid CO2-A high yielding sunflower hybrid for Tamil Nadu. Electronic Journal of Plant Breeding, 8(1): 153-156.

Pilorge, E. 2020. Sunflower in the global vegetable oil system: situation, specificities and perspectives. OCL, 27: 34.

Rauf, S., Jamil, N., Tariq, S. A., Khan, M., Kausar, M., Kaya, Y. 2017. Progress in modification of sunflower oil to expand its industrial value. Journal of the Science of Food and Agriculture, 97(7): 1997-2006.

Seiler, G.J., Qi, L.L., Marek, L.F. 2017. Utilization of sunflower crop wild relatives for cultivated sunflower improvement. Crop Science, 57(3): 1083-1101.

Sofalian, O., Darvishzadeh, R., Hatamzadeh, H. 2019. Evaluation of yield stability of sunflower inbred lines under salt stress conditions. Journal of Crop Breeding, 11(30): 1-10.

To Cite: Çilzel, A., Çil, A.Ş., Şahin, V., Yaşar, Y., 2023. Sunflower (*Helianthus annuus* L.) Advanced Breeding Materials in Field Trials in Different Geographical Regions of Turkey. *MAS Journal of Applied Sciences*, 8(2): 384-390.
DOI: http://dx.doi.org/10.5281/zenodo.8051748.