NARDI FUNDULEA, ROMANIA
www.incda-fundulea.ro; doi.org/10.59665/rar4024
ROMANIAN AGRICULTURAL RESEARCH, NO. 40, 2023
Print ISSN 1222-4227; Online ISSN 2067-5720

THE IMPACT OF CLIMATIC CONDITIONS ON OIL CONTENT AND QUALITY, IN SUNFLOWER

Florina Cojocaru[1], Maria Joiţa-Păcureanu[2,3], Mioara Negoiță[4], Laura Mihai[4], Gabriel Popescu[3], Laurenţiu Ciornei[3], Viorel Ion[5], Gabriel Florin Anton[2*], Luxiţa Rîşnoveanu[6,7*], Daniela Oprea[2], Alexandru Bran[8], Elisabeta Sava[8]

[1]University of Agronomic Sciences and Veterinary Medicine of Bucharest, Mărăşti Blvd, no. 59, 011464 Bucharest, District 1, Romania

[2]National Agricultural Research and Development Institute Fundulea, Nicolae Titulescu str., no. 1, 915200 Fundulea, Călăraşi County, Romania

[3]Reasearch and Study Centre for Agriculture and Forestry Biodiversity, 13 September str., no. 13, 050711 Bucharest, District 5, Romania

[4]National Research and Development Institute for Food Bioresources - IBA Bucharest, Dinu Vintilă str., no. 6, 021102 Bucharest, District 2, Romania

[5]Faculty of Agriculture - Plant Science Department, University of Agronomic Sciences and Veterinary Medicine of Bucharest, Mărăşti Blvd, no. 59, 011464 Bucharest, District 1, Romania

[6]Agricultural Research Development Station Brăila, Viziru km. 9 str., Brăila, Brăila County, Romania

[7]Bucharest University Economic Studies, Faculty of Agri-food and Environmental Economics, Research Center for Sustainable Development, Piaţa Romană, no. 6, 010374 Bucharest, District 1, Romania

[8]The State Institute for Variety Testing and Registration, Mărăşti Blvd, no. 60-61, 011464 Bucharest, District 1, Romania

[*]Corresponding authors. E-mail: gabriel.anton@incda-fundulea.ro; luxita_risnoveanu@yahoo.co.uk

ABSTRACT

Sunflower (*Helianthus annuus* L.) crop is grown world wide, under a range of agro-environments. This crop is primarily grown for its edible oil but also for its achenes (confectionery types), both commonly used in human food.

With ongoing climate change, sunflower, as a spring crop, could be more exposed to the direct effect of heat stress and to different drought scenarios, resulting in severe yield losses, oil content decrease and alteration of fatty acids composition.

The oil concentration in sunflower (whether linoleic or oleic varieties) is valued above the contribution of genotype, of environment but also of the crop management.

In our study, with different sunflower hybrids, experimented in different conditions of the environment, we obtained results on oil content and fatty acids composition.

The oil content in kernels is influenced by climate. This depends by air temperature in period of anthesis or during grain filing, also by rainfall. The unsaturated fatty acids of sunflower oil are much more affected by genotype and environment than the saturated ones. Cooler regions offer a more favorable climate for the oil and linoleic acid synthesis. There is an indirect relationship for oleic and linoleic content, in sunflower oil.

Keywords: sunflower, environment, hybrids, oil content, fatty acids.

INTRODUCTION

Sunflower (*Helianthus annuus* L.) crop is grown world wide, in temperate, subtropical and tropical climates, under a wide range of agro-environments (Brumă et al., 2021). This crop is primarily grown for its edible oil but also for its achenes (confectionery types), both commonly used in human food (Pilorge, 2020).

Many breeding efforts by public and private research give to sunflower an economic competitiveness, comparing with other oil crops (Duru, 2019; Conţescu and Anton, 2023).

A multicriteria approach, combining different breeding targets should be proposed for evaluating the multi-performance of a variety. Referring to the end-use of sunflower achenes and oil there is a choice of a linoleic

Received 30 November 2022; accepted 4 May 2023. First Online: May, 2023. DII 2067-5720 RAR 2023-122

(classic) versus high oleic type, in relation with a premium paid for quality, by the market (Nolasco et al., 2006; Ayerdi-Gotor et al., 2015; Debaeke et al., 2017).

With ongoing climate change, sunflower, as a spring - sown rainfed crop, could be more exposed to the direct effect of heat stress at anthesis or during grain filing and to different drought scenarios, resulting in severe yield losses, oil content decrease and alteration of fatty acids composition (Rondanini et al., 2006; Donatelli et al., 2015; Andrianasolo et al., 2016).

Current sunflower varieties potential, in more constrained conditions should be explored, by combining field networks, with water deficit (Duca et al., 2022). Breeding will be necessary to develop hybrids more tolerant to drought and heat (Miladinovic et al., 2019; Attia et al., 2021).

By anticipating the timing of critical growth stages, the exposure of sunflower to the most stressful factors (drought and heat) can be minimized by sowing in early spring, in order to escape the risk of high temperatures and water stress, during the flowering period (Petcu et al., 2010; Debaeke et al., 2012; Donatelli et al., 2015). In this case, breeding for cold tolerance should contribute to stabilizing sunflower cultivation exposed to early spring frosts (Vear, 2016).

The oil concentration in sunflower (whether linoleic or oleic varieties) is valued above the contribution of genotype, also among the contribution of producers (Debaeke et al., 2021). The oil potential of a variety is given by environment but also by crop management (Champolivier et al., 2019). It is important the choice of variety and crop management practices according with environmental factors (Andrianasolo et al., 2014).

The development of oleic acid concentration and thermal regim after flowering it has been studied (Bachelier et al., 2018).

This paper presents the results obtained on oil content and fatty acids composition study, with different sunflower hybrids, experimented in different conditions of the environment.

MATERIAL AND METHODS

There have been experimented 10 linoleic and 4 oleic sunflower hybrids, in six locations, situated in areas with different climatic conditions, in Romania, in two years, 2020 and 2021.

The oil content analysis was performed by MQC Oxford Instruments equipment, using small quantity of sunflower kernels.

Fatty acids composition was performed using SR EN ISO 12966-2-2017 method with modified procedure PS FC 28. Iodine index was performed according to European Standard ISO 3961:1996.

The calculation of minimum and maximum values were released using Excel program. The ecostability of the linoleic acid content was estimated in terms of regression coefficient and deviation from regression. The simple linear coefficient of correlation was computed according to the usual method.

RESULTS AND DISCUSSION

The data regarding the climatic conditions, presented in Figures 1 and 2 emphasize that in 2020 year, in Cogealac and Tulcea locations there have been registered the highest air temperatures, specially in a critical period of sunflower vegetation. In the same locations the rainfall was lowest in this year. The lowest air temperatures values in this period, in 2020 year have been registered in Livada location, also the highest rainfall.

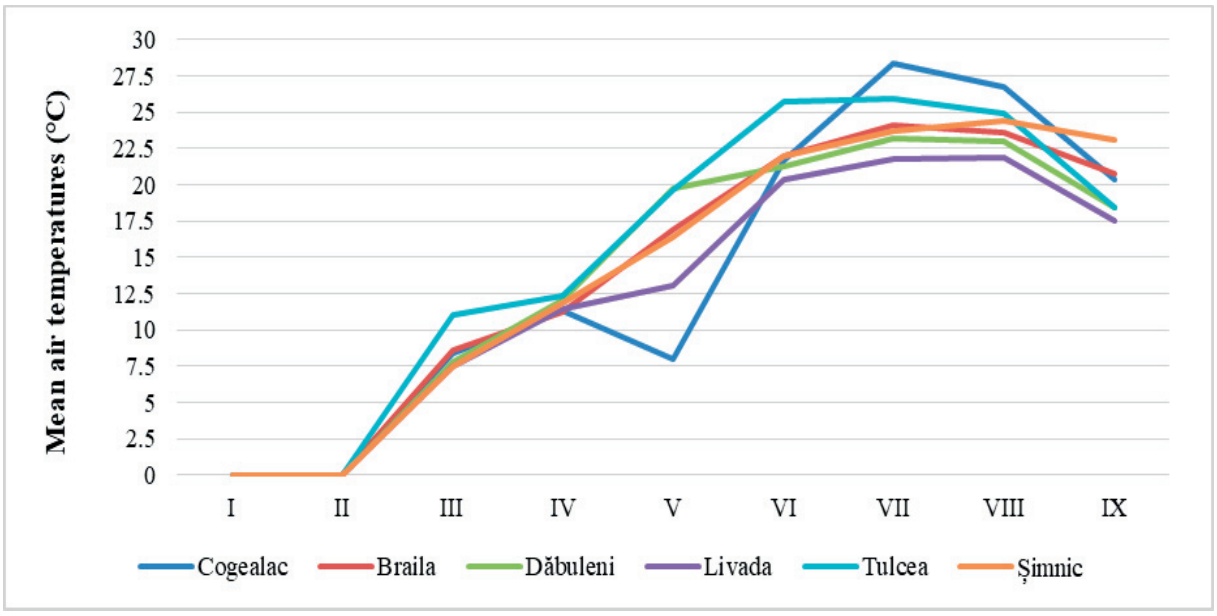

Figure 1. The air temperatures, in six locations, in 2020

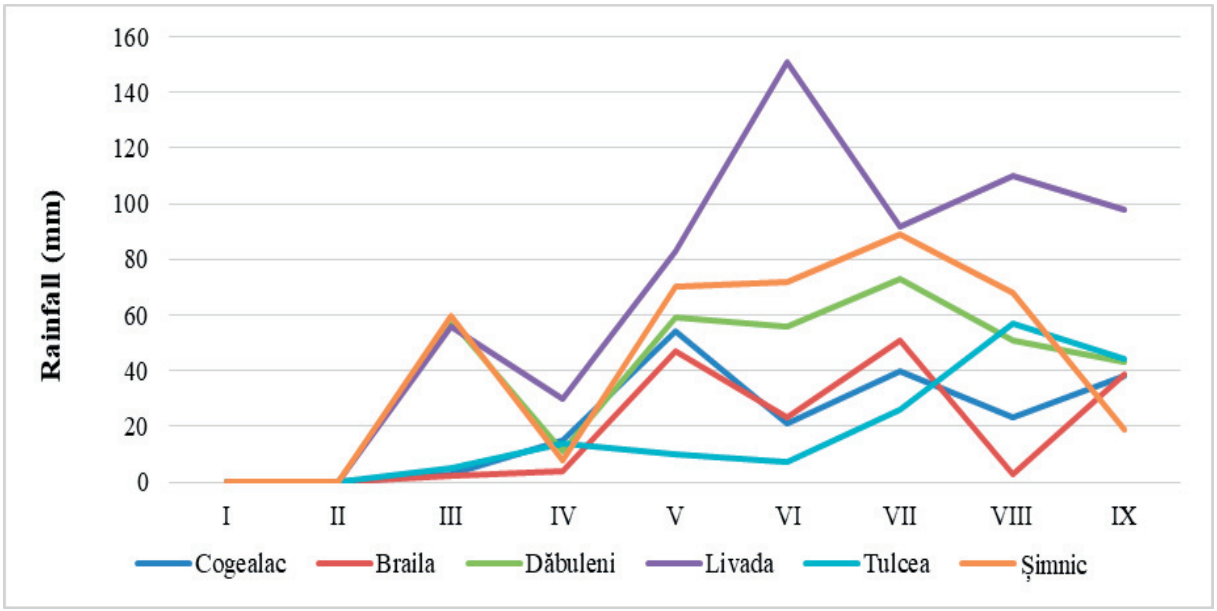

Figure 2. The rainfall, in six locations, in 2020

In Figures 3 and 4 there are presented data regarding the climatic conditions in 2021, in six locations. The air temperature values are lower compared with 2020. The temperatures are more favorable to sunflower crop development. The rainfall values have been quite higher, in all locations compared with 2020.

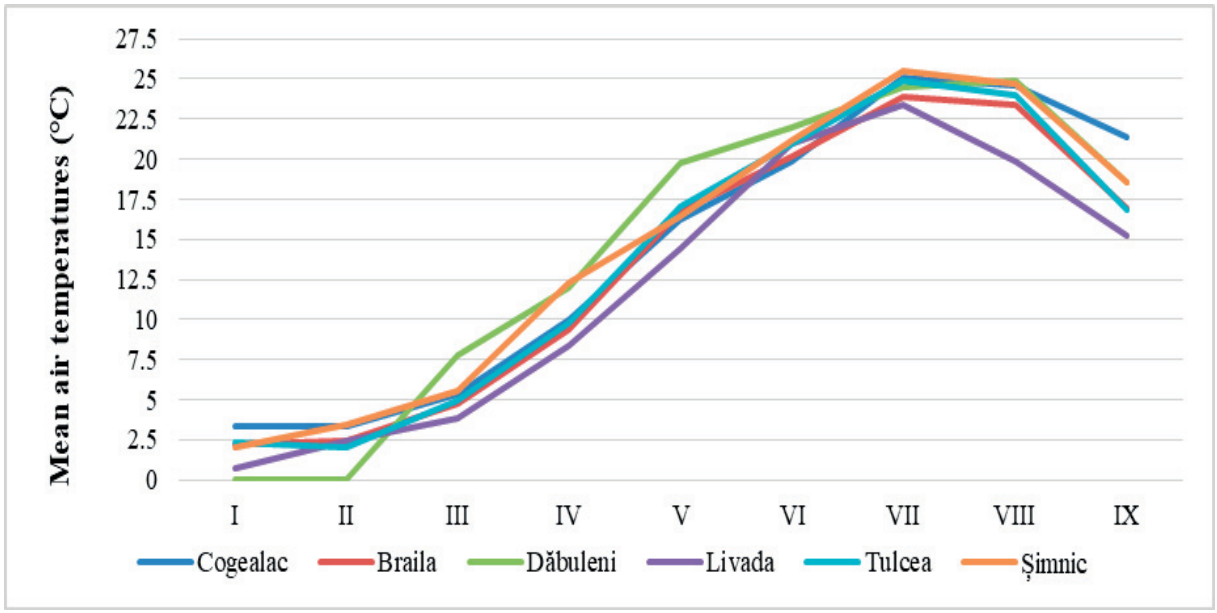

Figure 3. The air temperatures, in six locations, in 2021

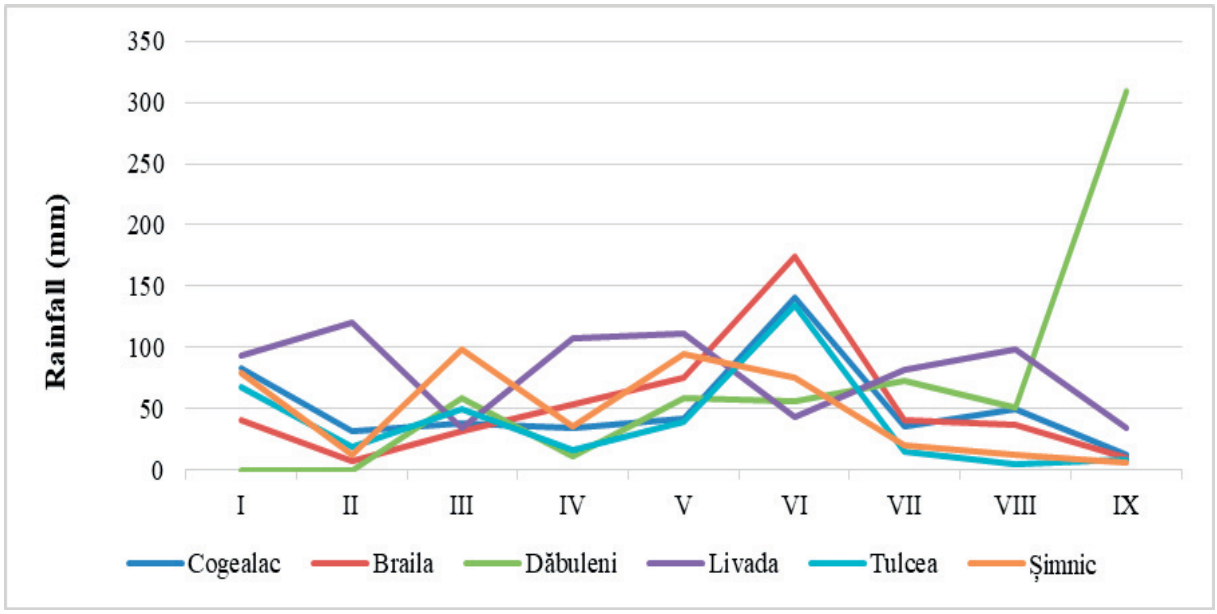

Figure 4. The rainfall, in six locations, in 2021

Sunflower is cultivated specially for the high oil content in kernels, 80% of its value coming from this.

The results regarding the oil content (Figure 5), for the ten studied hybrids emphasize that the higher average was registered in Şimnic location (51.0%) the lowest one, being in Cogealac location (46.1%), in 2020 year. The highest value of oil content was registered by HS 152 (52.4% in Şimnic) and HS 201 (50.8%, in Livada location). The lowest oil content was registered by HS 132 (46.3% in Cogealac) and HS 177 (46.8% in Tulcea location).

The results referring to 2021 year (Figure 6) emphasize that the higher average for oil content was in Livada location (51.0%) the lowest one being in Tulcea (48.1%). There are not big differences between locations. The higher value of oil content was registered for the hybrid HS 256 (52.1% in Livada) and HS 201 (51.9% in Brăila location), the lowest one, for the hybrid HS 177 (44.6% in Tulcea) and HS 223 (44.7% in Cogealac).

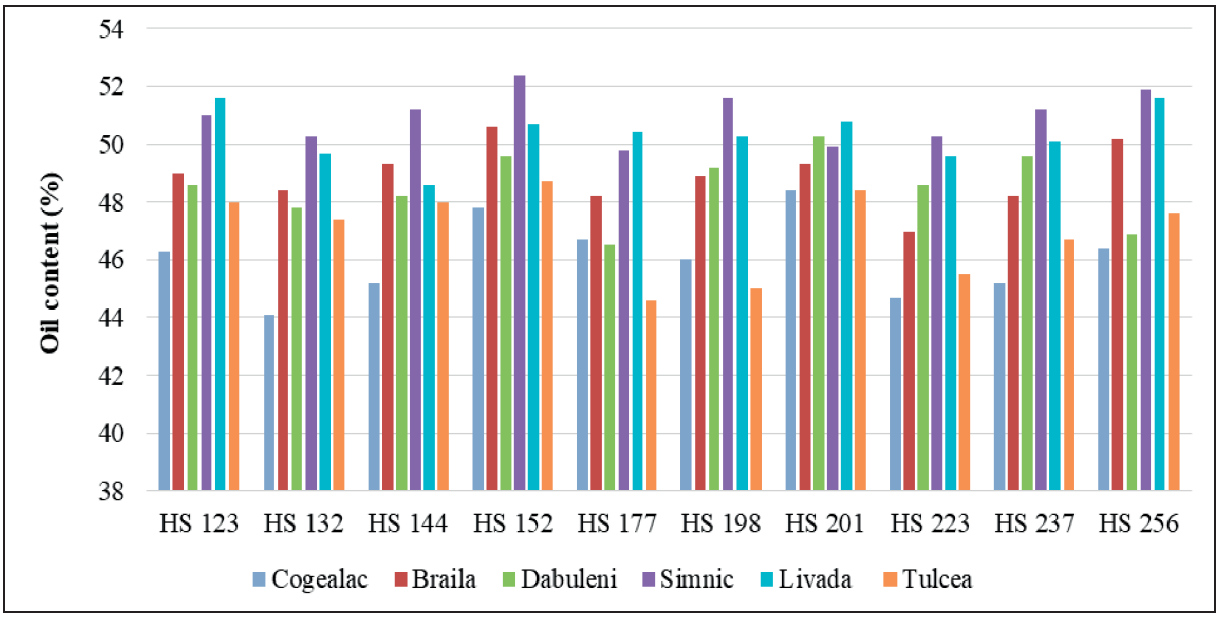

Figure 5. The oil content of studied hybrids, in six locations, in 2020

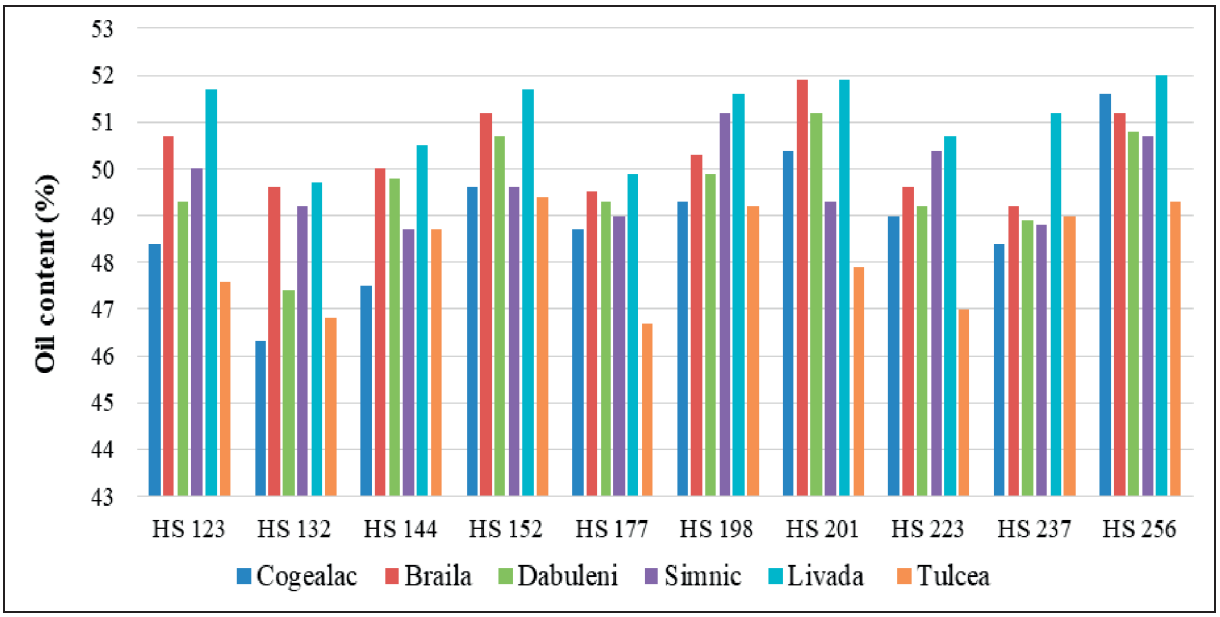

Figure 6. The oil content of studied hybrids, in six locations, in 2021

In Table 1 are presented the results regarding the mean and extreme values of fatty acids and iodine index for each genotype in all locations. The saturated fatty acids varied much less than the unsaturated ones. The oleic and linoleic acid content varied in large limits, of 12.7% for oleic (in case of high oleic sunflower hybrids), 30.2% for linoleic (in case of linoleic hybrids). For iodine value the limits varied from 77 to 143, taking into consideration both types (linoleic and oleic hybrids). It is well known that the high oleic hybrids have a lower iodine value, comparing with linoleic ones. There is an indirect relationship for oleic and linoleic content, in sunflower oil (Popa et al., 2017). As a consequence, the linoleic/oleic ratio exhibits a large variation.

Table 1. The mean and extreme values of fatty acids and iodine index, for sunflower hybrids, in all locations, in two years

No.	Hybrid	Fatty acids (%)				Iodine value	Linoleic/oleic
		Oleic acid	Linoleic acid	Palmitic acid	Stearic acid		ratio
1	HS 123	23	64.6	6	5.3	133	2.8
		14.3-30.9	59.2-73.9	5.6-8.0	3.9-6.5	128-140	1.9-5.2
2	HS 132	25.4	62.5	5.2	6.1	129	2.2
		15.7-43.8	45.6-72.0	5.0-7.4	4.8-7.8	116-140	1.0-4.6
3	HS 144	22.1	64.9	6.3	5.7	132	2.9
		13.4-32.2	56.6-74.7	5.6-7.3	4.6-8.1	126-141	1.7-5.6
4	HS 152	23.6	63.6	5.7	6.1	131	2.6
		15.0-36.6	51.2-72.4	5.0-6.8	4.7-7.8	121-138	1.4-4.8
5	HS 177	22.3	66	5.6	5.1	134	2.9
		13.4-37.5	58.6-76.4	5.2-7.1	4.5-6.3	123-143	1.4-5.7
6	HS 198	21.3	66.7	6	5.2	134	3.1
		13.7-34.9	59.4-74.7	5.3-7.0	4.7-6.8	122-142	1.6-5.9
7	HS 201	20.7	66.7	5.6	5.2	134	3.2
		12.0-41.0	60.3-75.6	5.1-7.6	4.5-6.6	120-142	1.2-6.3
8	HS 223	21.7	65.8	6.1	5	134	3
		12.6-39.4	49.9-75.3	5.4-7.4	4.2-6.5	120-141	1.2-6.1
9	HS 237	22.3	65.6	6	5.1	133	2.9
		14.0-37.3	53.5-73.5	5.3-8.1	3.6-7.5	123-140	1.4-5.3
10	HS 256	23	64.4	6	5.2	132	2.8
		15.3-39.6	49.7-72.0	5.5-7.8	4.0-7.6	120-140	1.3-4.7
11	HS 1032	82.8	11.7	2.5	2.2	89	0.14
		78.9-90.4	9.5-13.8	1.9-3.1	1.7-2.4	79-96	0.9-0.19
12	HS 1067	84.9	9.8	2.7	2	92	0.11
		80.4-91.6	8.7-11.9	1.4-3.7	1.9-3.8	88-95	0.8-0.16
13	HS 1084	85	9	2.9	2.3	86	0.1
		81.7-90.0	8.0-12.4	2.0-3.9	2.0-4.9	80-97	0.8-0.14
14	HS 1097	84.3	10.2	2.8	2.2	81	0.12
		81.2-90.5	8.0-14.1	1.7-3.2	1.9-3.3	77-89	0.7-0.18

In Table 2 are presented the results regarding the mean and extreme values of fatty acid for all genotypes experimented in each location.

All genotypes expressed the lowest oleic acid in Livada location and the highest in Tulcea. At Livada all genotypes posses more than 73.2% linoleic, with small differences between them. At Tulcea location, the linoleic synthesis is repressed up to 55% and the difference among genotypes is extended to around 3.1 percent.

Table 2. Location effects on fatty acid composition. Average values and variation range for 10 varieties

No.	Location	Fatty acids (%)				Iodine value	Linoleic/oleic ratio
		Oleic acid	Linoleic acid	Palmitic acid	Stearic acid		
1	Cogealac	21	65.9	6.8	5.1	132	3.1
		18.2-25.9	63.9-68.2	5.0-7.3	4.9-6.8	128-134	2.6-3.6
2	Livada	13.9	74.4	6.3	5.5	123	5.3
		12.9-15.3	73.2-75.9	5.1-7.2	4.1-6.5	111-127	4.4-5.9
3	Şimnic	22	65.7	6.3	5	131	2.9
		20.5-24.1	63.6-67.9	5.0-6.0	4.4-6.9	130-133	2.6-3.2
4	Tulcea	33.6	53.6	6.2	4.7	139	1.5
		31.8-39.7	51.9-55.0	5.4-6.6	3.7-5.5	138-142	0.8-1.7
5	Dăbuleni	20.3	66.4	6.9	5.6	133	3.2
		18.9-22.6	62.1-68.2	4.9-7.8	4.1-6.8	128-135	2.4-3.9
6	Brăila	23.9	64.9	5.9	4.7	131	2.7
		21.5-25.7	61.3-65.8	5.2-6.8	3.6-6.3	129-134	2.4-3.5

Taking into account the linoleic mean values, at 1% probability level (Table 3), all hybrids are statistically similar. Location effects are much greater that the genetic ones. Livada (mean of 74.4%) and Tulcea (mean of 53.6%) are the two extremes which differ highly significantly from all other locations.

Table 3. Linoleic acid content (%) in 6 different locations

No.	Hybrid	Cogealac	Livada	Şimnic	Tulcea	Dăbuleni	Brăila	Mean	Sx	S%
1	HS 123	66.4	73.9	63.1	59.2	63.8	61.6	64.6	1.37	7.9
2	HS 132	64.4	72	64.7	45.6	65	63.3	62.5	1.75	10.5
3	HS 144	66.7	74.7	63.8	56.6	65.7	62.4	64.9	1.53	8.9
4	HS 152	65.6	72.4	64	51.2	64.8	63.9	63.6	1.64	9.2
5	HS 177	64.9	76.4	65.9	58.6	65.4	64.7	66	1.80	10.2
6	HS 198	66.9	74.7	66.7	59.4	66.8	65.9	66.7	1.74	9.8
7	HS 201	65.5	75.6	67.3	60.3	66.9	64.8	66.7	1.73	9.8
8	HS 223	65.8	75.3	66.9	49.9	68.4	65.7	65.8	1.75	9.9
9	HS 237	66.7	73.5	65.3	53.5	69.2	66.3	65.6	1.44	8.2
10	HS 256	64.8	72	66.4	49.7	67.9	65.8	64.4	1.53	8.9
Mean		66	74.4	65.7	53.6	66.4	64.9	65.2		

According with some authors, a stable genotype is one which has the highest mean over a broad range of environments, a regression coefficient near the unit and a deviation from regression closed to zero.

The stability parameters are presented in Table 4. The results show that all hybrids have a regression coefficient of about 0.9 to 1.0 and relatively small deviation, suggesting that their response was almost the same from location to location. Only the hybrids HS 152 and HS 132 give particular poor response in such environments.

Table 4. Mean values of linoleic acid content and stability parameters for 10 sunflower hybrids in 6 locations and 2 years

No.	Hybrid	Linoleic acid	Regression coefficient	Deviation mean square
		Mean (%)	(bxy)	s^2b
1	HS 123	64.6	1.00	3.7
2	HS 132	62.5	0.85	2.0
3	HS 144	64.9	0.97	3.4
4	HS 152	63.6	0.77	2.4
5	HS 177	66.0	1.00	1.6
6	HS 198	66.7	1.06	0.7
7	HS 201	65.3	1.06	0.7
8	HS 223	66.8	0.91	1.1
9	HS 237	65.6	0.96	1.3
10	HS 256	64.4	1.00	0.9
Mean		65.2	0.98	2.2

All correlation coefficients between oil and linoleic content, established for each hybrid are positive and most of them are significant (Table 5). It is known that some contributing factors are the same for oil as well as for linoleic content in sunflower kernel.

When correlation coefficients were computed for a location, with 10 hybrids (Table 5) positive and significant correlation between the two traits were recorded in zones known as favorable for sunflower. In extreme environmental conditions, as Livada location, where the climatic conditions were favorable for linoleic synthesis, all genotypes are almost identical for linoleic and oil content, lack of found correlation. In Tulcea and Brăila, the linoleic synthesis was the most depressed.

Table 5. Linear correlation coefficients between oil and linoleic content

Hybrid	n	r	Locations	n	r
HS 123	6	0.63 *	Cogealac	10	0.69 **
HS 132	6	0.72 **	Livada	10	0.87 ***
HS 144	6	0.52	Șimnic	10	0.65 *
HS 152	6	0.55 *	Tulcea	10	0.40
HS 177	6	0.77 **	Dăbuleni	10	0.48 *
HS 198	6	0.69 **	Brăila	10	0.43
HS 201	6	0.70 **			
HS 223	6	0.65 *			
HS 237	6	0.63 *			
HS 256	6	0.75 **			

CONCLUSIONS

The oil content in kernels of sunflower hybrids is influenced by climatic conditions. This depends by air temperatures after genotypes flowering, also by rainfall.

The unsaturated fatty acids of sunflower oil are much more affected by genotype and environment, than the saturated ones.

Cooler regions offer a more favorable climate for the oil and linoleic acid synthesis.

There is an indirect relationship for oleic and linoleic fatty acids, in sunflower oil. Location effects are much greater than the genetic ones, on linoleic acid synthesis. There is a positive correlation between oil content and linoleic acid, in zones known as favorable for sunflower.

REFERENCES

Andrianasolo, F.N., Casadebaig, P., Champolivier, L., Maza, E., Maury, P., Debaeke, P., 2014. *Prediction of sunflower grain oil concentration as a function of variety, crop management and environment by the means of statistical models*. Eur. J. Agron., 54: 84-96.

Andrianasolo, F.N., Debaeke, P., Champolivier, L., Maza, E., Maury, P., 2016. *Analysis and modelling of the factors controlling seed oil content in sunflower: a review*. OCL, 23(2): D206.

Attia, Z., Pogoda, C.S., Reinert, S., Kance, N.C., Hulke, B.S., 2021. *Breeding for sustainable oilseed crop yield and quality in a changing climate*. Theor. Appl. Genet., published online: 21 Jan 2021. https://doi.org/10.1007/s00122-021-03770-w

Ayerdi-Gotor, A., Berger, M., Lablette, F., Centis, S., Dayde, J., Calmon, A., 2015. *Comparative analysis of fatty acids, tocopherols and phytosterols content in sunflower cultivars (Helianthus annuus) from a three-year multi-local study*. Phyton, 84: 14-25.

Bachelier, M., Champolivier, L., Debaeke, P., 2018. *Is predicting oleic acid percentage in sunflower oil from air temperature accurate enough?* International Symposium, Sunflower and Climate Change, 5-6 Feb, 2018, Toulouse, France, Conference Proceedings.

Brumă, I.S., Rodino, S., Petcu, V., Micu, M., 2021. *An overview of organic sunflower production in Romania*. Romanian Agricultural Research, 38: 495-504. https://doi.org/10.59665/rar3852

Conţescu, L.E., and Anton, F.G., 2023. *Study of the genetic diversity of some wild sunflower species using ISST markers*. Romanian Agricultural Research, 40: 31-37. https://doi.org/10.59665/rar4004

Champolivier, L., Debaelke, P., Dejoux, J.-F., Dizien, C., Micheneau, A., Colombet, C., Gibrin, H., Pontet, C., Al Bitar, A., Trépos, R., Ansart, A., Marais Sicre, C., Garric, B., Mestries, E., Casadebaig, P., Fernandez-Diclo, Y., 2019. *Construction d`un simulateur pour la prevision du rendement et de la qualite de tournesol a l`echelle territoriale mobilisant la teledectection satellitaire*. Innovations Agronomiques, 71: 15-34.

Debaeke, P., Uyttewaal, V., Mestries, E., Salvi, F., 2012. *Characterisations of drought stress environments for sunflower variety assessment*. Proc. 18th Int. Sunflower Conf., Mar del Plata, Argentina: 390-395.

Debaeke, P., Casadebaig, P., Flenet, F., Langlade, N., 2017. *Sunflower crop and climate change: vulnerability, adaptation, and mitigation potential from case-studies in Europe*. OCL, 24(1): D102.

Debaeke, P., Casadebaig, P., Langlade, N.B., 2021. *New challenges for sunflower ideotyping in changing environments and more ecological cropping systems*. OCL, 28: 29.

Donatelli, M., Srivastava, A.K., Duveiller, G., Niemeyer, S., Fumagalli, D., 2015. *Climate change impact and potential adaptation strategies under alternate realizations of climate scenarios for three major crops in Europe*. Environ. Res. Lett., 10: e75005.

Duca, M., Port, A., Burcovschi, I., Joiţa-Păcureanu, M., Dan, M., 2022. *Environmental response in sunflower hybrids: a multivariate approach*. Romanian Agricultural Research, 39: 139-152. https://doi.org/10.59665/rar3914

Duru, M., 2019. *Trends in agri-food choices for health since the 1960s: the case of fatty acids*. OCL, 26: 44.

Miladinovic, D., Hldni, N., Radanovic, A., Jocic, S., Cvejic, S., 2019. *Sunflower and climate change: Possibilities of adaptation through breeding and genomic selection*. In: Kole, C. (eds.), Genomic Design of Climate-Start Oilseed Crops. Springer Nature, Switzerland AG: 173-238.

Nolasco, S.M., Aguirrezabal, L.A.N., Luquez, J., Mateo, C., 2006. *Variability in oil tocopherol concentration and composition of traditional and high oleic sunflower hybrids (Helianthus annuus L.) in the Pampean region (Argentina)*. Grasas y Aceites, 57: 260-269.

Petcu, E., Băbeanu, N., Popa, O., Partal, E., Pricop, S., 2010. *Effect of planting date, plant population and genotype on oil content and fatty acid composition in sunflower*. Romanian Agricultural Research, 27: 53-59.

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

Popa, M., Anton, G.F., Rîşnoveanu, L., Petcu, E., Băbeanu, N., 2017. *The effect of planting date and climatic condition on oil content and fatty acid composition in some Romanian sunflower hybrids*. Agrolife Scientific Journal, 6: 212-217.

Rondanini, D., Mantese, A., Savin, R., Hall, A.J., 2006. *Responses of sunflower yield and grain quality to alternating day/night high temperature regimes during grain filling: effects of timing, duration and intensity of exposure to stress*. Field Crops Res., 96: 48-62.

Vear, F., 2016. *Changes in sunflower breeding over the last fifty years*. OCL, 23: D202.