IMPACT OF DROUGHT AND EXTREME HEAT ON SUNFLOWER SEED YIELD

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Abstract

Sunflower (Helianthus annuus L.) is generally considered moderately resistant to drought conditions. However, in years characterized by low rainfall and high air temperatures, significant reductions in seed yield can occur. At the Fundulea location in south eastern Romania, the year 2024 was marked by drought and extreme heat, resulting in low seed yields among the 15 tested sunflower hybrids. Yields ranged from 611 kg/ha for hybrid H5E in the ExpressSun system to 1,299 kg/ha for hybrid H10CLP in the Clearfield Plus system. In contrast, more favourable climatic conditions in 2025 led to substantially higher yields, ranging from 1,579 kg/ha for hybrid H2E (ExpressSun) to 3,046 kg/ha for hybrid H11CLP (Clearfield Plus). These results demonstrate the pronounced impact of extreme heat and drought, particularly during the flowering and seed-filling phenophases, which are the most sensitive stages of sunflower development. Stress occurring in these phases limits pollination efficiency, seed set, and oil accumulation, ultimately leading to significant yield reductions.

Key words**: **sunflower, seed yields, hybrids

INTRODUCTION

Sunflower (*Helianthus annuus* L.) represent an important oil crop plant and are cultivated in many countries around the world, such as Russia, Ukraine, the European Union, Argentina, Kazakhstan, Turkey, Moldova, South Africa, Serbia (Duca et al, 2022b; Kaya, 2020; Ma'ali et al, 2024). In Romania, sunflower is an important crop cultivated each year more than 1 million hectares and is very important for sunflower oil market (Kaya, 2020; Anton et al, 2025; Constantin et al, 2025; Chivu and Stanciu 2024; Ştefan and Constantinescu, 2022).

Due to a severe drought registered in year 2024, in Romania, the area cultivated with sunflower in 2025 (1183640 ha) decreased by 59,610 ha compared to 2024 (1243250 ha) (EUROSTAT 2025).

Drought and extreme heat represent the most restrictive abiotic factors regarding

seed yield on sunflower (Clapco et al, 2019; Jocković et al, 2024).

In years with low rainfalls and with high temperatures during growing season of sunflower reduce seed yield between 20% and 90% (Pekcan et al, 2022; Duca et al, 2022a; Shah et al, 2025).

High temperatures registered in faze of flowering lead to pollen sterility (Shah et al, 2025; Mehmood et al, 2023).

Drought affect negatively sunflower culture, in special traits like plant height, head diameter, seed size, seeds number/calatidium, number and surface of leaves, root length, one thousand seed weight (TSW-g), hectoliter weight (HW-kg/hl), seed yield, seed oil content (Constantinescu et al, 2024; Majumder and Mason, 2025; Ma'ali et al, 2024; Santos et al, 2024; Shah et al, 2025).

MATERIALS AND METHODS

In years 2024 and 2025, where sowing 15 sunflower hybrids, different technology and in different period of time, in trials plots on four rows and 6 meter long in three repetitions, in Fundulea location, in southeaster of Romania (tab. 1).

Nine sunflower hybrids from H1E up to H9E where sowing in technology Express Sun and in phenological stage of four true leaves (BBCH 14), where sprayed for weed control with selective post emergence herbicide with active substance tribenurol-metyl 500 gr/kg, in doze of 30g/ha.

Five sunflower hybrids from H10CLP up to H14CLP where sowing in technology Clearfield Plus and in phenological stage of four true leaves (BBCH 14), where sprayed for weed control with selective post emergence herbicide with active substance, imazamox 25g/l, in doze of 2l/ha.

Sunflower hybrid H15C was sowing in system conventional and in phenological stage of ten true leaves (BBCH 20), was sprayed for weed control with selective post emergence herbicide with active substance quizalofop-p-ethyl 96 g/L, in dose 0.75 L/ha. Pre-emergent plant of sunflower culture was wheat and before sowing was applied 250 kg/ha of NPK 20-20-0 fertilizers. Distance between rows was 70 cm and distance between plants on row was 35 cm.

Table 1. Data of sowing and harvesting of 15 sunflower hybrids, in Fundulea location, in years 2024 and 2025

Sunflower genotype	Technology	Data of sowing		Data of harvesting	
		2024	2025	2024	2025
H1E H2E H3E H4E H5E H6E H7E H8E H9E	Express	April 5, 2024	April 24, 2025	September 1, 2024	September 12, 2024
H10CLP H11CLP H12CLP H13CLP H14 CLP	Clearfield Plus	April 5, 2024	May 6, 2025	September 1, 2024	September 16, 2024
H15C	Conventional	May 15, 2024	May 6, 2025	September 14, 2024	September 16, 2024

Seed oil content was determined with MQC+ Oilseed analyser (Nuclear magnetic resonance analyser).

Hectoliter weight (kg/hl) where measured with Grain and seed moisture meter LDS-1G with hectoliter mass and temperature.

RESULTS AND DISCUSSIONS

Average monthly temperatures (°C) registered in Fundulea, in years 2024 and 2025, where higher in months June and July (faze of flowering and seed filing) than multiannual average of 60 years (fig.1). High temperatures recorded during the seed filling phase lead to a decrease in the oil content of the seeds.

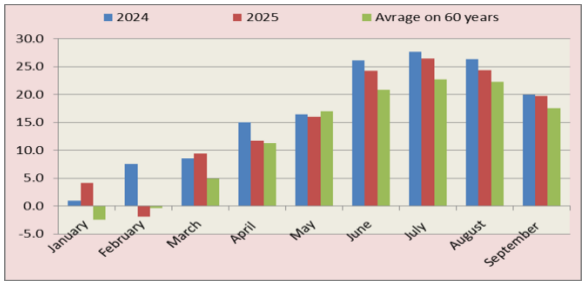

Figure 1. Average monthly temperatures (°C) registered in Fundulea, in years 2024 and 2025

Average temperatures registered in period of vegetation of sunflower, from April to September, was higher in year 2024 (21.91°C) than year 2025 (20.45°C) and much higher than average monthly temperature of 60 years (18.6C).

Table 2 Average monthly temperatures recorded during the sunflower growing season, in Fundulea, in 2024 and 2025

Month	Average monthly temperature registered in year 2024	Average monthly temperature registered in year 2025	Average monthly temperature of 60 years
April	15	11.7	11.3
May	16.4	16	17
June	26.1	24.3	20.8
July	27.7	26.5	22.7
August	26.3	24.4	22.3
September	20	19.8	17.5
Average temperature	21.91	20.45	18.6

Total amount of rainfalls (mm), from October to March, was lower than average rainfalls of 60 years (fig.2).

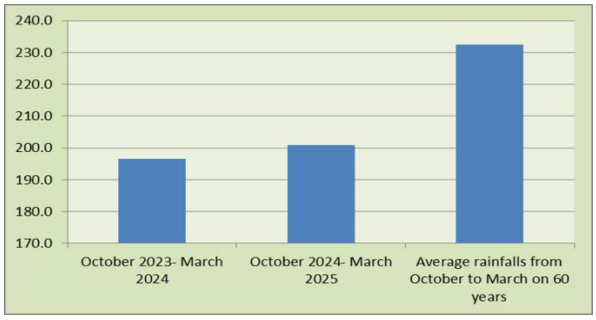

Figure 2. Total rainfalls (mm) registered in Fundulea, from October to March- water reserve for sunflower culture

Average rainfalls (mm) registered in faze of flowering and seed filing, from June to August, was lower than average monthly temperature of 60 years (figure 3). In year 2024, total amount of rainfalls from April to September was 237.6 mm and in year 2025 was 185.2 mm. Average of total amount of rainfalls on 60 years, from April to September, in Fundulea was 351.8 mm.

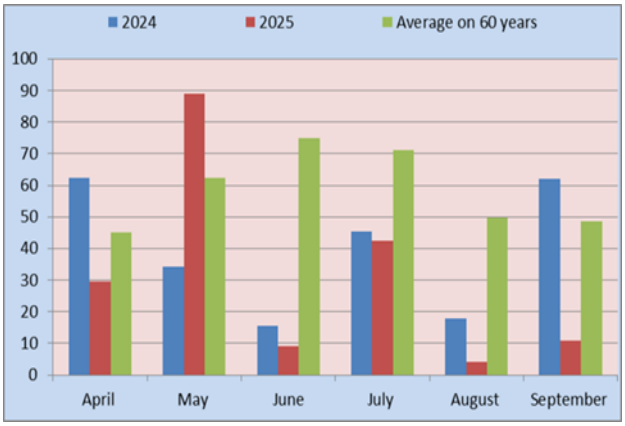

Figure 3. Rainfalls (mm) registered in Fundulea, in years 2024 and 2025, in growing season of sunflower

Hectoliter weight (kg/hl) of sunflower hybrids was in year 2024, between 34.2 kg/hl at sunflower hybrid H12CLP in system Clearfield Plus and 42.8 kg/hl at sunflower hybrid H15C in system conventional (tab. 3 and fig. 3). Seed oil content of 15 sunflower hybrids, registered in year 2024, in Fundulea was between 32.56% at H14CLP and 46.28% at H5E (tab. 3 and fig. 4). Average seed yield (kg/ha) of 15 sunflower hybrids, registered in year 2024, in Fundulea was between 611 kg/ha at H5E and 1299 kg/ha at 10CLP (tab. 3 and fig. 5). In year 2025, hectoliter weight (kg/hl) of sunflower hybrids was between 31.8 kg/hl at sunflower hybrid H4E in system Express Sun and 38.5 kg/hl at sunflower hybrid H11CLP in system Clearfield Plus. (tab. 4 and fig. 3). Seed oil content of 15 sunflower hybrids, registered in year 2025, in

Fundulea was between 31.25% at H12CLP and 39.62% at H5E (tab. 4 and fig. 4).

Table 3. Yield of 15 sunflower hybrids, registered in year 2024, in Fundulea

Sunflower hybrid	Hectoliter weight (kg/hl)	Seed oil content (%)	Average seed yield (kg/ha)
H1E	35.2	34.64	1011
H2E	35.7	37.24	1087
H3E	34.8	36.3	1069
H4E	34.8	40.51	964
H5E	39	46.28	611
H6E	35.6	36.96	866
H7E	35	37.72	1125
H8E	34.3	36.86	622
H9E	36.2	35.2	623
H10CLP	39.2	33.27	1299
H11CLP	36.06	34.86	967
H12CLP	34.2	35.54	1058
H13CLP	35.7	34.2	966
H14CLP	35.33	32.56	1036
H15C	42.8	41.61	1170

Pekcan et al, (2021) confirm that drought affect seed oil content in drought conditions. According to Guirrou et al (2024), seed oil content is influenced by water availability, air temperature, environment and growing period. Seed oil content was affected by high temperatures and low rainfalls registered in faze of flowering and seed filing, in booth years of studies, 2024 and 2025.

In 2025, seed yield where between 1579 kg/ha at sunflower hybrid H2E in the Express Sun system and 3046 kg/ha at sunflower hybrid H11CLP in the Clearfield Plus system (tab. 4 and fig. 4).

Table 4. Yield of 15 sunflower hybrids, registered in year 2025, in Fundulea

Sunflower hybrid	Hectoliter weight (kg/hl)	Seed oil content (%)	Average seed yield (kg/ha)
H1E	32.7	33.17	2396
H2E	33	36.7	1579
H3E	34.8	35.51	2453
H4E	31.8	38.03	2361
H5E	34.5	39.62	2326
H6E	35	36.33	2123
H7E	34.7	36.93	2044
H8E	35.8	33.83	2202
H9E	35.2	31.58	1999
H10CLP	35.5	31.79	2663
H11CLP	38.5	37.03	3046
H12CLP	35.4	31.25	2684
H13CLP	36.8	31.37	2009
H14CLP	37	33.74	2507
H15C	34.4	32.08	2575

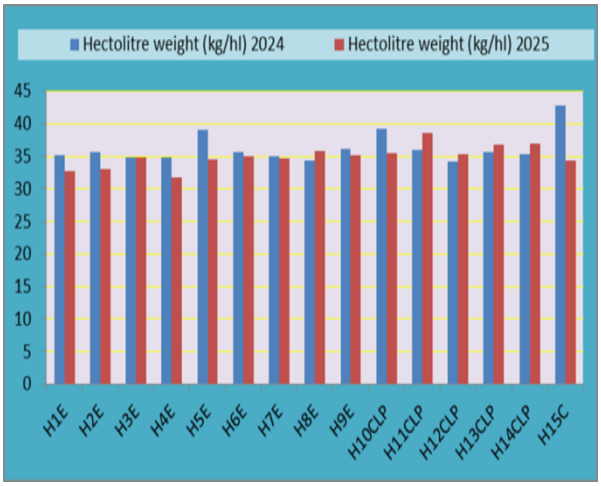

Figure 3. Hectoliter weight of 15 sunflower hybrids registered in years 2024 and 2025, in Fundulea

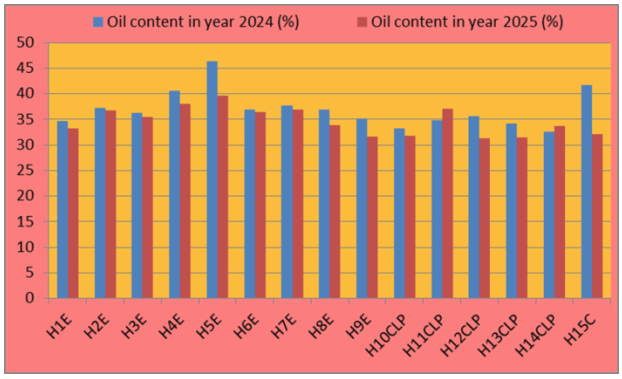

Figure 4. Seed oil content of 15 sunflower hybrids registered in years 2024 and 2025, in Fundulea(%)

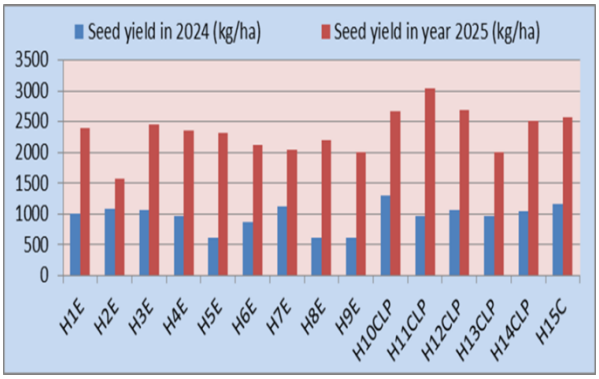

Figure 5. Seed yield of 15 sunflower hybrids registered in years 2024 and 2025, in Fundulea (kg/ha)

CONCLUSIONS.

Although in period of sunflower vegetation, in year 2025 where registered, less rainfall than in year 2024, with 52.4 mm, all 15 sunflower hybrids registered a higher seed yield due to rainfalls from month May, from 2025 with a total of 89 mm toward 34.2 mm from 2024.

Average monthly temperature from 2025 was lower than 2024, in faze of flowering and seed filing and this is the reason of reasonable seed yield registered in 2025.

Regarding hectoliter weight of 15 sunflower hybrids registered in years 2024 and 2025, in Fundulea, there are no significant differences between this two year of studies, 2024 and 2025.

Seed oil content of 15 sunflower hybrids registered in years 2024 and 2025 was where low, because of pronounced drought and high air temperature from faze of flowering and seed filing.

REFERENCES

Anton, F.G., Joița-Păcureanu, M., Contescu, L., Cergan, M., Partal, E., Pintilia, S., 2025. Sunflower production of some genotypes in years 2022, 2023 and 2024, in Romania. *Scientific Papers. Series A. Agronomy*, Vol. LXVIII, 1: 246-253.

Chivu, M., Stanciu, S.. (2024). The sunflower oil market in Romania: trends and perspectives from the processing industry. Scientific Papers Series Management Economic Engineering in Agriculture and Rural Development. 24. 169-176.

Clapco, S.; Gisca, I.; Cucereavii, A.; Duca, M. (2019). Analysis of yield and yield related traits in some sunflower (*H. annuus L.*) hybrids under conditions of the Republic of Moldova. *AgroLife Scientific Journal*, 8:2:248-258.

Constantin, D. M., Grigore, E., Tatu, F., Ionac, N., Radu, M.G., Lüftner G.D., Ilea, R. (2025). Sunflower production performance under climate change in Dobrogea region, Romania. *Scientific Papers Series Management Economic Engineering in Agriculture and Rural Development*. 25(2): 209-214.

Constantinescu E., Bonea, D., Dunăreanu, I.C,. Botu, M., Sărăcin, I., Olaru, L.A., Nitu, S. (2024). Agronomic performance of sunflower hybrids grown in the semi-arid climate of Romania. *Chilean journal of agricultural research*. 84. 43-55..

Duca, M., Boian, I., Domenco, R. (2022 a). The impact of droughts on sunflower production in the Republic of Moldova. *Notulae Botanicae Horti Agrobotanici Cluj-Napoca*. 50. 13040. 10.15835/nbha50413040.

Duca, M., Clapco, S., Burcovschi, I. (2022 b). Management of sunflower crop in Moldovan agricultural households.

Akademos.. 4. 60-68. 10.52673 /18570461.21.4-63.07.

Guirrou, I., Kouighat, M., Kettani, R., Houmanat, K., Kassimi, C., Harrak, A. E., Nabloussi, A. (2024). A comprehensive analysis of the influence of variety and climate on some properties of sunflower oil. *Acta Scientiarum Polonorum-Technologia Alimentaria*, 23(2) : 225–243.

Kaya, Y. (2020). Sunflower production in Blacksea region: the situation and problems. *International Journal of Innovative Approaches in Agricultural Research*, *4*(1), 147–155.

Jocković, M., Jocić, S., Cvejić, S., Dedić, B., Jocković, J., Ćuk, N., Radanović, A., Marjanović Jeromela, A., Miklič, V., Miladinović, D. (2024). Unveiling sunflower morphological and phenological adaptations to drought stress, *OCL,* 10.1051/ocl/2024026, **31**, (29), (2024).

Ma'ali, S., Cochrane, N., Makgoga, W., Erasmus, J. (2024). The impact of planting dates and hybrid selection on sunflower seed yield and oil content. *South African Journal Of Plant And Soil*, 41(1): 1–10.

Majumder, S., Mason, C. (2025). Sunflower yield modeling with explainable artificial intelligence: Historical weather impacts across half a century of American production. *Agronomy Journal*. 117. 10.1002/agj2.70204.

Mehmood, M., Qamar, R., Joyia, H.A. (2023). Effect of high temperature stress on pollen grains in sunflower (*Helianthus annuus* L.) inbred lines. *Brazilian Archives of Biology and Technology.* 66(e2322097):1-11.

Pekcan, V. Yilmaz, M. Evci, G.I Çil, A. Sahin, V. Gündüz, O. Koç, H. Kaya, Y. (2022). Oil content determination on sunflower seeds on drought conditions. *Journal of Food Processing and Preservation*. 46. 10.1111/jfpp.15481.

Santos, J.R.P. dos, David, A.M.S. de S., Custodio, D.C.S., Borges, J.B., Ribeiro, R.C.F., Amaro, H.T.R., Freitas, H.K.C., Barbosa, R.S., Santos, H.S.N., Silva, B.S. da. (2024). Physiological quality of sunflower seeds under water stressed conditions. *Contribuciones A Las Ciencias Sociales*, 17(5), e6831.

Shah, S., Jamali, A., Kaleri, A., Chandio, F., Baloch, R., Bukhash, D., Chano, W., Shah, A., Shah, E., Lakho, A. (2025). Performance of Sunflower (Helianthus annuus L.) Genotypes for Morpho- Yield Traits under Drought conditions. *Global Research Journal of Natural Science and Technology.* 03. 01-24.

Ştefan, I.O., Constantinescu, E. (2022). Research on the behavior of some sunflower cultivations of the north area of Olt County. *Annals of the University of Craiova, Agriculture, Montanology, Cadastre Series* 52(2):170-173.

https://ec.europa.eu/eurostat/databrowser/view/tag00100/default/table?lang=en&category=t_agr.t_apro.t_apro_cp