IDENTIFICATION OF SUNFLOWER GENOTYPES TOLERANT AT DROUGHT

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Abstract

Sunflower represents the main oil crop in Romania and is considered a moderately crop drought tolerant but in years with low precipitations seed yield is affected. In recent years, the temperature increased by 2-3 degrees Celsius compared to multi-year average over 60 years. In south-eastern of Romania (agricultural area Fundulea), in 2020, the average annual temperature was 13.5°C, in 2021, it was 12.1°C and in 2022, it was 13.3°C compared with multi-year average over 60 years who was 10.9°C. Rainfalls decreased in last four years from value of 303.3 mm, multi-year average over 60 years total from months April to August in South eastern of Romania, to a total of 180 mm in years 2020 and 2022, 269 mm in year 2021 and a total of 200 mm in 2023. In conditions of water stress and global warming we must identify sunflower genotypes with tolerance at drought and heat. In this paper we present results regarding resistance at water stress through observations development root system of sunflower genotypes under artificial condition in greenhouse and behavior in non-irrigated field in Calarasi county (Fundulea area) and Braila, in year 2023. Sunflower genotypes, S 23-5, S 23-6 and S 23-7 with very developed root system in water stress conditions was obtained thought interspecific hybridization with wild annual specie *Helianthus argophyllus* and with wild perennial species *Helianthus tuberosus* and *Helianthus maximiliani*.

Key words: sunflower, drought, *Helianthus argophyllus*, root system, water stress

Seed yield and oil content of sunflower genotypes, are affected in agricultural years with low precipitations, especially in phenophase of vegetation of seed filing. Sunflower plants suffer when is water missing and temperature of air is very high and negative effects are reduction of fertility through viability of pollen is decreasing followed by low seed yield (Port A. *et al*, 2023; Clapco S. *et al*, 2018). In conditions of water stress, sunflower has morpho-physiological and biochemical mechanisms that allow maintaining high hydric potential in the plant and saving water (Andrade A. *et al*, 2021; Ahmad H.M. *et al*, 2020; Boero A. *et al*, 2023). To avoid drought in the sunflower growth stage, we must obtain very early hybrids and select genotypes with the phenomenon stay green (Hilli H.J., Immadi S.U., 2021).

MATERIAL AND METHOD

Sunflower genotypes studied for tolerance to drought was obtained through by interspecific hybridization between inbred sunflower lines and wild sunflower species in various generations of selection (*table 1*).

Table 1

Sunflower genotypes studied for tolerance to drought

Sunflower genotype	Interspecific hybridization with annual/ perennial wild species	The selection generation	Branching/ No branching
S 23-1	1C x *Helianthus argophyllus*	F3	Branching
S 23-2	2C x *Helianthus maximiliani*	F4	Branching
S 23-3	3B x *Helianthus maximiliani*	F3	No branching
S 23-4	4B x *Helianthus argophyllus*	F3	No branching
S 23-5	5C x *Helianthus argophyllus*	F3	Branching
S 23-6	6C x *Helianthus tuberosus*	F3	Branching
S 23-7	7C x *Helianthus maximiliani*	F3	Branching
S 23-8	8B x *Helianthus debilis*	F8	No branching

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S 23-11	11C x *Helianthus mollis*	F8	Branching
S 23-13	13C x *Helianthus petiolaris x Helianthus praecox*	F8	Branching
S 23-14	14C x *Helianthus petiolaris x Helianthus debilis*	F8	Branching
S 23-15	15C x *Helianthus praecox*	F8	Branching
S 23-16	16C x *Helianthus praecox*	F7	Branching
S 23-17	17C x *Helianthus debilis*	F8	Branching
S 23-18	18C x *Helianthus maximiliani*	F8	Branching
S 23-19	19C x *Helianthus mollis*	F8	Branching
S 23-20	20B x *Helianthus neglectus*	F7	No branching
S 23-21	21Bx *Helianthus argophyllus*	F12	No branching
S 23-22	22B x *Helianthus argophyllus*	F12	No branching
S 23-23	23C x *Helianthus argophyllus*	F12	Branching
S 23-25	25C x *Helianthus argophyllus*	F12	Branching

B = maintainer of fertility sunflower line
C = restorer of fertility sunflower line

These sunflower genotypes were sown on date February 1, 2023, in Fundulea, in artificial condition, in green house, in 4 buckets of 10 liter with soil, one watered every two days (the irrigated control) and three, every 4 days (*figure 1a*). We make notations about root development and height plant compared with check irrigated normal.

In natural condition, in no irrigated field was sowing in Fundulea, on April 28, 2023 and in Braila, on May 1, 2023 for testing to drought (*figure 1b, 1c*).

a. b. c.

Figure 1a **Sunflower genotypes in artificial conditions, in the greenhouse, in Fundulea, in 2023;** 1b **Sunflower genotypes tested for drought, in natural conditions, in no irrigated field, in Fundulea;** 1c **Sunflower genotypes tested for drought, in natural conditions, in no irrigated field in Braila, in 2023**

RESULTS AND DISCUSSIONS

Observations were made regarding tolerance and drought resistance through numbers from 1 (drought-sensitive genotypes) to 5 (drought-tolerant genotypes) after analyzing the development of the root system and after analyzing the height of the plants in comparison with the normal irrigated control (*table 2* and *figure 2*).The most tolerance at drought in artificial conditions, in greenhouse, was observed at genotypes S23 -5, obtained from interspecific hybridization between restorer inbred line 5C and annual wild species *Helianthus argophyllus*, at S23-6, obtained from interspecific hybridization between restorer inbred line 6C and perennial wild species *Helianthus tuberosus*, at restorer inbred line S23-7, obtained from interspecific hybridization between restorer inbred line 7C and perennial wild species *Helianthus maximiliani*.

In the flowering vegetation stage, in Fundulea, in 2023, in month July, average monthly temperature of air, was 26.1 degrees Celsius and in Braila was 24.7 degrees Celsius, compared with multi-year average over 60 years (Braila) who was 22.7 degrees Celsius. Absolute monthly maximum temperatures registered in Fundulea, in 2023, in month July, was 39.6^{o} Celsius and in Braila, was 31.8 ^{o} Celsius.

Table 2

Notes about resistance/tolerance to drought, in artificial conditions, in greenhouse,in Fundulea, in year 2023

Sunflower genotype	Interspecific hybridization with annual/ perennial wild species	Resistance\tolerance at drought
S 23- 1	1C x *Helianthus argophyllus*	1
S23- 2	2C x *Helianthus maximiliani*	3
S23- 3	3B x *Helianthus maximiliani*	3
S23 -4	4B x *Helianthus argophyllus*	1
S23 -5	5C x *Helianthus argophyllus*	4.5
S23-6	6C x *Helianthus tuberosus*	4.5
S23-7	7C x *Helianthus maximiliani*	4.5
S23-8	8B x *Helianthus debilis*	2.5
S23-11	11C x *Helianthus mollis*	2.5
S23-13	13C x *Helianthus petiolaris x Helianthus praecox*	1
S23-14	14C x *Helianthus petiolaris x Helianthus debilis*	3.5
S23-15	15C x *Helianthus praecox*	2.5
S23-16	16C x *Helianthus praecox*	3.5
S23-17	17C x *Helianthus debilis*	3
S23-18	18C x *Helianthus maximiliani*	3
S23-19	19C x *Helianthus mollis*	3
S23-20	20B x *Helianthus neglectus*	4
S23-21	21Bx *Helianthus argophyllus*	1
S23-22	22B x *Helianthus argophyllus*	3.5
S23-23	23C x *Helianthus argophyllus*	3.5
S23-25	25C x *Helianthus argophyllus*	1.5

1= sensible; 5=resistant/tolerant

Figure 2 **The root system at sunflower genotypes S23-5, tolerant to drought and S23-8 sensible to drought**

In stage of vegetation of seed filing, in Fundulea, in 2023, in month August, the average month temperature of air, was 26.1 degrees Celsius and in Braila was 24.7 degrees Celsius, compared with multi-year average over 60 years (Braila) who was 22.3 degrees Celsius. We observe an increase of at least 2 degrees Celsius compared to the multi-annual average for 60 years (Fundulea) in the months of June, July and August (*table 3* and *figure 3*).

Maximum absolute monthly temperatures recorded in Fundulea, in 2023, in month August, was 39.6º Celsius and in Braila, was 32.4 º Celsius. In stage of vegetation of seed filing, in Fundulea, in 2023, in month August, the average monthly rainfalls, was 6.6 mm and in Braila was 55.1 mm, compared with multi-year average over 60 years (Fundulea) who was 49.7 mm (*table 4* and *figure 4*).

Table 3

Average monthly air temperature, registered in Braila and Fundulea, in year 2023

Month	Fundulea 2023	Braila 2023	Average of 60 years (Fundulea)
January	4.9ºC	4.4 ºC	-2.4 ºC
February	3.3 ºC	1.4 ºC	-0.4 ºC
March	8.2 ºC	7.9 ºC	4.9 ºC
April	10.8 ºC	10.4 ºC	11.3 ºC
May	16.9 ºC	16.6 ºC	17 ºC
June	22.3 ºC	21.6 ºC	20.8 ºC
July	26.1 ºC	24.7 ºC	22.7 ºC
August	26.1 ºC	24.7 ºC	22.3 ºC

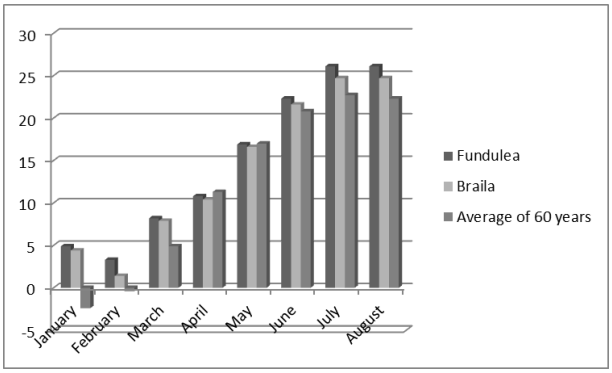


Figure 3 **Average monthly temperatures registered in Fundulea and Braila, in year 2023**

Table 4

Average monthly rainfalls, registered in Braila and Fundulea, in year 2023

Month	Fundulea 2023	Braila 2023	Average of 60 years (Fundulea)
January	64.2 mm	64.2 mm	35.1 mm
February	5.8 mm	7.1 mm	32 mm
March	10 mm	13.2 mm	37.4 mm
April	77.2 mm	65.5 mm	45.1 mm
May	32.2 mm	39.6 mm	62.5 mm
June	40.2 mm	25.6 mm	74.9 mm
July	43.8 mm	105.9 mm	71.1 mm
August	6.6 mm	55.1 mm	49.7 mm
Total rainfalls	280 mm	376.2 mm	407.8 mm

In Fundulea and Braila, in year 2023, the best average seed yield/sunflower plant was at sunflower genotypes S 23-8, obtained from interspecific hybridization between maintainer inbred line 8B and annual wild species *Helianthus debilis* and S 23-22, obtained from interspecific hybridization between maintainer inbred line 22B and annual wild species x *Helianthus argophyllus* (*table 5* and *figure 5a*).

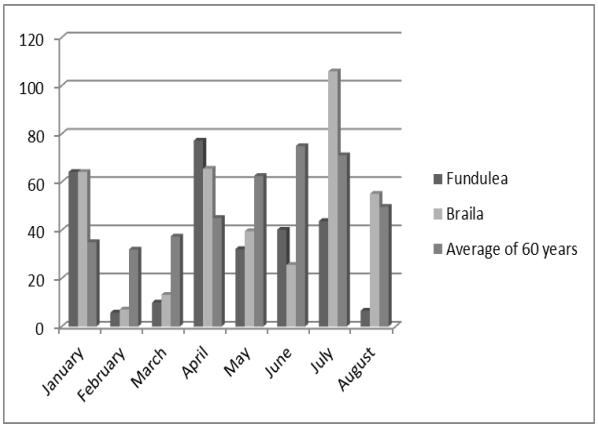


Figure 4 **Average monthly rainfalls registered in Braila and Fundulea, in year 2023**

Table 5

Average seed yield of sunflower genotypes, registered in Braila and Fundulea, in year 2023

Sunflower genotype	Interspecific hybridization with annual/ perennial wild species	Average seed yield /sunflower plant (grams) Fundulea, 2023	Average seed yield /sunflower plant (grams) Braila, 2023
S 23-1	1C x *Helianthus argophyllus*	9.77	9.16
S 23-2	2C x *Helianthus maximiliani*	12.71	10.71
S 23-3	3B x *Helianthus maximiliani*	10.87	8
S 23-4	4B x *Helianthus argophyllus*	5.55	15
S 23-5	5C x *Helianthus argophyllus*	21.46	12.9
S 23-6	6C x *Helianthus tuberosus*	20.24	15.29
S 23-7	7C x *Helianthus maximiliani*	4.75	11.85
S 23-8	8B x *Helianthus debilis*	55.19	61.73
S 23-11	11C x *Helianthus mollis*	34.44	20
S 23-13	13C x *Helianthus petiolaris x Helianthus praecox*	10.12	7.5
S 23-14	14C x *Helianthus petiolaris x Helianthus debilis*	25.64	18.75
S 23-15	15C x *Helianthus praecox*	10.18	16.47
S 23-16	16C x *Helianthus praecox*	4.64	5.6
S 23-17	17C x *Helianthus debilis*	23.39	27.5
S 23-18	18C x *Helianthus maximiliani*	5.53	7.69
S 23-19	19C x *Helianthus mollis*	18.44	18
S 23-20	20B x *Helianthus neglectus*	32.42	21.66
S 23-21	21Bx *Helianthus argophyllus*	22.94	29.6
S 23-22	22B x *Helianthus argophyllus*	43.68	53.75
S 23-23	23C x *Helianthus argophyllus*	11.83	10
S 23-25	25C x *Helianthus argophyllus*	14.57	9.09

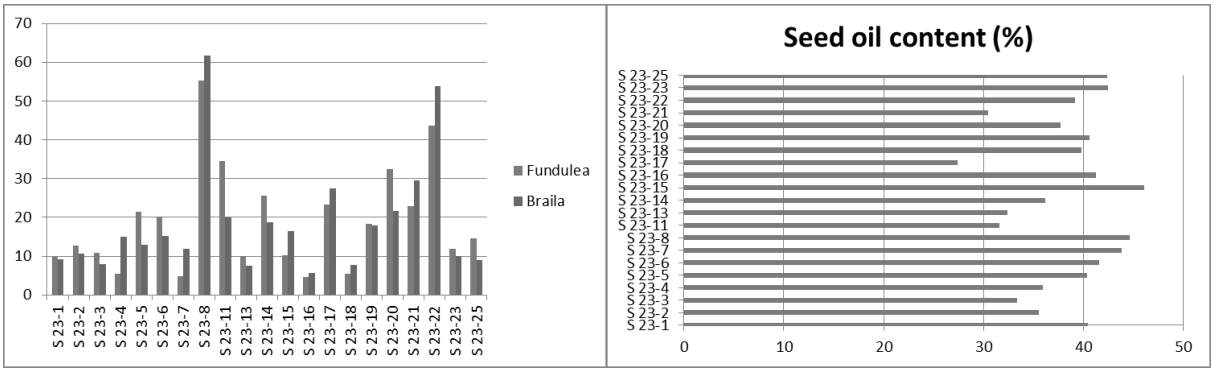
Seed oil contents was determined with magnetic resonance device Oxford MQC+5, only from genotypes tested for drought in Fundulea, in year 2023 and was between 27.39% at S23-17 and 46.1% at S23-15 (*table 6* and *figure 5b*).

Table 6

Seed oil content of sunflower genotypes, registered in Fundulea, in year 2023

Sunflower genotype	Interspecific hybridization with annual/ perennial wild species	Seed oil content (%)
S 23-1	1C x *Helianthus argophyllus*	40.44
S 23-2	2C x *Helianthus maximiliani*	35.53
S 23-3	3B x *Helianthus maximiliani*	33.39
S 23-4	4B x *Helianthus argophyllus*	35.94
S 23-5	5C x *Helianthus argophyllus*	40.38
S 23-6	6C x *Helianthus tuberosus*	41.55
S 23-7	7C x *Helianthus maximiliani*	43.86
S 23-8	8B x *Helianthus debilis*	44.63

S 23-11	11C x *Helianthus mollis*	31.56
S 23-13	13C x *Helianthus petiolaris x Helianthus praecox*	32.37
S 23-14	14C x *Helianthus petiolaris x Helianthus debilis*	36.16
S 23-15	15C x *Helianthus praecox*	46.1
S 23-16	16C x *Helianthus praecox*	41.26
S 23-17	17C x *Helianthus debilis*	27.39
S 23-18	18C x *Helianthus maximiliani*	39.82
S 23-19	19C x *Helianthus mollis*	40.62
S 23-20	20B x *Helianthus neglectus*	37.74
S 23-21	21Bx *Helianthus argophyllus*	30.44
S 23-22	22B x *Helianthus argophyllus*	39.18
S 23-23	23C x *Helianthus argophyllus*	42.49
S 23-25	25C x *Helianthus argophyllus*	42.36



a. b.

Figure 5a **Average seed yield of sunflower genotypes, in Braila and Fundulea, in year 2023;** 5b **Seed oil content (%) of sunflower genotypes registered in Fundulea, in year 2023**

In Fundulea, in year 2023, Thousand kernel weight (TKW) was between 20.32 grams at sunflower genotype S 23-1 and 66.56 grams at sunflower genotype S 23-8 (*table 7* and *figure 6*).

Table 7

Thousand Kernel Weight (TKW)of sunflower genotypes, in Fundulea and Braila, in year 2023

Sunflower genotype	Fundulea 2023 (TKW- grams)	Braila 2023 (TKW-grams)
S 23-1	20.32	13.75
S 23-2	26.36	15
S 23-3	58.8	13.6
S 23-4	59.31	29.82
S 23-5	30.08	15.4
S 23-6	32.96	15.47
S 23-7	24.75	13.79
S 23-8	66.56	32.94
S 23-11	32.16	30.52
S 23-13	34.92	15.8
S 23-14	40.08	21.26
S 23-15	16.32	16.77
S 23-16	16.45	15.72
S 23-17	35.61	35.42
S 23-18	26.02	10.99
S 23-19	47.28	20.95
S 23-20	22.88	22.64
S 23-21	55.2	28.35
S 23-22	63.56	21.48
S 23-23	25.04	19.94
S 23-25	22.04	13.2

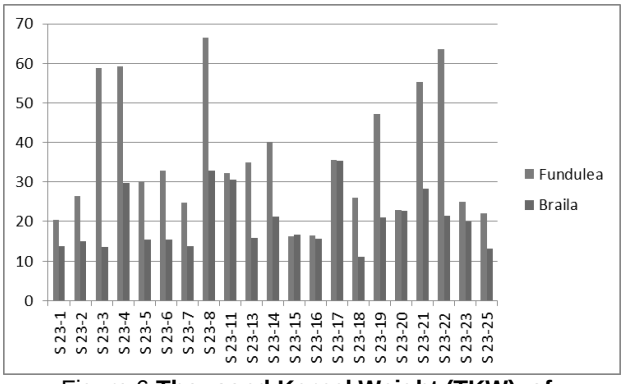


Figure 6 **Thousand Kernel Weight (TKW) of sunflower genotypes in Fundulea and Braila in year 2023**

CONCLUSIONS

Results from artificial conditions in greenhouse, regarding tolerance at drought not was the same like in natural conditions, in field. Average seed yield of sunflower genotypes, registered in Braila was different from Fundulea, in year 2023, when some inbreed line has a better yield in one location and other has a better yield in other location. Sunflower genotype S23-8 had a average seed yield of 55.19 grams/sunflower plant in Fundulea, in 2023 and 61.73 grams/sunflower plant, in Braila. One thousand seed weight (g) of sunflower genotypes tested for tolerance at

drought, had higher values in Fundulea than in Braila, in year 2023.

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