SUNFLOWER GENOTYPES WITH HIGH TOLERANCE TO DROUGHT AND EXTREME TEMPERATURES, HAVING GOOD RESISTANCE TO SOME SPECIFIC DISEASES

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Abstract

Sunflower is considered to be moderately resistant to drought, but in hot conditions, the plants suffer reduction in fertility, yield performance and quality of products. In literature there are mentioned some adoptive mechanisms of plants to drought: escape, avoidance and tolerance, as well as their genetic variability. For sunflower it is very important to increase the cold resistance in early development stages, at stage of germination, emergence and the stage of 2-3 leaves, in order to facilitate an early sowing. Wild *Helianthus* species are a very valuable source of resistance in increasing drought resistance as well as resistance to low temperatures in sunflower. Some of our best elite lines have been introduced in a process of improvement of resistance to drought, using recurrent selection. Also it has been transfered some genes for controling the attack of some important pathogenes. In this process of selection, we obtained inbred lines (CMS and pollen fertility restorer lines) having very good tolerance to drought as well as resistance to low temperatures.

Key words: sunflower, wild species; drought resistance, cold resistance

Climate changes characterized by higher temperatures, extreme climatic hazards and low water for agriculture determine the extension of the areas affected by drought. Agriculture is most affected by the climate variability, the extreme meteorological phenomenon, diminishing the yields with 35-50% each year.

In Europe, sunflower is mostly cultivated in Southern and Eastern regions. Sunflower crop is covering more than 4.5 Million ha in EU: Romania, Spain, France, Bulgaria and Hungary being the main contributors (90 % of the UE area). The average [CO2] in the atmosphere has been set to 420 ppm for 2030, in coherence with the Intergovernmental Panel on Climate Change (IPCC) assumption. This is expected to raise global temperatures due to the CO2 capacity to absorb infrared light and possibly change of precipitation patterns.

The elevation of air temperature was clearly observed and the climatologists are speaking of climatic trend (Cheng et al., 2000).

Global Climate Models (GCMs) indicate strongest warming over Eastern and Northern Europe during winter and over Western and Southern Europe during summer.

Heat waves and droughts will occur more often (especially in much of

Eastern Europe) due to the combined effect of warmer temperatures and less summer precipitation. In addition, droughts will start earlier and last longer. Therefore, in its traditional production areas, sunflower crop will be exposed to major climate change and potentially impacted by water and temperature stresses. Sunflower cultivation is currently limited to Southern Europe and parts of Central - Eastern Europe for temperature reasons.

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Sunflower could be more vulnerable to the direct effect of heat stress at anthesis and drought during its growing cycle, both factors resulting in severe yield loss, oil content decrease and fatty acid changes (Bran *et al*, 2019; Pacureanu-Joita *et al*, 2021). Some adaptations through breeding, crop management, and enhanced to cope with these negative impacts. The future of sunflower in Europe is probably related to its potential adaptation to climate change.

In literature there are mentioned some adoptive mechanisms of plants to drought: escape, avoidance and tolerance, as well as their genetic variability (Skoric, 2012).

It was stated that it is important to identify and incorporate into breeding material characteristics that contribute to physiological drought resistance. Different morphological and physiological characteristics were used in study of sunflower resistance to drought (Baldini *et al*, 1996; Chimenti *et al*, 2001).

Practical results in sunflower breeding for drought resistance have been achieved by using the stay-green phenomenon (Vranceanu, 2000).

For sunflower it is very important to increase the cold resistance in early development stages, at stage of germination, emergence and the stage of 2-3 leaves, in order to facilitate an early sowing (Skoric, 2012).

Wild Helianthus species are a very valuable source of resistance in increasing drought resistance, also resistance to cold.

Climate change could influence development of the pathogen, host resistance and host-pathogen interaction. Direct or indirect impacts of climate change on sunflower disease complex are expected. However, very few information has been produced for sunflower diseases (Debaeke *et al*, 2014). Primary infection could be limited by the lack of precipitation and evapotranspiration increase. To infect the plants, downy mildew (*Plasmopara halstedii*) requires about 50 mm of free water during the 10 days surrounding planting date Sclerotinia head rot (*Sclerotinia sclerotiorum*) needs 42 hours of free water for infecting florets. Phoma black stem (*Phoma macdonaldii*) requires free water at the trough level for significant stem infection. *Phomopsis* stem canker (*Phomopsis/Diaporthe helianthi*) will develop initial leaf lesions if relative moisture exceeds 90% during 36 hours within canopy.

High temperatures could slow down or stop the growth of fungi in the tissues as their thermal optimum often ranges from 15 to 25°C. Several successive days with Tmax > 32°C could be lethal for *Phomopsis*. At the same time some pathogens could be promoted by hotter and dryer conditions (Molinero – Ruiz, 2019). Macrophomina phaseolina could be stimulated by low soil water content and temperatures within 28-30°C range.

Premature ripening due to *Phoma* could be enhanced by dry conditions after flowering.

The weakest vegetative growth of sunflower exposed to early soil water deficit could reduce the risk of primary infection by fungi that directly cause damage to leaves and stems (Debaeke *et al*, 2014). More precipitation in winter and elevated [CO2] could promote plant growth and favour the development of associated diseases.

Some dominance changes may occur between pathogens (and pathotypes) according to their thermal preferences and their dependency to free water. Pathogens with long conservation forms in the soil (e.g sclerotia) could better tolerate unfavourable periods. The damage due to systemic pathogens could be reinforced if plants are suffering from water stress (Virany *et al*, 2015).

In our paper we present the results obtained in our breeding work, for improving the resistance of sunflower, to drought, to cold, also to some important diseases, using the wild sunflower species

MATERIAL AND METHOD

In our research work we have used different sources from our sunflower germplasm collection, some of them coming from the interspecific hybrids between wild *H. maximiliani* and *H. argopyllus* and cultivated sunflower. Some of our best elite lines have been introduced in a process of improvement of resistance to drought, using recurrent selection. We have used several parameters or characteristics in selection of the tolerant plants: deeper rooting depth and more efficient root uptake of water, area of lives and number of lives, plant ability to recover after wilting under heat stress. Each generation of selection was planted in drought natural conditions (missing water in soil and high air temperature).

All generations of selection were tested also, for resistance to low temperatures in germination and emergence time. There have been selected the more tolerant ones. It has been done the testing of the obtained genotypes, for resistance to some important diseases.

The experiments were placed in three locations, situated in different soil and climate conditions. Fundulea location is situated in south – central Romania, with chemozem soil, well supplied with nitrogen, phosphorus and potassium. Braila location is situated in central-estern Romania, with chemozem soils, mid supplied with main nutrients. Cogealac location is placed at north-eastern side of Constanta area, with chemozem soils, mid supplied with nitrogen and phosphorus and well with potassium.

In *tables 1, 2* and *3* there are presented the climate data for the two years of experimentation. Comparing the two years, 2019 and 2020, year 2020 was very dry, in all locations, with small difference. In Fundulea location the rainfall in the first period of sunflower vegetation, had more quantity, comparing with Braila and Cogealac. In both years, the locations Braila and Cogealac have been characterized by more drought conditions. The air temperatures were registered higher values, especially in Cogealac location, in period which is critically for well developing of sunflower crop, in both years.

Table 1

The climate data for two years, in Fundulea

Climate data		2019								
		I	II	III	IV	V	VI	VII	VIII	IX
Rainfall (mm)	Total/month	77	16,2	59	31	57,6	135	21,2	20,5	37,6
Temperature (°C)	Average	1,6	3,2	5,1	9,7	17,2	21,1	25,3	25,9	20,7
Climate data		2020								
		I	II	III	IV	V	VI	VII	VIII	IX
Rainfall (mm)	Total /month	12	3.6	10.1	22.7	31.2	41.4	26.3	19.6	31.7
Temperature (°C)	Average	3.8	7,2	7.9	12.4	20.6	23.4	26.0	24.9	22.6

Table 2

The climate data for two years, in Braila

Climate data		2019								
		I	II	III	IV	V	VI	VII	VIII	IX
Rainfall (mm)	Total/month	36	6	11	30	27	92	24	30	1
Temperature (°C)	Average	-1.4	2.9	8.3	10.9	17.7	23.0	23.3	23.6	15.4
Climate data		2020								
		I	II	III	IV	V	VI	VII	VIII	IX
Rainfall (mm)	Total/month	4	23	2.6	4.3	15.8	30.0	24.9	3.1	6.4
Temperature (°C)	Average	0.9	5.6	9.7	12.9	18.2	23.8	24.7	24.6	18.2

Table 3

The climate data for two years, in Cogealac-Constanta

Climate data		2019								
		I	II	III	IV	V	VI	VII	VIII	IX
Rainfall (mm)	Total/month	31	4	14	38	16	31	23	29	19
Temperature (°C)	Average	4.2	4.8	9.4	12.7	18.5	24.8	23.6	25.0	17.6
Climate data		2020								
		I	II	III	IV	V	VI	VII	VIII	IX
Rainfall (mm)	Total/month	31.4	11.3	6.4	7.2	9.4	21.4	32.6	10.2	7.5
Temperature (°C)	Average	2.6	5.4	10.2	10.5	17.9	20.9	25.8	24.5	18.0

RESULTS AND DISCUSSIONS

In this process of selection, from interspecific hybrids, we obtained inbred lines (CMS and pollen fertility restorer lines) having very good tolerance to drought as well as resistance to low temperatures (*table 4* and *5*).

Most of lines are in advanced generations of selection or already finished. Tested in conditions with drought, in Constanta area, they showed a good behavior regarding the resistance.

Table 4

Sunflower genotypes in different generations of selection, tested for resistance to drought and high air temperatures, in field, Constanta, 2019

Genotype	Generation	Total plants	Resistance
LC 2340	(C4)4	112	1
LC 2411	(C3)5	96	1
LC 2442	(C4)5	105	1
LC 2463	(C4)5	89	2
LC 2491	(C3)4	114	2
LC 2522	(C3)5	95	1
LC 2594	(C3)3	107	1
RS 1022	(C3)2	110	2
RS 1084	(C3)3	87	2
RS 1146	(C3)4	93	1
RS 1221	(C3)4	106	2
RS 1289	(C3)2	111	1
RS 1314	(C3)4	115	1
RS 1328	(C3)5	98	2
RS 1337	(C3)4	108	2
Check sensitive		118	5

Resistant=1; Sensitive=5

In testing for resistance to cold (low temperatures in germination and emergence time) these lines showed good resistance/tolerance.

Table 5

The inbred lines in different generations of selection for drought, tested for resistance to cold, Fundulea, 2020

Genotype	Generation	Total plants	Resistance to cold
LC 2340	(C4)4	49	1
LC 2411	(C3)5	51	2
LC 2442	(C4)5	48	1
LC 2463	(C4)5	50	2
LC 2491	(C3)4	50	3
LC 2522	(C3)5	47	1
LC 2594	(C3)3	45	1
RS 1022	(C3)2	50	3
RS 1084	(C3)3	51	2
RS 1146	(C3)4	49	1
RS 1221	(C3)4	47	2
RS 1289	(C3)2	49	2
RS 1314	(C3)4	45	1
RS 1328	(C3)5	42	2

RS 1337	(C3)4	45	2
Check sensitive	-	51	5

Resistant=1; Sensitive=5

By crossing these lines there have been obtined hybrids having good tolerance to drought (*figure 1* and *2*), some of them with good resistance to cold (*figures 3* and *4*)..

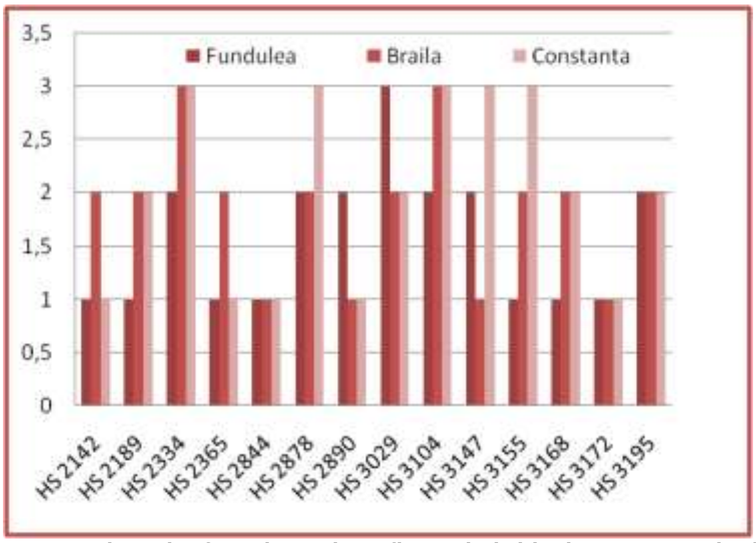

Figure 1 **Resistance to drought, for released sunflower hybrids, in 2019 year, in three locations**

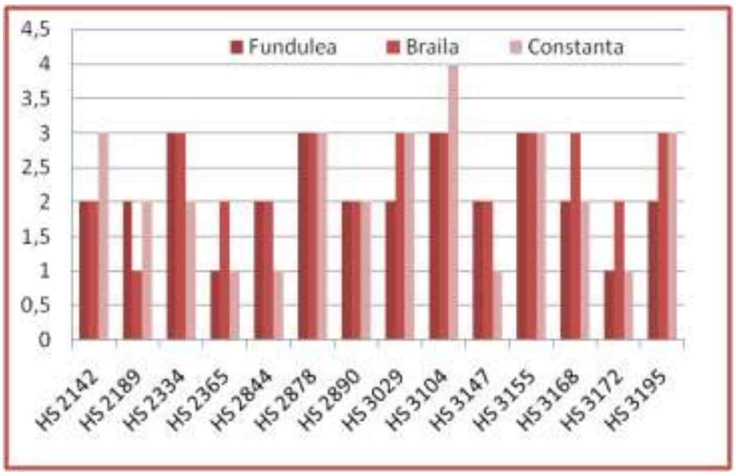

Figure 2 **Resistance to drought, for released sunflower hybrids, in 2020 year, in three locations**

Some of hybrids have shown good resistance/tolerance to drought, in both years and three locations. Also, they had a good resistance/tolerance to low temperatures, in time of germination-emergence..

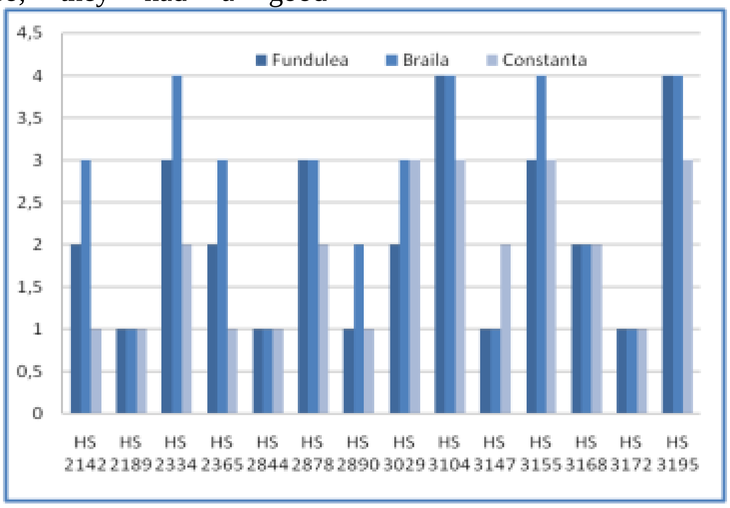

Figure 1 **Resistance to cold, for released sunflower hybrids, in 2019 year, in three locations**

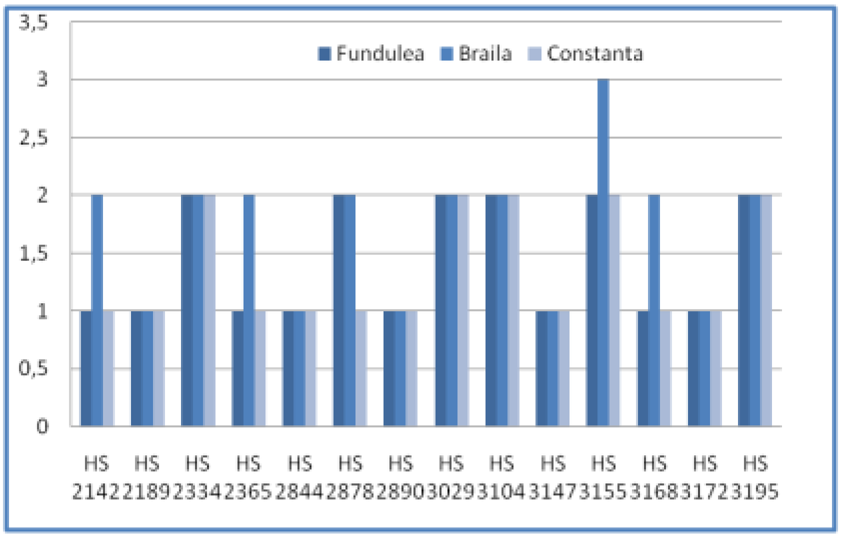

Figure 2 **Resistance to cold, for released sunflower hybrids, in 2020 year, in three locations**

The hybrids have been tested in comparative trials. The hybrids have shown good characteristics which determine the seed yield, as well as good resistance to the attack of some pathogens which produce important diseases to this crop (*table 6*).

Table 6

The behavior of released sunflower hybrids, regarding the resistance to the most important pathogens attack

Genotype	Resist. to *Plasmopara h.*	Resist. to *Phomopsis h.*	Resist. to *Sclerotinia s.*	Resist. to *Puccinia h.*	Resist. to *Orobanche c.*
HS 2142	1	1	1	1	1
HS 2189	1	1	2	1	2
HS 2334	2	1	2	1	2
HS 2365	1	1	1	1	2
HS 2844	1	1	2	1	1
HS 2878	2	2	2	2	2
HS 2890	1	1	1	1	1
HS 3029	3	2	3	2	3
HS 3104	2	2	3	1	3
HS 3147	1	2	2	1	1
HS 3155	2	2	2	2	2
HS 3168	2	2	1	1	2
HS 3172	1	2	2	1	1
HS 3195	3	2	3	2	3
Check res.	2	2	2	2	1
Check sens.	9	9	8	7	9

Resistant=1; Sensitive=9

The trials have been organized in Constanta area and in Fundulea. They released good seed yield, in conditions of soil and climate, in these areas (*table 7*). Even in 2020 year, the climatic conditions were very unfavorable, specially in Constanta area, due to a strong drought, the hybrids had a good behavior, releasing good seed yield. The oil content of the hybrids was very good, with lower values in conditions of Constanta area, due to the influence of high air temperatures.

Table 7

Results regarding the seed yield and oil content for the released hybrids, in two locations, year 2020

No	Hybrid/ Fundulea	Seed yield (kg/ha)	Oil content (%)	Hybrid/ Constanta	Seed yield (kg/ha)	Oil content (%)
1	HS 2142	3778	52.6	HS 2142	3190	51,7
2	HS 2189	3357	51.4	HS 2189	2748	50,7
3	HS 2334	2675	50.6	HS 2334	2179	50,0
4	HS 2365	3744	52.4	HS 2365	2967	51,9
5	HS 2844	3360	53,0	HS 2844	3056	52,3
6	HS 2878	2558	49.8	HS 2878	2241	49,4
7	HS 2890	3120	50.2	HS 2890	2180	49.0
8	HS 3029	3254	48.9	HS 3029	2325	49.2
9	HS 3104	2862	49.6	HS 3104	2055	48.6
10	HS 3147	3247	51.3	HS 3147	2354	50.3
11	HS 3155	2359	50.6	HS 3155	2044	48.1
12	HS 3168	3340	52.0	HS 3168	2360	49.4
13	HS 3172	3782	51,7	HS 3172	2853	50.6
14	HS 3195	3445	48.6	HS 3195	2376	49.2
15	Check 1	3652	51.2	Check 1	3108	51.0
16	Check 2	2230	49.9	Check 2	889	49.5

LSD 5% 8,7 12,3

CONCLUSIONS

Even sunflower crop is quite tolerant to drought, in conditions of the climate changes, this crop is reducing the level of the seed yield, the oil content and fatty acids ratio.

Using the wild relatives of cultivated sunflower there have been released new and valuable inbred lines, having good resistance/tolerance to drought, also to low temperatures in germination-emergence time. By combining some of these lines, it could be obtained sunflower hybrids, these having a high potential for the seed yield and oil content, in conditions of drought. They have a good resistance/tolerance to cold, also to the diseases produced by the most important pathogens.

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