

SUNFLOWER GENOTYPES IN FIELD INFESTED WITH BROOMRAPE IN BRAILA LOCATION, IN YEAR 2022

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Abstract

In Romania, sunflower represent the main oil crop and occupies the third place after wheat and maize. *Orobancha cumana* Wallr (sunflower broomrape) is a parasitic plant who infested sunflower plants and causes low seed yield. In this paper we present behaviour of sunflower genotypes in field natural infested with broomrape, in Braila location, in year 2022. We tested for resistance/tolerance at parasite *Orobancha cumana*, 21 experimental sunflower hybrids, belonging to NARDI Fundulea and 10 differential genotypes and one additional for determination of broomrape races. Degree attack (GA) of broomrape was between 0.05 at sunflower hybrid H1 and 6.2 at H10 and infested sunflower plants (I %) was between 5% at H1 and 100% at H3 and from H6 to H21. All sunflower differential genotypes was infested with broomrape from 25% at K441 (gene *Or₁*) to 100% at AD66 (no *Or* gene), Record (gene *Or₃*), S1358, LC 1002 (gene *Or₄*), P1380, LC 1003 (gene *Or₃*), P96 (gene *Or₆*, *Or₇*). Only one sunflower genotype (additional differential genotype), Neagra de Cluj (accession PI 650368), was resistant at broomrape race *H_{RO}* or *I_{RO}*.

Key words: broomrape, sunflower, race, gene *Or*, resistance/tolerance.

INTRODUCTION

The most aggressive populations of sunflower broomrape with high virulence (*Orobancha cumana* Wallr) is located in Turkey, Ukraine, Romania (Braila, Tulcea) and Republic of Moldova (Clapco, 2021). In Romania, in the counties Braila, Tulcea, Constanta is present the most virulent populations of broomrape, more than race H. (Škorić et al., 2020; Duca et al., 2022). In more countries such as Romania, Ukraine, Turkey, Republic of Moldova, Bulgaria, Spain, China, Rusia, race G and H of broomrape was reported (Duca et al., 2022; Antonova et al., 2022, Ryzhenko et al., 2021; Onisan et al., 2018) and race E of broomrape in Serbia (Cvejić et al., 2020).

Sources of broomrape resistance is represented by wild sunflower species, open pollinated varieties, gene pool of cultivated sunflower (Clapco et al., 2020; Cvejić et al., 2020; Kaya, 2022; Seiler, 2019; Seiler et al., 2017).

In Romania in last years (Table 1), area cultivated with sunflower was over one million hectares (Radu et al., 2019; Georgescu et al., 2022; Manole et al., 2022).

Table 1. Area cultivated with sunflower in Romania in years 2015-2020

Year	Area cultivated with sunflowers (ha)	Average seed yield (kg/ha)	Total production (t)
2015	1.011.527	1.765	1.758.771
2016	1.039.823	1.955	2.032.340
2017	998.415	2.917	2.912.743
2018	1.006.994	3.041	3.062.690
2019	1.282.697	2.783	3.569.150
2020	1.170.372	1.883	2.204.312

Source: <https://www.madr.ro/culturi-de-camp/plante-tehnice/floarea-soarelui.html>

Orobancha cumana Wallr can be controlled by herbicide Pulsar 40 (active substance imazamox 40 g/l) in system Clearfield and herbicide Pulsar Plus (active substance imazamox 25 g/l) in system Clearfield Plus (Škorić et al., 2020; Manole et al., 2018; 2019).

MATERIALS AND METHODS

In field natural infested with broomrape, in Braila location, in year 2022, we tested for resistance/tolerance at parasite *Orobancha cumana*, 21 experimental sunflower hybrids belonging to NARDI Fundulea, from which 15 derived from interspecific hybridization with wild sunflower species (from H1 until H15), one sunflower hybrid in system Sun Express (H16E), one sunflower hybrid in system Clearfield (H17CL), four sunflower hybrids in system Clerfield Plus (from H18CLP until H21CLP) and 10 differential genotypes and one additional for determination of broomrape races.

Interspecific hybridization between cultivated sunflower (lines B, lines with cytoplasmic androsterility, fertility maintainer and C lines, fertility restorer lines) and wild sunflower species (annual and perennial) was made in year 2014 in Fundulea at NARDI Fundulea.

Hybridizations between mother lines (A- sterile line) and father lines (C- restorer line) was made in year 2021 in Fundulea.

Sunflower hybrids H16E (with resistance at sulfonilurea herbicide-Express 50SG), H17CL (with resistance at imidazolinone herbicide-Pulsar 40), H18CLP, H19CLP, H20CLP, H21CLP (with resistance at imidazolinone herbicide-Pulsar Plus) were not treated with herbicide to observe the genetic resistance to the *Orobancha cumana* parasite. The sunflower genotypes were sown in micro plots (9.8 m²), on two rows, 7 meters long, in three repetition/genotype, in Braila on April 22, 2022 and harvested on September 20, 2022 and sown in Fundulea, on April 21, 2022 and harvested on September 29, 2022 (Table 2).

Table 2. Sunflower genotypes tested for resistance/tolerance at broomrape, in year 2022, in Braila, in field infested natural with parasite *Orobancha cumana* Wallr and in Fundulea in no infested field

No.	Sunflower genotype
H1	(Line A1 x <i>Helianthus maximiliani</i> P14Max) x (Line C1 x <i>Helianthus maximiliani</i> P14Max)
H2	(Line A1 x <i>Helianthus maximiliani</i> P14Max) x (Line C2 x <i>Helianthus maximiliani</i> P3Max)
H3	(Line A1 x <i>Helianthus maximiliani</i> P14Max) x (Line C3 x <i>Helianthus maximiliani</i> P14Max)
H4	(Line A1 x <i>Helianthus maximiliani</i> P14Max) x (Line C4 x <i>Helianthus molis</i> P9Mo)
H5	(Line A1 x <i>Helianthus maximiliani</i> P14Max) x (Line C5 x <i>Helianthus maximiliani</i> P3Max)

No.	Sunflower genotype
H6	(Line A1 x <i>Helianthus maximiliani</i> P14Max) x (Line C6x <i>Helianthus molis</i> P9Mo)
H7	(Line A1 x <i>Helianthus maximiliani</i> P14Max) x (Line C7x <i>Helianthus molis</i> P9Mo)
H8	(Line A1 x <i>Helianthus maximiliani</i> P14Max) x (Line C8 x <i>Helianthus maximiliani</i> P14Max)
H9	(Line A2 x <i>Helianthus maximiliani</i> P5Max x <i>Helianthus neglectus</i> A1Ne x <i>Helianthus argophyllus</i> A13Arg) x (Line C9 x <i>Helianthus divaricatus</i> P12Div)
H10	(Line A2 x <i>Helianthus maximiliani</i> P5Max x <i>Helianthus neglectus</i> A1Ne x <i>Helianthus argophyllus</i> A13Arg) x (Line C10 x <i>Helianthus petiolaris</i> A7Pe A x <i>Helianthus praecox</i> A12Pr)
H11	(Line A2 x <i>Helianthus maximiliani</i> P5Max x <i>Helianthus neglectus</i> A1Ne x <i>Helianthus argophyllus</i> A13Arg) x (Line C11 x <i>Helianthus maximiliani</i> P14Max)
H12	(Line A2 x <i>Helianthus maximiliani</i> P5Max x <i>Helianthus neglectus</i> A1Ne x <i>Helianthus argophyllus</i> A13Arg) x (Line C12 x <i>Helianthus maximiliani</i> P14Max)
H13	(Line A3 x <i>Helianthus argophyllus</i> A13Arg) x (Line C13 x <i>Helianthus argophyllus</i> A13Arg)
H14	(Line A4 x <i>Helianthus argophyllus</i> A13Arg) x (Line C14 x <i>Helianthus argophyllus</i> A13Arg)
H15	(Line A5 x <i>Helianthus argophyllus</i> A13Arg) x (Line C15 x <i>Helianthus argophyllus</i> A13Arg x <i>Helianthus maximiliani</i> P3Max)
H16E	Line A6Ex Line C16E
H17CL	Line A7CL x Line C17CL
H18CLP	Line A8CLP x Line C18CLP
H19CLP	Line A9 CLP x Line C19CLP
H20CLP	Line A10CLP x Line C20CLP
H21CLP	Line A11CLP x Line C21CLP

In flowering time of sunflower, we make notations about broomrape attack. For identification of broomrape race present in Braila, in year 2022, we used 10 differential genotypes and Neagra de Cluj (Table 3), an old Romanian sunflower variety (Bran and Ion, 2018).

Table 3. Differential genotypes used for identification of broomrape races, present in Braila, in year 2022, in field infested natural with parasite *Orobancha cumana* Wallr

Sunflower genotype	Gene <i>Or</i>	Differential genotype for broomrape race
KA-411 (PI 251902)*	<i>Or</i> ₁	A
J 8281 (PI 265100)*	<i>Or</i> ₂	B
Record (PI650343)*	<i>Or</i> ₃	C
LC1002	<i>Or</i> ₄	D
S1358	<i>Or</i> ₄	D
LC1003	<i>Or</i> ₅	E
P1380	<i>Or</i> ₅	E
LC1093	<i>Or</i> ₆	F
P96 (PI 633614)*	<i>Or</i> _{6,7}	F,G
0305CxP9Mo	<i>Or</i> _{Mo} <i>Or</i> _{Mo}	G+
AD66	No <i>Or</i> gene	
Neagra de Cluj (PI 650368)*	<i>Or</i> ????	

*provided from gene bank North Central Regional Plant Introduction Station (NCRPIS), part of United States National Plant Germplasm System (NPGS)

RESULTS AND DISCUSSIONS

All sunflower differential genotypes was infested with broomrape from 25% at KA41 (gene *Or₁*) to 100% at AD66 (no *Or* gene), Record (gene *Or₃*), S1358, LC 1002 (gene *Or₄*), P1380, LC 1003 (gene *Or₅*), P96 (gene *Or₆*, *Or₇*). Only one sunflower genotype (additional differential genotype), Neagra de Cluj (accession PI 650368) was resistant at broomrape race H_{RO}, I_{RO} or more (Table 4, Figures 1 and 2).

Table 4. Observations regarding behaviour of differential genotypes in Braila, in year 2022, in field infested natural with parasite *Orobanche cumana* Wallr

Sunflower genotype	Number of broomrape/number of sunflower plants	Infested sunflower plants with broomrape (I %)	Degree of attack (GA) with broomrape (average number of broomrape stalks per sunflower plant)
KA-41	3/12	25	0.25
J 8281	7/12	58.3	0.58
Record	66/33	100	1.93
LC1002	89/34	100	2.61
S1358	65/20	100	3.25
LC1003	47/41	100	1.14
P1380	66/11	100	6
LC1093	7/26	26.9	0.26
P96	8/5	100	1.6
0305CxP9Mo	26/29	89.65	0.89
AD66	40/25	100	1.6
Neagra de Cluj	0/27	0	0



Figure 1. Infested differential sunflower genotypes with broomrape (I %) in Braila, in year 2022

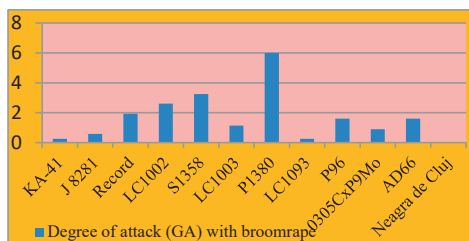


Figure 2. Degree of attack with broomrape on differential sunflower genotypes in Braila, in year 2022

In Braila location, in year 2022, is present broomrape races A, B, C, D, E, F, G, H, I or more. Degree attack (GA) of broomrape was between 0.05 at sunflower experimental hybrid H1 and 6.2 at H10 and infested sunflower plants (I %) was between 5% at H1 and 100% at H3 and from H6 to H21CLP (Table 5, Figures 3 and 4).

Table 5. Observations regarding behaviour of sunflower experimental hybrids at broomrape, in Braila, in year 2022, in field infested natural with parasite *Orobanche cumana* Wallr

Sunflower genotype	Number of broomrape/number of sunflower plants	Infested sunflower plants with broomrape (I %)	Degree of attack (GA) with broomrape (average number of broomrape stalks per sunflower plant)
H1	2/40	5	0.05
H2	113/26	100	4.3
H3	285/371	76.8	0.76
H4	74/118	62.7	0.62
H5	26/48	54.1	0.54
H6	583/123	100	4.7
H7	151/33	100	4.5
H8	166/40	100	4.1
H9	178/67	100	2.6
H10	443/71	100	6.2
H11	245/68	100	3.6
H12	169/79	100	2.1
H13	213/97	100	2.1
H14	108/20	100	5.4
H15	315/85	100	3.7
H16E	256/101	100	2.5
H17CL	178/70	100	2.5
H18CLP	246/41	100	6
H19CLP	284/47	100	6
H20CLP	205/53	100	3.8
H21CLP	150/49	100	3

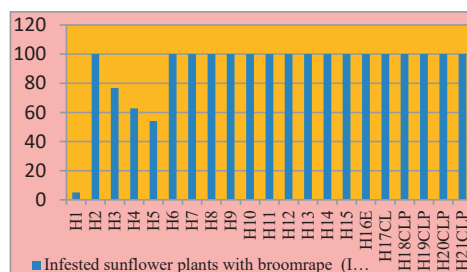


Figure 3. Infested sunflower experimental hybrids with broomrape (I %) in Braila, in year 2022

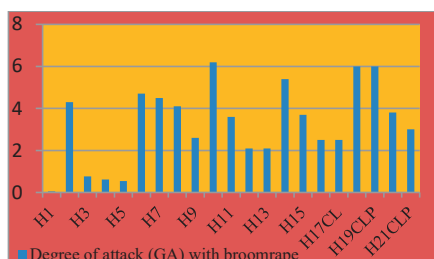


Figure 4. Degree of attack with broomrape on sunflower experimental hybrids in Braila, in year 2022

From all sunflower experimental hybrids tested in Braila, in year 2022, H1 was more tolerant/resistant than other at parasite broomrape and perennial sunflower specie *Helianthus maximiliani PI4Max* is in mother line (sunflower line A) and father line (sunflower line C).

In Fundulea in year 2022 with total rainfalls of 258.4 mm, was the most driest year of last 60 years (average on 60 years, 584.3 mm), with a high temperature in every month than average on 60 years (excepting month March). In Braila was registered a total rainfalls of 238 mm (Table 6, Figures 5 and 6).

Table 6. Temperature and rainfalls registered, in Braila and Fundulea, in year 2022

Temperature (°C)			
Locality area Month	Braila	Fundulea	Average of 60 years (Fundulea)
January	1.3	2.1	-2.4
February	4.1	4.7	-0.4
March	3.8	4.4	4.9
April	11.9	12.1	11.3
May	18	17.9	17
June	22.7	22.6	20.8
July	24.8	25	22.7
August	24.9	25.6	22.3
September	17.9	18.6	17.5
October	13	13.5	11.3
November	8.1	9	5.4
December	2.9	3.5	0
Rainfalls (mm)			
Locality area Month	Braila	Fundulea	Average of 60 years (Fundulea)
January	6.5	4.8	35.1
February	11.1	5.4	32
March	13.8	12.3	37.4
April	25.1	47.6	45.1
May	24.3	30.1	62.5
June	33.3	59.6	74.9
July	8.9	29.2	71.1
August	26.9	14.4	49.7
September	31.8	35.4	48.5
October	6.1	5.2	42.3
November	30.7	19.6	42
December	19.9	21.8	43.7
Total (mm)	238.4	285.4	584.3

In month July, 2022, in the phenophase of seed filling, in Braila rainfalls registered was 8.9 mm and in Fundulea was 29.2 mm (average rainfalls of 60 years in Fundulea was 1.1 mm).

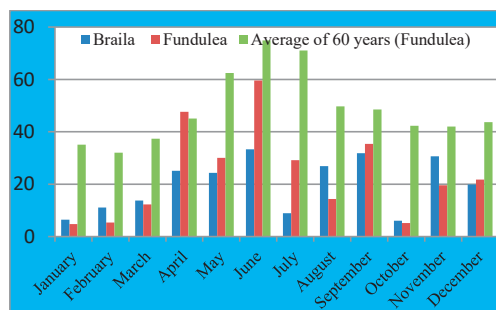


Figure 5. Rainfall (mm) registered in Braila and Fundulea, in year 2022

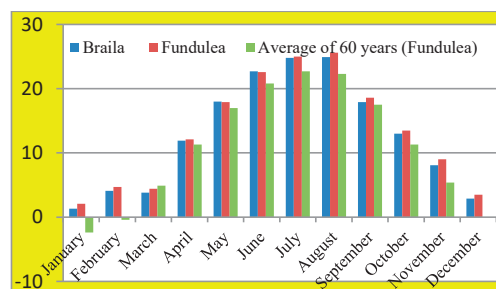


Figure 6. Temperature (°C) registered in Braila and Fundulea, in year 2022

Hectolitre weight, was between 33 kg/hl at sunflower experimental hybrid H3 and 47 kg/hl at sunflower experimental hybrid H15 (Table 7).

One thousand weight (TSW), was between 34 g at sunflower experimental hybrids H2, H11 and 55 g at sunflower experimental hybrid H15 (Table 7).

In Braila, in year 2022, seed yield (kg/ha) was between 357 kg/ha at sunflower experimental hybrid H17CL and 2684 Kg at sunflower experimental hybrid H18CLP (Table 7).

In Braila in field infested with the most aggressive broomrape races, in year 2022, the best seed yield was registered at sunflower experimental hybrids H18CLP (2684 kg/ha) with and H19CLP (2242 kg/ha) although the attack degree was 6 and the percentage of infested plants with parasite *Orobancha cumana* was 100%.

Table 7. Agronomic traits of sunflower experimental hybrids, in Braila, in year 2022, in field infested natural with parasite *Orobanche cumana* Wallr

Sunflower genotype	Hectolitre weight (kg/hl)	TSW (one thousand weight) (g)	Seed yield (kg/ha)
H1	41	45	978
H2	42	34	944
H3	39	41	1374
H4	42	43	1608
H5	43	51	1180
H6	43	48	1530
H7	43	43	962
H8	44	44	1690
H9	43	44	684
H10	41	40	596
H11	39	34	681
H12	38	35	1200
H13	42	42	859
H14	43	44	489
H15	47	55	1259
H16E	37	44	553
H17CL	41	39	357
H18CLP	45	43	2684
H19CLP	46	41	2242
H20CLP	45	39	1871
H21CLP	45	38	1595

In Fundulea, in field without broomrape, in year 2022, seed yield (kg/ha) was between 1487 kg/ha at sunflower experimental hybrid H10 and 4053 kg/ha at sunflower experimental hybrid H6 (Table 8). Hectolitre weight, was between 51 kg/hl at sunflower experimental hybrid H9 and 67 kg/hl at sunflower experimental hybrid H12 (Table7). One thousand weight (TSW), was between 34 g at sunflower experimental hybrids H2, H11 and 67 g at sunflower experimental hybrid H6 (Table 7).

Table 8. Agronomic traits of sunflower experimental hybrids, in Fundulea, in year 2022, in field no infested with parasite *Orobanche cumana* Wallr

No.	Average hectolitre weight (kg/hl)	Average TSW (one thousand weight) (g)	Average seed yield (kg/ha)
H1	60	56	3818
H2	54	45	2693
H3	57	48	2198
H4	66	49	2400
H5	66	59	3474
H6	60	67	4053
H7	61	56	3084
H8	61	53	2443
H9	51	49	1675
H10	55	54	1487
H11	66	52	1783
H12	67	49	2686
H13	58	53	2385
H14	64	59	3139
H15	55	57	2234
H16E	62	66	4030
H17CL	52	51	3054
H18CLP	55	49	2691
H19CLP	64	56	2695
H20CLP	58	56	3312
H21CLP	61	53	2829

Low rainfalls in phenophase of seed filling, combined with the attack of the parasite *Orobanche cumana* in Braila, led to lower seed yields of experimental sunflower hybrids then in Fundulea where is no infested field with broomrape (Figure 7). Dunăreanu and Radu (2020) reported that yield and yield components were affected by water stress.

Interaction between genotype and environment (G x E), is visible in Figure 7 at all sunflower hybrids tested in booth areas and only sunflower hybrid H18CLP is stable regarding seed yield.

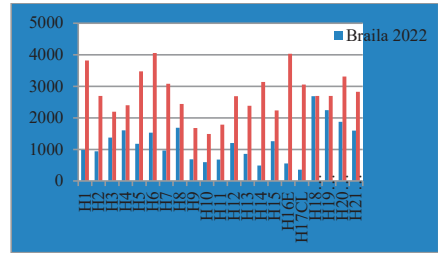


Figure 7. Average seed yield (kg/ha) of experimental sunflower hybrids, in Braila and Fundulea, in year 2022

Average hectolitre weight (kg/hl), of sunflower experimental hybrid, was lower in Braila then in Fundulea, in year 2022 (Figure 8).

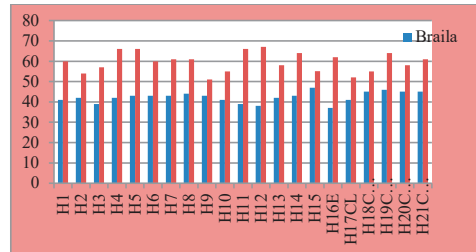


Figure 8. Average hectolitre weight (kg/hl) of experimental sunflower hybrids, in Braila and Fundulea, in year 2022

Average one thousand weight (TSW), was of sunflower experimental hybrid, was lower in Braila then in Fundulea, in year 2022 (Figure 9).

According to Borleanu and Bonea (2020), hectolitre weight was negatively and significantly associated with thousand seed weight.

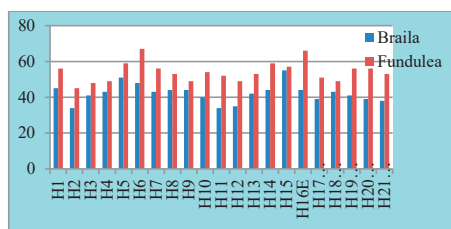


Figure 9. Average one thousand weight (TSW), of experimental sunflower hybrids, in Braila and Fundulea, in year 2022

CONCLUSIONS

In Fundulea, 2022 was the driest agricultural year from past years and this allow us to see behaviour of sunflower genotypes in these conditions.

One thousand weight (TSW) and hectolitre weight (kg/hl), influenced seed yield of sunflower genotypes tested in booth area together with presence/absence of parasite *Orobanche cumana* and lack of precipitation during the seed filling period.

In Braila, in year 2022, we identified a new source of resistance at broomrape at races G, H, I or more and this is old Romanian variety named Neagra de Cluj.

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