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THE BEHAVIOR OF SOME SUNFLOWER HYBRIDS TO WHITE RUST (*Albugo tragopogonis*) UNDER BRĂILA COUNTY CONDITIONS

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ABSTRACT

As a part of an extensive study on the behavior of different genotypes of sunflower to solid and liquid fertilizers and plant protection products to the attack of the main parasitic agents, this paper presents the dynamics of *Albugo tragopogonis*. Symptoms during the asexual phase were expressed, symptoms that became visible as white pustules on the infected plants. Although the tested fungicides were not approved to control this pathogen, a reduction in the development of the pathogen have been observed in the variants where have been applied the fungicides. The best percentage calculated for effectiveness was the fertilization variant Last N (250 g/l N) in two doses where was applied the fungicide Tanos WG (0.4 kg/ha) with 86.96%, followed by the variant Urea 46% N (90 kg/ha a.s.) where was applied the fungicide Sfera 535 SC (0.4 l/ha) with an effectiveness of 78.26%. Even if in 2019 no genotype of the sunflower under study showed symptoms, in 2020 all nine hybrids showed symptoms with different frequencies and intensities. The impact of white rust on Romania commercial sunflower crops has not been determined. Research needs to be done to find possible seed treatment that will keep the disease at bay and protect the sunflower crops.

Keywords: sunflower, white blister rust, pustula, degree of attack, effectiveness.

INTRODUCTION

In Romania, sunflower was introduced for oil production, around the mid-19th century in Moldavia, being the main vegetable oil producing plant (Panaitescu et al., 2010).

Known as an important source of edible vegetable oil throughout the world due to its oil content (40-52%), high non saturated fatty acids content ranging between 85-91% and no cholesterol (Leland, 1996; Khalifa and Awad, 1997), sunflower (*Helianthus annuus* L.) is an important crop also for Romania, ranking third in area after maize and wheat and it is necessary for sunflower production to provide the need for oil in human food (Chiriac et al., 2018a; Chiriac et al., 2018b). Due to its ability to grow in different agroecological conditions and its moderate drought tolerance, sunflower may become the oil crop of preference in the future, especially in the light of global environmental changes (Miladinović et. al., 2019).

Concerning biotic stresses in sunflower, it can be safely concluded that diseases caused by different fungi present the most serious problem. Broomrape, the parasitic angiosperm, is in the second place, viruses and bacteria in third and fourth (Škorić, 2012). The current situation regarding the spread of broomrape

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around the world shows that in addition to Russia, Ukraine, Romania, Bulgaria, Turkey and Spain, as the main producers of sunflower seeds, we can also add Serbia, Moldova, Hungary, Greece, Tunisia, Israel, Iran, Kazakhstan, China, Mongolia and Australia because the parasite it has been also reported in these states and in a few other countries as well (Dedic et al., 2009; Molinero-Ruiz et al., 2009; Burlov and Burlov, 2011; Pricop et al., 2011; Amri et al., 2012; Joiţa-Păcureanu et al., 2012; Marinkovic et al., 2014). The holoparasitic *Orobanche cumana* Wallr. has become a limiting factor for sunflower yield in Eastern Europe (Duca et al., 2020).

Sunflower (*Helianthus annuus*) is a known host for over 36 pathogenic organisms, mostly fungi, that can cause serious economic losses, depending on the climatic conditions (Gulya et al., 1997b). Also, soil pests can reduce sunflower yield (Georgescu et al., 2018; Georgescu et al., 2020). The fungal foliar diseases, leaf spot which are caused by *Alternaria helianthi*, *Septoria helianth*, *Albugo tragopogonis* and *Plasmopara halstedii* by inducing brown and grey spots, white rust and downy mildew are relatively important (Van Wyk et al., 1999; Achbani et al., 2000; Masirevic and Jasnic, 2006). Of the two diseases of sunflower caused by oomycetes, downy mildew caused by *Plasmopara halstedii* is regarded as the most serious, the economic relevance of white blister rust (WBR) caused by *Pustula helianthicola* (syn. *Albugo tragopogonis*) (Thines and Spring, 2005; Rost and Thines, 2012) has often been questioned.

Albugo or white rust is a disease historically found primarily in the Southern Hemisphere (Argentina, Australia, South Africa) (Kajornchaiyakul and Brown 1976; Delhey and Kiehr-Delhey 1985). Is an emerging disease that is among the most important diseases in this crop in South Africa and has recently spread to Europe (Rost and Thines, 2012). Incidences of epidemiologically relevant infections of sunflower with white blister rust have been reported from areas with hot and also dry summer, such as South Africa (Van Wyk et al., 1995; Viljoen et al., 1999), Argentina (Delhey and Kiehr-Delhey, 1985), Australia (Allen and Brown, 1980) and sporadically from the United States (Gulya et al., 2000b; Gulya et al., 2002). Meanwhile, the pathogen appeared also in temperate climate, such as France (Penaud and Perny, 1995), Hungary (Zoltan, 1995), Germany (Thines et al., 2006) and Belgium (Crepel et al., 2006). As Rîşnoveanu, et al. (2019), for improving sunflower resistance to the main diseases, genetic resources can be used, as well as sunflower wild species.

Rost and Thines (2011) found that *Pustula tragopogonis* is an illegitimate name because the oldest name of the genus level, *Uredo tragopogonis* (Pers.) DC., is a later homonym of *Uredo tragopogonis* Pers., a rust fungus. The earliest legitimate name on genus level is *Caeoma obtusata* Link. Based on the earliest legitimate name available at species level (Rost and Thine, 2011), as a consequence the name *Pustula tragopogonis* (Pers.) was abandoned in favour of *Pustula obtusata* (Link) Rost. For nearly two centuries, *Albugo tragopogonis* (now *Pustula obtusata*) was mostly considered to be the sole causal pathogen of white blister rust (WBR) disease on the *Asteraceae*, including many economically important crops and ornamental plants, such as *Helianthus annuus*, *Austroeupatorium* and *Scorzonera* (Choi et al., 2012). A few additional species, varieties and forms have been described under *Albugo* (also known such as *Cystopus*) (Săvulescu and Rayss, 1930; Săvulescu, 1946; De Bary, 1862; Mäkinen and Hietajärvi, 1965). The taxonomy of *Pustula* on *Asteraceae* was documented by Wilson (1907) and Whipps and Cooke (1978). Also, Van Wyk et al. (1999) described many species of the genus *Albugo* and some of them are known as crop pathogens. A revision of the genus *Albugo* was presented by Thines and Spring (2005), supported after by molecular phylogenetic studies (Thines and Voglmayr, 2009). Based on previous phylogenetic reconstruction in combination with differences in oospore ornamentation, it is revealed that *Pustula* on sunflower, previously attributed to *Pustula tragopogonis* (syn. *Albugo tragopogonis*) is distinct from *Pustula* on *Tragopogon*. Therefore, this pathogen is described as a new species, *Pustula helianthicola* (Rost and Thines, 2012).

MATERIAL AND METHODS

The component presented in this paper is part of an extensive study on the behavior of different genotypes of sunflower to applied solid and liquid fertilizers and plant protection products to the attack of the main parasitic agents.

Table 1. Experimental components

Factor 1			Factor 2	Factor 3
Hybrid		Producer	Fertilizer	Plant protection products
H_1	ES Janis CLP	Euralis	F_1 = Control - Untreated F_2 = Urea 46% N (90 kg/ha N active substance). F_3 = Last N liquid fertilizer (250 g/l N applied in a single dose: 15 l/ha in 200 l water in the 4-6 leaf stage). F_4 = Last N liquid fertilizer (250 g/l N in two doses: the first application 15 l / ha in 200 l water at the stage of 4-6 leaves and the second, 15 l/ha in 200 l water after 14 days from the previous application.	P_1 = Sfera 535 SC (160 g/litre Cyproconazole 375 g/litre; Trifloxystrobin) dose 0.4 l/ha. P_2 = Tanos 50 WG (Famoxadone: 250 g/kg; Cymoxanil: 250 g/kg) dose 0.4 kg/ha.
H_2	MAS 92. CP	Maisadour		
H_3	SY Neostar CLP	Syngenta		
H_4	SY Bacardi CLP	Syngenta		
H_5	LG 50.635 CLP	Limagrain		
H_6	LG 55.55 CLP	Limagrain		
H_7	Performer	NARDI Fundulea		
H_8	FD-15 C27	NARDI Fundulea		
H_9	ES Genesis CLP	Euralis		

The wide variation of the phytopathological picture of the sunflower is due not only to the complex interactions between the host and parasite genotypes, but also to the close interactions with the variable conditions of the environment and of the culture technology (Vrânceanu, 2000).

The experiment was set up in the fields of the Agriculture Research and Development Station Braila between 2018-2020 on a soil of vermic, groundwater, wet, loam-sandy chernozem type, moderately carbonate on loess, with a medium humus content in the upper horizons (2.4-3.1%), a nitrogen content total, normal and moderate phosphorus (P_2O_5) and a very good mobile phosphorus content (174-225 ppm). The pH was alkaline dominant (7.9-8.4).

Sunflower recovered less fertilizer than other crops because its root system with a high capacity to extract nutrients and soluble harder combinations mineral fertilizers are less valued and that seed has a small share of the plant biomass is formed (sixth or seventh of biomass epigenous), and in some areas and in some years hydric soil improperly makes mineral fertilizers to be less valued by short seeds. (Moisii et al., 2012). Several studies shown the positive respons of sunflower to fertilization under irrigation and rain fed conditions (Elhassan et al., 2006; Lotfie and Salah, 2013) and to the application of fungicides in the control of the main parasitic agents (Manole et al., 2018; Chiriac and Cristea, 2021).

From the climatic point of view, the years 2018, 2019, 2020 can be characterized by a warm autumn, with positive deviations, about 3.3°C for 2018 and 2019 and 7.5°C for 2020, compared to the sum of the multiannual monthly averages for the same period and a rainfall contribution of 125 mm and a positive deviation of 30 mm compared to the sum of the multiannual monthly averages of the same period for 2018, but with a deficit of 51 mm for 2019 and 54.7 mm for 2020. Mild winters, with positive seasonal deviations from the sum of the multiannual average temperatures for the same period, were followed by deficient springs in terms of rainwater intake by -42.0 mm for 2018, -41.0 mm for 2019 and -56.0 mm for 2020 compared to the sum of the multiannual monthly averages of the same period. If we analyze the summer season of the research years, we can observe temperature increases from year to year with positive deviations over 4°C compared to the sum of multiannual monthly averages. Analyzing the rainfall regime of the agricultural year 2019-2020, it was characterized as an excessive year of drought, rainfall totaled 234 mm, with a deficit of 207 mm compared to the multiannual monthly average of 442 mm, and from thermal temperature, an annual average air temperature of 13.3°C was recorded, which exceeded the multiannual average of 10.9°C by 2.3°C, thus requiring crop irrigation. The context was favorable for the development of pathogens, with periods of excessive drought and episodes of severe weather.

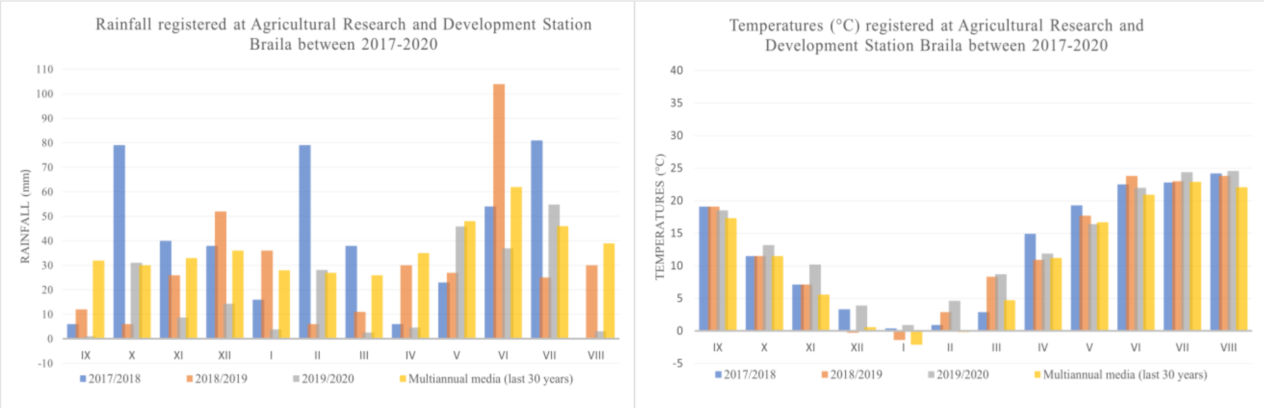


Figure 1. Rainfall (mm) and temperatures (°C) registered at Agriculture Research and Development Station Brăila between 2017-2020

Sunflower is a mesothermal plant, relatively demanding in heat which, to go through the vegetation stages, needs at least 2,350°C (T>0°C) or 1,600°C (T≥5°C) (Bîlteanu et al., 1988).

Assessments were made on the frequency (F%) and the intensity (I%) of the pathogen attack, the degree of attack (DA%) and effectiveness (E%). The degree of attack was calculated using the formula:

$$DA\% = \frac{F\% \cdot I\%}{100}$$

The effectiveness of the chemicals tested was calculated using the Abbott formula:

$$E\% = 1 - \frac{DA\%Tp}{DA\%Up} \cdot 100$$

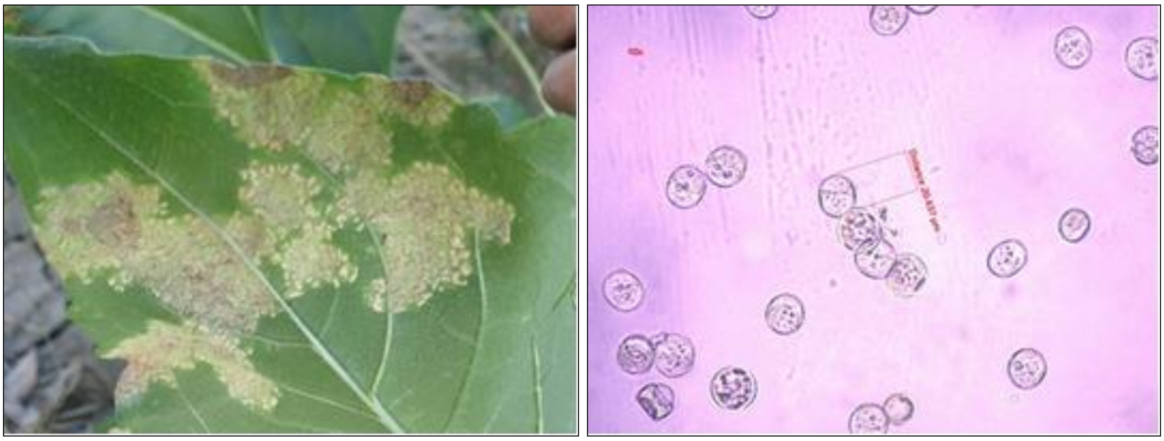
where DA%Tp = degree of attack in the treated plot; DA%Up = degree of attack in the untreated plot.

Morphological characteristics were determined by preparing native preparations from fresh material and observing them under light microscope. The formation of oospores was investigated in freehand sections of infected plant tissue using a Zeiss microscope - Primo Star. Data processing was performed statistically, according to the method of analysis of variance.

RESULTS AND DISCUSSION

Albugo tragopogonis has both a sexual and asexual life cycle (Agrios, 1988; Nowell and Viljoen, 1997) and the asexual stage becomes visible when in the pustules are produced sporangia, on the lower surfaces of leaves. Concerning the sexual stage, this is characterised by spherical dark brown to black oospores (Mukerji and Brown, 1976; Gulya et al., 1997a). The oospores are visible as grey lesions on stems, receptacles, petioles, involucral bracts and veins on leaves (Allen and Brown, 1980; Van Wyk et al, 1995).

Between 2018-2020, in our experiment set up in the fields of the Agriculture Research and Development Station Brăila, *Albugo tragopogonis* expressed symptoms during the asexual phase, symptoms that became visible as white pustules on the infected plants. Early symptoms of white rust consisted of chlorotic spots located on the upper surface of the leaves. Below these spots, were formed white to creamish blister-like swellings called pustules. Sporangia (Figure 2) were produced in pustules and with the pressure exert on the host epidermis caused rupture. The infected leaves became necrotic, turned brown and gave the plant a blighted appearance.



a) *b)*

Figure 2. Albugo tragopogonis: a) pustules; b) sporangia

Table 2. Results regarding the evaluation of *Albugo tragopogonis* attack and the effectiveness of the applied treatments between 2018-2020 in the fields of the Agriculture Research and Development Station Brăila

			Dynamics of the pathogen *Albugo tragopogonis*							
			2018				2020			
Hybrid x Plant protection products x Fertilizer			F (%)	I (%)	GA (%)	**E (%)**	F (%)	I (%)	GA (%)	**E (%)**
H_1 ES Janis CLP	**F_1 Control**						**10.2**	**2.3**	**0.23**	**-**
	P_1	F_2	-	-	-	-	6.1	2.1	0.13	45.40
		F_3	-	-	-	-	6.2	1.8	0.11	52.43
		F_4	-	-	-	-	5.2	2.1	0.11	53.45
	P_2	F_2	-	-	-	-	2.9	1.2	0.03	85.17
		F_3	-	-	-	-	4.4	2.7	0.12	49.36
		F_4	-	-	-	-	4.8	2.5	0.12	48.85
H_2 MAS 92. CP	**F_1 Control**		**12.5**	**1.8**	**0.23**	**-**	**8.0**	**3.3**	**0.26**	**-**
	P_1	F_2	8.1	1.2	0.10	56.52	6.3	1.2	0.08	71.36
		F_3	6.5	1.0	0.07	69.57	3.8	1.4	0.05	79.85
		F_4	8.2	1.1	0.09	60.87	4.8	2.2	0.11	60.00
	P_2	F_2	4.3	1.1	0.05	78.26	3.1	1.1	0.03	87.08
		F_3	3.2	1.0	0.30	86.96	5.1	2.3	0.12	55.57
		F_4	5.3	2.5	0.13	43.48	5.3	1.5	0.08	69.89
H_3 SY Neostar CLP	**F_1 Control**		**-**	**-**	**-**	**-**	**4.2**	**1.9**	**0.08**	**-**
	P_1	F_2	-	-	-	-	2.1	1.2	0.03	68.42
		F_3	-	-	-	-	2.1	1.0	0.02	73.68
		F_4	-	-	-	-	2.4	2.2	0.05	33.83
	P_2	F_2	-	-	-	-	3.6	2.1	0.08	5.26
		F_3	-	-	-	-	3.6	1.3	0.05	41.35
		F_4	-	-	-	-	2.5	1.5	0.04	53.01
H_4 SY Bacardi CLP	**F_1 Control**		**-**	**-**	**-**	**-**	**3.9**	**2.2**	**0.09**	**-**
	P_1	F_2	-	-	-	-	2.2	1.0	0.02	74.36
		F_3	-	-	-	-	3.1	2.0	0.06	27.74
		F_4	-	-	-	-	3.9	1.0	0.04	54.55
	P_2	F_2	-	-	-	-	2.8	2.1	0.06	31.47
		F_3	-	-	-	-	2.5	2.2	0.06	35.90
		F_4	-	-	-	-	1.9	2.1	0.04	53.50
H_5 LG 50.635 CLP	**F_1 Control**		**-**	**-**	**-**	**-**	**6.3**	**2.4**	**0.15**	**-**
	P_1	F_2	-	-	-	-	3.9	2.4	0.09	38.10
		F_3	-	-	-	-	5.2	1.9	0.10	34.66
		F_4	-	-	-	-	5.3	2.1	0.11	26.39
	P_2	F_2	-	-	-	-	4.3	2.9	0.12	17.53
		F_3	-	-	-	-	2.1	2.1	0.04	70.83
		F_4	-	-	-	-	3.2	1.8	0.06	61.90

			Dynamics of the pathogen *Albugo tragopogonis*							
			2018				2020			
Hybrid x Plant protection products x Fertilizer			F (%)	I (%)	GA (%)	**E (%)**	F (%)	I (%)	GA (%)	**E (%)**
H_6 LG 55.55 CLP	**F_1 Control**						**4.8**	**3.2**	**0.15**	**-**
	P_1	F_2	-	-	-	-	2.3	1.9	0.04	71.55
		F_3	-	-	-	-	2.5	2.3	0.06	62.57
		F_4	-	-	-	-	2.2	1.7	0.04	75.65
	P_2	F_2	-	-	-	-	3.2	1.6	0.05	66.67
		F_3	-	-	-	-	4.4	2.1	0.09	39.84
		F_4	-	-	-	-	3.9	1.2	0.05	69.53
H_7 Performer	**F_1 Control**		-	-	-	-	**8.2**	**2.1**	**0.17**	**-**
	P_1	F_2	-	-	-	-	5.3	2.0	0.11	38.44
		F_3	-	-	-	-	3.8	1.2	0.05	73.52
		F_4	-	-	-	-	2.1	3.2	0.07	60.98
	P_2	F_2	-	-	-	-	3.3	1.0	0.03	80.84
		F_3	-	-	-	-	5.3	2.0	0.11	38.44
		F_4	-	-	-	-	5.2	1.5	0.08	54.70
H_8 FD-15 C27	**F_1 Control**		-	-	-		**6.3**	**1.9**	**0.12**	**-**
	P_1	F_2	-	-	-	-	4.2	2.1	0.09	26.32
		F_3	-	-	-	-	3.8	2.1	0.08	33.33
		F_4	-	-	-	-	4.2	1.8	0.08	36.84
	P_2	F_2	-	-	-	-	3.8	1.2	0.05	61.90
		F_3	-	-	-	-	5.3	2.1	0.11	7.02
		F_4	-	-	-	-	5.2	1.9	0.10	17.46
H_9 ES Genesis CLP	**F1 Control**		-	-	-		**9.2**	**2.1**	**0.19**	**-**
	P_1	F_2	-	-	-	-	7.2	1.3	0.09	51.55
		F_3	-	-	-	-	7.1	2.2	0.16	19.15
		F_4	-	-	-	-	6.8	1.4	0.10	50.72
	P_2	F_2	-	-	-	-	4.9	1.2	0.06	69.57
		F_3	-	-	-	-	5.4	2.7	0.15	24.53
		F_4	-	-	-	-	2.8	2.5	0.07	63.77

Albugo tragopoginis overwinters as oospores in soil (Viljoen and Van Wyk, 1996; Gulya et al., 1997b) and serve as primary inoculum. Oospores, with the first rainfall, are wather splashed onto leaves of young seedlings (Viljoen and Van Wyk, 1996; Gulya et al, 1997a; Viljoen, 1997), germinate and release their zoospores that enter through stomata, encyst within the substomatal cavity and germinate to produce intercellulare hyphae (Kajornchaiyakul and Brown, 1976; Pernaud and Perny, 1995). Hyphae infect cells, produce white pustules, and pustules rupture and sporagia, disseminated by wind and splashed by water, can initiate secondary infections (Viljoen and Van Wyk, 1996; Gulya et al., 1997a). No fungicides are registred for the control of Albugo *tragopogonis* on sunflower in Romania. A trial conducted by Strauss and Viljoen (1997) shown that sunflower plants sprayed with metalaxyl/ mancozeb had white rust symptoms, but the chemical had prevented the development of new infection. As Viljoen and Van Wyk (1996), this fungicide did not cure infected tissue from infection by *A. tragopogonis*. The known activity of metalaxyl against the *Albuginaceae* led to be used, because metalaxyl inhibts RNA synthesis in Oomycetes (Saharan and Verma, 1992; Strauss and Viljoen, 1997). According to Mouzeyar et al. (1995), metalaxyl treatment on sunflower caused changes in susceptible plants infected by *Plasmopara halstedii* and they concluded that metalaxyl might have activated genes involved in genetic resistance by triggering host defence mechanism.

In 2018, of the sunflower genotypes under study, only the hybrid MAS 92.CP (Maisadour) showed obvious symptoms of *Albugo tragopogonis*. For the control variant, with a frequency of 12.5% and an intensity of 1.8%, the degree attack of the pathogen was 0.23%. For the variants where fertilizers and plant protection products were applied, the frequency and intensity were visibly lower, the degree of attack oscillating between 0.07% and 0.13%. Although fungicides are not approved to control this pathogen, a reduction in the development of the pathogen has been observed in the variants where these have been applied. The best percentage calculated for effectiveness was the fertilization variant Last N (250 g/l N) in two doses to the applied fungicide Tanos WG (0.4 kg/ha) of 86.96%, followed by the variant Urea 46% N (90 kg/ha a.s.) to the applied fungicide Sfera 535 SC (0.4 l/ha), with an effectiveness of 78.26%. Regarding the evolution of this pathogen in 2019, no genotype of the sunflower under study showed symptoms. The infection depends on the presence of water (Gulya et al., 1997a; Potgieter et al., 1997, Viljoen, 1997) also, all phases of the infection are influenced by temperature (Kajornchaiyakul and Brown, 1976; Pernaud and Perny, 1995). Secondary infection of sunflower leaves plays a very important role in build-up of the inoculum in the field and the spread of the disease during the growing season (Viljoen, 1997). Due to the obligate nature of the pathogen, it can only survive and multiply on living host tissue (Potgieter et al., 1997). A possible explanation for the lack of symptoms of the pathogen in the experimental field would be the high temperatures and lack of precipitation which broke the disease cycle of the fungus, 2019 being from a climatic point of view, a very dry year. Various cultural practices can influence disease development. For exemple, planting date, herbicide treatment, spacing and type of cultivar can have an effect on the control of the disease (Van Wyk and Jooste, 1997). Also, unfavourable environmental conditions contribute to a lower level of inoculum and the disease incidence (free water, low temperatures) can brake the disease cycle of the fungus (Nowell and Viljoen, 1997; Potgieter et al., 1997). It should be noted that in the extensive study undertaken at the Agriculture Research and Development Station Braila, the rotation of crops was considered, and the culture technology was the same. As Van Wyk and Jooste (1997), crop rotation has a little effect on the management of the white rust and the reason is that the oospores can survive for up to nine years or longer in soil (Potgieter et al., 1997).

In 2020, a favorable year for the development of the pathogen, all the genotypes under study showed obvious symptoms of *Albugo tragopogonis*, with frequencies and intensities that varied from one genotype to another. If we analyze the control variants, we can see that the highest degree of attack was recorded to the hybrid H_2 MAS 92.CP with 0.26%, followed by H_1 ES Janis CLP with 0.23% and H_9 ES Genesis CLP with 0.19%. On the variants where were applied fungicides in combination with liquid and solid fertilizers, the degree of attack was visibly lower, the pathogen manifesting symptoms in the lower leaf layers. Calculating the effectiveness of the tested fungicides, we noticed that on the variants where Urea 46% N (90 kg/ha a.s.) was applied, the Tanos WG (0.4 kg/ha) fungicide had an effectiveness of 85.17% in case of H_1 ES Janis CLP hybrid, 87.08% in case of H_2 MAS 92.CP and 80.84% in case of H_7 Performer hybrid. The degree of attack with the lowest values was calculated for the hybrids H_3 SY Neostar CLP and H_4 SY Bacardi CLP with 0.08% and 0.09%. Evaluating sunflower germplast of the United States Department of Agriculture (USDA) for *Albugo tragopogonis* resistance in South Africa, Gulya et al. (2000a), observed that leaf pustules were restricted to lower leaves and expressed as small, localised lesions on some lines, while petiole and stem lesions would be large and widespread on the plant. Before this study, Van der Merwe et al. (1997) also stated that there was a variation in susceptibility among sunflower breeding lines and this type of variation was suggestive of polygenic resistance to the disease. Based on the studies mentioned above, we can believe that the variation in the degree of attack of the pathogen from one genotype to another was also since the sunflower genotypes used, being commercial products, before packaging, the seeds were treated with fludioxonil+metalaxyl. Research is needed to find a possible seed treatment to keep the disease at bay and protect sunflower crops.

Table 3. Results concerning the influence of fungicide treatments and fertilizers in the context of different sunflower genotypes on the yield (kg/ha) between 2018-2020 in the fields of the Agriculture Research and Development Station Brăila

Hybrid x Plant protection products x Fertilizer			2018				2019				2020			
			Yield (kg/ha)	Production increase (%)	Dif.	Sign.	Yield (kg/ha)	Production increase (%)	Dif.	Sign.	Yield (kg/ha)	Production increase (%)	Dif.	Sign.
H_1 ES Janis CLP	**F_1 Control**		**2913.10**	**100**	**0.00**	/	**1929.27**	**100**	**0.00**	/	**1881.20**	**100**	**0.00**	/
	P_1	F_2	3755.93	128.93	842.83	-	2377.37	123.23	448.10	-	2777.37	147.64	896.17	*
		F_3	3502.97	120.25	589.87	-	2672.47	138.52	743.20	-	2905.80	154.47	1024.60	**
		F_4	3190.47	109.52	277.37	-	2623.90	136.01	694.63	-	3023.90	160.74	1142.70	**
	P_2	F_2	3305.07	113.46	391.97	-	2814.20	145.87	884.93	*	2844.20	151.19	963.00	*
		F_3	3462.80	118.87	549.70	-	2666.50	138.21	737.23	-	2999.83	159.46	1118.63	**
		F_4	3201.47	109.90	288.37	-	2605.40	135.05	676.13	-	2938.73	156.22	1057.53	**
			DL5%= 1194.09 DL1%= 1975.84 DL0.1%= 3698.23				DL5%= 844.09 DL1%= 1396.69 DL0.1%= 2614.24				DL5%= 594.53 DL1%= 983.76 DL0.1%= 1841.34			
H_2 MAS 92. CP	**F_1 Control**		**2395.27**	**100**	**0.00**	/	**1704.27**	**100**	**0.00**	/	**1886.10**	**100**	**0,00**	/
	P_1	F_2	2657.13	110.93	261.87	-	2328.00	136.60	623.73	-	3170.53	168.10	1284.43	*
		F_3	2553.00	106.59	157.73	-	2447.67	143.62	743.40	-	3103.90	164.57	1217.80	*
		F_4	3685.13	153.85	1289.87	**	2893.37	169.77	1189.10	*	3704.67	196.42	1818.57	**
	P_2	F_2	2683.50	112.03	288.23	-	2296.63	134.76	592.37	-	3325.03	176.29	1438.93	*
		F_3	2488.93	103.91	93.67	-	2869.17	168.35	1164.90	*	3489.33	185.00	1603.23	**
		F_4	3521.07	147.00	1125.80	*	3011.07	176.68	1306.80	*	3729.83	197.75	1843.73	**
			DL5%=754.57 DL1%=1248.57 DL0.1%= 2337.00				DL5%=888.15 DL1%=1469.60 DL0.1%= 2750.70				DL5%=925.92 DL1%=1532.09 DL0.1%= 2867.67			
H_3 SY Neostar CLP	**F1 Control**		**2293.47**	**100**	**0.00**	/	**1919.70**	**100**	**0.00**	/	**1853.03**	**100**	**0.00**	/
	P_1	F_2	2643.13	115.25	349.67	-	2679.00	139.55	759.30	*	2779.00	149.97	925.97	*
		F_3	2929.13	127.72	635.67	-	2644.20	137.74	724.50	-	2550.87	137.66	697.83	-
		F_4	2501.80	109.08	208.33	-	3123.20	162.69	1203.50	*	3156.53	170.34	1303.50	**
	P_2	F_2	2592.33	113.03	298.87	-	2817.83	146.79	898.13	*	2917.83	157.46	1064.80	*
		F_3	3241.00	141.31	947.53	-	2618.47	136.40	698.77	-	2729.43	147.30	876.40	*
		F_4	3169.00	138.18	875.53	-	2864.47	149.21	944.77	*	2959.43	159.71	1106.40	*
			DL5%= 1274.96 DL1%= 2109.64 DL0.1%= 3948.69				DL5% = 728.59 DL1%= 1205.57 DL0.1%= 2256.52				DL5% = 717.64 DL1%= 1187.46 DL0.1%= 2222.62			

			2018				2019				2020			
Hybrid x Plant protection products x Fertilizer			Yield (kg/ha)	Production increase (%)	Dif.	Sign.	Yield (kg/ha)	Production increase (%)	Dif.	Sign.	Yield (kg/ha)	Production increase (%)	Dif.	Sign.
H_4 SY Bacardi CLP	**F_1 Control**		**1575.07**	**100**	**0,00**	/	**1888.87**	**100**	**0.00**	/	**2034.87**	**100**	**0,00**	/
	P_1	F_2	1858.93	118.02	283.87	-	2456.93	130.07	568.07	-	2690.33	132.21	655.47	-
		F_3	2023.33	128.46	448.27	-	2814.50	149.00	925.63	*	2947.83	144.87	912.97	*
		F_4	2153.63	136.73	578.57	-	3269.27	173.08	1380.40	**	3943.60	193.80	1908.73	**
	P_2	F_2	2621.67	166.45	1046.60	-	2643.23	139.94	754.37	-	2976.57	146.28	941.70	*
		F_3	2726.67	173.11	1151.60	-	2603.60	137.84	714.73	-	3736.93	183.65	1702.07	**
		F_4	2820.30	179.06	1245.23	-	2785.07	147.45	896.20	*	3551.73	174.54	1516.87	**
					DL5%= 1302.61				DL5%= 830.85				DL5%= 816.58	
					DL1%= 2155.39				DL1%= 1374.79				DL1%= 1351.17	
					DL0.1%= 4034.33				DL0.1%= 2573.25				DL0.1%= 2529.04	
H_5 LG 50.635 CLP	**F_1 Control**		**2922.03**	**100**	**0.00**	/	**2074.13**	**100**	**0.00**	/	**2036.37**	**100**	**0.00**	/
	P_1	F_2	3570.83	122.20	648.80	-	2783.17	134.18	709.03	-	2886.77	141.76	850.40	*
		F_3	3326.20	113.83	404.17	-	3248.70	156.63	1174.57	*	3259.53	160.07	1223.17	*
		F_4	3327.37	113.87	405.33	-	3286.93	158.47	1212.80	*	3289.93	161.56	1253.57	*
	P_2	F_2	3488.67	119.39	566.63	-	2469.87	119.08	395.73	-	2770.10	136.03	733.73	-
		F_3	3429.33	117.36	507.30	-	3194.77	154.03	1120.63	*	3242.33	159.22	1205.97	*
		F_4	3192.67	109.26	270.63	-	3172.17	152.94	1098.03	*	3117.10	153.07	1080.73	*
					DL5%= 702.24				DL5%= 894.47				DL5%= 817.07	
					DL1%= 1161.97				DL1%= 1480.06				DL1%= 1351.99	
					DL0.1%= 2174.91				DL0.1%= 2770.29				DL0.1%= 2530.57	
H_6 LG 55.55 CLP	**F_1 Control**		**3217.23**	**100**	**0,00**	/	**1898.77**	**100**	**0,00**	/	**2680.10**	**100**	**0,00**	/
	P_1	F_2	3576.20	111.16	358.97	-	2556.93	134.66	658.17	-	3323.57	124.01	643.47	*
		F_3	3295.27	102.43	78.03	-	2733.33	143.95	834.57	-	3900.00	145.52	1219.90	**
		F_4	3409.53	105.98	192.30	-	3143.53	165.56	1244.77	*	4143.63	154.61	1463.53	**
	P_2	F_2	3308.67	102.84	91.43	-	2644.13	139.26	745.37	-	3644.13	135.97	964.03	*
		F_3	3057.43	95.03	-159.80	-	2674.43	140.85	775.67	-	3608.03	134.62	927.93	*
		F_4	3436.40	106.81	219.17	-	3216.17	169.38	1317.40	*	3582.93	133.69	902.83	*
					DL5%= 655.00				DL5%= 951.95				DL5%= 616.88	
					DL1%= 1083.81				DL1%= 1575.17				DL1%= 1020.74	
					DL0.1%= 2028.61				DL0.1%= 2948.32				DL0.1%= 1910.56	

			2018				2019				2020			
Hybrid x Plant protection products x Fertilizer			Yield (kg/ha)	Production increase (%)	Dif.	Sign.	Yield (kg/ha)	Production increase (%)	Dif.	Sign.	Yield (kg/ha)	Production increase (%)	Dif.	Sign.
H_7 Performer	**F_1 Control**		**2801.57**	**100**	**0.00**	/	**1645.67**	**100**	**0.00**	/	**1577.10**	**100**	**0,00**	/
	P_1	F_2	3126.80	111.61	325.23	-	2420.47	147.08	774.80	-	2513.93	159.40	936.83	*
		F_3	2019.40	72.08	-782.17	-	2687.90	163.33	1042.23	*	2715.50	172.18	1138.40	*
		F_4	2556.53	91.25	-245.03	-	2959.37	179.83	1313.70	*	3056.10	193.78	1479.00	**
	P_2	F_2	2942.27	105.02	140.70	-	2786.77	169.34	1141.10	*	2954.43	187.33	1377.33	*
		F_3	2457.00	87.70	-344.57	-	2892.50	175.76	1246.83	*	2962.30	187.83	1385.20	*
		F_4	2712.00	96.80	-89.57	-	2553.37	155.16	907.70	*	2786.92	176.71	1209.82	*
					DL5%= 1351.89 DL1%= 2236.93 DL0.1%= 4186.96				DL5%= 815.73 DL1%= 1349.78 DL0.1%= 2526.43				DL5%= 861.79 DL1%= 1425.98 DL0.1%= 2669.07	
H_8 FD-15 C27	**F_1 Control**		**2283.33**	**100**	**0,00**	/	**1617.43**	**100**	**0.00**	/	**2050.77**	**100**	**0.00**	/
	P_1	F_2	2546.43	111.52	263.10	-	2695.80	166.67	1078.37	-	2862.70	139.59	811.93	*
		F_3	2533.93	110.98	250.60	-	2874.50	177.72	1257.07	*	2841.17	138.54	790.40	*
		F_4	2463.60	107.89	180.27	-	2986.73	184.66	1369.30	*	2823.40	137.68	772.63	*
	P_2	F_2	2537.27	111.12	253.93	-	2409.07	148.94	791.63	-	2909.17	141.86	858.40	*
		F_3	2874.00	125.87	590.67	-	2680.07	165.70	1062.63	-	3371.83	164.42	1321.07	**
		F_4	2644.83	115.83	361.50	-	3168.73	195.91	1551.30	*	3466.87	169.05	1416.10	**
					DL5%= 1404.53 DL1%= 2324.04 DL0.1%= 4350.00				DL5%= 1185.21 DL1%= 1961.14 DL0.1%= 3670.75				DL5%= 692.34 DL1%= 1145.59 DL0.1%= 2144.25	
H_9 ES Genesis CLP	**F_1 Control**		**3027.87**	**100**	**0.00**	/	**1659.27**	**100**	**0.00**	/	**1999.67**	**100**	**0.00**	/
	P_1	F_2	3439.23	113.59	411.37	-	2572.03	155.01	912.77	*	2873.73	143.71	874.07	**
		F_3	3453.00	114.04	425.13	-	2624.70	158.18	965.43	*	2511.17	125.58	511.50	*
		F_4	3617.87	119.49	590.00	*	3141.87	189.35	1482.60	**	2993.03	149.68	993.37	**
	P_2	F_2	3295.37	108.83	267.50	-	2631.27	158.58	972.00	*	2808.33	140.44	808.67	**
		F_3	3529.23	116.56	501.37	-	3140.40	189.26	1481.13	**	2965.67	148.31	966.00	**
		F_4	3883.47	128.26	855.60	*	3165.77	190.79	1506.50	**	2996.80	149.86	997.13	**
					DL5%= 548.56 DL1%= 907.69 DL0.1%= 1698.96				DL5%= 790.57 DL1%= 1308.14 DL0.1%= 2448.50				DL5%= 446.00 DL1%= 737.98 DL0.1%= 1381.31	

Analyzing Tabel 3 the average yields (kg/ha) obtained in the three years of study we can conclude that they varied from year to year. The most productive hybrid proved to be H_6 LG 55.55 CLP in 2020, with an average production of 4143.63 kg/ha for the variant Sfera 535 SC (0.4 l/ha) - Last N foliar fertilizer (250 g/l N in two doses), with a production increase over 1200 kg compared to the control variant. The lowest average production was recorded by the H_7 Performer hybrid in 2018 in the variant Sfera 535 SC (0.4 l/ha) - Last N foliar fertilizer (250 g/l N in one dose), with 2019.4 kg/ha.

For the hybrid H_2 MAS 92.CP, the only hybrid that in 2018 showed obvious symptoms of white rust, we analyzed the yields obtained and we can conclude that at a frequency of 12.5% and a degree attack of 0.23%, the average production obtained (kg/ha) on the control variant was 2395.27 kg. There were distinctly significant production increases about 54% compared to the control variant in amount of 1289.87 kg/ha in the variant Last N (250 g/l N) in two doses to the applied fungicide Sfera 535 SC (0.4 l/ha) and at the same time, a significant production increase of 1125.80 kg for the variant Last N (250 g/l N) in two doses to the applied fungicide Tanos WG (0.4 kg/ha).

For 2020 we analyzed the control variants and the highest degree attack was recorded to the hybrid H_2 MAS 92.CP with 0.26% where the recorded yield (kg/ha) was 1886.10 kg/ha, followed by H_1 ES Janis CLP with a degree attack of 0.23% and a recorded yield of 1881.20 kg/ha and H_9 ES Genesis CLP with a degree attack of 0.19% and a recorded yield 1999.67 kg/ha. The lowest yield (kg/ha) was obtained by the H_7 Performer hybrid, with 1577.10 kg/ha where the degree attack of the monitored pathogen was 0.17%. Significant and distinctly significant production increases compared to the control variants were recorded in most hybrids. Liquid fertilizer applied by spraying, caused increases in leaf mass in most hybrids and we could explain that although in some hybrids the degree attack of the pathogen was noticeable, the yields recorded good values due to the application of plant protection products also, a stagnation of the pathogen was visible and it remained localized in the lower leaf layers.

CONCLUSIONS

The pathogen *Albugo tragopogonis* can well develop in special climatic conditions. There is need for the pathogen to have enough water, also all phases of development depend on air temperature.

In years with good climatic conditions for its development, the pathogen can produce high attack on sunflower cultivars.

For controlling this pathogen, the treatment with fungicides combined with liquid and solid fertilizers is more efficient.

The applied fertilizers can help the sunflower plants to develop better the leaf mass, producing a stagnation of the pathogen, also have a good protection by its attack.

The agricultural practices, including crop rotation have no effect in controlling the pathogen.

The seed yield released by sunflower hybrids is depending by the level of the pathogen attack, also by the genotype tolerance.

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