SPONTANEOUS POPULATIONS OF JERUSALEM ARTICHOKE'S (*HELIANTHUS TUBEROSUS L.*) DISEASE IN S-W ROMANIA

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Abstract. *Helianthus tuberosus is an herbaceous plant, perennial, with over 1.5 m high (average at 2.10 m high on the research area). This plant is known as Jerusalem artichoke or sunchoke, or earth apple and in Romania it is known as topinambur. Because it is used to feed pigs in some regions are known as as porcini turnip. This plant could play a very important role in the management of resources in the future, especially since it is also a plant used as a food source. From the anatomical point of view, the tubers are used. They have a potato-like shape but the tuber colors are generally white, purple or yellow. Ethanol is extracted from this species tubers. This kind of alcohol that is extracted from the main crop of a Jerusalem artichoke plants is considered biofuel and meets all the requirements of the European Union Directive RED II (Renewable Energy Directive). This is because Jerusalem artichoke is a plant that is easy to implement as a field crop, even on poorer soil types. Also, it has a diversified genetic resource needed for easy breeding. Tuber production can increase the biofuel industry or, in the worst-case scenario, it can be used to obtain biogas, another biofuel. This is because the tuber production transformation on assimilated organic matter varies between 0.4-0.8 t/ha. The tuber production on poor land is between 6-9 t / ha and on fertile land it can reach 20-30 t / ha . Also, the tubers of Helianthus tuberosus can be used in the pharmaceutical industry to obtain sweeteners. In view of all the above, it is important to know which pathogens affect topinabur plants in spontaneous flora and reserve their inoculation, as these are the most likely factors that will affect topinabur crops under these conditions. implemented by farmers. The existence of spontaneous Jerusalem artichoke populations on the river's valleys in the south-western part of Romania is a welcome fact because it shows the potential of the area for this plant on relatively poor and shallow soils. It should be noted, however, that these populations are affected relatively strongly in the first part of the summer (in June and July) of flouring and alternating.*

***Keywords**: Jerusalem artichoke, leaf diseases*

INTRODUCTION

Jerusalem artichoke (*Helianthus tuberosus*) is widely adapted to diverse and often marginal environments (PIMSAEN, W. ET.AL., 2010). Tubers can be used raw or cooked (HEDRICK. U.P., 1972). Jerusalem artichoke is a multi-purpose crop used for human food consumption (directly tubers or to obtain sweeteners), pharmaceutical applications, biomass and bioenergy (bioethanol and biogas) production (KAYS, S.J , 2008; MA, X.Y.; ZHANG, L.H., ET. AL. 2011; VOLK G.M., RICHARDS K., 2006) The tubers are rich in inulin (UPHOF. J. C. TH., 1959). The tubers are fairly large, up to 10cm long and 6 cm in diameter [Huxley. A.**,** 1992]. The tubers bruise easily and lose moisture rapidly so are best left in the ground and harvested as required [HUXLEY. A.**,** 1992]. The inulin from the roots can be converted into fructose, a sweet substance that is safe for diabetics to use (HILL. A. F., 1952). The roasted tubers are a coffee substitute (FACCIOLA. S.**,** 1990).

The plants of Jerusalem artichoke are a good source of biomass. The tubers are used in industry to make alcohol etc. (CARRUTHERS. S. P., 1986). The alcohol fermented from the tubers is said to be of better quality than that from sugar beets (DUKE. J., 1983). A fast-growing plant, Jerusalem artichokes can be grown as a temporary summer screen (HUXLEY. A., 1992*).* Very temporary, it is July before they reach a reasonable height and by October they are dying down.

A very easily grown plant, it grows best in a loose circumneutral loam but succeeds in most soils and conditions in a sunny position (SIMONS A.J., 1977). Plants are more productive when grown in a rich soil (SIMMONS A. E., 1978). Heavy soils produce the highest yields, but the tubers are easily damaged at harvest-time so lighter well-drained sandy loams are more suitable. Dislikes shade (CHITTENDON F., 1951). Likes some lime in the soil (SIMONS A. J., 1977). Jerusalem artichoke is reported to tolerate an annual precipitation of 31 to 282cm, an average annual temperature of 6.3 to 26.6°C and a pH in the range of 4.5 to 8.2 (DUKE. J., 1983).

MATERIAL AND METHODS

The experiment was carried out in the period 2017-2019 in the southwestern part of Romania, in the basin of Nera River, where the Jerusalem artichoke (*Helianthus tuberosus*) finds a very good habitat for develop some well-defined populations. In order to have an overview on the evolution of the pathogens that produces diseases on *Helianthus tuberosus*, we chose five different areas with distinctly populations of *Helianthus tuberosus*. The locations of these four from five populations are on a relatively linear west-east layout, in the basin of Nera river. The fifth population is inside the Șușara Canyon Reservation, more precise on the superior basin of Șușara river which is a tributary of the Nera river (figure 1).

Figure 1. Distribution of *Helianthus tuberosus* populations inside the research area.

As expected, the evolution of the pathogens is very strong influenced by the climatic conditions. In order to track the evolution of the climatic conditions, we have chosen the data provided by the Oravita meteorological station. The reason for this choice is because this station is located relatively close to the area where we carried out the observations, the average distance of the *Helianthus tuberosus* populations are at 15.7 km. The data we collect for the period between 2017 and 2019 are those shown in figure 2 regarding to the evolution of temperatures and in figure 3 regarding to the evolution of precipitation.

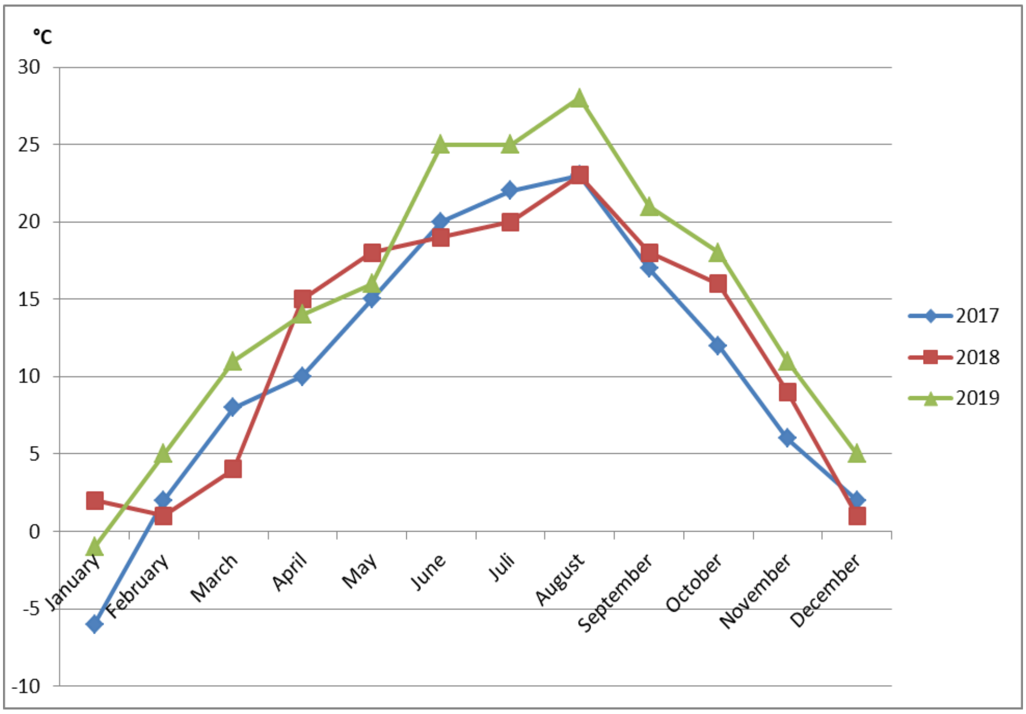

Figure 2. The evolution of temperatures monthly averages between 2017 and 2019

The temperatures evolution was a relatively normal (figure 2), but it should be noted that the warmest year (the highest monthly average temperatures) especially during the summer period, was recorded in 2019. And also, in 2019, the only negative monthly average was in January and the temperatures have grown steadily, with no syncope's and plateaus, until August and fell sharply in September. The other two years show a relatively normal evolution of the monthly average temperatures.

Rain distribution (figure 3) for each month of the time interval between 2017 and 2019 shows that in general the accumulated water is on a relatively low quantity in most years, with small exceptions. Thus, from the graph it is obvious that the year 2017 was relatively dry with the entire interval only an amount of 242.4 mm of rainfall. There were 1069.6 mm of water from rain accumulated in 2019, when there were months like May with 93.1 mm of rainwater and June with 274.4 mm of rain water records.

The highest amount of rain during the summer period, between the three years, was registered in 2019. The rainwater accumulated in June was 164 mm and in July was 87.8 mm. Also in August there were some rains, with a total of 31.9 mm of accumulated water, which maintain the soil humidity on a fair level.

This evolution of the climatic factors has greatly influenced the overall development of the pathogens reserve in general, regardless of the host plant species. For *Helianthus tuberosus* fungal diseases, there is very important the rain distribution during summer because each fungus have certain periods of time when they have the opportunity to infect the plants, and also each species have certain water necessity to develop all stages from the life cicle.

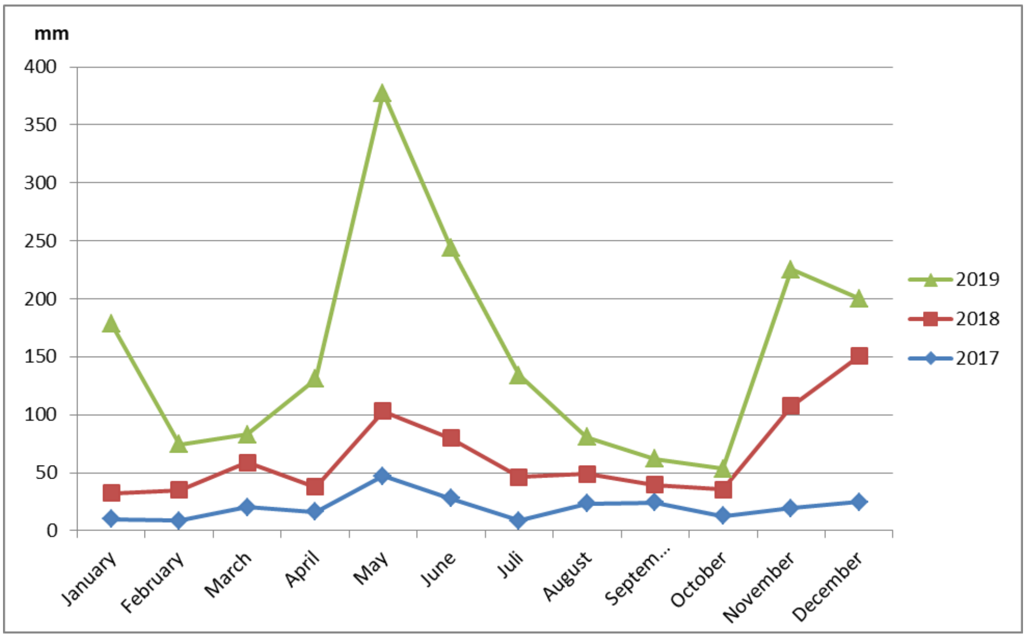

Figure 3. The evolution of monthly total rainwater between 2017 and 2019

The pathogens we found on our evaluation, and the years when we found them are on table 1. were as follow: stem black spots (*Plenodomus lindquistii* (Frezzi) Gruyter et al. (syns. *Phoma macdonaldii* Boerema), stem canker (*Diaporthe spp.*), root and basal stem rot (*Rhizoctonia solani Kühn*) and leaf necrosis (*Septoria helianthi Ellis& Kellerm.)* and head rot and leaf spots (*Alternariaster helianthin*)

Table 1.

Helianthus tuberosus fungal diseases and time period when we determined them between 2017-2019

nr.	Pathogen	Year of occurrence
1	*Golovinomyces cichoracearum*	2017, 2018, 2019
2	*Plenodomus lindquistii* (Frezzi) Gruyter et al. (syns. *Phoma macdonaldii* Boerema	2018. 2019
3	*Diaporthe spp*	2019
4	*Rhizoctonia solani Kühn*	2018, 2019
5	*Septoria helianthi Ellis& Kellerm*	2018.2019
6	*Alternariaster helianthi* Hansf.) E. G. Simmons (syn. *Alternaria helianthii* (Hansf.) Tubaki & Nishih.)	2019

As it came out from table 1, the only one pathogen present in all three years was powdery mildew (*Golovinomyces cichoracearum*) so we will refer to the results about this fungus evolution during the observation period. The most After that some fair amount of rains in a 10-14 days period of time, to develop secondary infections.

In order to evaluate the powdery mildew (*Golovinomyces cichoracearum*) attack and the inoculum reserve of the pathogens, the virulence (the intensity of the attack) and the aggressiveness of the pathogens (the frequency of the attack) were determined. The statistical calculation of the differences between populations and between the years of observation was performed by the method of statistic calculation for bifactorial experiences. In this calculation method which the first factor is the area in which the data were collected and the second factor is the experimental year. In order to have a common basis of comparison we used as a control the average of both factors.

We collect the data for the present paper from five areas. Four of this areas were located on a distance of maximum 1 km between them and the fifth area is located on a distance average of 2.5 km from the other four. In each area were delimitated 3 plots with almost same area and *Helianthus tuberosus* plant density, constituting three repetition. On each of those repetitions we analyze 100 plants of Jerusalem artichoke (*Helianthus tuberosus*) located in random positions on this location, but we take care to cover all the location area.

The frequency and intensity of the fungus attack was noted for each plant and these is the base for statistic calculation for attack frequency and intensity for both funguses. Starting from this data (for attack frequency and intensity) we calculate attack degree as sintetic indicator for our pathogen attack. There for, in the tables of the present paper, the frequency and intensity of each repetition is an average of those three areas determined inside each plot.

RESULTS AND DISCUSSIONS

The activity of determining Jerusalem artichoke diseases performed during 2017 showed that of all pathogens only *Golovinomyces cichoracearum* one of the phytopathogenic fungi that produce Jerusalem artichoke powder was the only one that after the appearance was permanently present in the populations in which they were performed. determinations. The results regarding the aggressiveness of the pathogen given by the frequency of attack and the virulence of the pathogen given by the intensity of attack, are summarized below. after being subjected to statistical processing, the data on the frequency of attack of Jerusalem artichoke flour in populations showed a very varied evolution.

a b

Figure 4. Plants of *Helianthus tuberosus* with powdery mildew symptoms (original)

a. Plants with necrotic leaves after *Golovinomyces cichoracearum* attack

b.Golovinomyces cichoracearum mycelia developed on plants leaves.

Thus, there were populations that were less affected, even if the pathogen was permanently present during the three years. Here we can highlight both the population near the Nera Monastery but especially the population of Sasca Montană. In the case of the latter population, the average frequency of attack over the three years was statistically significantly different from the control (Table 1).

Table 1.

Results regarding the frequency of attack of the *Golovinomyces cichoracearum* in the populations evaluated during the period 2017-2019.

Factor A Local populations	Factor B - Experimental year			Aggressivity average	Difference	Significance
	2017	2018	2019			
Slatina Nera	55.0	60.0	81.7	65.6	4.6	-
Mănăstirea Nera	43.3	51.7	71.7	55.6	-5.4	-
Sasca Montană	41.7	46.7	63.3	50.6	-10.4	○○
Sasca Română	55.0	61.7	70.0	62.2	1.2	-
Șușara	58.3	68.3	86.7	71.1	10.1	**
Populations average	50.7	57.7	74.7	61.0	Control	-

DL 0,1% = 13.2 DL 5% = 6.1 DL 1% = 8.8

Table 2

Results regarding the frequency of attack *Golovinomyces cichoracearum* between 2017-2019

Factor B Experimental year	2017	2018	2019	Years average
Averages	50.7	57.7	74.7	61
Differeces	-10.3	-3.3	13.7	Control
Significance	○○○	-	***	-

DL 5% = 5.5 DL 1% = 7.4 DL 0,1% = 10.1

On the populations of Sasca Română and Slatina Nera we register high values of the fungus frequency of attack, higher than those of the population of Sasca Montană. Even so, the difference between the population's values of attack frequency and the control value was very small and this drives to locate the differences below the limit of significance. Only the population of Șușara records a remarkable aggressiveness of the powdery mildew. Attack frequency had a value located at a distinctly significant difference from the control (table 1).

Looking at the perspective of the three years in which we performed determinations of the evolution of the fungus *Golovinomyces cichoracearum*, the synthesis data (table 2) indicate the difference between the three years, the difference given by the evolution of major climatic factors, temperature and precipitation. Thus, it can be seen that the average frequency of attack in 2017 was the lowest (Table 2), being located at a very significant negative difference from the control. This is only due to the very dry summer and with quite high temperatures that led to the cessation of the attack of the pathogen at the end of June. The year 2019 in which both the temperatures were the highest of the three and especially the significantly higher rainfall since the beginning of summer, led to a sustained attack of the fungus Golovinomyces cichoracearum. The value of the average frequency of attack on all five populations (Table 2) in 2019 was a very significant difference from the control

The intensity of the attack indicating the virulence of the pathogen shows that in fact the tolerance of the plants to the pathogen shows that the four populations have relatively the same behavior as the one shown in the case of the aggressiveness of the pathogen. Thus, if we analyze the results of the statistical calculation (table 3), the most sensitive to powdery mildew were the population of Șușara with a distinctly significant difference from the control and the population from Nera Monastery with a significant difference from the control. Of the two populations, the one from Șușara registered the greatest aggression

Table 3.

Results regarding the intensity of attack of the *Golovinomyces cichoracearum* on the populations evaluated during the period 2017-2019

Factor A Local populations	Factor B - Experimental year			Aggressivity average	Difference	Significance
	2017	2018	2019			
De Slatina Nera	23.3	36.7	56.7	38.9	2.9	-
De Mănăstirea Nera	30.0	35.0	61.7	42.2	6.2	*
De Sasca Montană	20.0	26.7	33.3	26.7	-9.3	○○○
De Sasca Română	21.7	31.7	33.3	28.9	-7.1	○○
De Șușara	31.7	35.0	63.3	43.3	7.3	**
Populations average	25.3	33.0	49.7	36.0	Control	-

DL 5% = 8.5 DL 1% = 12.4 DL 0,1% = 18.6

Table 4

Results regarding the frequency of attack *Golovinomyces cichoracearum* during the period 2017-2019

Factor B Experimental year	2017	2018	2019	Years average
Averages	25.3	33.0	49.7	36.0
Differeces	-10.7	-3.0	13.7	Control
Significance	○○○	-	***	

DL 5% = 4.8 DL 1% = 6.5 DL 0,1% = 8.8

The lowest values of attack intensity (table 3) were recorded in the population of Sasca Monatană with a statistically assured difference as very significant negative compared to the control and the population of Sasca Română located at a distinctly significant negative difference compared to the control. And in this case it can be seen that the population of Sasca Montană recorded the lowest values both for the intensity of attack (table 3) and for the frequency of attack (table 1). Over the three-year observation period, the statistical results obtained (table 4) show that of the five populations, the lowest average intensity of attack occurred in 2017 and the highest intensity of attack was the highest. recorded in 2019. These results are practically in the mirror with those obtained in the case of the frequency of attack and come to confirm the fact that in this pathogen, both aggression and virulence are greatly influenced by climatic conditions.

CONCLUSIONS

After three years of observations, it can be stated that this fungus resists in these stabilized populations even for longer periods of drought, producing after the first rainfall new infections on upper leaf floors. The attack parameters of the pathogen varied greatly as follows:

- within the same population in the time interval between determinations, but especially from year to year, depending on the evolution of temperatures and precipitation;
- the differences between the populations were determined by the location of the population, and in particular by the exposure to the sun and the distance from water sources such as rivers, the most affected populations being those located on river banks and somewhat in the shade of forest edge, or of willows on the river bank;

- the pathogen that produces Jerusalem artichoke powder in southwestern Romania, the Golovinomyces cichoracearum mushroom is very well adapted to environmental conditions, which allows it to appear and manifest every year in Jerusalem artichoke populations;

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