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IDENTIFICATION OF SOME POTATO CLONES WITH RELATIVE RESISTANCE TO LATE BLIGHT (*Phytophthora infestans*) IN CENTRAL PART OF ROMANIA

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Abstract

In the National Institute of Research and Development for Potato and Sugar Beet Brasov, sixteen potato clones were evaluated to find the relative resistant one to late blight (Phytophthora infestans) and thereby diminish the number of fungicide sprays required. In the two years of study the presence of clones relatively resistant, which allows the development of an adequate protection strategy and the possibility to reduce the number of treatments has been observed. Disease development on foliage was assessed as percentage of foliage area damaged. The research was conducted under natural pressure of infection. From all clones studied, 1895/1, 1901/11 and 1895/4 showed the lowest level of resistance on the foliage, followed by 1927/1, 1941/8 and 1939/2. Instead, the clones 1901/6, 1930/ and, 1979/5 were located towards the upper limit of resistance on the foliage during the entire vegetation period.

Key words*: foliage, late blight (Phytophthora infestans), potato clones, resistance.*

INTRODUCTION

Today, more than three thousand potato cultivars are widely distributed in more than 125 countries, particularly under temperate, subtropical and tropical regions covering a major economic share in the global agricultural market (Birch et al., 2012).

Potato late blight is an important crop disease caused by the oomycete *Phytophthora infestans* (Mont.) De Bary. Variations in disease severity are mainly due to climatic factors i.e. rainfall, relative humidity, temperature and pathogen virulence.

The increase in disease severity could be due to a change in the pathogen population. It is always advisable to use resistant varieties, even when sprays with fungicides are considered the main control strategy, because resistant varieties delay the onset of the disease or reduce its rate of development so that fewer sprays on a resistant variety may be needed to obtain a satisfactory level of control of the disease (Agrios et al., 2005). For tuber infection reduction, ridge sowing, maximum number of hoeings, proper maturity harvesting time and avoiding long potato harvest products transportation is recommended (Arora et al., 2014). Mixing and growing susceptible and resistant cultivars yield is better than grown solo (Garrett and Mundt, 2000; Singh and Singh, 2018). Search of effective, environmentally safe, economically viable and low risk to human health fungicides and resistant varieties are always the primary objectives of research.

The severity of the disease produced by this oomycete is mainly due to the complexity and aggressiveness of the existing strains, which makes it one of the most difficult plant pathogens to control (Alvarez-Morezuelas et al., 2021). The continuous changes in populations worldwide have made the control of late blight increasingly complicated, due to the gradual reduction of the effectiveness of fungicides, a consequence of the continuous applications (Jaramillo et al., 2003).

As long as potato is part of the diet of humankind, the problems that arise from *Phytophthora infestans* will remain a factor in food security. Since the potato was one of the first crops treated with a fungicide, the production system has co-evolved together with pesticides, and many potato cultivars require

either regular applications of such a chemical, or possess resistance genes that may or may not work, depending on evolution and change of the pathogen (Yuen et al., 2021).
Our goal in this study was to test new potato clones regarding the level of resistance to late blight so they can be used in future breeding programs as parental lines to develop varieties with resistance to the pathogen.

MATERIALS AND METHODS

Trial was performed in the experimental field of the Technology and Good Agricultural Practice Laboratory to the National Institute for Research and Development for Potato and Sugar Beet Brasov, Romania. Planting was done manually in May 3rd 2021, respectively April 7th 2022 in variants of 4 rows with 11 plants per row. Fertilizer, NPK 16-16-16+S, was applied at 1000 kg/ha rate in both years before potato planting. Planting distance was 75 cm between rows and 30 cm between plants per row. The biological material was represented by fifteen clones and Riviera variety. During the vegetation period were applied the usual maintenance works, including 2 treatments for Colorado beetle unless late blight control with fungicides. Has not been interfered with artificial *Phytophthora infestans* inoculum sprayers, using only the natural pressure of infection.
Late blight severity was recorded as percent leaf area damaged for the two central rows of each plot at 10 day intervals starting from the initiation of disease symptoms. For each plot and assessment date, the area under the disease progress curve (AUDPC) was estimated using the following formula:

$$\mathrm{AUDPC} = \frac{(\mathrm{T1} + 1 + \mathrm{T1}) \times (\mathrm{D1} + 1 + \mathrm{D1})}{2}$$

where T is the time in days since planting and D was the estimated percentage for area with blighted foliage (Campbell and Madden, 1990).
The statistical and rating differences between mean values regarding the yield were performed by LSD test.
The weather conditions of the two years studied are presented in Table 1.

April 2021 was colder than normal and the rainfalls lower than the multiannual average (MAA) with 10.8 mm. In May, the air temperature was lower by 1.3°C compared to the MAA, and the amount of precipitation was lower by 4.97 mm compared to the MAA value. The summer months (June-August) recorded higher temperatures than the multiannual ones, with an average of almost 3°C higher in July. Also, the amount of precipitation was much lower (-28.7 mm/m^2) in July, and in August, even if the monthly amount was exceeded, the precipitation was not uniform and balanced, at the end of the month, in a single day registering 61.5 mm/m^2. The month of September recorded a lower temperature by 0.8°C compared to the MAA and a lower volume of precipitation by 20.5 mm compared to the sum of multiannual precipitation.

Table 1. Average monthly temperatures (°C) and rainfall (mm) during the vegetation period (2021-2022)

Month	Temperatures (°C)			Rainfall (mm)		
	Average of 2021	Average of 2022	MMA	Sum of 2021	Sum of 2022	MMA
April	6.9	8.3	8.5	39.2	64.8	50.0
May	13.8	14.8	13.6	77.5	48.3	82.0
June	17.3	19.0	16.5	109.0	62.2	96.7
July	21.0	20.6	18.1	71.1	50.1	99.8
August	18.5	20.2	17.5	100.9	50.4	76.4
September	12.8	13.6	13.6	32.0	65.6	52.5

April 2022 start with higher temperature and rainfalls and May was more hot and drier than usually, but despite all this, the potato crop emerged uniformly. The months of summer (June, July and August) recorded higher temperatures (by 2.5°C in the first two months and 2.7°C in August) than the MAA and a very low volume of precipitation, especially in June and July (with 65.1 mm, respectively 49.7 mm less), establishing the phenomenon of pedological drought, which negatively influenced the potato plants, some clones not having the capacity to respond to water stress. In September, during the harvest period, the temperatures were similar to the multiannual ones, and the precipitation even exceeded the average values by 13.1 mm.

RESULTS AND DISCUSSIONS

At the end of June 2021, late blight had already spread to some susceptible clones and to Riviera variety. Although at the beginning of July, precipitation was low, the pathogen continued to evolve in the case of some clones, as can be seen in the assessment of July 12th. On the 23th of July, late blight infection was recorded on most cultivars, with the lowest intensity to clones 1901/6, 1930/3 and 1979/5. After ten days, on the 3rd of August, significant differences were observed. Clones 1901/6, 1930/3 and 1979/5 continue to have the lowest level, while Riviera variety had all plants affected. Clones 1901/12, 1897/2, 1891/1, 1927/3 and 1876/7 presented a moderate rate of infection and a slow progression. Instead clones 1901/11, 1941/8, 1895/4, 1939/2, 1901/7, 1895/1 and 1927/1 showed a significant increase in the degree of attack (Figure 1).

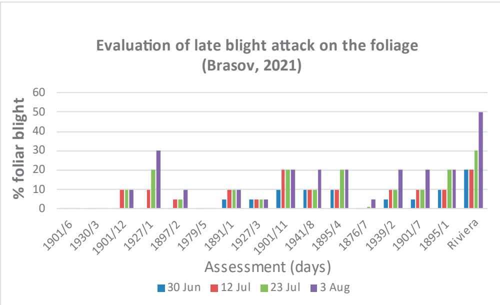

Figure 1. Development of foliar late blight disease in tested clones in 2021

In our trial in 2022, late blight was first noticed on the 6th of July. Ten days later on the 15th July, the early variety Riviera were infected. Other cultivars were infected on the 25th of July and 4th of August, although the infection rate remained at a very low level. Clones 1901/6, 1930/3 and 1979/5 were located towards the upper limit of the resistance on the foliage during the entire vegetation period. The clones 1927/1, 1091/11, 1941/8, 1895/4, 1939/2, 1901/7, 1895/1 showed the lowest level of resistance on the foliage, followed by 1901/12, 1897/2, 1891/1, 1927/3 (Figure 2).

AUDPC is a standard procedure used to estimate the amount of disease across a given season and the higher the value, the higher is the disease infection (Forbes et al., 2014).

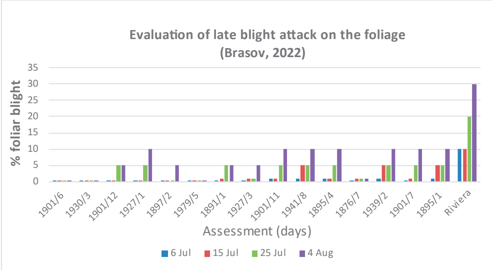

Figure 2. Development of foliar late blight disease in tested clones in 2022

There was a wide range in resistance reactions among the 16 clones in the two analysed years, with the most resistant having AUDPC values of less than 3 and the most susceptible with value of between 505. There was also a different distribution of clones between high and low values, with several having intermediate values. The highest level of AUDPC was observed to Riviera variety (955 scale-days), which confirm the high susceptible of the variety to late blight pathogen on foliage. The AUDPC value obtained in 2021 was less for clones 1901/6, 1930/3 and 1979/5 (3.4 scale-days) compared to other clones, indicating their level of resistance. During 2022, the highest AUDPC value (490 scale-days) was recorded from variety Riviera followed by AUDPC values of 152 scale-days from clones 1941/8,1939/2 and 1895/1, while the lowest AUDPC value (3.0 scale-days) was recorded from 1979/5 followed by 12.14 scale-days from the clones 1901/6 and 1930/3 (Table 2).

Table 2. Area under disease progress curve (AUDPC) of late blight on the 16 clones cultivated to NIRDPSB Brasov (2021-2022)

No.	Potato clones	Area under disease progress curve (AUDPC) value	
		2021	2022
1	1901/6	3.4	12.14
2	1930/3	3.4	12.14
3	1901/12	221.2	76
4	1927/1	441.2	101
5	1897/2	168.1	27
6	1979/5	3.4	3
7	1891/1	310	76
8	1927/3	170	45
9	1901/11	620	114
10	1941/8	395	152
11	1895/4	505	114
12	1876/7	40.25	25
13	1939/2	365	152
14	1901/7	365	110
15	1895/1	505	152
16	Riviera (reference)	955	490

To synthesize, the resistance to late blight of presented clones was done a classification on a 1-9 scale based on the computed resistance scale value developed by Malcolmson (1976) (Cruickshank et al., 1982) (Table 3).

Table 3. Category scale for resistance to potato late blight disease

Category of resistance	Resistance scale value (1-9 point scale)	Clones
Highly resistant	1	1901/6, 1930/3
resistant	1-2	1979/5
Moderately resistant	3-4	1927/3, 1901/12, 1897/2, 1891/1
Moderately susceptible	5-6	1927/1, 1941/8
Susceptible	7-8	1901/11, 1901/7, 1939/2
Highly susceptible	9	1895/1, Riviera

Differences in crop yield were found between the two years.

Due to dry weather conditions in 2022, late blight appeared with very low intensity in the season and was not the cause of decrease tuber yield.

The lower tuber yield in 2022 is explained by the hot and dry weather conditions in the vegetation season. The productions obtained are a clear reflection of the climatic conditions, the year 2022 being characterized as one of the hottest and driest years in the last 50 years. Drought established after the emergence of plants inhibits stolonization and can cause the resorption of stolons, thus reducing the number of tubers. These processes are irreversible, even if soil moisture is later restored. The drought between sunrise and budding hinders plant development and prolongs the period of tuber formation.

Table 4. Total yield tubers/hectare (t/ha) (Brasov, 2021-2022)

No.	Clone	Yield (t/ha) 2021	Signif.	Yield (t/ha) 2022	Signif.
1	1901/6	34.27	Ns	26.43	ns
2	1901/11	39.87	Ns	29.59	ns
3	1927/1	48.03	**	34.97	**
4	1895/4	42.52	*	31.69	**
5	19-1876/7	44.10	*	38.39	***
6	1979/5	57.90	***	42.41	***
7	1941/8	43.04	*	35.04	**
8	21-1901/7	45.55	**	33.12	**
9	1939/2	47.93	**	40.45	***
10	1901/12	34.34	Ns	27.19	ns
11	21-1895/1	29.13	Ns	21.09	ns
12	1927/3	24.33	Ns	30.15	**
13	1891/1	18.61	Ns	30.70	**
14	1930/3	30.11	Ns	19.33	ns
15	1897/2	40.31	*	34.17	**
16	Riviera (reference)	23.65	-	19.50	-

We subscribe to what other authors have presented (Kankwatsa et al., 2003; Legesee et al., 2021), namely that variations in disease severity scale, AUDPC values and yield between locations might be due to differences in environmental factors. Late blight epidemics were severe only when weather conditions are suitable for the pathogen such as heavy rains, cool temperatures and presence of moisture on the potato leaves for an extended period.

In 2021 the best yield was provided by line 1979/5 (57.90 t/ha), followed by lines 1927/1 (48.03 t/ha) and 1939/2 (47.93 t/ha). Also significantly high yield was registered to clones 21-1901/7 and 19-1876/7.

In 2022 a reduction in tuber yield was observed for majority of clones. The highest yield was recorded to clone 1979/5 (42.41 t/ha), while clone 1891/1 obtained almost a double production, and clone 1930/3 showed the exact opposite result.

The main causes of lower yields in some clones are the lack of water in the soil during tuber growth and the uneven distribution of precipitation during the vegetation period.

The continental climate, characterized by hot summers and low precipitation in the second part of the vegetation period, negatively influences the formation and accumulation of production.

The differences in production in the two years cannot be entirely attributed to the severity of the disease, but are influenced by the reproductive potential in certain climatic conditions. This is illustrated by clone 1930/3 which, although it is stable from the point of view of susceptibility to late blight.

CONCLUSIONS

Potato late blight disease development was different in the two years and depended from meteorological factors. Disease spread depending to the meteorological conditions was in the middle of July. In 2021 the disease growth was intensive and in August the control variety (Riviera) was destroyed. In 2022 late blight have not showed evidence, the attack level was very low.

Consequently, with the concerns about the negative effects of fungicides on the environment and on human health, some clones (1901/6, 1930/3, 1979/5) that presented higher levels of resistance to late blight are suitable to be used in the breeding programs as parental lines in crosses to generate populations aiming to develop varieties with resistance.

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