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RESPONSE OF SOME POTATO CLONES WITH POTENTIAL RESISTANCE TO LATE BLIGHT DISEASE (*PHYTOPHTHORA INFESTANS*) UNDER FIELD CONDITIONS

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ABSTRACT

In the present study thirteen potato clones were evaluated for resistance against late blight caused by Phytophthora infestans. Field experiment was conducted to NIRDPS Brasov, Romania, under natural epiphytotic conditions. The first symptoms of potato late blight disease were observed at 58 days after planting on Sasa x Pamela and R7Sasa x Orchestra clones. Out of 13 genotype, the incidence showed 2 genotpyes (Sasa R3 x Oceania and Sasa R7 x Orchestra) as highly susceptible, 2 varieties as moderately susceptible (Agria x Rustic (Cl1) and Agria x Rustic (Cl2)), 1 genotype as susceptible (Sasa x Pamela), 5 genotpyes relatively resistant (Sasa R3 x Rustic (Cl2), Sasa (R3) x Rustic (Cl3), Sasa (R3) x Orchestra, Sasa (R8) x Orchestra) Sasa (R6) x Orchestra) and 3 genotpys resistant (Sasa (R3) x Rustic (Cl1), Sasa x Fribel, Sasa x Florice). The Area under the disease progress curve (AUDPC) value was less for R3Sasa x Rustic, Sasa x Fribel and Sasa x Florice compared to other clones, indicating their higher level of resistance.

INTRODUCTION

Potato cultivation involves huge efforts. A classic breeding program often begins with 100,000 seedlings and ends with two or three varieties in more than 10 years (Bradshaw and Mackay, 1994). Potato, after wheat and rice, it is the third crop in order of consumption. The largest areas of potatoes are found in Asia and Europe.

There are two main challenges in its cultivation:

1. the crop multiplies vegetatively and a healthy seed is needed; to be grown in an area and/or period of the year free of insect vectors of viruses (aphids) in order to be productive;

2. the culture is not resistant to its main enemy: the late blight produced by the fungus *Phytophthora infestans.*

Potato late blight caused by the pathogen *Phytophthora infestans* first occured in 1840 in Belgium being imported from the Toluca Valley in Mexico which was thought to be its centre of origin. The disease spred rapidly to The Netherlands, France, Britain and Ireland, where was responsable for the Great Famine (1848-1848) (Bourke, 1964, Colon et al., 1995).

Under conducive climatic conditions, it takes only two days to destroy potato field (Sajid et al., 2019). Late blight association with secondary pathogens and soft

rotting bacteria can conduct to severe disease of tuber blight (2-5%) that can lead to complete loss of potatoes in storage (Dalsgaard and Pedersen, 1996).

Two type of resistance against late blight have been described in potato: qualitative resistance and quantitative resistance (Rauscher et al., 2010).

Late blight qualitative resistance is governed by resistance (R) genes that encode immunity through a hypersensitive reaction and is thought to be monogenic, specific and often of short durability due to the high genetic variability of the pathogen. Since the early part of the last century breeding activities have mainly focused on the high level of resistance conferred by dominant major R genes from the Mexican hexaploid wild *Solanum* species, *Solanum demissum*. Presently, many cultivars with *S. demissum* in their pedigree are available (Hajianfar et al., 2014).

Sixty-three resistance genes to *P. infestans* have been identified from various *Solanum* species and out of them twenty-seven have already been cloned (Rodewald and Trognitz, 2013). Eleven major resistance genes (R1-R11) which derive from the hexaploid wild potato species *S. demissum* (Black et al., 1953; Malcolmson, 1969) were identified and have been introgressed into cultivated potato (Gebhardt and Valkonen, 2001). These resistance genes are race-specific, thus they provide non-durable resistance and are rapidly overcome by virulent strains of the pathogen (Malcolmson and Black, 1966). From the *S. demissum*-derived R genes four have been cloned and analyzed. These are R1 (Ballvora et al., 2002), R2 (Lokossou et al., 2009), R3a (El-Kharbotly et al., 1996; Huang et al., 2005) and R3b (Li et al., 2011) Recently, Rpi genes were identified in the diploid wild potato species *S. bulbocastanum*l, and some of them were cloned. These cloned genes are the Rpi-blb1 also known as RB (Song et al., 2003), the Rpi-blb2 (Vossen et al., 2005), the Rpi-blb3 and the Rpi-bt1 (Oosumi et al., 2009). Another Rpi gene which possibly derives from *S. bulbocastanum* is the Rpi-abpt (Lokossou et al. 2009), that was isolated from a complex quadruple hybrid of *S. acaule* Bitter. S. bulbocastanum, *S. tuberosum* group *Phureja* and *S. tuberosum* (Park et al., 2005).

With the possibility of sexual recombination, genetic diversity has increased among the descendants of the pathogen, which causes difficulties in controlling late blight. In addition, the development of fungicide resistance in *Phytophthora* populations requires more frequent applications during the growing season to control the disease, causing contamination with a negative impact on the environment and human health (Grünwald et al.,2001).

MATERIAL AND METHODS

Experiments were carried out at the National Institue of Research and Development for Potato and Sugar Beet Brasov, Romania, on a cambic chernozeum soil, with 6.7 pH, humus 4.68% and clay 27%. The pre-crop was wheat and for current fertilizer was used 1000 kg/ha N:P:K:15:15:15+S.

Planting distance was 75 cm between rows and 30 cm between plants per row, having 4 rows with 10 plants each one. Planting was done manually in May 3, 2021.

During the vegetation were applied the usual maintenance works (hilling, herbicides), including three treatments for Colorado beetle unless late blight control with fungicides.

The biological material was represented by some varieties (Orchestra, Pamela, Florice, Rustic, Fribel) and genotypes with gene (R3, R6, R7, R8) with specific field resistance to late blight.

Observations were performed from the beginning of July to the middle of August once in 7-10 days.

Disease incidence was recorded by counting of plants that showing visible symptoms of late blight and the data were expressed as a percentage of the total assessed plants. The disease incidence was calculated with the following formula:

Disease incidence = (Number of diseased plant/total number of plant on a plot) x 100

Because late blight is a polyciclic disease it is recommanded to use the **Area under the disease progress curve** (AUDPC) to mesure resistance (Fry, 1978), using the formula (Campell and Madden, 1990):

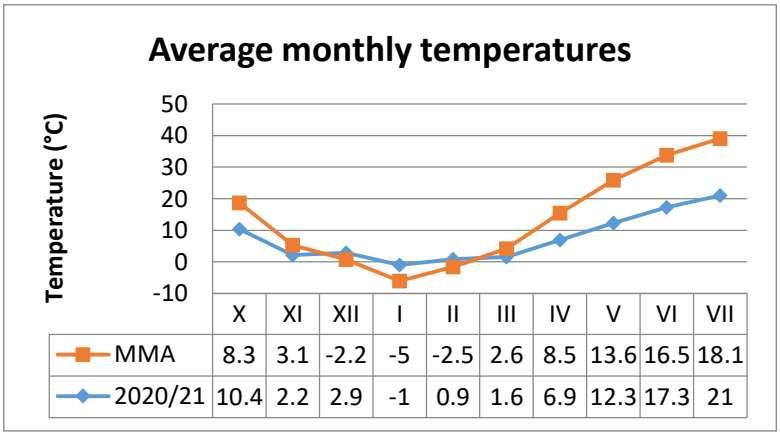
$$\mathbf{AUDPC} = \sum_{i=1}^{n-1} \left[\frac{Xi + Xi + 1}{2}\right](ti + 1 - ti)$$

, where „t" is the time of each reading, ‚y' is the percent of affected foliage at each reading and ‚n' is the number of readings. The variable ‚t' represent, in our case, the days after planting.

RESULTS AND DISCUSSIONS

1.1. Meteorological data

April month was colder than normal, with minimum negative air temperatures recorded for 10 consecutive days. Negative values were also recorded at ground level. The amount of precipitation that fell in April was 39.2 mm, which is 10.8 mm lower than the MAA. In May, the air temperature was lower by 1.3°C compared to the multiannual average, and the amount of precipitation was lower by 4.97 mm compared to the MAA value. June was a rainy month (106,1 mm), with precipitation in the first two decades even daily and with slightly higher temperatures than average (+0.8°C). in July the situation changed completely, registering much higher temperatures (+2.9°C) and a lower level of precipitation, by 28.7 mm compared to the multiannual average (Figure 1 and 2).



	X	XI	XII	I	II	III	IV	V	VI	VII
MMA	8.3	3.1	-2.2	-5	-2.5	2.6	8.5	13.6	16.5	18.1
2020/21	10.4	2.2	2.9	-1	0.9	1.6	6.9	12.3	17.3	21

Figure 1. Monthly temperature average

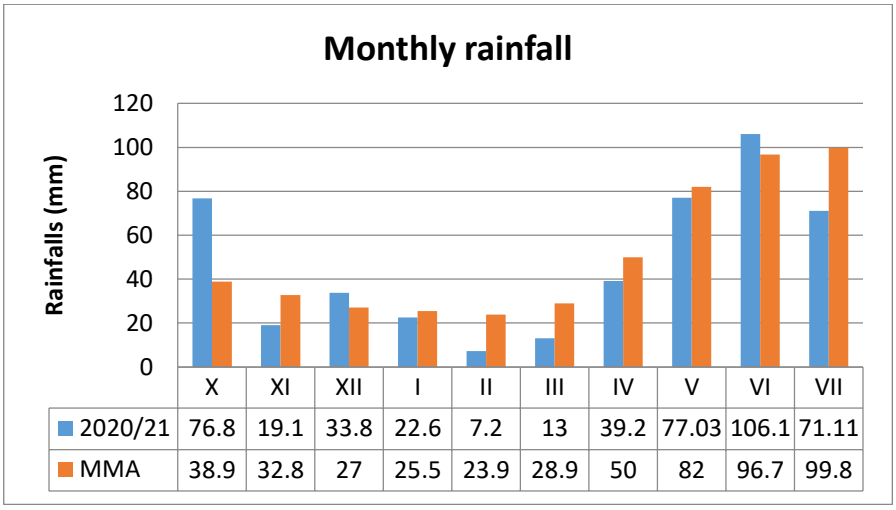


Figure 2. Monthly rainfall amount

Late blight is one of the most dangerous diseases of potato worlwide and cause significant yield loss. The pathogen is highly variable and adapt to the newly bred varieties and fungicides. The enviromental conditions decisively influence the resistance of varieties to late blight attack. In order to obtain conclusive results, the behavior towards the presence of the pathogen is studied both temporally (for several years) and spatially (same varieties in different locations), because not all varieties adapt to different environmental conditions.

1.2. Disease incidence and Area under disease progress curve (AUDPC)

The first symptoms of potato late blight disease were observed at 58 days after planting (DAP) on Sasa x Pamela and Sasa (R7) x Orchestra clones**.** The symptoms had appear on lower leaves, having light-to-dark green color and circular to irregularly shaped. In literature Pamela variety is considered like a resistant variety to foliage late blight, but with fairly low tuber resistance. Orchestra variety is considered moderately susceptible. It is noted that although one of the parents has a clearly defined resistance, under specific field conditions, it can be compromised. *P. infestans* rapidly overcome R genes and limits the durability of any single R gene. As a result, the R genes intro-gressed from *S. demissum* to the current clones have been overcome as new pathogen strains evolve that are virulent on the previously resistant hosts.

Disease incidence of the studied clones showed statistically significant difference at 5% level of significance. Out of 13 genotypes, the incidence showed 2 genotpyes (Sasa R3 x Oceania and Sasa R7 x Orchestra) as highly susceptible, 2 genotpyes as moderately susceptible (Agria x Rustic (Cl1) and Agria x Rustic (Cl2)), 1 genotpye as susceptible (Sasa x Pamela), 5 genotpyes relatively resistant (Sasa R3 x Rustic (Cl2), Sasa R3 x Rustic (Cl3), Sasa (R3) x Orchestra, Sasa (R8) x Orchestra) Sasa (R6) x Orchestra) and 3 genotpyes resistant (Sasa (R3) x Rustic (Cl1), Sasa x Fribel, Sasa x Florice) (Figure 3).

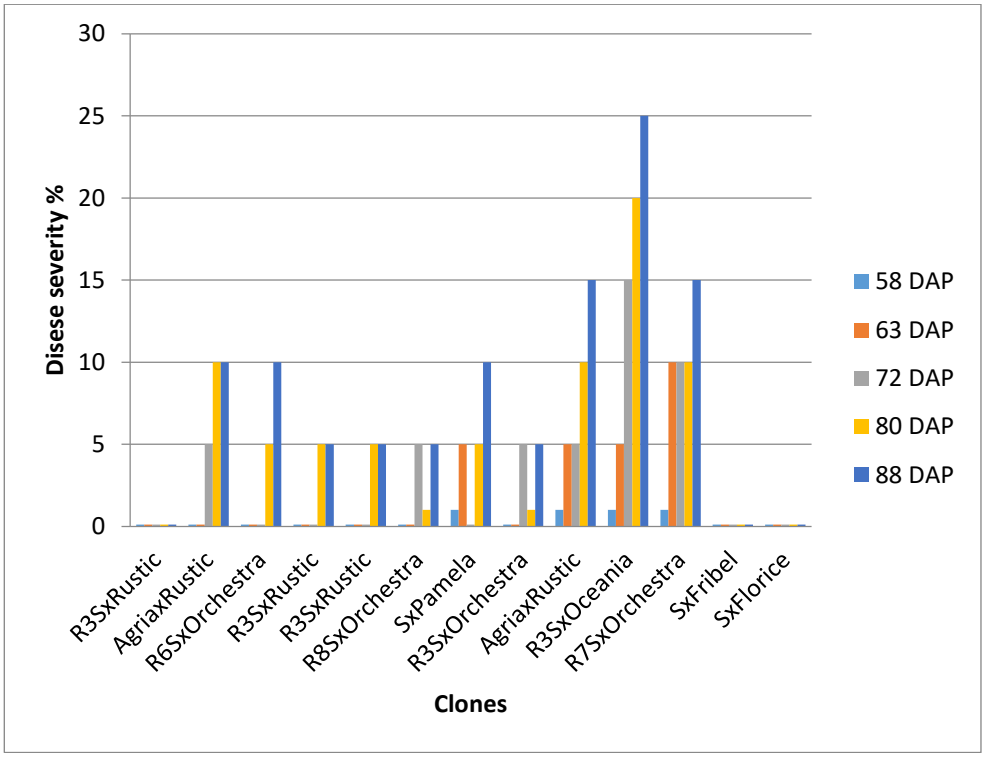


Figure 3. Disease severity (%) recorded

AUDPC estimates the area under the disease progress curve. This value is expressed as % - days, that is, the sum of non transformed daily percentage values of infection. Highest values will correspond to more susceptible and lowest values will correspond to more resistant genotpyes (Table 1).

Table 1.

Area under disease progress curve (AUDPC) of late blight on 13 potato clones cultivated to NIRDPSB Brasov in 2021

No.	Potato clones	Area under disease progress curve (AUDPC) value
1	Sasa (R3) x Rustic (Cl1)	3
2	Agria x Rustic (Cl 1)	163
3	Sasa (R6) x Orchestra	77
4	Sasa (R3) x Rustic (Cl2)	62
5	Sasa (R3) x Rustic (Cl3)	62
6	Sasa (R8) x Orchestra	71
7	Sasa x Pamela	118
8	Sasa (R3) x Orchestra	71
9	Agria x Rustic (Cl 2)	184

10	Sasa (R3) x Oceania	425
11	Sasa (R7)x Orchestra	298
12	Sasa x Fribel	3
13	Sasa x Florice	3

High level of AUDPC (425) were observed on Sasa (R3) x Oceania, which can be associated with the favorable environmental conditions registered in the first period of vegetation from this year. The lowest AUDPC (3) levels were observed to Sasa (R3) x Rustic (Cl1), Sasa x Fribel and Sasa x Florice clones.

The AUDPC value obtained was less for clones Sasa (R3) x Rustic (Cl1), Sasa x Fribel and Sasa x Florice compared to other clones, indicating their higher level of resistance. In the beginning, the increase of disease on all clones was slower however, afterwards the disease increase on clones Sasa (R3) x Oceania and Sasa (R7) x Orchestra was highly fast followed by both Agria x Rustic (Cl1) and (Cl2), but slower in Sasa (R6) x Orchestra, Sasa (R8) x Orchestra and Sasa (R3) x Orchestra.

CONCLUSIONS

Clones resistance with a fungicides correct strategy are the efficient solution to control late blight. The current assessment provides information on adaptability to specific environmental conditions, being predominantly influenced by location and season.

In the current study, three clones, Sasa (R3) x Rustic, Sasa x Fribel and Sasa x Florice exhibited the highest levels of resistance to late blight under field conditions.

The level of resistance of the tested clones can help the breeder to select materials which contain genes against the pathogen (major R genes and/or minor resistance genes) and assure the posibility to introduce them in new cultivars to reach highest and durable levels of resistance.

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