

IMPACT OF WEATHER PARAMETERS AND THE FUNGICIDE SPRAYING PROGRAM ON THE LATE BLIGHT (*Phytophthora infestans*) OF POTATO IN BRASOV AREA

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Abstract

Diseases like potato late blight (*Phytophthora infestans*) are among the major constraints that limit potato production. Climate changes have a strong impact both on the destructive potential of diseases and on the environment. A field investigation was conducted during 2023-2024 to National Institute of Research and Development for Potato and Sugar Beet Brasov. Twelve potato Romanian varieties and a fungicidal program were used. Data on first disease symptom appearance, disease incidence, and disease progress rate were recorded. The impact on the obtained yield was also analyzed. Generally, late blight severity in 2024 was greater than it was in 2023 as several varieties (Darilena and Marvis) reached high severity in both years. Furthermore, to other varieties late blight was absent (Cosiana and Asinaria in 2023) or its severity was less than 1% for the entire duration of the epidemic (Sarmis in 2023 and Asinaria in 2024).

Key words: assessment, climatic conditions, late blight, potato, yield.

INTRODUCTION

The oomycete *Phytophthora infestans* (Mont.) de Bary, the causal agent of the late blight disease in potato, is considered to be the most harmful pathogen in potato crops due to its rapid evolution, high adaptability and short epidemic cycle (Leesutthiphonchai et al., 2018; González-Jiménez et al., 2023). Potato late blight was one of the main factors involved in the infamous famine in Ireland in the mid nineteenth century (Yoshida et al., 2013). Moreover, this disease reappears in the form of different genotypes and causes huge losses in potato yields (Sawicka, and Kapsa, 2001; Yuen, 2021). Its harmfulness consists in destroying the aerial parts of plants, which in turn results in a reduction in the assimilation area and, thus, the quantity and quality of the yield of progeny tubers. The development of the disease is closely related to the meteorological conditions in potato field (Sawicka et al., 2022). It is well known that potato can be cultivated in diverse climatic conditions, and its production can be elevated significantly. Potato can yield 35 t/ha depending on environmental conditions and the cultivated varieties (Reddy et al., 2018).

Being considered a drought-sensitive crop, potato yield is impacted by the vegetative development of plant, such as plant height, haulms number, and leaves number and size (Deblonde et al., 2001). Besides vegetative growth, drought may affect the reproductive stage of potatoes by shortening the growth cycle (Kumar et al., 2007) or by reducing the size and the number of tubers (Eiasu et al., 2007; Nasir et al., 2022).

A study conducted in Finland (Kaukaranta, 1996) showed that an increase in temperature of even one degree will lead to the appearance of late blight 4-7 days earlier and a longer time of 10-20 days in which the crop will be susceptible. Milder winters allow tubers discarded in what constitute waste pile to survive as hosts for pathogens, including *Phytophthora infestans*, and to become a source of infection when tuber debris germinates (Haverkort & Verhagen, 2008). Also the pathogen might occur earlier in the season due to additional sources of inoculum in the soil - e.g. infected tubers from volunteer potato plants and/or oospores surviving in soil at low temperature (Quiroz et al., 2018).

Pesticide use is predicted to be higher if disease pressure increases, which will consequently affect the income from higher yields.

MATERIALS AND METHODS

The field trials were established in 2023 and 2024 to the National Institute of Research and Development for Potato and Sugar Beet Brasov. The experiment was laid out in a randomized complete block design with four replications. The experimental plot size was 18 m² planted with 4 rows spaced 0.75 m to each other and 0.30 m plant to plant spacing in a row. Twelve potato cultivars were included in the trials. Their tolerance/resistance to late blight on foliage and on tuber according to registration is presented in Table 1.

Table 1. Late blight tolerance/resistant registered level (according to the NIRDPSB Brasov varieties catalogue)

Variety	Foliage resistance	Tuber resistance
Sevastia	medium resistance	medium resistance
Marvis	medium resistance	medium resistance
Castrum	medium resistance	medium resistance
Asinaria	medium resistance	medium resistance
Sarmis	medium resistance	medium resistance
Braşovia	medium susceptible	medium susceptible
Cezarina	relatively resistant	relatively resistant
Cosiana	susceptible	susceptible
Azaria	relatively resistant	relatively resistant
Ervant	medium resistance	medium resistance
Darilena	medium susceptible	medium resistance
Foresta	relatively resistant	relatively resistant

Late blight observations were performed from the first disease appearance (2023, July 3rd, and 2024, June 4th). Plots were assessed for the extent of blight spots on the leaves. Each plot was assessed as a whole for percentage disease severity using a standard international accepted severity key (Anonymous, 1947; Cruiskshank et al., 1982), as follows: 1: none or very few lesions on the leaflets (0% foliage affected), 2:

(3% foliage affected), 3: (10% foliage affected), 4: (25% foliage affected), 5: (50% foliage affected), 6: (more than 50% but less than 75% stem and foliage affected), 7: (more than 75% but less than 90% affected), 8: only very few green areas of stem and leaf (much less 10%) and 9: 100% foliage destroyed.

In all cases, cultivation and maintenance was in line with current good agricultural practice.

The fungicide programs including the following fungicides applied (the active substance, and the label dosage are indicated in brackets):

2023 – Polyram DF (metiram 1.8 kg/ha), Zorvec Endavia (oxathiapripolin+benthiavalicarb 0.4 l/ha), Lieto (cymoxanil + zoxamide 0.45 kg/ha), Zorvec Endavia (oxathiapripolin + benthiavalicarb 0.4 l/ha), Carial Star (mandipropamid + difenoconazol 0.6 l/ha), Banjo (fluazinam 0.4 l/ha), and Banjo (fluazinam 0.4 l/ha).

2024 - Zetanil (cimoxanil+zoxamide 0.45 kg/ha), Cymbal 45 (cimoxanil 0.25 kg/ha), Zorvec Endavia (oxathiapripolin + benthiavalicarb 0.4 l/ha), Carial Star (mandipropamid+difenoconazol 0.6 l/ha), Cymbal 45 (cimoxanil 0.25 kg/ha), Banjo (fluazinam 0.4 l/ha), and Banjo (fluazinam 0.4 l/ha).

Yield assessment: two rows in the center of each plot were harvested mentioned the number and the weight of tubers with blight (blighted tubers assessments are usually based on a sample of 100 tubers per plot).

RESULTS AND DISCUSSIONS

In 2023 growing season was warm but no so dry. The temperatures between May and August (18.2°C) was higher on average by 1.8°C, compared to MAA, registering higher values by 1.1°C in June, 2.4°C in July and 3.4°C in August compared to MAA. The rainfalls in June (111.1 mm) and August (77.5 mm) exceeded the MAA (96.7 mm, respectively, 76.4 mm) as volume, but it must be stated that there were quantitatively significant rains in a short period of time After a wet August a significant precipitation deficit was registred in September, only 11 mm compared to 65.6 mm.

In 2024, in May, the air temperature was at the level of the MAA, but the amount of precipitation was much lower than the MAA values, registering only 42.7 mm compared to 82 mm. The summer months (June-August) recorded higher temperatures than the MAA, with an average of 4.6°C higher in June. Also, the volume of precipitation was much lower in all three months, establishing the phenomena of atmospheric and pedological drought. It should be emphasized that a large volume of precipitation fell in a very short time (for example, the month of August when 90% of the total quantity of the month fell in four days). The month of September recorded a temperature 3.5°C higher than the MAA and a volume of precipitation of 57.8 mm (Figures 1-2).

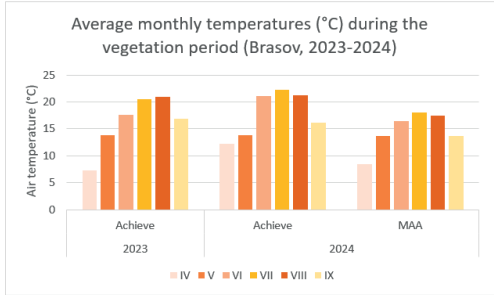


Figure 1. Air temperature during the experiment (Brasov, 2023-2024)

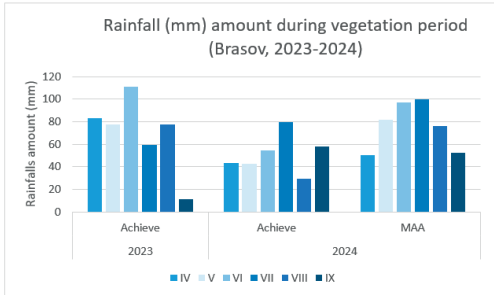


Figure 2. Rainfalls during the experiment (Brasov, 2023-2024)

In 2023, the first symptoms of the disease appear in July 3rd as a result of heavy rainfall in June and the high temperatures, but during July the situation had changed (Figure 3). There was a low volume of precipitation, with 40.7 l/mp less than MAA accompanied by a temperature level higher with 2.4°C, and the disease ability to manifest has been diminished.

In 2024, the first symptoms of late blight were observed on June 4 to the Cosiana variety (Figure 4). However, it must be emphasized that the attack was of low intensity due to the climatic conditions, severe drought, lack of precipitation over long periods of time. The preventive application of treatments also contributed to the inactivation of the fungus, the possibilities of sporulation being very low. Currently, European legislation requires member states to promote a disease and pest control policy that uses fewer chemicals within an integrated plant protection management. Knowing the mode of action of fungicides and using them according to the situation in the field contributes to reducing losses. Carrying out the registration and the subsequent analysis of climatic variables is fundamental to the development of agronomic and sanitary management recommendations for the crop (Kessel et al., 2018). Climatic variables such as relative humidity, precipitation, and temperature are relevant factors for the proper development of late blight epidemic (Rodríguez et al., 2023).

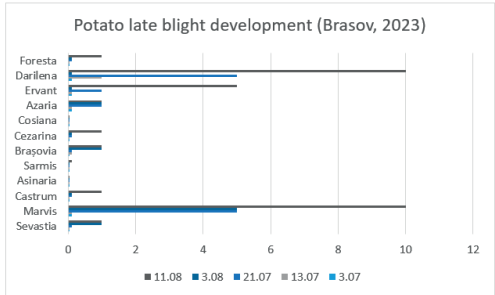


Figure 3. Potato blight development dynamics in potato cultivars (Brasov, 2023)

In 2023, first signs of late blight presented varieties Marvis, Azaria, Ervant, Darilena in 3rd July, when the first treatment (Polyram DF) was done after ten days, at the time of the second treatment (Zorvec Endavia) also Brasovia variety presented symptoms. Disease was found only on the leaves. However, the infection rate was very low at approximately 0.1-0.5% of total foliage surface. Two weeks later, on the 21st of July, late blight spots were noticed on foliage of the varieties Marvis and

Darilena, but the disease developed very slowly, still progressing till 11 of August.

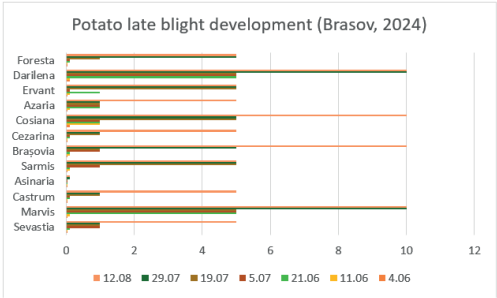


Figure 4. Potato blight development dynamics in potato cultivars (Brasov, 2024)

At the time of the first treatment (Zetanil), some spots were observed only in the Cosiana and Darilena varieties. Assessments were made and sporadic spots were recorded in most varieties and was applied the second treatment (Cymbal 45). Starting with the third treatment (Zorvec Endavia), a differentiation is produced based on the climatic conditions and the resistance level of the variety in the given specific conditions. Thus, after the fourth treatment (Carial Star), the Asinaria variety responded best, followed by the Cezarina, Ervant and Castrum. At the end of the assessments, the intensity of the attack was between 0.1% to Asinaria variety and 10% to Marvis, Brasovia, Cosiana and Darilena. Prophylactic spray with contact fungicide and second spraying with translaminar/ contact fungicide when the first symptoms appeared, followed by third spraying with systemic or contact fungicide according to the climatic conditions and the two final spraying with contact fungicide effectively managed the late blight disease. The weather was not conducive for late blight, the disease development was impeded in both years, because of high temperature and lack of rainfalls. We subscribe to what other authors have observed (Cucak et al., 2021), namely that potato production is completely dependent on the prophylactic use of fungicides due to the high potential risks of crop loss associated with potato late blight outbreaks. Significant differences in yields between varieties were observed in September 2023. The

medium late variety Cosiana had a lower yield (21.11 t/ha), which can be justified by the later maturity, but Foresta (14.0 t/ha) and Darilena (21.06 t/ha) did not give the expected results. In terms of total yield, Ervant (45.47 t/ha), Castrum (41.31 t/ha), and Azaria (40.69 t/ha) varieties were homogeneous, whereas for marketable yield, the Marvis (33.36 t/ha) and Asinaria (31.11 t/ha) varieties were homogeneous in this trait. Sarmis being a cultivar that accumulates early, the production of large tubers was high (11,92 t/ha), the total yield (26,94 t/ha) being similar with that of Cezarina (26,08 t/ha) and Sevastia (25,69 t/ha) varieties, which, however had a high production of tubers of 35-45 mm (the seed fraction). Also Brasovia variety was registered as having a high seed production (20.72 t/ha) from the total of 26.11 t/ha (Table 2). The visual inspection made at the harvest not revealed latently infected tubers. Tubers with low infection severity may be overlooked and therefore, after storage for the seed material in the following year, in spring is made another selection.

Table 2. Potato yield obtain in 2023 to NIRDPSB Brasov

Variety	Tuber >45 mm yield	Tuber 35-45 mm yield	Tuber <35 mm yield	Total yield
Cosiana	8.03	11.33	1.75	21.11
Marvis	12.28	21.08	1.69	35.06
Darilena	6.19	14.17	0.69	21.06
Asinaria	13.08	18.03	0.53	31.64
Sarmis	11.92	13.94	1.08	26.94
Cezarina	7.53	16.78	1.78	26.08
Foresta	6.03	7.19	0.78	14.00
Ervant	25.03	19.31	1.14	45.47
Sevastia	7.14	17.69	0.86	25.69
Azaria	20.50	19.19	1.00	40.69
Castrum	16.03	23.36	1.92	41.31
Brasovia (Mt)	4.03	20.72	1.36	26.11
DL 5%	3.78	3.66	0.84	4.99
DL 1%	5.06	4.91	1.13	6.69
DL 0.1%	6.68	6.48	1.49	8.83

In 2024, the lack of water and excessive temperatures lead to the installation of the phenomenon of excessive drought, with serious consequences on potato production. At the harvest, on September 19, it was observed that Ervant and Azaria varieties recorded the highest number of large (5.22 t/ha, respectively 4.86 t/ha) tubers, differentiating very significantly from the other varieties. Also, Azaria (16.97 t/ha), Ervant (16.94 t/ha) and Castrum (16.58 t/ha) registered a significant number of tubers in the 35-55 mm fraction, which actually represent the seed potato. However, the Darilena variety

registered a very significant number of small tubers, which is not gratifying. The total production was not at the level of the productive potential of any of the varieties. The recorded values were between 25.72 t/ha for the Azaria variety and 7.58 t/ha for the Cezarina variety (Table 3).

Table 3. Potato yield obtain in 2024 to NIRDPSB Brasov

Variety	Tuber >45 mm yield	Tuber 35-45 mm yield	Tuber <35 mm yield	Total yield
Cosiana	1,81	14,50	4,31	20,61
Marvis	1,89	7,44	2,69	12,03
Darlena	0,75	7,03	6,50	14,28
Asinaria	2,67	11,75	2,97	17,39
Sarmis	1,58	9,14	3,39	14,11
Cezarina	0,67	4,64	2,28	7,58
Foresta	2,50	9,00	1,53	14,00
Ervant	5,22	16,94	2,53	24,69
Sevastia	3,19	8,69	1,19	13,08
Azaria	4,86	16,97	3,89	25,72
Castrum	2,08	16,58	3,19	21,86
Brasovia (Mt)	0,53	8,56	3,50	15,58
DL 5%	2,18	3,41	1,27	3,34
DL 1%	2,92	4,57	1,70	4,47
DL 0.1%	3,85	6,03	2,24	5,90

Comparing the productions obtained in 2024 with those of 2023, which from a climatic point of view was warmer and with less precipitation, was observed that most varieties (Castrum, Azaria, Ervant, Sevastia, Asinaria, Sarmis and Braşovia) had production halved, Marvis and Cezarina registered dramatic decreases, Cosiana and Foresta varieties maintained their production at low level.

CONCLUSIONS

There is already an observed warming trend and major changes in the distribution of precipitation over an agricultural year. Currently are in use a large number of late blight forecasting modes which gives satisfactory information. Thus, the implementation of a forecasting model reduces the frequency of fungicides application up to 50 % as compared with conventional, calendar based schedule. Chemical control must be judicious and treatments carried out only when necessary to keep disease below economic thresholds. A spray program that alternates between fungicides may be effective in controlling the disease but also in avoiding the build-up of resistance of *Phytophthora infestans*. In the years 2023-2024 at NIRDPSB Brasov in adverse climatic conditions, high temperatures, the lack of precipitation and at the time of their appearance, their unevenness, made the potato

late blight not manifest at an epidemic level. By also applying foliar treatments at "key moments", the control of the disease was effective.

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