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Results Regarding the Re-emergence of Early Blight (*Alternaria* spp.) and Risk Management in Potato Growing Areas

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ABSTRACT

Early blight caused by *Alternaria* spp. is a problem in many potato and tomato growing areas. Since some years, more and more countries report an increasing occurrence of early blight in the fields. Attacks of early blight was not see in potato fields from Barsa country, Romania, in the last years. But 2019 was an year with reemergence of early blight attack to different potato varieties. Application of fungicides is commonly used to effectively control the disease, although they are undesirable due to environmental consequences. Use of resistant cultivars would be the most optimal solution, but there are no cultivars with high level of resistance available on the market. Potato trials were carried out between 2019-2020 to the NIRDPSB Brasov on chernozeum soil with a randomised complete block design and four replicates with five Romanian varieties: Brasovia, Cezarina, Asinaria, Sevastia and Castrum. At the time of the disease, observations were made regarding the level of the attack. The determinations were performed on the lower, middle and upper level of the foliage of the tested plants (10 plants x 2 rows x 4 repetitions). Area under the disease progress curve (AUDPC) was calculated based on visual assessment of foliar disease during the growing season each year. AUDPC ranged from 3143 to 170.5 in 2019 and from 1681.6 to 54 in 2020, respectively. The obtained productions varied between 27.17 t/ha (Castrum variety) and 43.03 t/ha (Cezarina variety) in 2019 and between 37.06 t/ha (Castrum variety) and 61.12 t/ha (Sevastia variety) in 2020.

Keywords: *Alternaria* spp., lesions, potato, varieties, yield.

INTRODUCTION

Early blight caused by *Alternaria* spp. is a problem in many potato and tomato growing areas. Since some years, more and more countries report an increasing occurrence of early blight in the fields.

In recent years, there has been a concern about the increase of early blight in potato fields, even in areas where the disease barely caused problems. The climatic tendency of increases in the temperature has shown changes in the behaviour of *Alternaria*, with a higher severity of early potato blight (Abuley and Nielsen, 2017; Adavi et al., 2018).

Early blight is caused by a group of species of the fungal genus *Alternaria*. At least two species are responsible for early blight symptoms on potatoes, *A. solani* and *A. alternata*. These fungi overwinter in the soil, on crop debris and infected tubers. They are pathogenic to *Solanaceous* plants, potatoes and tomatoes, but can also be considered as saprophytes. The spores are spread by the wind and rain splashing.

In Europe beem latent present, early blight has not been in the focus of plant protection until reports on an increase in the frequency and severness of the disease in the field a decade ago (Leiminger, 2009; Nottensteiner et al., 2019).

Immature potato plants are relatively resistant to early blight. After the tubers initiation, susceptibility increase gaduallly and mature plants are very susceptible to *A. solani* (Rotem, 1994; Shtienberg, 2013).

Climate change may modify rainfall, soil water, runoff, and may reduce crop maturation period and in the same time increase yield variability and could reduce the areas suitable for the production of many crops (Olesen and Bindi, 2002; Haș et al., 2022).

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Factors such as more favourable weather conditions or stricter fertilisation guidelines with lower nitrogen dosage could be contributing to the disease increase (Vanhaverbeke et al., 2019). Besides the age of the plant, the state of health and vigor, the susceptibility to the disease is also influenced by the nutrition of the plant.

To suppress *Alternaria* spot disease causal agents and to prevent the losses it causes, potato fields are intensively sprayed with fungicides (Harrison and Venette, 1970; Pasche et al., 2004). Fungicides of various chemical groups are currently used worldwide to control *Alternaria* spp. on potato. Optimization of fungicide use for the control of *Alternaria* diseases is still a considerable challenge due to the capacity of pathogen to produce huge amounts of inoculum (Ahmed, 2017), so there is a challenge of selecting fungicide resistance in target populations of *Alternaria* spp. (Campo et al., 2007).

For environmentally friendly farming in conventional farming systems it is essential to include early blight resistant potato cultivars and thereby save on the cost of fungicides (Runno-Paurson et al., 2015).

Climate change during the last decade has exerted its influence both on the plants, as well as the pathogens in an area. As such, either certain unknown pathogens have emerged or the existing ones have modified their traits under the influence of genetic or environmental factors (Popescu, 1998), thus leading to significant damage (Suciu et al., 2020). The humidity is a limiting factor with consequences on plant growth and distribution, when it is associated with a high temperature (Zheng et al., 2012).

Attacks of early blight was not see in potato fields from Barsa country in the last years. But 2019 was an year with reemergence of early blight attack to different potato varieties.

MATERIAL AND METHODS

The potato trials were carried out at National Institute of Research and Development for Potato and Sugar Brasov on chermozeum soil cambic chernozeum with 6.6 pH, humus 4.68% and clay 27%. The pre-crop in both years was wheat.

The field experiments were set up in random block, 4 replicate plots with 4 rows each with 21 plants. The size of elementary plot was 9 m^2, with the distance 75/30 cm. Fertilizer, NPK 15-15-15+S, was applied at 1000 kg/ha rate in both years before potato planting.

In 2019 the potatoes were planted on 4 April and in 2020 were planted in 6 April

Because the impact of late blight is normally more severe than that of early blight were used fungicides which effectively controls the both diseases, like metiran 700 g/ha a.i. (1.8 kg/ha), Bravo 500 SC clorotalonil 500 g/l a.i. (2.0 l/ha), Carial Star mandipropamid 250 g/l + difenoconazol 250 g/l a.i. (0.6 l/ha) and twice Shirlan 500 Scfluazinam 500 g/l a.i. (0.4 l/ha).

Readings were recorded with the appearance of natural disease symptoms. Disease severity and incidence were estimated as follows:

0 = no leaf lesion;

1 = lesions on <25% of leaf area;

2 = lesion on 26-50% of leaf area;

3 = lesion on 51-75% of leaf area;

4 = lesions on 76 up to 100% of leaf area, according to the scale suggested by Cohen et al. (1991), then the traits calculated using the formula:

$$D.S. = \sum (n \times c)/N$$

where:

D.S. = intensity of attack;

N = number of infected plants per category;

c = category number;

N = total examined plants.

Observations were made at the time of the onset of the disease level of the attack, assessing 10 plants on the two middle rows of each variant. Attack level determinations were performed on the lower, middle, and upper level of the tested plants. During the vegetation period, 5 observations were made; in 2019 in 5, 15, 25 July and 5 and 19 August and in 2020 in 2, 13 23 July, 3 and 13 August.

Whereas, area under disease progress curve (AUDPC) was estimated to compare different responses of the varieties, the following equation described by Pandey et al. (1989):

$$AUDPC = D\,[1/2\,(Y1 + YK) + Y2 + Y3 +\ldots+ Y\,(K-1)]$$

where:

D = Days between readings;

Y1 = First disease record;

Yk = last disease record.

Tubers from the two centre rows of each plot were harvested. After the tubers were harvested, they were graded into three categories, tubers >60 mm, 35-60 mm and >60 mm and the totaly yield by weight was determinated.

Statistical analysis: Data were subjected to statistical analysis by M-STAT C (Russel, 1991). The differences among means were performed using least significant difference (LSD) at 5% level.

RESULTS AND DISCUSSION

In May 2019 the average monthly temperature was close to normal, but in June exceeded with 3.1°C the MAA. In the second part of the vegetation (July, August and September) the average monthly temperatures fluctuated, with values between +0.9°C in July, less with 2.0°C in August and +1.2°C in September).

The relatively high quantity of rainfall in May and June (208.6 mm) together with the optimum temperatures, favored (16.5 average), besides the development of plants, the attack of foliar diseases, including early blight.

In 2020 in the June - August period, higher average temperature values were recorded compared to MAA, reaching an average of +1.3°C. Rainfalls above the multiannual values was also recorded in June and July (Table 1), but it should be noted that rainy days were frequent (15 days in June and 12 in July), but with light rainfall, less than 5 mm (8 days in June and 4 days in July), a phenomenon that favors rapid evaporation. Immediately after the rain, the humidity of the air increases, not of the soil, thus creating favorable conditions for the attack of foliar diseases.

Table 2. Air temperature and rainfalls during the experiment (Brasov, 2019-2020)

Year	Month					
	May	June	July	August	September	
	Air temperature (°C)					Average
2019	13.4	19.6	19.0	15.5	14.8	16.5
2020	12.8	17.8	19.2	19.7	16.3	17.2
MAA	13.6	16.5	18.1	17.5	13.6	15.9
	Amount of rainfall (mm)					Total
2019	98.6	110.0	68.6	86.2	8.9	372.3
2020	106.0	120.1	104.1	53.4	75.5	459.1
MAA	82.0	96.7	99.8	76.4	52.5	407.4

The most of the cultivars in both years showed the first symptoms (1%) on July 7th 2019 and respectively in July 2nd 2020 during the phase of starting potato maturity.

First symptoms appeared at same time in all cultivars, excepting Asinaria, in which started two week later. Castrum and Sevastia presented the highest severity to the lower level, with near to 50% of rate of affectation.

Highest disease attack in 2019 was recorded to the lower level of Castrum variety (53.3% in August 5th) and the lowest attack was registred to Asinaria variety (3.7%). Also Sevastia variety presented highest intensity to the lower level, with 39.9% (in August 19th) rate of affectation, while Brasovia and Cezarina varieties presented a medium level of attack (26.3%, respectively, 22.4%) at the same time (Figure 1).

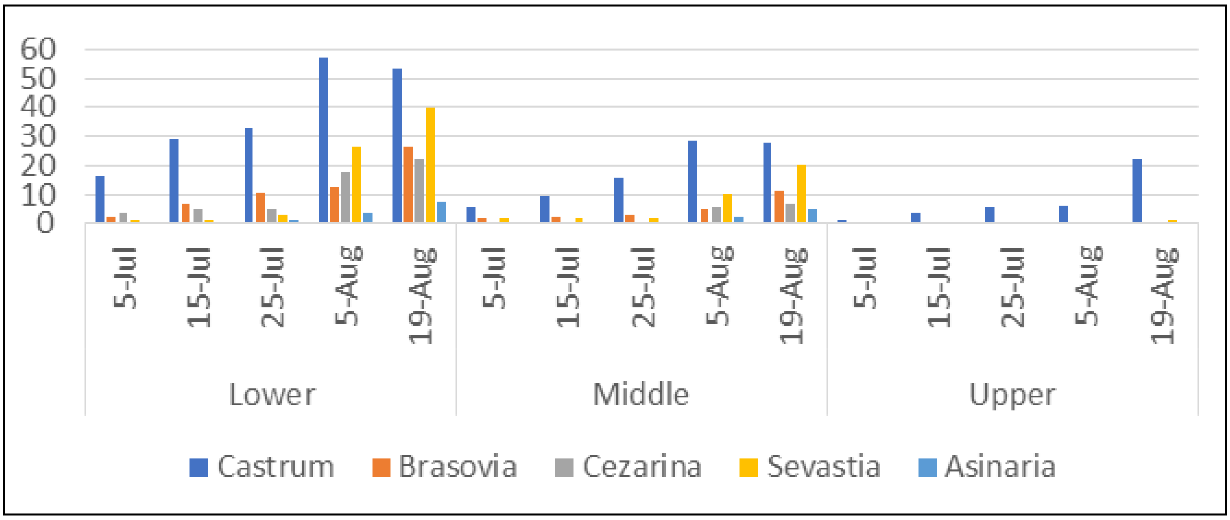

Figure 1. Disease incidence of early blight in different potato varieties (Brasov, 2019)

Also in 2020 Castrum variety presented highest attack to the lowest level in August 13th. At the upper level, no signs of attack were presented, with the exception of the Castrum variety. Unlike the year 2019, Sevastia variety recorded very low attack values, to the lower level 1.7%, respectively, 0.6% to the middle one in the same period (Figure 2).

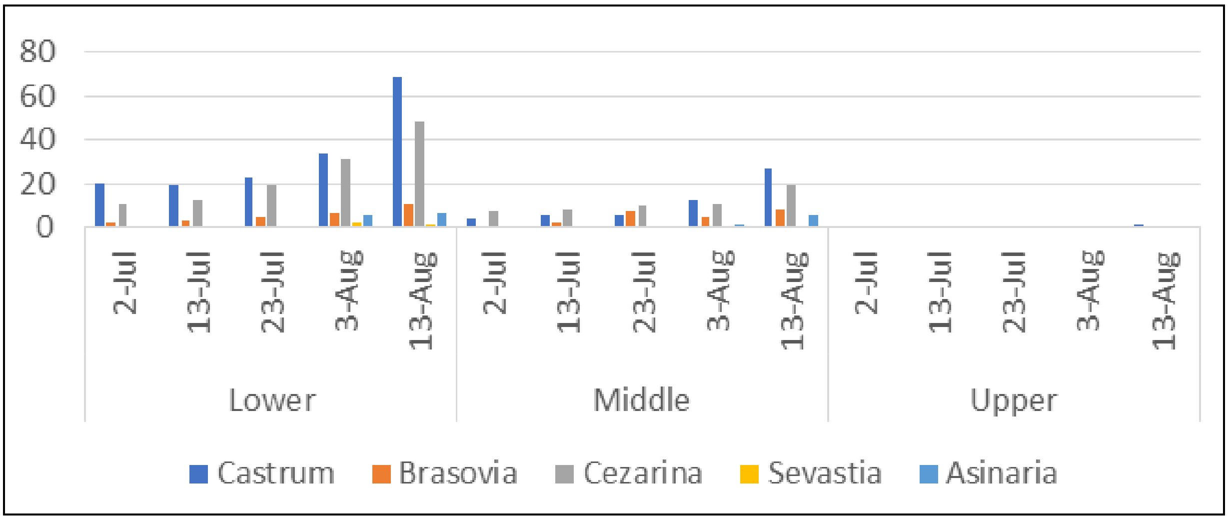

Figure 2. Disease incidence of early blight in different potato varieties (Brasov, 2020)

The area under the disease-progress curve (AUDPC) is considered one of the main criteria to be used in comparative epidemiological studies, and there was high correlation between AUDPC and the progress rate of the disease.

Data from the growing seasons 2019 and 2020 divided the varieties into three main groups. In 2019 the first group included Asinaria with the lowest values of AUDPC (less than 200), the second group Cezariana, Brasovia and Sevastia (less than 1000) and the third group Castrum (with more than 3000).

In 2020 first group included Asinaria and Sevastia with the lowest values of AUDPC (less than 100), the second group Brasovia (less than 500) and the third group Castrum and Cezarina (more than 1400).

Very high levels of AUDPC (>3000 in 2019 and >1500 in 2020) were observed in both years to Castrum variety and in 2020 also to Cezarina. In the case of Cezarina variety the high AUDPAC was possibly associated with the early manifestation of disease and the very favorable environmental conditions registered. The lowest AUDPC levels were observed to Asinaria variety in both years with an AUDPC of 170.5 and 54, respectively (Table 2).

Table 2. Area under disease progress curve (AUDPC) of early blight on 5 potato varieties cultivated to NIRDPSB Brasov during seasons 2019 and 2020

Potato varieties	Area under disease progress curve (AUDPC)	
	Season 2019	Season 2020
Castrum	3143	1650
Brasovia	742	421.75
Cezarina	610.10	1681.6
Sevastia	992.85	99.5
Asinaria	170.5	54

Results from the present study are similar with those reported in the literature regarding the impact of climatic conditions on the development of disease epidemics. In the two warm years evaluated in the present study, early blight epidemics developed faster to a sensitive variety based on the AUDPC.

In the present trials were recorded severe early blight infection with destruction of most of the potato canopy. The results showed that application of fungicides against late blight give some control of early blight also.

The results showed clearly that Castrum and Cezarina varieties can be infected severely by early blight in favorable climatic conditions, causing early defoliation of potato plants.

So genetic resistance of cultivars to pathogens is a major factor for consideration where there is severe pressure from the early blight pathogen (Kapsa and Osowski, 2012).

Table 3. Synthesis of variance analyses for early blight determinations (Brasov, 2019-2020)

	No. lesions/leaf (2019)				No. lesions/leaf (2020)			
	Upper level	Middle level	Lower level	Total plant	Upper level	Middle level	Lower level	Total plant
Experimental mean	0.1	8.2	12.3	20.6	0	5.0	9.5	14.5
CV%	-	28.3	37.5	29.8	-	19.3	27.2	28.3
DL1%	-	4.3	6.4	7.1	-	3.5	4.2	5.0

From the synthesis of the results of the analysis of variance (Table 3) for the determination of early blight attack to the studied varieties, it was observed that the number of lesions decreases from the lower level to the upper one. On the lower level an average of 12.3 lesions was recorded/level/leaf, on the middle level there were 8.2 lesions/level/leaf and on the upper level there were 0.1 in 2019. In 2020, generally the values were smaller, on the lower level an average of 9.5 lesions was recorded /level/leaf, on the middle level there were 5.0 lesions/level/leaf and on the upper level no lesions.

The disease severity can affect tuber yield and its development, therefore, the total tuber yield of each variety were quantified.

In 2019 Cezarina variety was the cultivar with the best yield (43.30 t/ha) followed by Brasovia (control), Asinaria and Castrum, with production that ranging between 38.25 and 27.17 t/ha. Sevastia was the least productive cultivar (Table 4).

In 2020 Brasovia and Asinaria varieties were the cultivars with the best total yield, with values between 30.09 and 29.10 t/ha (Table 5).

Table 4. Total tuber yield (t)/hectare (Brasov, 2019)

Variety	Total yield (t)	Dif. (t)	Sign.
Brasovia (control)	38.25	-	-
Asinaria	28.41	-9.84	ns
Castrum	27.17	-11.08	o
Cezarina	43.30	5,05	ns
Sevastia	16.83	-21.42	o o

DL 5% = 10.82 t/ha;
DL 1% = 14.50 t/ha;
DL 0.1% = 19.14 t/ha.

Table 5. Total tuber yield (t)/hectare (Brasov, 2020)

Variety	Total yield (t)	Dif. (t)	Sign.
Brasovia (control)	30.09	-	-
Asinaria	29.10	-0.99	ns
Castrum	19.57	-10.53	o
Cezarina	24.04	-6.05	ns
Sevastia	25.90	-4.19	ns

DL 5% = 8.42 t/ha;
DL 1% = 11.28 t/ha;
DL 0.1% = 14.89 t/ha.

Analyzing the plots and trying to relate the symptoms with the yields, Brasovia and Asinaria varieties showed less symptoms and higher yield (Brasovia 38.25 t/ha in 2019, respectively, 30.09 t/ha in 2020 and Asinaria 28.41 t/ha in 2019, respectively, 29.10 t/ha in 2020). Cezarina variety presented the highest production, 43.30 t/ha, in 2019, but a lowerone in 2020, below the variety’s potential (24.04 t/ha). It is worth mentioned the case of Castrum variety that under natural conditions is sensitive to the disease and, once infected, quickly reached senescence. This is reflected in 2020 in the yield, being the variety that obtained the lowest (19.57 t/ha).

Fungicides are important in suppressing damage caused by early blight. But there are reports of certain fungicides losing their efficacy on many isolates of the early blight pathogen. It is important to use fungicide chemistries with different modes of action in the spray program to prevent fungicide resistance build-up.

As the frequency of hot summers in Romania has increased, so the pressure of early blight, particularly on susceptible potato cultivars has increased. Thus, the opinion of other researchers regarding climate changes and possible changes in the epidemiology of the pathogen must be taken into account and investigated (Runno-Paurson et al., 2014).

CONCLUSIONS

The goal of the present study was to identify and develop a disease management system with only a few fungicide applications and which can be adapted to some relative resistant varieties. Early blight is often more severe when the potato crop has been under stress, ie., poor nutrition, injury, insect damage, or drought.

Considering the drier summers and the increased temperature in central part of Romania, we could expect a longer duration and an increased intensity of early blight epidemics in potato crops in future years.

Several factors may have led to increased incidence of early blight in potato crops:

- Climate change, resulting in warmer summers;
- Growing of more susceptible potato varieties;
- Decreased use of broad-spectrum fungicides for the control of late blight (*Phytophthora infestans*).

With an adequate number of treatments on the vegetation, a reduction in the incidence of the disease and an increase in yields can be achieved.

It should be noted that monitoring the early blight attack is necessary to compare the results on several varieties and in different environmental conditions.

REFERENCES

Abuley, I.K., Nielsen, B.J., 2017. *Evaluation of models to control potato early blight (Alternaria solani) in Denmark.* Crop Prot., 102: 118-128.

Adavi, Z., Moradi, R., Saeidnejad, A.S., Tadayon, M.R., Mansouri, H., 2018. *Assessment of potato response to climate change and adaptation strategies*. Sci. Hortic., 228: 91-102.

Ahmed, A.I.S., 2017. *Biological Control of Potato Brown Leaf Spot Disease Caused by Alternaria alternata Using Brevibacillus formosus Strain DSM 9885 and Brevibacillus brevis Strain NBRC 15304*. J. Plant Pathol. Microbiol., 8: 413. doi: 10.4172/2157-7471.1000413

Campo, A.R.O., Zambolim, L., Costa, L.C., 2007. *Potato early blight epidemics and comparison of methods to determine its initial symptoms in a potato field*. Rev. Fac. Nac. Agron. Medellin Colomb., 60: 3877-3890.

Cohen, Y., Gisi, U., Mosinger, E., 1991. *Systemic resistance of potato plants against Phytophthora infestans induced by unsaturated fatty acids*. Physiol. Mol. Pl. Pathol., 38: 255-263.

Harrison, M.D., Venette, J.R., 1970. *Chemical control of potato early blight and its effect on potato yield.* Am. Potato J., 47: 81-86.

Haș, V., Tritean, N., Copândean, A., Vana, C., Varga, A., Călugăr, R., Ceclan, L., Simon, A., 2022. *The impact of climate change and genetic progress on performance of old and recent released maize hybrids created at the ARDS Turda*. Rom. Agric. Res., 39: 99-110. https://doi.org/10.59665/rar3910

Kapsa, J.S., Osowski, J., 2012. *Host-pathogen interaction between Alternaria species and S. tuberosum under different conditions*. In: Schepers, H.T.A.M. (eds.), Proceedings of the 13th EuroBlight Workshop, PPO-Special Report, 15: 107-112.

Leiminger, J.H., 2009. *Alternaria spp. an Kartoffeln-Empirische Untersuchungen zur Epidemiologie, Schadrelevanz und integrierten Bekampfungsstrategien.* PhD. Thesis, Technische Universitat Munchen, Druck und Verlang H. Hieronymus.

Nottensteiner, M., Absmeier, C., Zellner, M., 2019. *QoI fungicide resistance mutations in Alternaria solani and Alternaria alternata are fully established in potato growing areas in Bavaria and dual resistance against SDHI fungicides is upcoming*. Gesunde Pflanzen, 71(3): 155-164.

Olesen, J., and Bindi, E.M., 2002. *Consequences of climate change for European agricultural productivity, land use and policy*. Eur. J. Agron., 16: 239-262.

Pandey, H.N., Menon, T.C.M., Rao, M.V., 1989. *A simple formula for calculating area under disease progress curve*. Rachis, 8(2): 38-39.

Pasche, J.S., Wharam, C.M., Gudmestad, N.C., 2004. *Shift in sensitivity of Alternaria solani in response to QoI-fungicides*. Plant Dis., 88: 181-187.

Rotem, J., 1994. *The genus Alternaria. Biology, Epidemiology and pathogenicity*. APS Press, St Paul, MN, USA, 326.

Popescu, Gh., 1998. *Fitopatologie generală*. Volumul I, Editura Mirton, Timișoara.

Runno-Paurson, E., Hansen, M., Tein, B., Loit, K., Jõgi, K., Luik, A., Metspalu, L., Eremeev, V., Williams, I., Mänd, M., 2014. *Cultivation technology influences the occurrence of potato early blight (Alternaria solani) in an organic farming system*. Zemdirbyste-Agriculture, 101(2): 199-204.

Runno-Paurson, E., Loit, K., Hansen, M., Tein, B., Williams, I., Mänd, M., 2015. *Early blight destroys potato foliage in the northern Baltic region*. Acta Agriculturae Scandinavica, Section B - Soil and Plant Science, 65(5): 422-432. DOI: 10.1080/09064710.2015.1017003

Russel, F., 1991. *Statistical analysis by M-STAT C. Statistical software package*. Crop and Science Department, Michigan Satte University, USA.

Shtienberg, D., 2013. *Alternaria diseases of potatoes: epidemiology and management under Israeli conditions*. In: Schepers, H.T.A.M. (eds.), Proceedings of 14th workshop of a European network for development of an integrated control strategy of potato late blight PPO Special Report, 16: 169-179.

Suciu, L., Șopterean, L., Puia, C., Florian, T., Kadar, R., Russu, F., Mureşanu, F., Morea, A., Crișan, V., Florian, V., Gheţe, A., 2020. *The behaviour of* *some winter wheat varieties, created at ARDS Turda against Fusarium sp. attack, during 2015-2018*. Rom. Agric. Res., 37: 17-24. https://doi.org/10.59665/rar3703

Vanhaverbeke, P., Cornelissen, K., Demeulemeester, K., Landschoot, S., 2019. *Towards a knowledge-based approch for an integrated control of Alternaria spp. in potatoes*. In: Schepers, H.T.A.M. (eds.), Proceedings of the 17th Euroblight Workshop PPO Special Report, 19: 99-104.

Zheng, X., Zheng, X., Li, Y., 2012. *Distribution and change of different precipitation pulse sizes in southern marginal zone of Junggar Basin, China*. Arid Zone Res., 29(3): 495-502.