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DEVELOPMENT OF THE CHERRY LEAF SPOT EPIDEMICS IN DIFFERENT REGIONS OF BULGARIA

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Abstract

A 2-year research on the epidemics of the cherry leaf spot (CLS) was conducted in unsprayed cherry orchards at two locations in Bulgaria (Krichim and Gabarevo). The primary infections for both years at Gabarevo happened in mid-May during fruit development. In Krichim during 2018 the first symptoms of the disease appeared in early June (fruit ripening), while in 2019 they became evident in the second half of May (fruit development). In both locations and years, the period of a rapid increase in the CLS incidence and defoliation was from mid-June till late July. The maximum of the disease incidence and defoliation was observed in early September. More seasonal rather than regional trend in the disease dynamics was observed. In 2018 the orchards in both locations exhibited delayed the CLS progression compared to 2019 due to the relatively dry conditions in April and May. The higher disease incidence and defoliation in 2019 could be assigned to the high infection background and weather conditions in the beginning of the growing season.

Keywords: Blumeriella jaapii, epidemics progress, secondary infections, weather conditions

INTRODUCTION

The cherry leaf spot (CLS), caused by *Blumeriella jaapii* (Rehm) Arx (anamorph stage: *Phloeosporella padi* (Lib.) Arx), is a widely-spread disease in the most sweet and sour cherry growing areas all over the world (Jones, 1995). Bulgarian climatic conditions are often favorable for the epidemics of B. *jaapii*. Infections caused by ascospores and winter conidia, followed by repeated secondary conidial cycles, cause leaf chlorosis and premature defoliation, resulting in low fruit quality and poor fruit size. In some instances, the summer development of the CLS can be severe even if the spring disease pressure from the primary infection is relatively low (Jones et al., 1993). When not properly managed these infections may lead to increased amount of overwintering inoculum in leaf litter (Holb, 2013), inner bud tissues (Joshua & Mmbaga, 2014) or wood lesions (Olivier, 1974). The long-term effects of the disease include reduction of fruit bud survival and fruit set during the following year, and in the case of severe defoliation the trees could die (Howell & Stackhouse, 1973; Keitt et al., 1937). Jones et al. (1993) reported at least a two-season delay in fruit set when plants were infected with B. jaapii. Crop losses due to the CLS could be about 40-50% in sweet cherry and up to 100% in sour cherry if no control measures are undertaken (Dimova et al., 2014; Kaszonyi, 1966). In spite of the fact that many aspects of the disease development have been investigated (Eisensmith & Jones, 1981; Keitt, 1937) the information about the CLS epidemics is relatively scarce.

The aim of this study was to evaluate the effect of the climate on the CLS progress in two different geographical regions in Bulgaria during two consecutive years.

MATERIALS AND METHODS

Location, plant material and orchard management

The study was carried out from 2018 to 2019, in Krichim (42° 3′ 0″ N, 24° 28′ 0″ E, 253 m a.s.l.) and Gabarevo (42° 37′ 0″ N, 25° 10′ 0″ E, 423 m a.s.l.). The experiment was set up in unsprayed cherry orchards planted with CLS-susceptible cv. ‘Van’ grafted on *Prunus mahaleb* (Mahaleb ‘IK M9’) seedlings and pruned to a modified central-leader. The orchard in Krichim was 2 ha in size with a spacing of 5 x 4 m and tree-age 15-16 years. The orchard in Gabarevo was 6 ha in size with a spacing of 4 x 3 m and tree-age 6-7 years. In both locations rows were planted at northwest-southeast direction and the trees’ height was about 3.5–4.5 m in the study period. The ground surface was mowed two times during the season in the zone between the rows. No irrigation was applied.

The CLS infection periods and apothecia maturation

Number and intensity of infection periods (low – L, moderate – M, or high – H) by the CLS were forecasted for each site-year through the platform RIMpro (B.V., Netherlands), where Eisensmith and Jones model (1981) is programmed and coupled with the climate data. An automatic weather station (AWS) model iMETOS IMT200 (Pessl Instruments, Weiz, Austria) at Krichim and Meteobot Pro (Prointegra Ltd., Varna, Bulgaria) at Gabarevo provided hourly records of precipitation (mm), temperature (ºC), relative humidity (%), and leaf wetness (h). The weather stations were installed at 2 m height from the ground in the close vicinity of the plots and no more than 100 m away.

In order to detect the first potential ascospores discharge, an event termed biofix, ten infected with *B. jaapii* and overwintered leaves were collected on weekly intervals after the middle of March. If present, from each leaf 10 randomly chosen apothecia were excised and their stage of development was defined according to a 6-grade scale (Jones et al., 1993). The ratings were averaged to give a mean value for the development stage of apothecia at each sampling date.

Disease assessment and phenological observations

To characterize the progression of the CLS infection ten trees were marked and rated at one week interval starting from April 1. The last assessment was done on September 2, one month after the previous one, due to the unfavorable conditions in August for disease development in both years/locations. On each tree 10 branches of the current season’s growth were tagged and monitored. The branches were selected to represent different locations in the canopy (East/West; High/Middle/Low). For each branch observations included a count of leaves unfolded to an angle >90° as well as the number of those leaves with symptoms of the CLS. The disease was quantified on the basis of its incidence on leaves which was calculated as the percentage of infected leaves on each branch. The CLS was presumed to be the predominant cause of premature defoliation; therefore, the percentage of defoliated versus total number leaves was assessed in 10 terminal shoots per tree.

The disease epidemics was correlated to the main stages of plant development. New phenological stage was recorded not before 50% of the trees acquired description mentioned in the BBCH scale of Meier et al. (1994). The observations were performed every week in both locations from March 1 (BBCH 00) till September 2 (BBCH 91).

Data analyses

After every observation, data from each location were averaged to obtain a single value for disease incidence and defoliation. Disease progress curves were constructed by plotting percentages of disease incidence and defoliation against time, measured in days.

RESULTS AND DISCUSSION

Weather conditions and development of the CLS infection

Usually the spring in Bulgaria is mild in temperature with uniform rainfalls and occasional snowfalls. Summer is dry and hot. In 2018 both locations experienced cold spells in March followed by April with few precipitations (Fig. 1). In Krichim during 2018 the first mature ascospores were observed on April 20 (full bloom). The first incidence of the CLS (1.1%) appeared on June 1 during harvesting (BBCH 87) and increased as follows - 27.9% on July 5 (BBCH 91), 70.6% on August 2 and 89% on September 2 (Fig. 2). Defoliation began on June 22 (12%), reached 72% on August 2 and 93% on September 2 (Fig. 3).

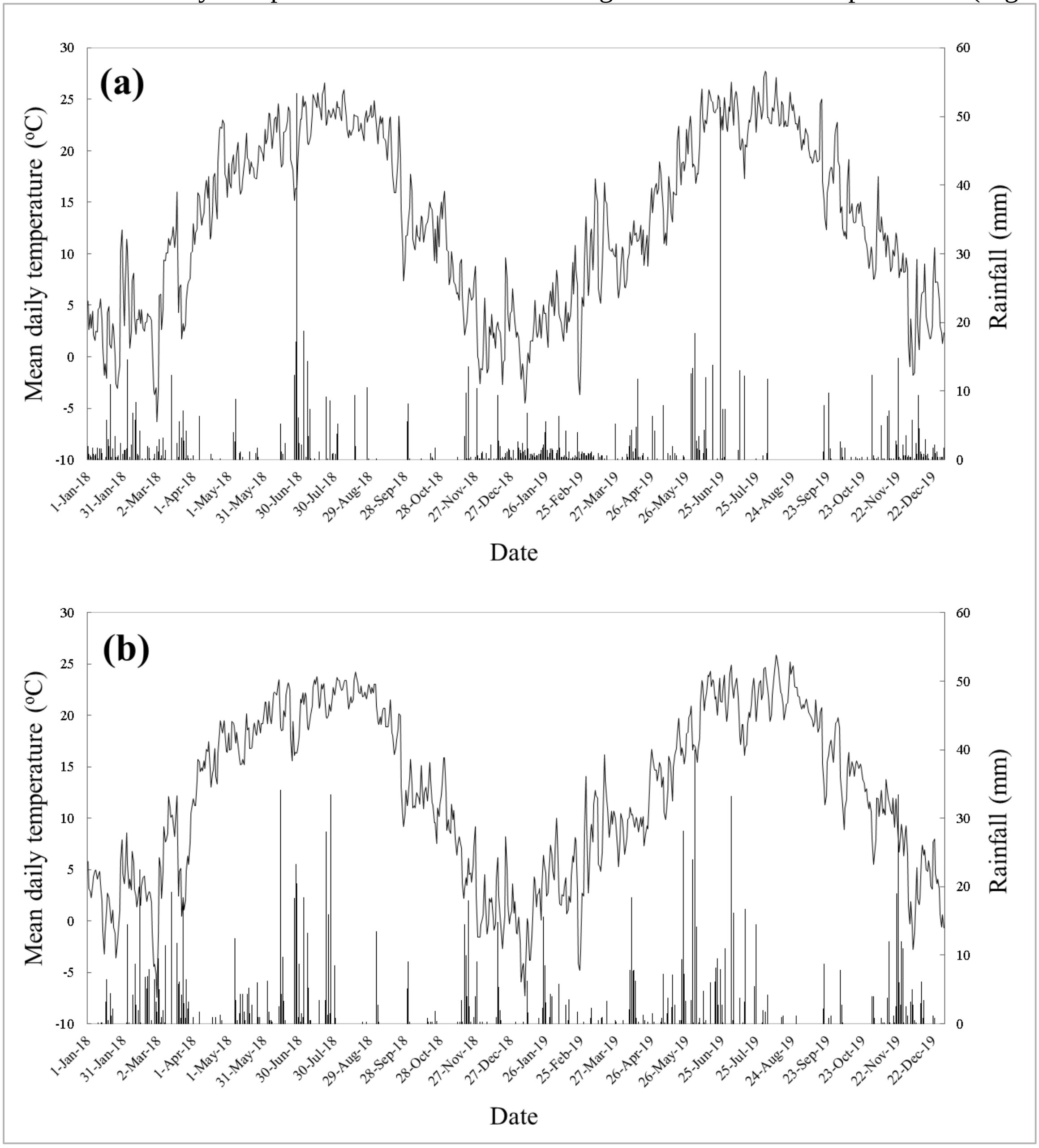

Fig. 1. Annually climate data during the years 2018-2019 in Krichim (a); and Gabarevo (b).

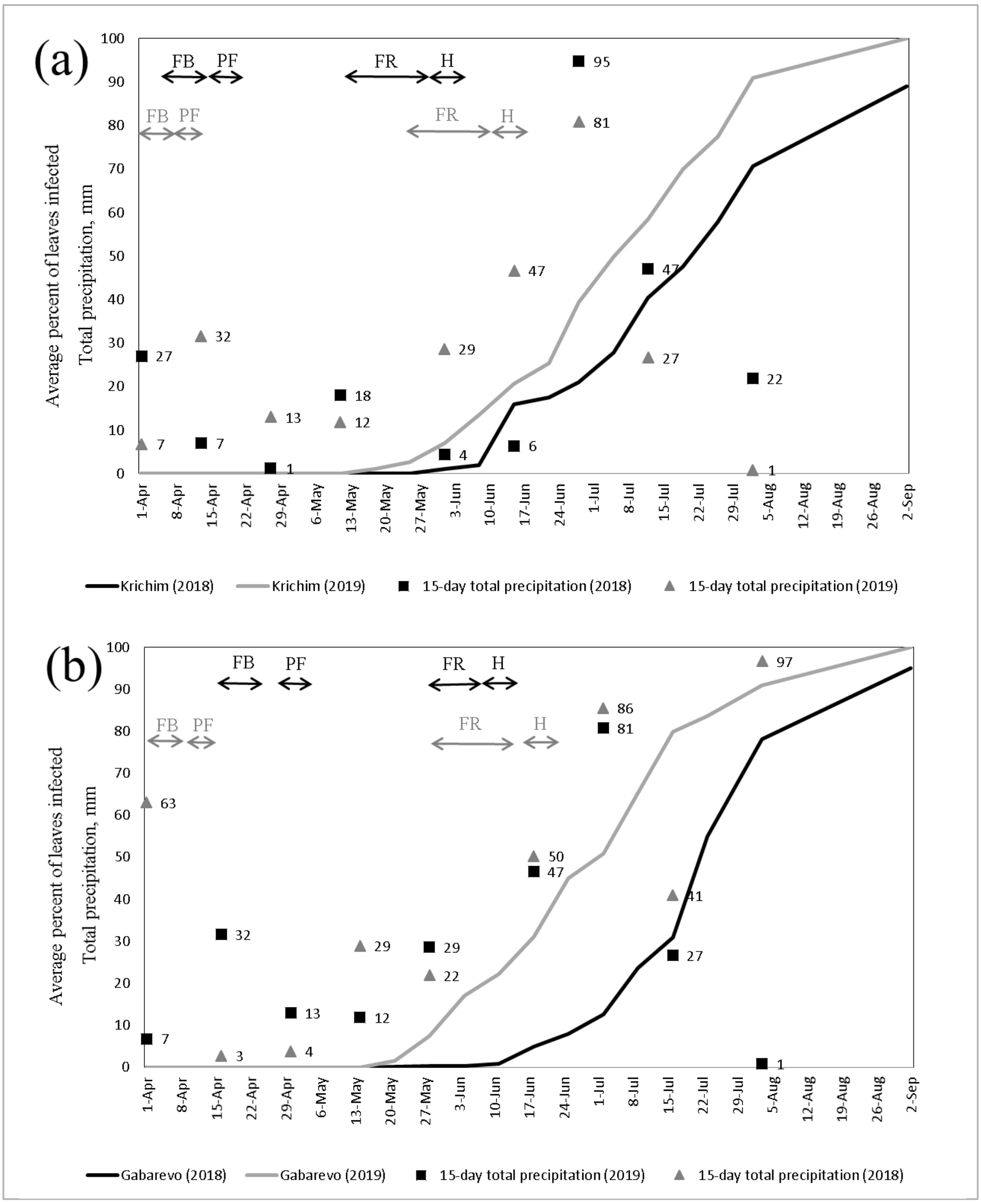

Fig. 2. Incidence of CLS in Krichim, (a) and Gabarevo, (b) with 15-days total precipitations (2018, 2019); FB – full bloom; PF – petal fall; FR – fruit ripening; H – harvesting; Left-right arrow: dark – 2018; grey – 2019.

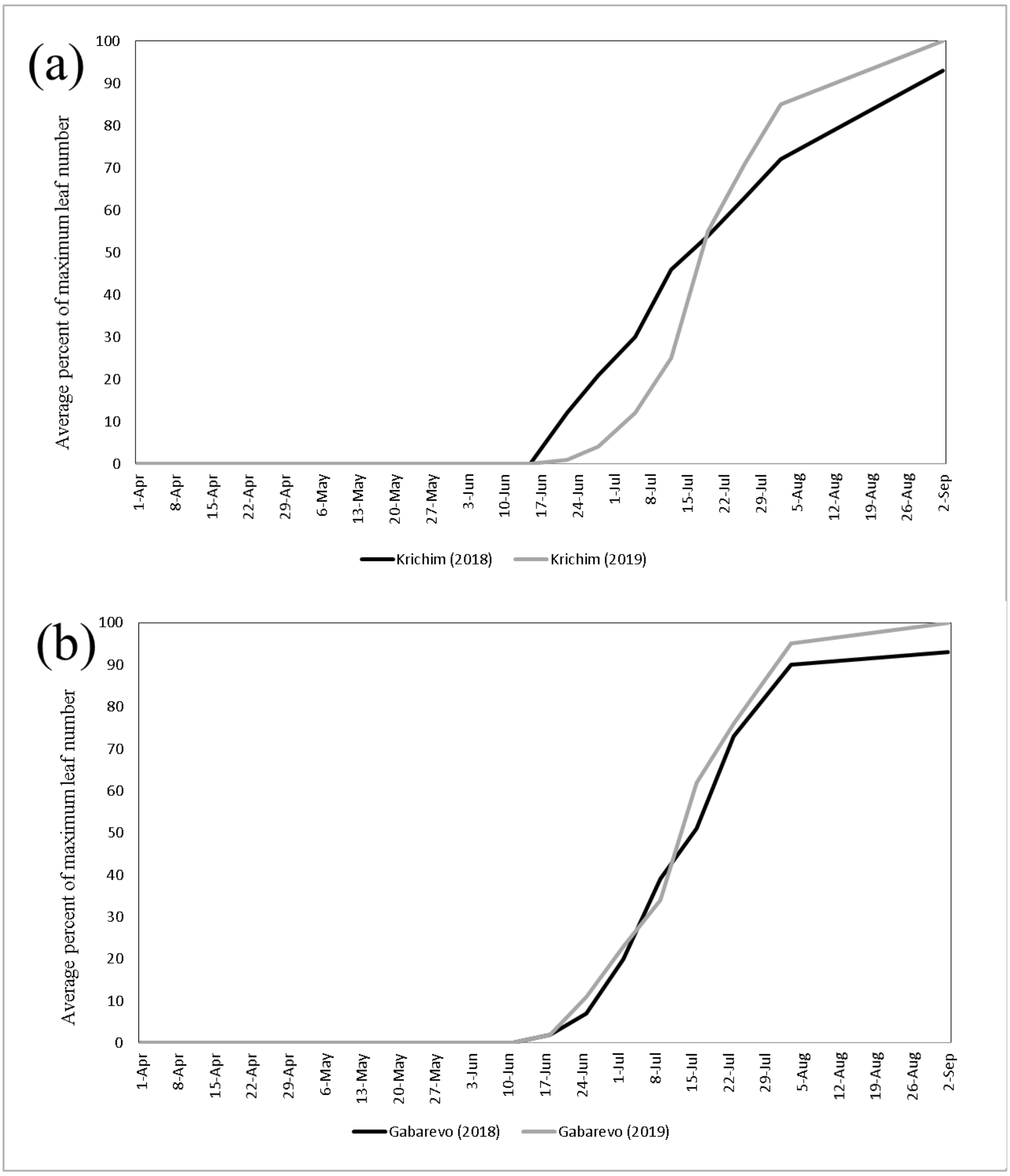

Fig. 3. Comparison of CLS defoliation in Krichim, (a) and Gabarevo, (b); (2018, 2019).

During 2019 the first mature ascospores of B. *jaapii* were observed on May 6 after the end of the petal fall. The first symptoms were observed on May 18 during fruit development (BBCH 78) and the incidence increased from 1 to 100% in the period between this date and September 2 (Fig. 2). Defoliation began on June 22 (1%), reached 85% on August 2, and 100% on September 2 (Fig. 3). From the presented data it is evident that in 2018 the trees exhibited slower CLS progression in comparison with 2019. However, in both seasons the incidence of the CLS reached 90.9% till the beginning of August. Interestingly the number of the high and moderate infections was almost the same in both vegetations, while the light infections were twice as higher in 2018 (Table 1). It could be presumed that the explanation lies in the higher amount of total precipitations during July (68.8 versus 27.4 mm) and August (31.2 versus 12.8 mm) in the first compared to the second year (Fig. 1). Many authors state in their reports that the summer epidemics correlates with the frequency of rain events and relative humidity

(Holb, 2009; Khan et al. 2017; Valiushkaite, 2002). Plyetnikova (2004) mentioned that the main factors for the development of the CLS are precipitation and air temperature during the period between May and August. In this sense, the mean temperature and total precipitation for this period were almost the same for both years: 21.6oC, 223.6 mm in 2018 and 21.8oC, 208 mm in 2019. The early establishment of the primary infection during 2019 could be explained with the higher quantity of rainfalls during April (44.6 mm) and May (40.4 mm). In 2018 the environmental conditions were not so conducive; resp. precipitations in April were 16.1 mm and in May 18.5 mm.

Table 1. Number and intensity of the CLS infections

Location	*Year*	*Infections*			
		high	*moderate*	*light*	*total number*
Krichim	*2018*	*3*	*4*	*13*	*20*
	2019	*3*	*5*	*6*	*14*
Gabarevo	*2018*	*14*	*3*	*4*	*21*
	2019	*6*	*8*	*7*	*21*

Source: RIMPRO B.V., Netherlands

During 2018 in the second location Gabarevo the first mature ascospores and symptoms were observed resp. on May 8 (BBCH 73) and May 21 during the fruit development stage (BBCH 76). Similarly to Krichim the incidence of the CLS progressed slowly from very low to quite high values 0.1 on May 21 and 93% on September 2 (Fig. 2). Defoliation began on June 18 with 2% to reach 90% on August 3 and 93% on September 2 (Fig. 3). During 2019 the first mature ascospores were observed on April 22 (BBCH 73). The first symptoms appeared on May 21 during fruit development (BBCH 79) and the incidence of infected leaves was 1.6% on May 21, 45.1% on June 25 (BBCH 91), 83.6% on July 23, and 100% on September 2 (Fig. 2). Defoliation began on June 18 (2%), reached 95% on August 3, and 100% on September 2 (Fig. 3). Despite the coincidence of the first symptoms appearance in both years, the rapid increase of the CLS in 2019 could be attributed to the high precipitation during April (55.7 mm) and May (103 mm). In contrast, during 2018 the precipitations in these months were resp. 6.6 mm and 50.8 mm (Fig. 1). In all site-year combinations the climatic conditions in June were characterized with a limited sum of rainfalls (3.4-4.5 mm).

The secondary infections usually take place in the end of June as a result of conidia formed on overseen lesions caused by primary spores (Jones et al., 1993). The secondary cycle is more efficient in the dissemination of the disease due to the large number of asexual spores (Stanosz, 1992; Velichkova, 1983), which are rain splashed to neighbor foliage (Diaz et al., 2007), and only partial resistance of the leaves (Jones, 1995). Therefore the high number of precipitations in July and August during 2018 in both locations led to a period of intensive infections and the CLS managed to compensate for the delay. These results are in agreement with those obtained by Andersen (2016) who suggested that even after a delayed infection the CLS incidence progressed rapidly when more regular rainfall events occur during the season.

The higher disease incidence and defoliation in 2019 could also be with the year-to-year increase of disease inoculum (Vamos & Holb, 2019). More specifically, Joshua & Mbaga (2014) indicated that in warmer regions the dormant buds could serve as an additional source of primary inoculum which could build up during the orchard lifetime resulting in higher initial infection levels. Besides, the present study showed similar patterns of the rate of defoliation in the two seasons and locations. It followed the initial leaf infection by 2-4 weeks and reached a level of approx. 70% within a month in the period June 18 – July 23. These results are consistent with Andersen et al. (2018) work who concluded in cv. ‘Montmorency’ defoliation levels of >50% could occur prior to September. It should, however, be emphasized that relatively low CLS severity could cause a physiological shock and accelerated detachment of the leaves (Gruber et al., 2012; Wargo et al., 1972).

In both locations and years, the period of rapid increase of the CLS incidence and defoliation was from mid-June till late July which coincides with a flower bud differentiation of sweet cherry (Watanabe & Umetsu, 1980). This could lead to a delayed acclimation and a reduced fruit bud survival leading to a reduction of the fruit set during the following spring (McManus et al., 2007).

CONCLUSION

The cherry leaf spot is a disease with a dynamic epidemiology, influenced by climate, inoculum availability and cultivars reaction. The first symptoms of its appearance for both locations of the study happened in the second half of May till early June. In both of them the disease spread increased relatively fast, but more slowly in 2018. The subsequent defoliation reached a high level in July (30-70%) and progressed even further till the beginning of September. It was impressive how fast the pathogen compensated for the slow start with a dynamic progress after the secondary infections and conidia came into action. All this proves the need of chemical treatments not only before, but also after the harvesting. The extended period of infection risks suggests adequate, and if possible, climate based timing in order for control measures to become economically justified. The reduction of the overwintering inoculum through sanitation and other control measures has the potential to postpone the disease onset after the ripening period when fungicides application could be hazardous for the fruit consumers.

REFERENCES

Andersen, K. L. (2016). Comparison of resistant, tolerant, and susceptible host responses to Cherry Leaf Spot and assessment of trait inheritance. Michigan State University.

Andersen, K. L., Sebolt, A. M., Sundin, G. W., & Iezzoni, A. F. (2018). Assessment of the inheritance of resistance and tolerance in cherry (*Prunus sp.*) to *Blumeriella jaapii*, the causal agent of cherry leaf spot. Plant pathology, 67(3), 682-691.

Dimova, M., Titjnov, M., Arnaudov, V., & Gandev, S. (2014). Harmful Effect of Cherry Leaf Spot (*Blumeriella jaapii*) on Sour Cherry and Influence on Fruit Yield. *Agroznanje*, 15(4), 393-400.

Eisensmith, S. P., & Jones, A. L. (1981). A model for detecting infection periods of *Coccomyces hiemalis* on sour cherry. *Phytopathology*, 71(7), 728-732.

Gruber, B. R., Kruger, E. L., & McManus, P. S. (2012). Effects of cherry leaf spot on photosynthesis in tart cherry ‘Montmorency’ foliage. *Phytopathology*, 102(7), 656-661.

Holb, I. J. (2013). Effect of sanitation treatments on leaf litter density and leaf spot incidence in integrated and organic sour cherry orchards. Plant Disease, 97(7), 891–896. https://doi.org/10.1094/PDIS-09-12-0811-RE.

Holb, I. J. (2009). Some biological features of cherry leaf spot (*Blumeriella jaapii*) with special reference to cultivar susceptibility. *International Journal of Horticultural Science*, 15(1-2), 91-93.

Howell, G. S., & Stackhouse, S. S. (1973). The effect of defoliation time on acclimation and dehardening in tart cherry (*Prunus cerasus* L.). *Amer. Soc. Hort. Sc. J.*, 98, 132–136.

Jones, A. L. (1995). Cherry leaf spot. Pages 21-22. in: Compendium of Stone Fruit Diseases. Ogawa, J. M., Zehr, E. I., Bird, G. W., Ritchie, D. F., Uriu, K., and Uyemoto, J. K., eds. American Phytopathological Society, St. Paul, MN.

Jones, A. L., Ehret, G. R., Garcia, S. M., Kesner, C. D., & Klein, W. M. (1993). Control of cherry leaf spot and powdery mildew on sour cherry with alternate-side applications of fenarimol, myclobutanil, and tebuconazole. *Plant disease*, 77(7), 703-706.

Joshua, J. O., & Mmbaga, M. T. (2014). Perpetuation of cherry leaf spot disease in ornamental cherry. *Phytopathology*, 163, 194–201. doi:10.1111/jph.12309.

Kaszonyi, S. (1966). Life cycle of *Blumeriella jaapii* (Rehm) v. Arx infecting stone-fruits. *Acta Phytopathologica Academiae Scientiarum Hungaricae*, 1(1-2), 93-100.

Keitt, G. W., Blodgett, E. C., Wilson, E. E., & Magie, R. O. (1937). The epidemiology and control of cherry leaf spot. Wisconsin Research Bulletin., 132, 1-117.

Khan, K. A., Nabi, S., Saleem, M., & Khan, N. A. (2017). Correlation of Different Weather Parameters with *Blumeriella* Leaf Spot Disease Development and Disease Intensity in Kashmir Valley. *Environment & Ecology*, 35(1), 165-168.

McManus, P. S., Proffer, T. J., Berardi, R., Gruber, B. R., Nugent, J. E., Ehret, G. R., & Sundin, G. W. (2007). Integration of copper-based and reduced-risk fungicides for control of *Blumeriella jaapii* on sour cherry. *Plant disease*, 91(3), 294-300.

Meier, U., Graf, H., Hack, H., Hess, M., Kennel, W., Klose, R., & Boom, T. V. D. (1994). Phanologische Entwicklungsstadien des Kernobstes (*Malus domestica* Borkh. und *Pyrus communis* L.), des Steinobstes (*Prunus*-Arten), der Johannisbeere *Ribes*-Arten) und der Erdbeere (*Fragaria* x *ananassa*. *Nachrichtenblatt des Deutschen Pflanzenschutzdienstes*, *46*(7), 141-153.

Olivier, J. M. (1974). Infection of cherry tree pruning wounds by *Cylindrosporium padi* (Lib.) Karst. *Annales de* Phytopathologie, 6 (1), 103-107. Institut National de la Recherche Agronomique.

Plyetnikova, N. Ya. (2004). Kokomikoz vyshni i chereshni ta zaxody po obmezhennyu joho shkodochynnosti u Sxidnomu Lisostepu Ukrayiny [Tekst] : dys... kand. s.-h. nauk: 06.01.11 / Plyetnikova Nina Yakivna ; Xarkivs"kyj nacional"nyj ahrarnyj un-t im. V.V.Dokuchayeva. - X.,185 ark.: rys. - ark. 135-157.

Stanosz, G. R. (1992). Effect of cherry leaf spot on nursery black cherry seedlings and potential benefits from control. Plant disease, 76(6), 602-604.

Valiushkaite, A. (2002). Investigation of biological peculiarities of *Blumeriella jaapii*. *Plant protection science-Prague*, 38, 399-401.

Vamos, A., & Holb, I. J. (2019). Training system and tree-age affect leaf spot epidemics and tree defoliation on commercial sweet cherry cultivars. *Crop Protection*, 125, 104881.

Velichkova, S. (1983). Prouchvania varhu tsilindrosporiozata (*Blumeriella jaapii*) Rehm v. Arx po chereshata i vishnyata [Cherry and sour cherry studies on (*Blumeriella jaapii*) Rehm v. Arx]. Disertatsia, Sofia, 195 s.

Wargo, P. M., Parker, J., & Houston, D. R. (1972). Starch Content in Roots of Defoliated Sugar Maple. *Forest Science*, 18(3), 203–204.

Watanabe, S., & Umetsu, K. (1980). Flower-bud differentiation and development in sweet cherry. *Journal of the Yamagata Agriculture and Forestry Society*, 36, 19-24.