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BEHAVIOUR OF SOUR CHERRY CULTIVARS TO THE CAUSES OF CYLINDROSPORIOSIS AND SHOT HOLE DISEASE

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Abstract

The study was conducted in the period 2018-2020 on the territory of RIMSA Troyan with three cherry cultivars, such as 'Oblachinska', 'Karneol' and 'M 15', grafted on 'Alkavo' rootstock and planted in 2002 by trench method with local, stockpile organic fertilizing. The planting scheme was 4 x 3 m and they were grown under nonirrigated conditions.
The reaction of the sour cherry cultivars, the intensity of the infestation and the manifestation of cylindrosporiosis and shot hole disease for the optimization of the schemes for sustainable Plant Protection under the climatic conditions of the Troyan region were studied.
'Karneol' was found to have the lowest susceptibility to both diseases studied (shot hole disease <8.7%; white rust 21.3%). The average fruit weight was 5.5 g, it is suitable for fresh consumption, with an extremely balanced taste and with opportunities for organic and sustainable cultivation, and the later ripening period allows to extend the harvesting period.
'M15' had a higher infestation index of Stigmina carpophila (Lev.) Ell (15.3%) compared to the other two cultivars and was more susceptible. Infestation index of Blumeriella jaapii (Rehm.) was slightly higher, but was well below 50%. It has attractive fruits with greater weight, bears abundant fruit and can be included in the cultivar list of modern sustainable technologies.

Key words: *cherries, fungal diseases, climatic conditions, biometric indicators.*

INTRODUCTION

The Carpathian Basin, the Balkans and Asia Minor are considered the main birthplaces of sour cherries as a fruit crop.

A study by Surányi (2021) compared 472 sour cherries cultivars based on 7 relative ecological indicators and 3 biological, where 'Karneol' and 'M 45' rank 5-6, i.e. mountain location (deciduous forest belt), while 'Oblachinska' (on a scale from 1 to 9) is in 7 thermophilic forest belt. The same cultivars are defined as resistant to moderately susceptible to diseases 1-2 (on a scale of 3 degrees) and are moderately drought-resistant (for semi-humid habitats - 5 (on a scale of 12 points).

In Bulgaria, sour cherries are grown as an industrial crop in some regions, such as Plovdiv and Kyustendil and in some districts of the country, where critical temperatures during deep dormancy are not lower than (-25°C) and the risk of return winter and late spring frosts is small (Taseva et al., 2007).

The research and enrichment of sour cherry assortment with new large-sized cultivars for Bulgaria, with increased cold resistance, disease resistance, high fruitfullness and different ripening period in recent years has been supported by the Bulgarian-German project FAMAD. Cultivars with different origin, growth strength, fertility, ripening period, size, fruit color, etc., such as 'Keleris', 'Karneol', 'M15' and others were introduced.

Sour cherry fruits are consumed as fresh, but are used for the production of juices, syrups and alcoholic beverages, confectionery. Due to their high content of vitamin C and other biologically active substances that could act as antioxidants, sour cherries are used to prevent cancer and other cardiovascular diseases, as well as to treat osteoarthritis and gout (Bastos et al., 2015).

It has been established that cherries (*Prunus avium* L.) and sour cherries (*P. cerasus* L.) are seriously endangered by a significant number of phytopathogens affecting the leaves and causing premature defoliation, reduced shoot growth, increased susceptibility to winter injuries, higher mortality of trees. *Blumeriella jaapii* (Rehm.), caused by *Cylindrosporium* *padi*, is one of the most important and economically significant fungal pathogens affecting sweet cherries and sour cherries worldwide and in Serbia (Iličić et al., 2019). The pathogen mainly affects the leaves, thus compromising photosynthetic ability, causing early defoliation, decreasing yields and reducing fruit quality.

Many studies provide information on factors that favour sporulation, spore spreading, spore germination, disease penetration and development. Scientists report that temperatures of 15-20°C are most favourable for the development of *Blumeriella jaapii* (Rehm.), (Valiushkaite et al., 2002). Joshua and Mmbaga (2014) report that the disease caused by *B. jaapii* (Rehm) Arx. is getting more and more economic significance for sour cherry growers in the southeastern United States. In their study, spores were captured in late March, before field symptoms were observed, indicating that the remains of diseased tree leaves are an important source of primary inoculum. Previously infected trees of six cultivars (‘Kwanzan’, ‘Yoshino’, ‘Okami’, ‘Snowgoose’, ‘Autumnalis’ and ‘Akebono’), which overwintered in a controlled environment protected from airborne spores, developed symptoms of the disease in late spring, which indicates that dormant buds can also be a source of primary inoculum.

Disease management should include cultural practices that focus on the propagation of healthy trees and the application of Plant Protection, starting with the fall of flower petals, in order to protect emerging leaves.

The amount and timing of rainfall play an important role in the disease epidemic. The disease usually appears at the beginning of the rainy season due to the presence of airborne pathogens that require high humidity and leaf moisture for its development. Rain can help release or spread pathogens by washing spores from plant and soil surfaces (Khan et al., 2017). In rainy weather, light pink to white masses of conidia (in spots) appear on the underside of the leaf in the center. The spots turn brown and a sufficient number can cause premature defoliation and weakening of the tree. Fruits of trees that are heavily defoliated before harvesting will not be able to ripen normally and are light in color, low in soluble solids, soft and watery. The formation of flower buds and fruits of highly defoliated trees can be reduced for at least two seasons. Trees that defoliate in mid-summer are less resistant to cold and can be damaged by low temperatures in winter.

Tezcan H. (2008) discuss possible causes of disease outbreaks and the effectiveness of some pathogen control methods. After one year with fungicidal control and collection of diseased leaves on the ground with a special machine the incidence decreased from 90% to 10%.

An overview of short-term fluctuations in long-term trends will help to understand the nature and extent of the evolutionary adaptation of plants and pathogens and to determine the fate of plants in future climate change (Burdon & Zhan, 2020). The interest in the effects of climate change on the dynamics of the population of pathogens in agricultural systems is understandable. When climatic conditions are particularly favorable for the development of the disease, the harvest can be completely compromised. Major epidemics are possible, but people can improve their impact on agricultural systems by manipulating certain host factors, environmental parameters or pesticide applications.

The objective of the present study is to trace the infectious process of infection and development and to take into account the infestation index of cylindrosporiosis and shot hole disease in sour cherry cultivars, to optimize the schemes for sustainable plant protection, in the climatic conditions of Troyan.

MATERIALS AND METHODS

The study was conducted in the period 2018-2020 on the territory of RIMSA Troyan with three sour cherry cultivars ‘Oblachinska’, ‘Karneol’ and ‘M 15’, grafted on ‘Alkavo’ rootstock and planted in 2002 by trench method with local, stockpile organic fertilizing. The soil is light gray forest, with a shallow "A" horizon - 10-15 cm, poor in humus (about 1%), with a strong highly gleyed, water impermeable "B" horizon. The annual amount of precipitation for the region is on average about 750 ml. The data on temperatures and precipitation, which are essential for the development of diseases, were used by the Meteorological Station of RIMSA Troyan.

The planting scheme is 4 x 3 m and they are grown under nonirrigated conditions.
Variants of the experiment are the three cultivars and each tree is a replication (5 trees per cultivar were observed). Crown are free-growing and are maintained with annual winter prunings, the soil surface is covered with turf.
Shot hole disease - *Stigmina carpophila* (Lev.) Ell. Symptoms: At first small-sized purple spots appear on the leaves, which grow to small-sized round spots (1-6 mm) with pale brown to ocher color. The tissues around the spots acquire a reddish-brown colour in the form of a ring. In young still growing leaves, the tissues in the middle of the spots necrotize, fall off and perforations form on the leaf blade. On older tissues, the spots are larger and rarely perforated. Purple spots form on the shoots, which grow to rounded or elliptical and slightly concave spots of dark brown colour.
Brown-red spots form on the fruits of cherries and sour cherries. Damaged tissues stop growing and sagging, and the fleshy part of the fruit remains fused with the stone. Epidemiology: The fungus overwinters as mycelium and conidia in infected twigs and buds. At high humidity and temperature above 3 °C on the surface of the infected parts conidia are formed, which in the spring cause primary infections. Due to the low minimum temperature required for the development of the fungus, it is able to multiply in mild winters and dormant periods. The fungus enters the tissues through wounds, pimples and leaf prints formed during the fall, through the stomata or directly through the cuticle.
Dispersal of spores is carried out by rain, wind or insects. Water drops are needed for germination of spores. Any significant wave of infection occurs after prolonged rainy periods (Anon, 2013).
White rust - *Blumeriella jaapii* (Rehm.) v. Arx. (anamorph *Cylindrosporium hiemalis* Higgins) Hosts: Sweet cherry and sour cherry.
Symptoms: Numerous small dots appear on the upper side of the leaves, which are initially purple and later turn brown and burn. On the underside of the leaves, in the places of the spots, a deposit of whitish piles can be seen. Infected leaves begin to turn yellow around the site of damage, then fall off. In highly sensitive cherry and sour cherry cultivars, similar signs are also observed on the stalks and green fruits
Epidemiology: The fungus overwinters in fallen leaves, where ascospores and conidia form in spring. Maturing and discharging of ascospores takes place in rain and moderately warm weather and often coincides with leafing. This period lasted about a month and a half. Conidiospores are also a source of primary inoculum. Mass infections during the vegetation season are carried out only with conidia. They can be dispersed by raindrops and insects (Anon, 2013).
During the mass manifestation of the studied diseases, *Blumeriella jaapii* (Rehm.) and *Stigmina carpophila* (Lev.) Ell, samples of 200 leaves were taken, from each cultivar (variant), 5 trees (replications) from 4 directions and layers of the trees.
The infestation of the studied diseases was reported on the respective score scales (Nedev et al., 1979), according to the spotting of the leaf blade.
The Mc Kenney (1923) formula adopted in phytopathology was used to calculate the infestation index (%).

$I=\Sigma \frac{n.k}{N.K} . 100$, where:

I - infestation disease index in %;
n - number of infected leaves of the respective degree;
k - number of the degree;
N - number of degrees;
K - number of all reported leaves;
Plant protection measures include - winter, post-blossoming and two summer sprays (against aphids, fungal and bacterial diseases). During the last two vegetations, plant protection was carried out in accordance with the requirements for organic fruit production - by using sulfur and copper-containing fungicides.
The following indicators are taken into account
fruit weight and stone weight (g)
fruit size (height, average diameter) (mm)
fruit stalk length (mm)
infestation index (%) for cylindrosporiosis and shot hole disease, determined by the formula of Mc Kynney (1923).
Statistical data processing was performed with A
NOVA (Excel 2019).

RESULTS AND DISCUSSIOINS

The susceptibility to cylindrosporiosis (*Blumeriella jaapii*) (Rehm.) and shot hole disease (*Stigmina carpophila*) of sour cherry cultivars, such as 'Karneol', 'Oblachinska' and 'M 15' was studied.

The shot hole disease infestation was in the range of 6% to 15% for all variants for the three years (Figure 4).

In 2019, when 'Oblachinska' and 'Karneol' had the highest infestation index of shot hole disease, the climatic conditions during the manifestation period (end of June) were T 20°C; 106 mm of precipitation; 80% humidity (Figure 1). In 2020, the index for 'Karneol' and 'Oblachinska' was lower, as T was 19.3°C and the humidity was 80.4% (Figure 2), i.e. they were lower for pathogen development.

In 2021 (Figure 3) the temperatures at the end of June were higher (23.4°C); low air humidity 77.7% and very small amounts of precipitation 18 mm. Despite the appropriate high T, the atmospheric humidity was low and there were no necessary conditions for the development of the fungal shot hole disease. That was the lowest infestation index for the three cultivars (Figure 4). The relatively uniform low values of the index are due to the accumulated infectious background from previous years, because the plantation has been grown according to a biological scheme (excluding RH).

During the study period, 'Karneol' had the lowest rate of shot hole disease <8.7%.

'M15' had a high index of manifestation for the period of the study and showed a stronger and more constant susceptibility to shot hole disease in time.

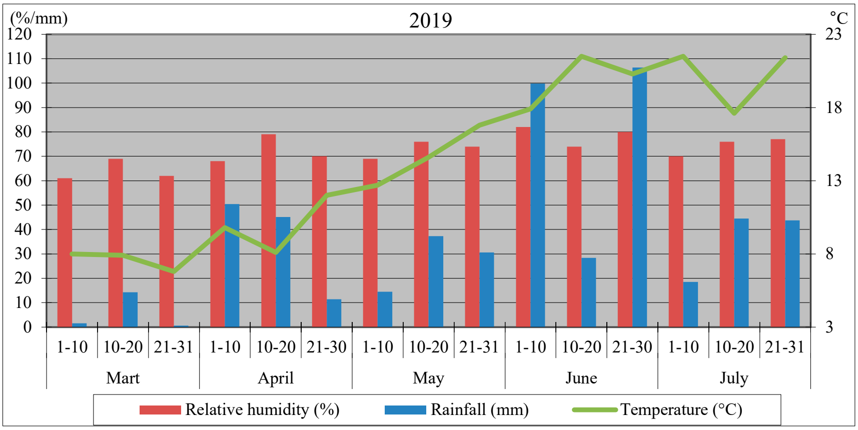

Figure 1. Climatic factors by ten days March-July (2019)

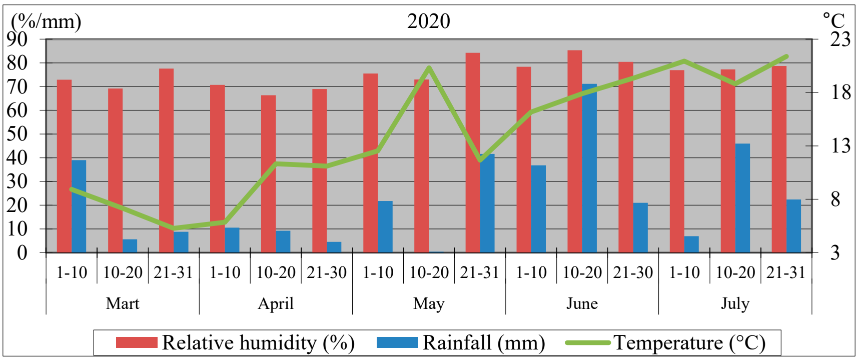

Figure 2. Climatic factors by ten days March-July (2020)

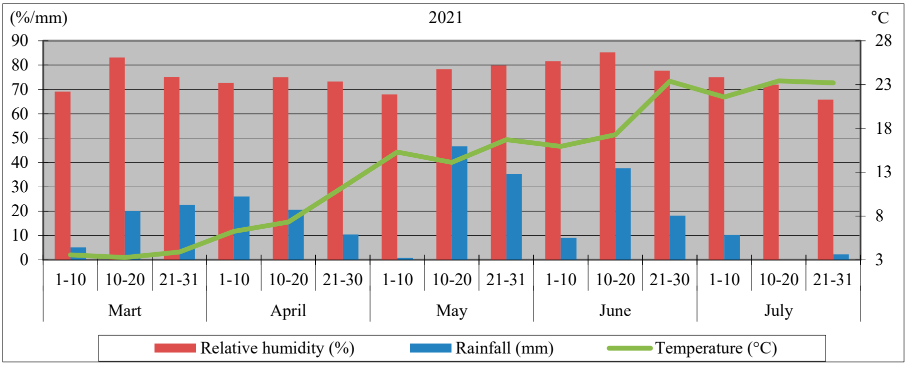

Figure 3. Climatic factors by ten days March-July (2021)

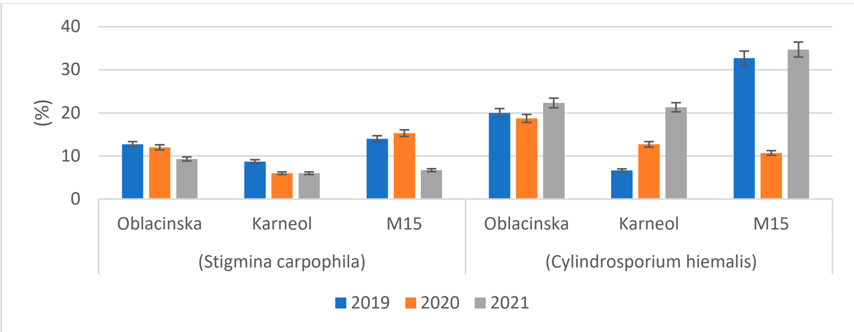

Figure 4. Infestation degree (%) by cultivars (2019-2021)

For white rust the strongest infestation index was reported in 2021 for the three cultivars (Figure 4).

2020 is characterized by low T (11.7°C), during the period of manifestation of cylindrosporiosis, which despite the high humidity (84.2%) did not allow the development of the fungus (Figure 2).

Precipitation for the three years at the end of May was about 35-45 mm, but in 2019 and 2021 there were significantly higher temperatures (>16.5°C) and humidity was 74.0-79.8% (Figures 1 and 3), and this was exactly what favours the development of the disease.

In 2019 and 2021 was the strongest manifestation of cylindrosporiosis, reported in 'M15' (32.7% in 2019; 34.7% in 2021), and in 2021 in all three cultivars was the highest % (Figure 4).

The present study corresponds to the data of Khan et al. (2017), when the average atmospheric temperatures in Kashmir, maximum and minimum were 27.30°C and 8.88°C, respectively, with average relative humidity, maximum and minimum respectively 71.21 and 49.21%, as the maximum value of the infestation index was in the second two weeks of June, which was the favourable temperature, precipitation and relative humidity for the manifestation of the disease. The percentage of leaf disease intensity shows a positive correlation with the average maximum relative humidity and the average precipitation. Thus, both high humidity, optimum temperature and rainfall significantly favor the development of *Blumeriella* leaf spot disease in the Kashmir Valley. The relationship between the development of the disease and meteorological factors reveals that the percentage of disease intensity is strongly and positively correlated with the average maximum relative humidity ($r = 0.69$), followed by the average precipitation ($r = 0.73$) (Khan et al., 2017).

Climate change will affect the measures that farmers use to effectively manage disease, as well as the feasibility of certain crop systems in certain regions (Yigal & Ilaria, 2014).

Biometric measurements of the fruits were made. The fruit weight (g) is extremely variable during the 3 years of the study, the smallest was found in ‘Oblachinska’ (2.50-2.99 g), ‘Karneol’ had a fruit weight of 3.74-5.72 g, ‘M 15’ from 4.39 to 7.20 g (Table 1).
It is noteworthy that in 2019 the fruits of the three cultivars had more mass than in the next 2 years, as the lowest weight was registered in 2021. The largest relative share of stone was found in the last year, as for ‘Karneol’ it was 9,98%, and the lowest values were in 2020 (8.08% for ‘Oblachinska’; 2.78% for ‘M 15’) (Table 1).

Table 1. Reproductive characteristics of fruits

	Fruit weight (g)	Stone weight (g)	Relative share of stone (%)	Height (mm)	Diameter (mm)	Fruit stalk length (mm)
2019	X ± St Dev					
‘Oblachinska’	3.46±0.27	0.28±0.07	8.09	15.16±0.86	17.27/16,12	29.66±2.08
‘Karneol’	6.07±0.94	0.44±0.05	7.25	19.90±0.87	22.68/19,83	34.12±2.94
M-15	6.52±0.30	0.42±0.06	6.44	17.91±0.55	22.65/20,34	42.59±3.65
LSD 0,05	*0,57*	*0,06*		*0,75*	*1,22/0,98*	*2.86*
LSD 0,01	*0.77*	*0.08*		*1.01*	*1.65/1.33*	*3.87*
2020						
‘Oblachinska’	2.60±0.49	0.21±0.05	8.08	14.89±0.68	17.34/15.29	24.98±2.59
‘Karneol’	5.53±0.59	0.35±0.05	6.33	16.46±2.86	18.41/16.94	31.04±4.31
M-15	7.20±0.60	0.20±0.04	2.78	17.21±0.71	22.54/20.48	31.88±1.50
LSD 0,05	*0.54*	*0.05*		*1.69*	*1.60/1.42*	*2.93*
LSD 0,01	*0.73*	*0.06*		*2.28*	*2.17/1.92*	*3.96*
2021						
‘Oblachinska’	3.11±0.34	0.27±0.06	8.68	15.09±1.05	20.09/17.81	24.55±2.06
‘Karneol’	4.51±0.45	0.45±0.05	9.98	18.50±0.80	20.09/17.81	32.19±4.82
M-15	4.39±0.34	0.34±0.05	7.74	16.68±0.24	19.81/18.38	37.99±2.98
LSD 0,05	*0.37*	*0.05*		*0.75*	*0.73/0.76*	*3.37*
LSD 0,01	*0.49*	*0.07*		*1.01*	*0.99/1.03*	*4.55*

The length of fruit stalks is different, for Oblachinska 25-29 (mm), for ‘Karneol’ 31-34 (mm), and for ‘M 15’ - 310.04 (mm) in 2020, 43.0 (mm) in 2019.

CONCLUSIONS

The strength of the infestation and the degree of manifestation of fungal diseases, compared to the studied sour cherry cultivars are directly dependent on meteorological factors (temperature, precipitation, humidity).
The strength of the pathological process is determined by the interaction of meteorological factors and the immunity of the cultivars. On this basis, annual models can be prepared for preliminary forecasting of the intensity of the manifestation of fungal diseases and thus to carry out adequate plant protection.
‘Karneol’ had the lowest susceptibility to both diseases studied. The lowest infestation index of shot hole disease was found for the three years of the study (6.7-21.3%). The average fruit weight was 5.5 g, which is suitable for fresh consumption, with an extremely balanced taste and with possibilities for organic cultivation.
For ‘M15’ the infestation index was slightly higher, but was significantly below 50%, had attractive fruits with greater fruit weight, abundant fruit bearing and can be included in the cultivars list of modern sustainable technologies.
For ‘Oblachinska’ the infestation index was relatively high and with constant values, which defines it as susceptible to white rust (cylindrosporiosis).

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