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Effect of training system on the incidence of *Stigmina carpophila* and fruit size and weight of European plum (*Prunus domestica*)

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Summary: In a two-year study (2017-2018), the aim was to determine the incidence of shot hole disease (*Stigmina carpophila*) on plum cultivar 'Čačanska lepotica' in four different training systems with tree spacings of 4 x 1.5, 4 x 2, 5 x 2.5 and 6 x 3 m. Fruit size (width and length) and fruit weight were also assessed during harvest of fruit in the four training system. Cultivar 'Čačanska lepotica' was susceptible to shot hole disease and showed shot hole symptoms in both years and in all training systems. In 2017, the highest disease incidence was observed in the 4 x 1.5 m plot (34% in June and 85% at the end of September). In June and July, the 6 x 3 m training system had the lowest disease incidence. In August and September, the 5 x 2.5 m training system had the smallest incidences of the disease among the training systems. In 2018, except for one assessment date (18 August) the 4 x 1.5 m plot had higher incidences than the other three training systems. Training system and years had almost no effect on fruit size, but there were some differences in fruit weight among the training systems.

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Key words: plum, training system, *Stigmina carpophila*, fruit quality

Introduction

Significance of European plum production is very high in Hungary as it is the third most important fruit sector in the country covering almost 7000 hectares of land and with a production of around 30-40 000 tonnes each year (KSH, 2021). Its industrial purpose is limiting the level of disease management to 5-9 applications as the price of the fruit is usually very low (Holb, 2005; Földes et al., 2015). Shothole disease (*Stigmina carpophila*) has large economic importance and the disease occurs all over the world in plum orchards (Ogawa, 1991). Symptoms appear on various plant parts and are different on every host the disease infects (Glits, 2000; Ivanová, 2012). On European plum leaf spots are the most frequent creating a shothole like appearance damaging leaf surface. Fruits of plum are rarely affected, but leaf damage can lead to poor condition of the trees which affects yield indirectly (Bubici et al, 2010). As infection of Stigmina carpophila occurs at a low temperature therefore it is able to cause a problem early in the season when fruit growers are rather paying attention to other main diseases and pests (Evans et al., 2008). Regarding fruit quality and quantity loss, Stigmina carpophila can cause 30-90% damage under favorable weather conditions (Nabi et al., 2018).

Nowadays implanting environmentally-friendly plant protection strategies into practice is inevitable therefore chemical control is limited. One of the best method is using varieties that are less susceptible for the damage of the disease. Choosing a tolerant or resistant variety should be well considered before planting as there is no or little chance to change it during the life of the orchard (Agrios, 2005). There are a few publications about the susceptibility of different plum varieties to Stigmina carpophila but more research is needed especially for hungarian conditions and for new varieties (Benedek et al., 1991; Brózik-Kállay, 2000; Bubici et al., 2010; Grantina-Ievina and Stanke, 2015; Savov, 2015; Bálint et al., 2016).

Another approach to non-chemical protection against diseases is choosing tree spacing. As a part of training system tree spacing plays a key role and has an effect on plant density. Regarding hungarian conditions training system hasn't changed in the past three decades – mostly because there aren't many new plantings -, most plum orchards are still in extensive training system which means bigger spacings between plum trees (Szabó, 2004). There is a huge need for disease progress research in smaller – more intensive- training systems, because sprayings are more effective but plant density and microclimate is much different than in the extensive system.

Indirect effect of the disease on plum fruits is less investigated, because without the fruit symptom it is very difficult to determine the effect on fruits. Indirect effect is caused by deterioration of condition which harms the sprouts during its development (Surányi, 2006).

In a two-year study (2017-2018), the aim was to determine the incidence of shot hole disease (*Stigmina carpophila*) and fruit size (width and length) and fruit weight on plum cultivar 'Čačanska lepotica' in four different training systems with tree spacings of 4 x 1.5, 4 x 2, 5 x 2.5 and 6 x 3 m.

Materials and methods

Orchard site

The experimental plum orchard is located in Debrecen, Eastern Hungary and was planted in 1997 in four different training system and grafted on Myrobalan 'C359'. Soil type is sandy loam with low humus content, average year temperature is 10-11 °C and average annual rainfall is between 500 and 550 mm.

There were four plum cultivars in the orchard but in this study we assessed the disease on cv. 'Čačanska lepotica' which is very popular in Hungary and all around Europe as well. The cultivar is originated from Serbia and susceptibility to shot hole disease is various.

The orchard size is 1 ha divided into 0,25 ha plots with different tree spacings: 4 x 1.5, 4 x 2, 5 x 2.5 and 6 x 3 m (***Table 1***).

Table 1. Training system and structure of experimental plum orchard at Debrecen, Hungary Č- placement of cultivar 'Čačanska lepotica'.

B	Č	S	P	P	B	S	P
P	S	Č	B	S	Č	Č	B
Č	B	P	S	B	S	P	Č
S	P	B	Č	Č	P	B	S
4×1.5 m		**4×2 m**		**5×2.5 m**		**6×3 m**	

Disease and fruit assessments

Our study was conducted during the 2017-2018 seasons in 5 times during the seasons. In both years, between June and September, shot hole disease progress was determined once a month on four trees of each training system plot. On each tree, 25 leaves were selected randomly. 4 x 25 = 100 leaves were observed for each training system plot. A leaf was considered as diseased if there was at least one spot or shot hole symptom visible on the leaf surface.

Fruit size and weight were assessed at harvest. A total of 100 fruits (4 x 25 on four tree) were selected randomly in each plot for measurement.

Spraying schedule

In 2017, a total of 6 fungicide treatments were applied from the beginning of April until the end of June. In 2018 fungicides were sprayed from the beginning of April until the end of July 8 times in total.

Data analyses

Incidence of *Stigmina carpophila* on leaf was calculated for each year, each month and each training system. ANOVA were used to evaluate the effect of training system on disease incidence and fruit parameters. Means were separated with LSD t-test at 0.05 level.

Results and discussion

Incidence of Stigmina carpophila

Shot hole disease was identified both years on 'Čačanska lepotica' (***Figure 1***). In 2017 Disease incidence was the highest in the 4 x 1.5 m spacing during the whole season. At the end of September shot hole disease affected 85% of the foliage. In June and July the 6 x 3 m spacing had the least incidence with under 31%. Disease incidence was under 70% in 4 x 2 m; 5 x 2.5 m and 6 x 3 m spacings during the whole season.

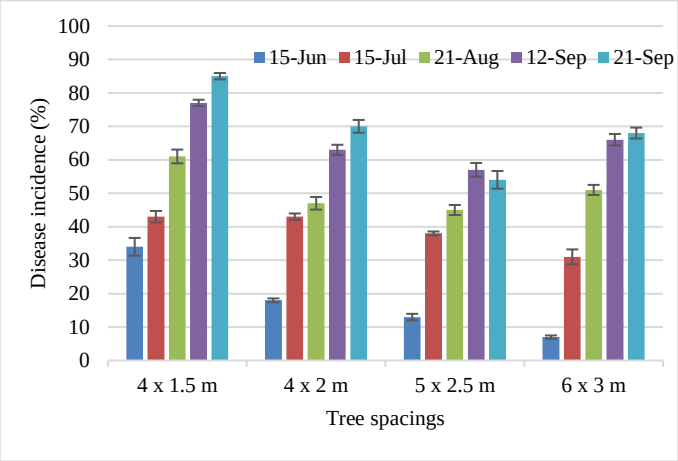

Figure 1. Incidence of shot hole disease caused by *Stigmina carpophila* on cv. 'Čačanska lepotica' in 2017 (Debrecen).

In 2018, the conditions were more favourable for the disease comparing to the previous year (2017) (***Figure 2***). Disease incidence was slightly higher in June and July and in September in the 4 x 1.5 m spacing than in the other three spacings. Overall there is an exception on 18 August when the 5 x 2.5 m spacing had highest incidence than the 4 x 1.5 m spacing.

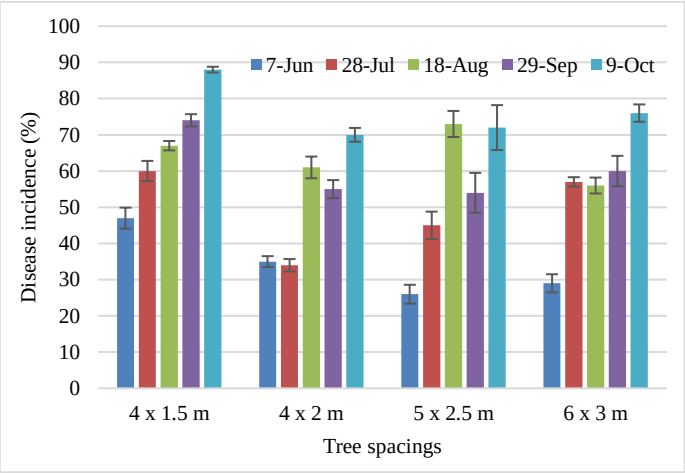

Figure 2. Incidence of shot hole disease caused by *Stigmina carpophila* on cv. 'Čačanska lepotica' in 2018 (Debrecen).

Fruit size and weight

Although fruit size is very important when it comes to the fresh fruit market, a few millimetres can make a huge difference, industrial use is not as strict as fresh market. Regarding fruit size, width was around 41 mm, length was around 43-45 mm in all spacings, no significance was observed between spacings (***Figure 3***).

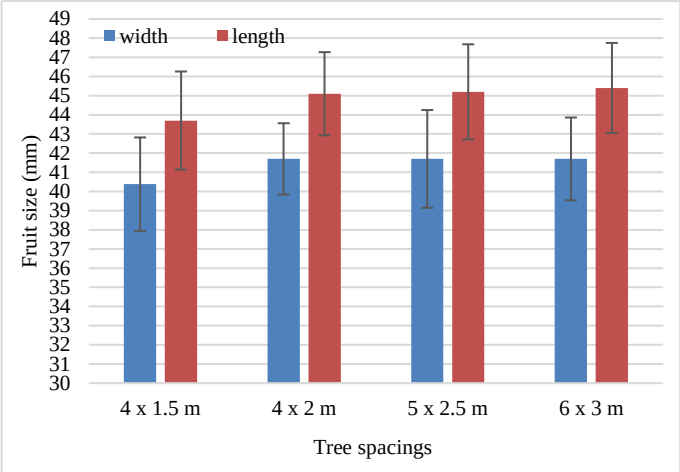

Figure 3. Fruit size of cv.'Čačanska lepotica' in 2017 (Debrecen).

In 2018 fruit width was slightly less than in 2017 with 38-40 mm and fruit length was the same with 43-45 mm (***Figure 4***). No significant difference was observed between the spacings.

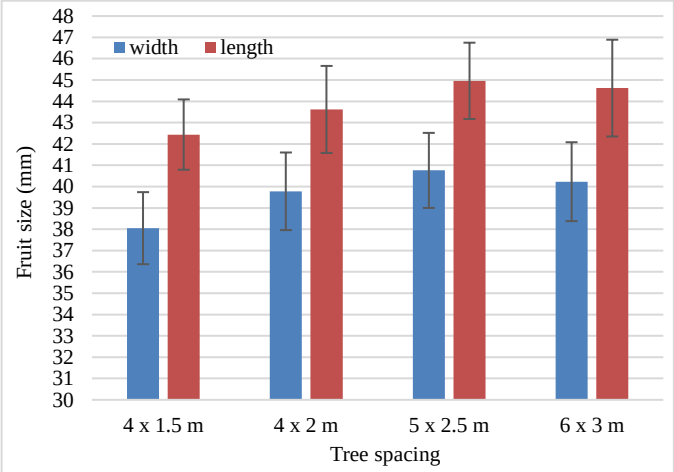

Figure 4. Fruit size of cv. 'Čačanska lepotica' in 2018 (Debrecen).

Fruit weight is a little more critical in the industrial market than fruit size. In both years the 4 x 1.5 m spacing had less fruit weight than in the other three spacings, with more than 300 g in 2017 and almost 800 g in 2018. In the 4 x 1.5 m spacing fruit weight was 274 g less in 2018 than in 2017. This difference in grams can mean kilograms of difference if we take the whole yield into consideration.

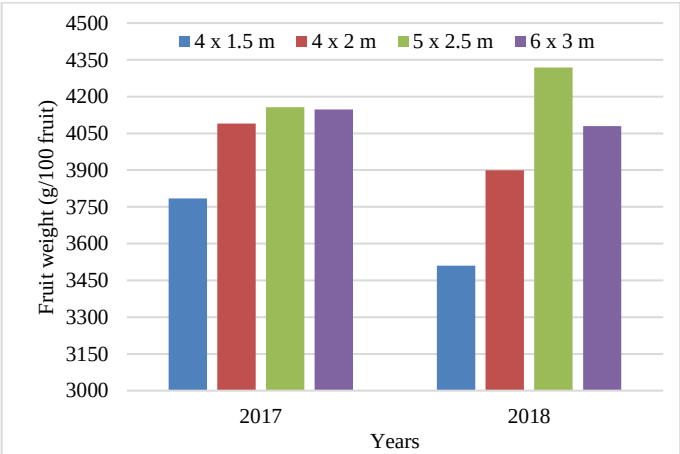

Figure 5. Fruit weight of cv. 'Čačanska lepotica' in 2017 and 2018 (Debrecen).

Conclusions

Our study confirmed that cultivar 'Čačanska lepotica' was indeed susceptible for shot hole disease *Stigmina carpophila*. Disease incidence was higher in the 4 x 1.5 m spacing altogether except for one occasion therefore spacing can play an important role in disease progress. Training system (cultivar and tree spacing) should be taken into serious consideration in plant protecting management. Tree spacing had little influence on fruit parameters.

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