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SEVERITY OF SYMPTOMS OF EUROPEAN STONE FRUIT YELLOWS ON DIFFERENT APRICOT VARIETIES

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ABSTRACT
Apricot is an important fruit crop in Hungary. There are large growing areas consisted of orchards of different sizes. These orchards are highly affected by a disease complex the so cold apoplexy with its characteristic symptoms. In this study, the effect of rootstocks and scion varieties on the severity of symptoms was investigated in an apricot orchard near Budapest. Symptoms were assessed in autumn at their most characteristic appearance on the combinations of 5 different scion varieties and 3 different rootstocks in 3 consecutive growing seasons. According to the results of the assessments in most cases, symptoms proved to be more frequent and stronger on trees grown on wild apricot rootstock than on plum intergrafted or myrobalan rootstocks. The variety Mandulakajszi proved to be consistently the least affected variety particularly on plum intergrafted rootstocks. Severity of symptoms observed on other investigated varieties deviated depending on the different rootstocks and growing seasons. To reduce the effect of growing seasons monitoring should be continued.

Keywords: apricot, rootstocks, scions, disease, apoplexy, symptoms

INTRODUCTION

Edaphic circumstances and climatic conditions of Hungary favour for growing apricots. Recently the total area of apricot production is about 5.000 ha.
In the orchards of the most important Hungarian apricot production areas ‘yellows’ symptoms, progressive necrosis, decline, and eventual death of the trees are present. Apoplexy is one of the most important diseases of apricots. Appearance of its symptoms is almost inevitable in the plantations. The annual decay of a producing orchard is between 5-10% in each year, depending on environmental and growing conditions. Apoplexy is a complex disorder which is difficult to study and treat because symptoms are caused by different pathogens separately or as a complex. Causes of the disease have been investigated in Hungary for a long time. KLEMENT ET AL. (1972) identified *Pseudomonas syringae* pv. *syringae* bacterium and *Valsaria insitiva* (syn. *Cytospora cincta*) fungus as the main causative agents. However, the above-mentioned pathogens only play a secondary role in disease development like do growing and environmental conditions. Recent studies lead to the conclusion that ‘*Ca.* Phytoplasma prunorum’ - associated with European stone fruit yellows (ESFY) disease – is the primary cause of the dieback. Symptoms first appear in the beginning or in the middle of the summer and often involves only a few branches at first but later the whole tree may become affected as the disease progresses. Shoots on infected trees are typically shorter. Early leaf yellowing or growth of latent buds which produce chlorotic leaves usually accompanied by leaf roll followed by early phylloptosis and total decay of the tree. Fruits on diseased branches develop poorly

and may fall prematurely. The disease can affect the flowers as well, which often leads to lack of fruit set.

Symptoms of ESFY are less typical than that of caused by other phytoplasmas and are often very similar to that of caused by viruses and bacteria or to disorders caused by different pesticides.

The prokaryote *Ca*. Phytoplasma prunorum infects plant species belonging to the Prunus genus. Symptoms can be observed on e.g. Japanese plum (*Prunus salicina*), peach (*Prunus persica*), flowering cherry (*Prunus serrulata*) (LORENZ ET AL., 1994) and on many rootstocks for stone fruits (KISON AND SEEMÜLLER, 2001). However, the pathogen can survive and multiply in the host asymptomatically as well. Concerning grafted plants the severity of symptoms on the scions is dependent on the susceptibility of the rootstock. Several studies showed that apricot is more severely affected on GF8/1 rootstock than on rootstocks of *Prunus domestica* selected genotypes or on *Prunus cerasifera* (myrobalan) (AUDERGON ET AL., 1991; AUDERGON AND BUISINE,1985; DOSBA ET AL., 1991; MORVAN, 1977). AUDERGON ET AL. (1991) observed differences in the susceptibility of different apricot varieties as well. According to the studies of KISON AND SEEMÜLLER (2001) severity of symptoms is influenced by the virulence of the pathogens and the different rootstock/scion combinations too.

The phytoplasma lives mainly in the sieve tubes of the plant phloem tissue. Colonization of the phloem is depending from the seasons (LEE AND DAVIS, 1992; SEEMÜLLER ET AL., 1984). According to some studies the multiplied phytoplasma cells clog the pores of the vascular system, while others report that this cannot cause the frequently observed intensive phloem necrosis (BRAUN AND SINCLAIR, 1976, 1978; SCHNEIDER, 1973). The amount of the pathogen within the woody parts of the plant is varying during the vegetation period. The highest level of phytoplasmas can be found generally at the end of summer or in early autumn which causes the appearance of the strongest symptoms in this period. The secondary formation of phloem tissues makes possible the survival of the pathogen within woody plant parts of stone fruits even in winter (SEEMÜLLER ET AL., 1998). According to DOUGLAS (1993) phytotoxins contribute to the development of characteristic symptoms. It is not sure whether the plant produces the toxins as a consequence of the infection or the pathogen produces them. The toxins disseminating within the plant cause malfunction of the cells and consequently the development of the symptoms. This phenomenon may explain why phytoplasmas were not detected in diseased plant parts in some studies (PARTHASARATHY, 1974; LEÓN ET AL., 1996).

MATERIAL AND METHOD

According to the related literature, the severity of symptoms depends on the differences among the growing seasons, the varieties and the rootstocks. In this present study, the effects of these factors on disease severity were investigated. Five varieties ('Gönci magyarkajszi', 'Magyarkajszi', 'Tomcot', 'Mandulakajszi', 'Bergeron') grown in an apricot orchard (Sóskút, Hungary) on myrobalan (*Prunus cerasifera*), wild apricot and myrobalan with plum intergrafted rootstocks were involved in the assessment (*Table 1*). The apricot plantation was established in 2001 with an open vase training system. Distance between rows and plants are 7 m and 4 m, respectively.

Table 1. Rootstock/scion combinations

Scions	Rootstocks		
	Myrobalan	Plum intergrafted r.	Wild apricot
Bergeron	x	x	x
Gönci magyarkajszi	x	x	x
Magyarkajszi	x		
Mandulakajszi	x	x	x
Tomcot	x		

Monitoring has been carried out for three consecutive years (2014-2016). Severity of symptoms was assessed in autumn in each year when their appearance proved to be the most severe. Eighty trees from each variety were classified into disease categories according to the severity of the symptoms. For the calculation of disease severity a four grade scale was used (*Table 2*).

Table 2. Scales used for the assessment of disease severity

Grade	Description
0	Tree with no symptom
1	Tree with mild symptoms
2	Tree with moderate symptoms
3	Tree with heavy symptoms / already died tree

Statistical analysis was carried out from different perspectives. In the first case, the effect of rootstocks to the development of symptoms was evaluated within the cultivars. In the second case, the effect of varieties grafted onto the same rootstock was evaluated to the evolution of the symptoms. The results were evaluated in the different years separately. Crosstabulation was carried out with Pearson's Khi-square test. In case of significant result, adjusted residuals were analysed as a post hoc test. Throughout the analysis, IBM SPSS 23 was applied.

RESULTS

The frequencies of apoplexy symptoms were remarkably high in the investigated apricot orchard in each year concerned. Level of disease incidence exceeded 70% in certain varieties.

Effect of the rootstocks on disease severity

Bergeron

Regarding the apricot variety Bergeron frequency of diseased trees was significantly different on all types of rootstocks in 2014 ($p<0.05$). Trees on Myrobalan rootstock were most affected by the disease while the least number of occurrences was on wild apricot rootstock in 2014. The highest number of diseased trees was observed on wild apricot rootstock in 2015 and on intergrafted plum rootstock in 2016. However, there were no significant differences among the rootstocks in the years 2015 and 2016 ($p>0.05$). Severity of symptoms was similarly high on trees grafted to the different rootstocks in 2014. The same tendency could be observed in 2015 and in 2016. The least severe symptoms occurred on trees on myrobalan while the strongest symptoms developed on trees on wild apricot rootstock. Deviation among the different rootstocks was significant ($p<0.05$) only in 2015 (*Figure 1*).

Gönci magyarkajszi

Regarding the apricot variety Gönci magyar kajszi the highest number of diseased trees could be counted in the populations on wild apricot rootstock in each year. Significant differences among the rootstocks could be observed in 2014 and 2016 ($p<0.05$). In these years, the least number of disease occurrences was on plum intergrafted rootstock. Similar tendency could be observed in each year concerning disease severity. The strongest symptoms developed on trees on wild apricot rootstock while trees on plum intergrafted rootstock remained the healthiest. Deviation among the different rootstocks was significant in 2014 and in 2016 ($p<0.05$, *Figure 1*).

Mandulakajszi

Regarding the apricot variety Mandulakajszi frequency of diseased trees on the different rootstocks deviated significantly only in 2016 ($p<0.05$). Symptoms could be observed most frequently on trees on wild apricot, in the same time, the least number of occurrences could be counted on myrobalan in this year. The trees grafted to wild apricot showed the strongest symptoms in the years investigated. The healthiest trees were found on intergrafted plum in 2014 and 2016 and on myrobalan in 2015. Deviation among the different rootstocks was significant in every year investigated ($p<0.05$, *Figure 1*).

Effect of the scions on disease severity

Myrobalan

Regarding the rootstock Myrobalan frequencies of diseased trees of the different varieties showed similar patterns in 2014 and in 2015 from which the data obtained in 2016 slightly differed. Trees of the variety Tomcot were most affected in 2014 and in 2015 as well. The least number of occurrences was observed in Mandulakajszi in 2014 and with almost the same occurrences in Bergeron and in Mandulakajszi in 2015. The highest number of diseased trees was observed in Gönci magyar kajszi in 2016, however the deviation of frequency was not significant compared to the varieties Tomcot, Bergeron and Magyarkajszi ($p>0.05$). The fewest number of the trees of Mandulakajszi showed disease symptoms in 2016 as well. The differences in the occurrences of the symptoms were significant in each year investigated in this variety ($p<0.05$). Heavy severity frequency of the symptoms were the strongest in Magyarkajszi in 2014, in Magyarkajszi and Tomcot in 2015, and in Tomcot and Gönci magyar kajszi in 2016. Concerning disease heavy severity, the least affected trees were found in Mandulakajszi with a significant difference compared to other varieties ($p<0.05$, *Figure 2*).

Plum intergrafted

The effect of scions on disease severity was assessed on plum intergrafted rootstock in three varieties Bergeron, Gönci magyar kajszi and Mandulakajszi. Occurrences of symptoms were not affected significantly by the varieties in any of the years investigated ($p>0.05$). Nevertheless, significant differences in severity of symptoms were found in more cases ($p<0.05$). The strongest symptoms developed on Bergeron in 2014 and on Bergeron and Gönci magyar kajszi in 2015 and 2016. The significantly least affected trees were observed in Mandulakajszi in each year ($p<0.05$, *Figure 2*).

Wild apricot

Regarding wild apricot rootstock, the significantly highest number of diseased trees was observed in Gönci magyar kajszi in each year investigated ($p<0.05$). The fewest trees was affected in Mandulakajszi and in Bergeron with almost the same frequency in 2014. The least affected population was in Manadulakajszi in 2015 and in Bergeron in 2016. The strongest symptoms were observed in Gönci magyar kajszi in 2014 and in 2016 as well. The varieties Bergeron and Gönci magyar kajszi were affected the most in 2015 with similar severity of symptoms. The trees of Mandulakajszi remained the healthiest in each year with significant deviation compared to the other varieties (p<0.05, *Figure 2*).

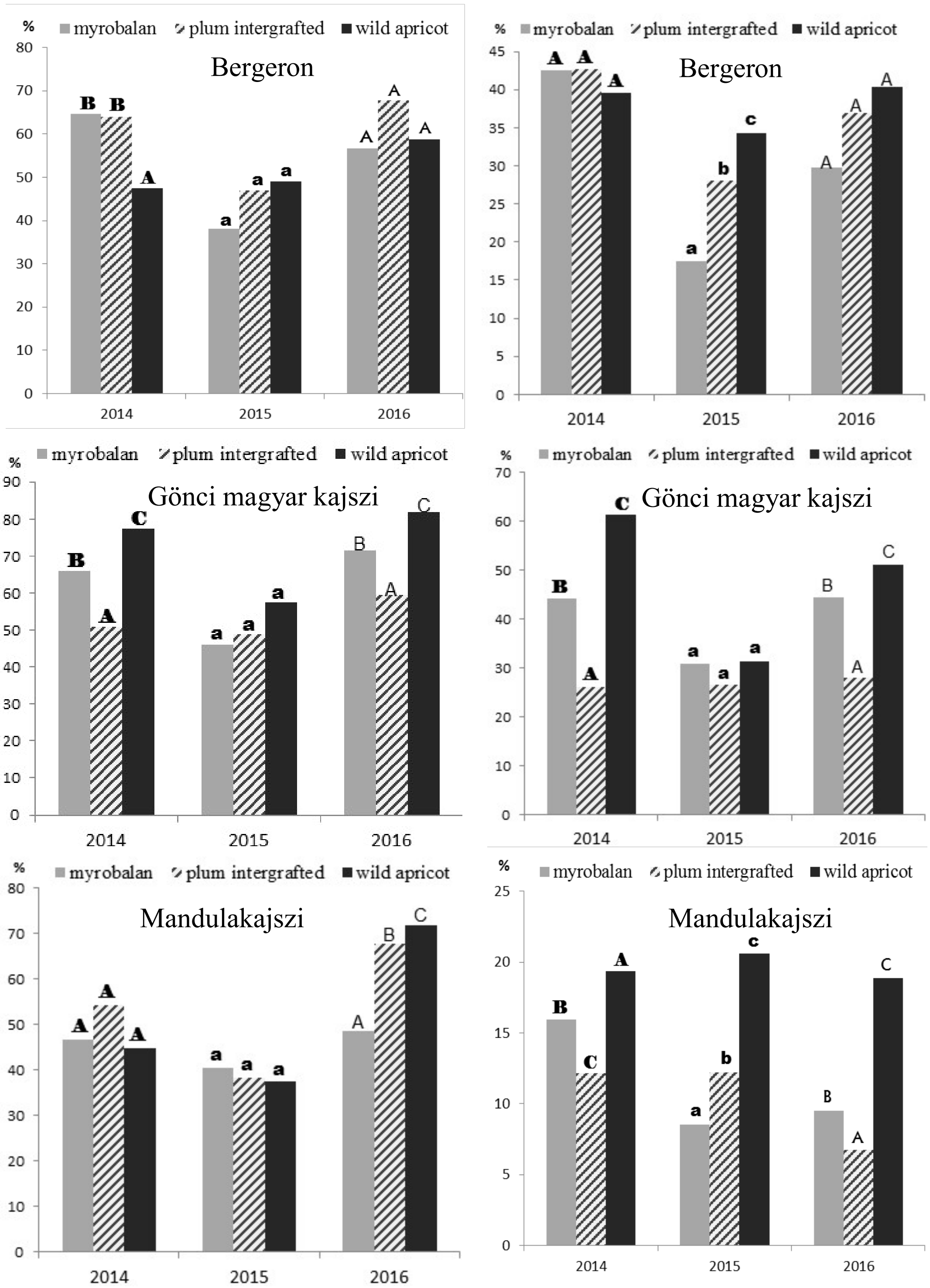

Figure 1. Frequency of trees with symptoms (grade 1, 2 or 3, left) and frequency of trees with heavy symptoms (right) on the different rootstocks.
Different letters are for significantly different groups (Pearson's Chi-square, p<0.05)

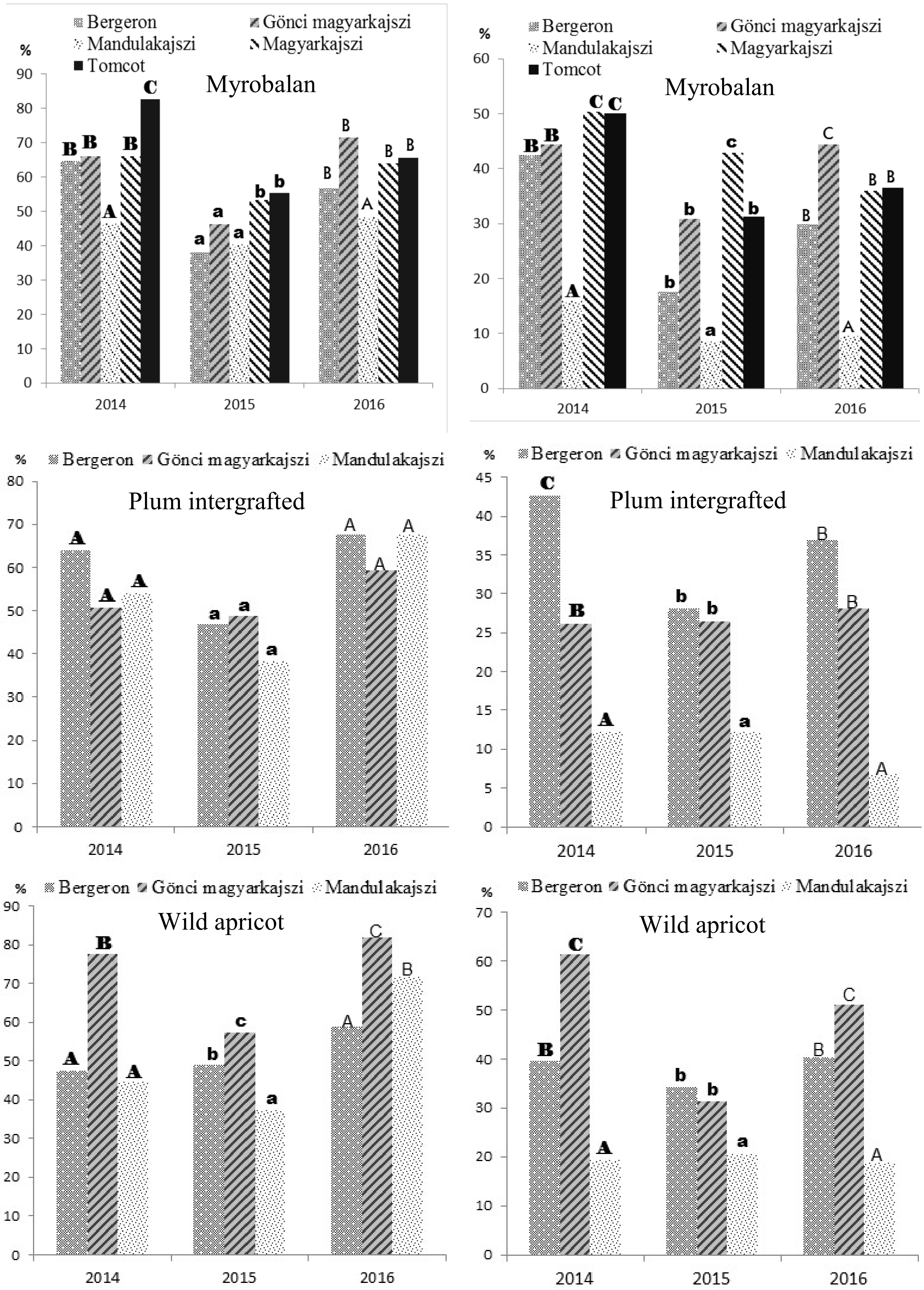

Figure 2. Frequency of trees with symptoms (grade 1, 2 or 3, left) and frequency of trees with heavy symptoms (right) on the different varieties.
Different letters are for significantly different groups (Pearson's Chi-square, p<0.05)

CONCLUSIONS

Symptoms of apoplexy were observed in high frequency in the investigated apricot orchard in each year. At the same time trees were less affected in 2015.
The effect of the different rootstocks on disease frequency deviated depending on growing seasons and varieties. Nevertheless, in the most cases symptoms could be observed in the highest frequencies on varieties grown on wild apricot rootstock. The higher susceptibility of this rootstock was particularly visible on the bases of the assessments of severity of symptoms. The least affected trees were on plum intergrafted rootstock apart from the few exceptions observed.
The effect of the different varieties on disease severity could be observed principally on the bases of the assessments of severity of symptoms. Mandulakajszi proved to be consistently the least affected variety particularly on plum intergrafted rootstocks. Severity of symptoms observed on other investigated varieties deviated depending on the different rootstocks and growing seasons.
Based on the results only preliminary conclusions can be drawn. In order to confirm the results of the survey monitoring should be continued in the following years.

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