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Effect of pruning on disease incidence of apple scab and powdery mildew in integrated and organic apple production

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Summary: In a three-year study, the effect of two winter pruning treatments (strong and weak) on apple scab (*Venturia inaequalis*) and powdery mildew (*Podosphaera leucotricha*) was evaluated on six apple cultivars ('Rewena', 'Elstar', 'Liberty', 'Gala', 'Pilot' and 'Jonica') in two environmentally-benign apple production systems (integrated and organic). Results on apple scab showed that compared to the integrated production system, the pathogen caused significantly more infection on the leaves of cvs. 'Elstar', 'Gala' and 'Jonica' in the organic production system. The effect of pruning treatments on apple scab was mainly detectable on the cultivars susceptible to the disease such as cvs. 'Gala' and 'Jonica'. The weak pruning correlated with a higher level of apple scab infection than the strong pruning, especially in the organic production system. Primary mildew infection was very low in both protection systems (below 2 %), therefore, effect of pruning on primary mildew infection could not be analysed. Low secondary mildew incidence was detected in the organically treated orchard part; however, incidence of powdery mildew was significantly higher ($P > 0.05$) on cvs. 'Elstar', 'Pilot' and 'Jonica' in the integrated orchard part compared to cvs. 'Gala', 'Rewena' and 'Liberty'. The highest incidence of mildew was on cv. 'Elstar'. Pruning had very low effect on incidence of secondary mildew infection on leaves.

Key words: apple scab, environmentally-benign apple production, high-density apple orchard, integrated, *Malus x domestica* Bork., organic, *Podosphaera leucotricha*, powdery mildew, pruning, *Venturia inaequalis*

Introduction

Since the last few decades, there has been a great deal of interest in environmentally-benign (integrated and organic) apple production systems. These new production systems paid great attention to non-chemical control methods in plant protection. Among non-chemical control methods, the general agro-technical elements are considered to be of great value (e.g. soil cultivation, fertilisation, pruning) used as indirect control methods against diseases and pests (*Gonda*, 1993, 1995, 2000; *Soltész*, 1997).

One of the most important agro-technical elements is tree pruning which enables management of tree shapes, increased growth of fruiting spurs, improved fruit coloration, and management of disease by the removal of diseased stems or dead wood that can harbour pathogens (*Childers*, 1961; *Teskey & Shoemaker*, 1978; *Gonda*, 1979, 1997, 2000, 2005). Moreover, mechanical modification of the canopy during summer (summer pruning) can also remove secondary inoculum of diseases and alter the microclimate, therefore, eliminate or reduce disease (*Childers*, 1961; *English* et al., 1984; *Gonda*, 1993, 1997, 2005; *Cooley* et al., 1997). In the case of apple diseases, effect of pruning has been studied on incidence of powdery mildew, flyspeck and sooty blotch. Powdery mildew overwinters as vegetative mycelia in dormant buds, therefore, several studies showed that winter pruning before bud burst effectively reduced the primary inoculum sources of powery mildew (*Csorba*, 1962; *Borovinova*, 1982, 1994; *Bartha*, 1984; *Hickey & Yoder*, 1990; *Komonyi & Gonda*, 1995; *Gonda*, 2000; *Glits*, 1993; 2000; *Szentiványi & Kiss*, 2003; *Veisz* et al., 2005). *Csorba* (1962) demonstrated that incidence of powdery mildew on apple shoots of cv. Jonathan ranged from 60–80% if trees received no pruning; while, mildew incidence could be reduced to 13% if all mildew infected shoots were removed during the dormant period of trees. *Bartha* (1984) emphasised that winter pruning can be an effective control method against powdery mildew, if trees received a balanced nutrient supply. *Komonyi & Gonda* (1995) showed that removal of mildew infected shoots by winter pruning resulted in a significant increase (15–20%) of vegetative production. In apple orchards, *Kiss* (1993) and *Szentiványi & Kiss* (2003) demonstrated that fungal antagonist (*Ampelomyces* spp.) could overwinter inside powdery mildew mycelia and it can reduce primary mildew infection in early spring, which might be a possible control option for environmentally-benign apple orchards. Investigations of *Glits* (1993, 2000) on apple powdery mildew revealed that

terminal buds of cv. Jonathan were always infected by *Podosphaera leucotricha* and it continuously decreased to 0% until the ninth lateral buds, therefore, he suggested that infected shoots had to be pruned at least until the fourth or fifth lateral buds. In spite of the above reasons, pathological pruning in winter received less attention due to the large tree canopy of low-density orchards and the subsequently large labour costs (*Hickey & Yoder*, 1990; *Komonyi & Gonda*, 1995; *Glits*, 1993, 2000). However, it may be a useful disease management option for high-density integrated and organic orchards with small tree canopy but no scientific study has been available on this respect. *Cooley* et al. (1997) and *Ocamb-Basu* et al. (1988) in the United States demonstrated that pruning treatments significantly reduced flyspeck and sooty blotch on apple. They suggested that pruning improves drying in the apple tree canopy, therefore, it was a useful control method to reduce both diseases. No scientific study has been performed on the effect of pruning on apple scab, except for one preliminary study of *Holb* et al. (2001) on the basis of which the present study was performed.

The aim of the present study was to evaluate the effect of pruning on disease incidence of apple scab and powdery mildew in high-density integrated and organic apple orchards. Incidence of primary and secondary infections was evaluated on six cultivars differing in their susceptibilities to powdery mildew during three consecutive growing seasons.

Material and method

Orchards and plant materials

Observations were made in the apple orchard of the University of Debrecen, Department of Fruit Production at Debrecen-Pallag. The 1 ha orchard was divided into two fields: one of the fields was treated following the Hungarian Integrated Fruit Production Guidelines (*Anonymous*, 1995); and the other one following the Hungarian Organic Production Guidelines (*Anonymous*, 1997). The orchard was established in 1997, trees were planted on M.26 rootstock, in a spacing of 4 × 1.5 m. Forty cultivars in three replications were arranged in a randomised complete block design both in the organic and the integrated fields.

Treatments

In both the integrated and organic fields, two pruning treatments were prepared in two replicates (experimental units) in 2000, 2001 and 2002. Treatments were prepared as follows: 1) weak winter pruning coupled with summer pruning and 2) strong winter pruning coupled with summer pruning. Twenty and forty percent of shoots were removed by the weak and the strong pruning techniques, respectively. Two replicates of each field with six trees per replications were chosen for the experiment. Three out of six trees in each selected experimental units were pruned weakly and the rest strongly. In each year, winter-pruning was prepared once on February 27, 26, and 24, while summer-pruning twice on June 10, 14, and 17, in 2000, 2001, and 2002, respectively. Six apple cultivars ('Rewena', 'Elstar', 'Liberty', 'Gala', 'Pilot' and 'Jonica') differing in their susceptibility to apple scab and powdery mildew were observed (*Tóth*, 1977, 1997, 1998; *Norton*, 1981; *Borovinova*, 1982, 1994; *Kovács*, 1993).

Assessments

Incidence of leaf scab (%) was assessed on 14, 16, and 19 September in 2000, 2001, and 2002, respectively. Three hundred leaves and forty fruits were observed on each selected tree in each production system and pruning treatment. Scab incidences were calculated for each cultivar, pruning treatment and production system.

Primary and secondary infections by *Podosphaera leucotricha* were assessed in 2000, 2001 and 2002. Powdery mildew infected shoots resulting from overwintered mycelia were observed on 12, 16, and 18 May; while secondary infected leaves on 14, 16, and 19 September in 2000, 2001, and 2002, respectively. In May, all shoots of each selected tree were assessed for mildew symptoms in each experimental unit. In September, three hundred leaves were observed on each selected tree in each production system and pruning treatment. Mildew incidences were calculated for each cultivar, pruning treatment and production system.

Statistical analyses

Data of scab and mildew incidences were pooled over three years. Pooled incidence data were subjected to analysis of variance (ANOVA) using the Genstat 5 Release 4.1 statistical package. Then, for each disease and cultivar, significant *F*-tests ($P = 0.05$) were followed by a Least Significance Difference (LSD) test for comparison of pruning treatment means using $LSD_{0.05}$ values.

Results

Incidence of apple scab

Leaf incidence was zero or very low in the integrated production system on all cultivars under both pruning treatments (*Figure 1*). Pruning had no significant effect at $P < 0.05$ on scab incidence of either cultivar in the integrated production system. Considerable leaf infestations were observed on cvs. 'Elstar', 'Gala', 'Pilot' and 'Jonica' in the organic production system (*Figure 2*). Pruning significantly affected disease incidence of most cultivars in the organic production system. In this system, leaf incidences of cvs. 'Elstar', 'Gala', 'Pilot' and 'Jonica' were significantly higher when they were weakly pruned ($P < 0.1$). The scab resistant cv. 'Liberty' showed no leaf scab in either production systems under different pruning techniques (*Figures 1 and 2*). The plant production system had a strong effect on scab incidence of all cultivars ($P < 0.01$), except for the

resistant cvs. 'Liberty' and 'Rewena'. Statistical analyses of different pruning treatments showed that infection level was affected by cultivar susceptibility, especially in the organic production system.

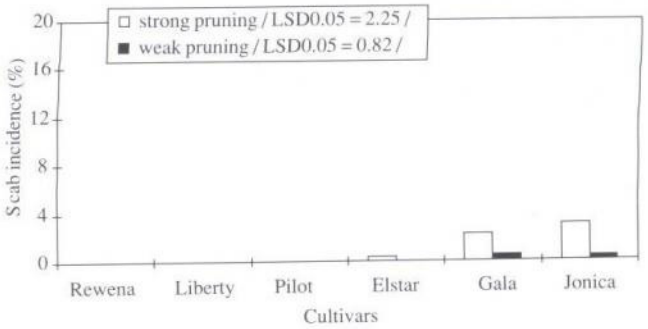

Figure 1 Effect of different pruning techniques (weak and strong) on leaf scab incidence of six apple cultivars in integrated apple production (Debrecen-Pallag, 2000–2002). Presented data are means of the three-year data set.

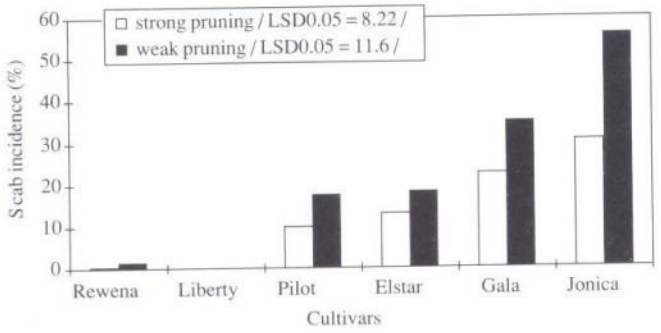

Figure 2 Effect of different pruning techniques (weak and strong) on leaf scab incidence of six apple cultivars in organic apple production (Debrecen-Pallag, 2000–2002). Presented data are means of the three-year data set.

Incidence of powdery mildew

Primary mildew infection was very low in both production systems (below 2%), therefore, the effect of pruning on primary mildew infection can not be analysed (data not shown). However, secondary infection of apple powdery mildew could be observed on the susceptible cultivars. Low mildew incidence was detected in the organically treated orchard part (*Figure 3*).

However, incidence of powdery mildew was significantly higher (P> 0.05) on cvs. 'Elstar', 'Pilot' and 'Jonica' in the integrated orchards part compared to cvs. 'Gala', 'Rewena' and 'Liberty' (*Figure 4*). The highest incidence of mildew was on cv. 'Elstar' (20.7 and 22.6% in strongly and weakly pruned treatments, respectively). Pruning had no or very low effect on incidence of secondary mildew infection on leaves.

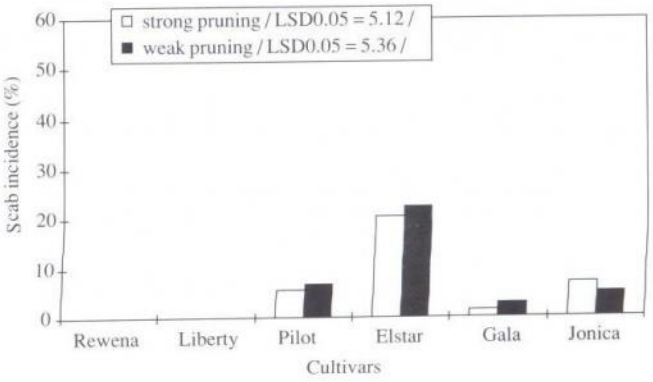

Figure 3 Effect of different pruning techniques (weak and strong) on secondary powdery mildew incidence of six apple cultivars in integrated apple production (Debrecen-Pallag, 2000–2002). Presented data are means of the three-year data set.

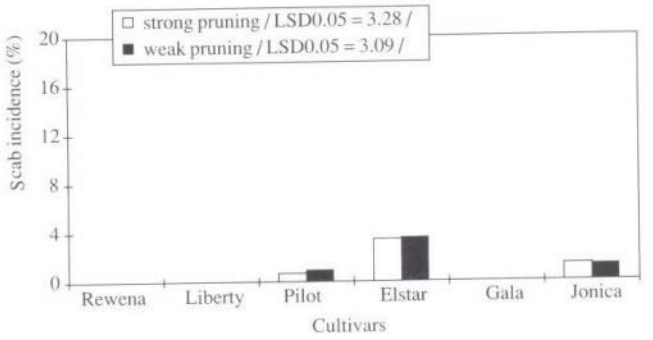

Figure 4 Effect of different pruning techniques (weak and strong) on secondary powdery mildew incidence of six apple cultivars in organic apple production (Debrecen-Pallag, 2000–2002). Presented data are means of the three-year data set.

Discussion

Scab incidence was low in the integrated production system (*Figure 1*) due to effective sprayings against scab at the beginning of the growing season. Consequently, the effect of pruning on leaf incidence of apple scab was negligible. At the same time, susceptible cultivars showed considerable infestation in the organic production system, which was in agreement with the study of *Ellis* et al. (1998) and *Holb* (2000, 2002). The reason for this was that approved fungicidal products, such as sulphur and copper compounds, are less effective than modern synthetic fungicides.

Pruning had significant effect on leaf incidence of apple scab only in the organic apple production system (*Figure 2*). Results showed that weak pruning resulted in a higher level of scab incidence compared to the effect of the strong pruning technique on scab incidence. The possible explanations of the pruning effect are that first, tree crown is more airy after a strong pruning and second, spray deposition is better inside a well-pruned tree crown, therefore, the amount of disease is larger on leaves of a weakly pruned tree than on those of a strongly pruned one. Our conclusion is supported by

Travis et al. (1987) and *Cooley* et al. (1997). They found that deposition was greater and less variable on leaves in well-pruned trees than in unpruned ones. This resulted in a reduction of leaf scab on well-pruned apple trees.

Although, several earlier studies demonstrated the positive correlation between pruning and reduction of powdery mildew incidence (*Csorba*, 1962; *Bartha*, 1984; *Hickey & Yoder*, 1990; *Komonyi & Gonda*, 1995; *Glits*, 1993; 2000; *Veisz* et al., 2005), pruning had no effect on powdery mildew in this study (*Figures 3 and 4*). The reason for this was probably that almost no primary and only low secondary inoculum sources were present in the orchard, which was due to the young age of the orchard. A certain level of secondary infection was probable due to airborne inoculum from neighbouring orchards. The low or zero values of mildew incidence in the organic orchard part were due the prolonged use of sulphur fungicides in all years which are known to be effective against powdery mildews. The wide use of sulphur fungicides is also common in other organic apple orchards, as there are only few approved fungicides for organic disease control (*Anonymous*, 1997; *Ellis* et al., 1998; *Holb & Heijne*, 2001; *Holb* et al., 2003). Mildew incidence was larger in the integrated orchard part compared to the organic one which might implicate a fungicide resistance of the fungus; however, this was not further investigated.

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