Pruning and incidences of diseases and pests in environmentally oriented apple growing systems: some aspects

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Key words: *Venturia inaequalis, Podosphaera leucotricha, Leucoptera malifoliella, Pannonychus ulmi*, pruning, integrated fruit production, organic apple production

Abbreviations: cv. = cultivar

Summary: In Hungary, fruit growers are increasingly interested in environmentally oriented growing methods, such as organic and integrated systems. The main factor in creating such systems is the establishment of a system of cultivar-pruning-plant protection based on production technology. Therefore, our aim was to examine the susceptibility of apple cultivars to diseases and pests and the effect of pruning technique on diseases and pests in organic and integrated growing systems.

Two pathogens *(Venturia inaequalis, Podosphaera leucotricha)* and two pests *(Leucoptera malifoliella, Pannonychus ulmi)* were observed in organic and integrated systems under "strong" and "weak" pruning techniques. Our results showed that, compared to integrated production, the pathogens and pests infected the trees more in the organic system. The pruning technique affected mainly the cultivars susceptible to diseases and pests. In general, the "weak" pruning technique correlated with a higher level of damage caused by diseases and pests than the "strong" pruning technique, especially in the organic growing system. The reason that techniques should be carefully chosen is that shoots grow faster and more vigorously after employing the "strong" pruning technique. This supports a better preservation of the trees, as a result of reduced susceptibility of plant tissues to diseases and pests.

Introduction

Quality product is a complex definition in agricultural practice. Attractiveness and excellent inner content of products, as well as an environmental production method are becoming increasingly essential for quality fruit production.

Apple production as the most important cultivated fruit has been wrestling with difficulties over the last few years (declining production, loss of East-European markets, obsolete assortment of cultivars). Moreover, cultivar make-up has changed and there is a great deal of interest in environmental production. However, a new production structure and a radical break from the traditional mentalities prevalent in plant production are required. The selection of site, cultivar and rootstock before plantation and production technology after plantation are even more relevant than they were in the past. Cultivar, pruning technique and plant protection systems are the main priorities in the new production technology. Today an essential criterion must be the adoption of these elements of production technology into environmentally friendly growing systems (*Gonda*, 1993, 1995).

The connection between pests and their parasitoids has been extensively studied and clarified since the 1970s in Hungary. Much faunistical information is available about host-parasite interactions, the dynamics of pest populations and the life cycle of pests (*Molnár*, 1975, 1979; *Balázs*, 1989, 1992; *Molnár*, 1991; *Papp*, 1994). Moreover, various suggestions and standpoints have been made about the technological development of environmental apple growing systems (*Balázs*, 1991; *Miklay*, 1995; *Balázs* et al., 1997; *Holb*, 2000).

Although there is a great deal of interest in environmental apple growing, little information is available about the relationship between the elements of production technology and the incidence of diseases or pests. Consequently the objective of this study was to evaluate the effect of pruning on the incidence of two diseases and two pests in organic and integrated growing systems.

Material and methods

Orchard site and spraying

Observations were made in the apple cultivar collection in the Debrecen-Pallag experimental fruit plantation of Debrecen University, Department of Horticulture. The orchard was established in 1997. Trees were planted on *M26* rootstock at a spacing of 4 x 1.5 m. Cultivars are in randomised block system, 5 plots per cultivar, each plot consists of 7 trees. The 1 ha orchard is divided into two fields according to two different plant protection systems (integrated and organic). Spraying schedules in both production systems are summarized in *Table 1*.

Experimental layout and assessment

Two plots of each plant protection system with 6 (2 x 3) trees per plots were chosen for the experiment. Six apple cultivars (*Rewena, Elstar, Liberty, Gala must, Pilot* and *Jonica*) were selected for assessments.

Two different pruning techniques were prepared from the autumn of 1999, one using a "weak" and the other using a "strong" winter and summer pruning technique. Three out of six trees per selected plots were pruned "weakly" and the rest "strongly". Pruning was performed once in winter 1999/2000, and twice in summer 2000.

The populations of two pathogens (*Venturia inaequalis, Podosphaera leucotricha*) and the damage from two pests (*Leucoptera malifoliella, Pannonychus ulmi*) were assessed on 14–15 September 2000. 6 x 50 leaves per tree were observed on each selected tree in both plant protection systems according to both pruning techniques. Incidences of each disease and pest damage were calculated in both plant protection systems for each cultivars and pruning techniques.

Statistical analysis

All incidence data of each disease and pest were subjected to analysis of variance (ANOVA) using the

Table 1 Spraying schedule in organic and integrated apple orchard, Debrecen-Pallag, 2000

		Integrated apple production	
Date	Phenological stage	Applied product (active ingredient)	Dosage (%)
04. April	Green tip	Agrol plusz (vaseline oil)	30 l/ha
		Cuproxat 50 WP (copper hydroxide)	4 l/ha
10. April	Appearence of flower bud	Cuproxat 50 WP (copper hydroxide)	4 l/ha
19. April	Beginning of bloom	Zolone 35 EC (foszalon)	1.7 l/ha
		Chorus 75 WG (cyprodinil)	0.2 kg/ha
26. April	Full bloom	Streptomycin	
		Chorus 75 WG (cyprodinil)	0.2 kg/ha
03. May	First petal fall	Chorus 75 WG (cyprodinil)	0.2 kg/ha
		Frigocur (alfa-naftil-acetic acid)	0.5 l/ha
09. May	Last petal fall	Discus DF (krezoxim-metil)	0.2 kg/ha
		Insegar (fenoxikarb)	0.25 l/ha
		Magus 200 SC (fenazaquin)	0.5 l/ha
16. May	Fruit setting	MgSO4	15 kg/ha
		Discus DF (krezoxim-metil)	0.2 kg/ha
25. May	Fruit swelling	Danadim 40 EC (dimetoát)	1 l/ha
		Discus DF (krezoxim-metil)	0.2 kg/ha
02. June	Fruit swelling	Score 250 EC (difenoconazole)	0.2 kg/ha
		MgSO4	15 kg/ha
		Kasumin (kasugamicin)	1.5 l/ha
		Efuzin 500 FW (dodine)	2 l/ha
17. June	Fruit swelling	Score 250 EC (difenoconazole)	0.2 l/ha
		Dimilin (diflubenzuron)	0.6 kg/ha
		Kasumin (kasugamicin)	1.5 l/ha
17. July	Fruit swelling	Discus DF (krezoxim-metil)	0.2 kg/ha
		Dimilin (diflubenzuron)	0.6 kg/ha
		Integrated apple production	
Date	Phenological stage	Applied product (active ingredient)	Dosage (%)
04. April	Green tip	Agrol plusz (vaseline oil)	30 l/ha
		Cuproxat 50 WP (copper hydroxide)	4 l/ha
10. April	Appearence of flower bud	Cuproxat 50 WP (copper hydroxide)	4 l/ha
26. April	Full bloom	Sulfur 900 FW (elementary sulphur)	3 l/ha
09. May	Last petal fall	Methylated alcohol	2 l/ha
		Green soap	4 kg/ha
16. May	Fruit setting	Sulfur 900 FW (elementary sulphur)	3 l/ha
		Biomit C	5 l/ha
25. May	Fruit swelling	Sulfur 900 FW (elementary sulphur)	3 l/ha
		Methylated alcohol	2 l/ha
		Ecotec bio	1 kg/ha
02. June, 17. July	Fruit swelling	Sulfur 900 FW (elementary sulphur)	3 l/ha
		Methylated alcohol	2 l/ha

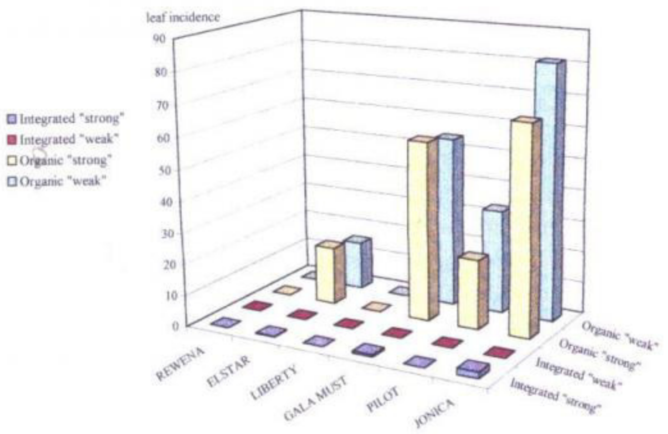

Figure 1 Effect of plant protection system (organic and integrated) and pruning technique ("strong" and "weak") on leaf incidence of apple scab on 6 apple cultivars (Debrecen-Pallag, 2000)

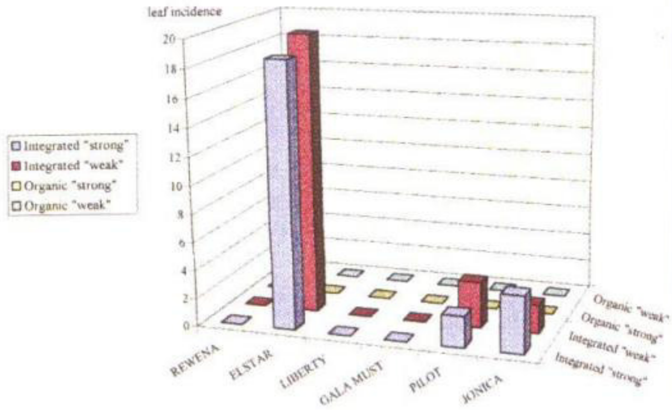

Figure 2 Effect of plant protection system (organic and integrated) and pruning technique ("strong" and "weak") on leaf incidence of apple powdery mildew on 6 apple cultivars (Debrecen-Pallag, 2000)

Genstat 5 Release 4.1 statistical package (*Genstat 5 Committee*, 1993). One-way ANOVA was made between both pruning techniques and between both plant protection systems as well as among cultivars.

Results

Incidence data of Venturia inaequalis

The scab resistant cv. *Rewena* and cv. *Liberty* showed no leaf scab in either plant protection systems under different pruning *(Figure 1)*. Leaf incidence of scab was 0 or very low in the integrated system on all cultivars under both pruning techniques. Leaf infection levels were considerable only in the organic system. Cv. *Gala must* and cv. *Jonica* had high level of leaf infection by the middle of September (54.4 %, or 81.2 %).

Pruning had very little effect on the incidence of leaf scab in integrated production *(Table 2)*. However, pruning significantly affected disease incidence in organic production. Leaf incidences of cv. *Pilot* and cv. *Jonica* were significantly lower in the organic growning system with "weak" pruning (F-test < 0.01). The plant protection system had a strong effect on scab incidence of all cultivars (F-test < 0.01) except for the resistant ones. Statistical analyses among cultivars showed that the cultivars only influenced the infection level in the organic production.

Incidence data of Podosphaera leucotricha

Typical secondary infection of apple powdery mildew could be observed in the orchard. No mildew symptoms were detected in the organically produced apples *(Figure 2)*. However, in the integrated systems three cultivars (cv. *Elstar*, cv. *Pilot* and cv. *Jonica*) were infected by the pathogen. Cv. *Elstar* displayed the highest incidence of mildew (18.7 % and 19.8 %).

Pruning had no or very low effect on mildew incidence *(Table 3)*. A significant difference can only be seen on cv. *Jonica* and cv. *Pilot* in the organic system, but the plant protection system had a strong effect on the incidence of infested cultivars (F-test < 0.01).

Table 2 Effect of plant protection system and pruning technique on leaf incidence of apple scab, Debrecen-Pallag, 2000 (statistical analyses)

Plant protection	Integrated		Organic		Type of pruning	Type of pruning	Plant protection technology
Type of pruning	"strong"	"weak"	"strong"	"weak"	(Integrated)	(Organic)	("weak"+"strong" pruninig)
Cultivars							
REWENA	0[a] a[b]	0 a	0 a	0 a	ns[c]	ns	ns
ELSTAR	0.2 a	0 a	18.5 b	15.5 b	ns	*	***
LIBERTY	0 a	0 a	0 a	0 a	ns	ns	ns
GALA MUST	0.7 a	0 a	57.1 c	54.3 d	*	*	***
PILOT	0 a	0 a	22.1 b	33.1 c	ns	***	***
JONICA	2 b	0 a	66.5 c	81.1 e	**	***	***
$LSD_{0.05}$	1.71	–	11.4	15.1			

[a] Used data set of leaf incidences are mean data of two plots with 6 (3 x 2) trees in both plant protection systems.

[b] Values within columns followed by different letters are significantly different.

[c] F-test = *** < 0.01, ** 0.01–0.05, * 0.05– 0.1, ns > 0.1.

Table 3 Effect of plant protection system and pruning technique on leaf incidence of apple powdery mildew, Debrecen-Pallag, 2000 (statistical analyses)

Plant protection	Integrated		Organic		Type of pruning	Type of pruning	Plant protection technology
Type of pruning	"strong"	"weak"	"strong"	"weak"	(Integrated)	(Organic)	("weak"+"strong" pruninig)
Cultivars							
REWENA	0[a] a[b]	0 a	0 a	0 a	ns[c]	ns	ns
ELSTAR	18.7 c	19.8 b	0 a	0 a	ns	ns	***
LIBERTY	0 a	0 a	0 a	0 a	ns	ns	ns
GALA MUST	0 a	0 a	0 a	0 a	ns	ns	ns
PILOT	2.2 a	3.2 a	0 a	0 a	*	ns	***
JONICA	4 b	2 a	0 a	0 a	**	ns	***
$LSD_{0.05}$	1.72	4.98	–	–			

[a] Used data set of leaf incidences are mean data of two plots with 6 (3 x 2) trees in both plant protection systems.
[b] Values within columns followed by different letters are significantly different.
[c] F-test = *** < 0.01, ** 0.01–0.05, * 0.05– 0.1, ns > 0.1.

Incidence data of Leucoptera malifoliella

Leaves of cultivars showed the spiral lesions of this pest in both production systems *(Figure 3)*. Among cultivars cv. *Rewena* and cv. *Jonica* showed relevant infestations in the organic production system (7.3 or 7.4 %). A relatively low level of infestation was detected on cv. *Elstar* (1.2 or 1.5 %) and cv. *Liberty* (0.7 or 0.5 %).

Pruning had a considerable effect on leaf damage on cv. *Rewena* and cv. *Jonica (Table 4)*. The "weak" pruning caused significantly higher damage on these cultivars in both plant protection systems. Pruning had little effect on leaf damage in the integrated system. Statistical analyses among cultivars showed that the cultivars had relatively little influence on the incidence of leaf damage.

Incidence data of Pannonychus ulmi

Cv. *Revena* was the most damaged by *Pannonychus ulmi*, leaf incidence ranged from 8.5–16.5% *(Figure 4)*. Relatively little damage was found on cv. *Jonica*, for which the leaf incidence ranged from 0–5.5%.

Pruning had little effect on leaf damage in the integrated system *(Table 5)*. In organic production trees under "weak" pruning showed significantly greater damage on cv. *Elstar* cv. *Liberty*, cv. *Rewena* and cv. *Jonica*. Statistical analyses between both plant protection systems showed that only cv. *Pilot* suffered more damage in the organic system compared to integrated production at P < 0.01 level.

Discussion

In Hungary, the spring of 2000 was relatively humid followed by a dry, hot summer. This hot summer prevented most of the diseases and pests from causing economically important losses compared to either 1998 or 1999. Although 2000 was unfavourable for most diseases and pests, leaf damage caused by *Venturia inaequalis*, *Podosphaera leucotricha*, *Leucoptera malifoliella* and *Pannonychus ulmi* reached relatively high levels, as shown in this study.

Scab infection appeared at a low level in the integrated growing system *(Figure 1 and Table 2)*. This was due to

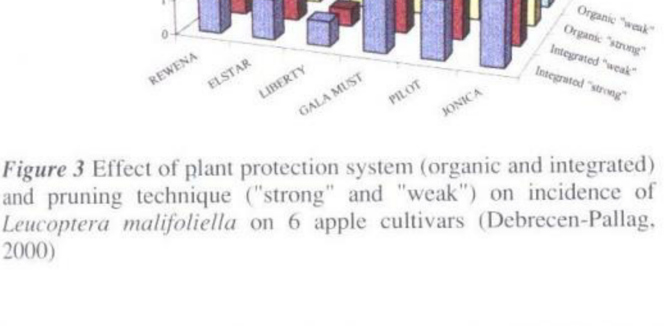

Figure 3 Effect of plant protection system (organic and integrated) and pruning technique ("strong" and "weak") on incidence of *Leucoptera malifoliella* on 6 apple cultivars (Debrecen-Pallag, 2000)

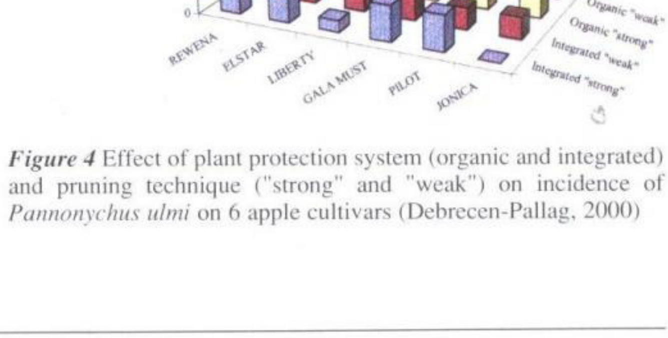

Figure 4 Effect of plant protection system (organic and integrated) and pruning technique ("strong" and "weak") on incidence of *Pannonychus ulmi* on 6 apple cultivars (Debrecen-Pallag, 2000)

Table 4 Effect of plant protection system and pruning technique on incidence of *Leucoptera malifoliella*, Debrecen-Pallag, 2000 (statistical analyses)

Plant protection	Integrated		Organic		Type of pruning	Type of pruning	Plant protection technology
Type of pruning	"strong"	"weak"	"strong"	"weak"	(Integrated)	(Organic)	("weak"+"strong" pruninig)
Cultivars							
REWENA	3.5[a] c[b]	5 c	3.5 cd	7.3 c	*[c]	***	ns
ELSTAR	1.2 ab	1.5 ab	1 a	1 a	ns	ns	ns
LIBERTY	0.7 a	0.5 a	1.8 ab	1.5 a	ns	ns	*
GALA MUST	2.3 bcd	2.7 b	6 c	5 bc	ns	ns	**
PILOT	1.7 abc	2.5 b	2.7 bc	4 b	*	*	*
JONICA	3 de	2.5 b	4.7 d	7.4 c	*	**	**
$LSD_{0.05}$	1.24	1.41	1.65	2.45			

[a] Used data set of leaf incidences are mean data of two plots with 6 (3 x 2) trees in both plant protection systems.
[b] Values within columns followed by different letters are significantly different.
[c] F-test = *** < 0.01, ** 0.01–0.05, * 0.05– 0.1, ns > 0.1.

Table 5 Effect of plant protection system and pruning technique on incidence of *Pannonychus ulmi*, Debrecen-Pallag, 2000 (statistical analyses)

Plant protection	Integrated		Organic		Type of pruning	Type of pruning	Plant protection technology
Type of pruning	"strong"	"weak"	"strong"	"weak"	(Integrated)	(Organic)	("weak"+"strong" pruninig)
Cultivars							
REWENA	11[a] c[b]	16.5 c	10.5 d	8.5 cb	*[c]	*	ns
ELSTAR	4.2 b	5.8 b	0 a	10 c	ns	***	ns
LIBERTY	0.8 ab	1.6 a	2.6 ab	6.5 b	ns	**	**
GALA MUST	2.5 b	5.5 b	6.5 c	9.7 c	ns	ns	*
PILOT	2.5 b	1.5 a	10 d	7.5 bc	ns	ns	***
JONICA	0 ab	1.5 a	5.5 bc	3.5 a	**	*	**
$LSD_{0.05}$	2.52	2.98	3.42	2.92			

[a] Used data set of leaf incidences are mean data of two plots with 6 (3 x 2) trees in both plant protection systems.
[b] Values within columns followed by different letters are significantly different.
[c] F-test = *** < 0.01, ** 0.01–0.05, * 0.05– 0.1, ns > 0.1.

effective treatments 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 organic production. The reason for this was that approved fungicidal products, like sulphur and copper, are less effective than modern synthetic fungicides. Consequently, in spite of the dry, hot summer the scab epidemic was well established by the second half of the growing season.

The secondary infection of powdery mildew was remarkable in the integrated system *(Figure 2 and Table 3)*. The number of sprays against mildew was low during the growing season and the spray schedule stopped in the middle of July *(Table 1)*. Therefore the small amount of primary inoculum could produce a notable secondary infection by the middle of September. However no mildew symptoms were observed in the organic growing system, possibly initially due to the absence of primary inoculum and secondly to the good efficacy of sulphur against apple scab.

Pruning had less effect on the impact of pests than of diseases *(Figure 3, 4, Table 4 and 5)*. However, our study showed that pruning had a considerable effect on leaf incidence of diseases and pests in some cases. Results generally showed that "weak" pruning could correlate with a higher level of damage caused by diseases and pests, especially in the organic growing system, compared to the effect of the "strong" pruning technique. The reason of such techniques should be carefully chosen because shoots grow faster and more powerfully after employing the "strong" pruning technique. This facilitates a better preservation of the trees, which resulted in a reduced susceptibility of plant tissues to diseases and pests.

Our one-year project represents a preliminary study of the relation between one element of plant production technology and the effectiveness of plant protection. The effects of pruning or other elements of plant production technology on disease and pest damage require more research in various elements of plant production technology under different weather conditions.

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