UREA APPLICATION AS A SANITATION PRACTICE TO MANAGE PEAR SCAB

Regīna Rancāne[1,2], Līga Vilka[1,2], Biruta Bankina[1]
[1]Latvia University of Agriculture
[2]Latvian Plant Protection Research Centre
regina.rancane@laapc.lv

Abstract
Several fungicide applications are used to control a pear scab (*Venturia pirina* Aderh.) on pear (*Pyrus communis* L.) trees. Minimal chemicals use in fruit-growing constantly has been important condition in the integrated fruit production; therefore, sanitation is recommended to reduce a primary inoculum in orchards. The study was carried out in an integrated pear orchard located in Sigulda district, in the central part of Latvia to estimate if a fall treatment of a pear orchard with urea reduces an amount of pseudothecia and pear scab incidence level the following season. Six treatments trial was arranged in the autumn 2011 on a moderately susceptible pear cultivar 'Belorusskaya Pozdnaya'. An amount of leaf litter, pseudothecia and incidence level of a disease on leaves and fruits were determined. The results showed that urea application reduced both an amount of leaf litter and a number of pseudothecia. An average amount of leaf litter was 127 leaves per 0.25 m^2 in a control and 89 leaves in a treatment with urea application. The number of pseudothecia reached 250 pseudothecia per one leaf disc in a control and 160 pseudothecia in a treatment with the urea application, the difference was not significant ($p>0.05$). The reduction of disease incidence level on leaves was significant ($p<0.05$) only in the first assessment of five in total.
Key words: *Venturia pirina*, pear disease, fungicide applications, pseudothecia.

Introduction

Venturia pirina Aderh. (anamorph *Fusicladium pyrorum* (Lib.) Fuckel is the causal agent of scab on pear (*Pyrus communis* L.) trees. The disease is common in all pear-growing areas of the world and causes heavy crop losses by producing lesions on leaves, young shoots and fruits (Shabi, 1990). In pear orchards, crop losses due to pear scab would be about 50-100% if appropriate control measures are not applied; therefore, several fungicide applications are used to suppress disease development. In pear orchards in Latvia, a number of applications could reach seven times, depending on weather conditions, the amount of inoculum and cultivar susceptibility to the pathogen.

The pear scab pathogen overwinters primarily as pseudothecia in pear leaf litter which is the main inoculum source in spring (Shabi, 1990). In addition, the fungus can overwinter as mycelium in twig lesions (Stensvand et al., 1996); this phenomenon has never been investigated in Latvia. During spring, ascospores are released from the pseutothecia and cause primary infection. Fungicide sprays against pear scab are most effective when they coincide with discharge of ascospores; therefore, primary infection period is the most critical time for controlling pathogen. Under Latvian conditions ascospores are released over a 1.5 to 2 month period, from the middle of April until the middle of June when leaves are decomposed.

An important practice for managing apple scab (*Venturia inaequalis* (Cooke) Wint.) and pear scab (*Venturia pirina* Aderh.) in an integrated plant protection program is the reduction of primary inoculum in order to lessen fungicide use during the growing season (MacHardy, 1994). Several nonchemical sanitation procedures against apple scab have been evaluated, such as burning or ploughing (Curtis, 1924), the shredding of leaf litter (Sutton et al., 2000; Vicent et al., 2004), covering the orchard floor with plastic (Holb, 2006) and the use of fungal antagonists to suppress the ascigerous stage of *V. inaequalis* (Vincent et al., 2004). Several studies revealed that mulch cover increased the biological activity of soils, which enhanced leaf degradation (Haynes, 1981). An autumn application of dolomitic lime reduces the percentage of apple and pear leaves with pseudothecia, the number of pseudothecia per leaf, and number of asci per pseudothecium (Spotts et al., 1997). Leaf collection has a direct reduction effect on fallen leaves and primary inoculum (Heitefuss, 1989). Applying urea to leaf litter and in a tree canopy is one of the mostly used sanitation practices to reduce an apple scab inoculum.

Urea applications between all those sanitation procedures have showed the highest efficacy. Urea applied to trees in autumn before leaf fall or to the leaf litter in autumn or spring before bud break reduced the ascosporic inoculum 50 to 90% (Sutton et al., 2000). A urea solution in water should be applied to apple (*Malus x domestica* Borkh.) trees as leaves begin fall in the autumn. This should been done as late as possible to prevent the urea from being translocated into the tree. Trees sprayed with urea may defoliate more quickly than unsprayed trees. Urea inhibits the development of scab fruiting bodies on the fallen leaves. High nitrogen content also helps the leaves to decompose much faster than normal (Jesperson, 1995). Urea increases the softening rate of leaf litter and their palatability to earthworms (Burchill et al., 1971). Urea has been widely tested in apple orchards,

but there is a lack of information how effective it is in pear orchards.

The purpose of this study was to determine the effect of an autumn application of urea to manage pear scab. In this study the potential of urea application to reduce the amount of pseudothecia and scab lesions on leaves and fruits was investigated.

Materials and Methods

The study was carried out in an orchard at Sigulda district, in the central part of Latvia, in 2011 and 2012. In this orchard integrated fruit production practice was used.

The planting distance of pear cultivar 'Belorusskaya Pozdnaya' on seedling rootstock: 5 × 3 m (tree density – 666 pear trees per 1 ha. The pear orchard was planted in 2002.

Soil: sandy loam with the following characteristics: pH KCL – 6.3, content of organic substance 26 g kg^{-1}, content of plant-available K – 183 mg kg^{-1}, P – 302 mg kg^{-1}. In the orchard an apple scab warning system RIMpro (Relative Infection Measure program) was used for specifying the border value of apple and pear scab infection risk.

The trial with six treatments in three replications was arranged in the autumn 2011 on a moderately susceptible pear cultivar 'Belorusskaya Pozdnaya' (Kārkliņš, 2004). The size of experimental unit (replication) was 18 × 25 m, including 30 trees. Following treatments were made:

1) untreated, non-sanitized control;
2) fungicide applications according to RIMpro (2012);
3) urea application in a tree canopy in autumn (2011) + RIMpro (2012);
4) collection of fallen leaves in spring (2012) + RIMpro (2012);
5) urea application in a tree canopy in autumn (2011) + copper hydroxide in a high dosage in spring (2012) + RIMpro (2012);
6) fungicide applications according to the conventional schedule suggested by the company Syngenta (2012).

A urea (46-0-0) solution (50 g of agricultural grade urea in 950 mL of water) at a rate of 570 L ha^{-1} was applied on 14 October 2011.

Champion 50 WP (a. i. copper hydroxide, 77%), 10 kg ha^{-1} sprayed on 13 April 2012.

Collection of fallen leaves was done on 18 April 2012 before ascospore discharge.

Following fungicide applications were done according to the RIMpro – apple scab warning system or according to the conventional schedule suggested by the company Syngenta (distributer of plant production means) in 2012.

Applications according to RIMpro: Champion 50 WP (a. i. copper hydroxide, 77%), 3 kg ha^{-1} – 26 April; Dithane NT (a. i. mancozeb, 750 g kg^{-1}), 2 kg ha^{-1} – 8 May; Chorus 50 WG (a. i. cyprodinil, 500 g kg^{-1}), 0.3 kg ha^{-1} – 23 May; Score 250 EC (a. i. difenoconazole, 250 g L^{-1}), 0.2 L ha^{-1} – 5 June.

Applications according to the conventional schedule: Champion 50 WP (a. i. copper hydroxide, 77%), 3 kg ha^{-1} – 26 April; Chorus 50 WG (a. i. cyprodinil, 500 g kg^{-1}), 0.3 kg ha^{-1} – 3 May, 10 May, 23 May; Score 250 EC (a. i. difenoconazole, 250 g L^{-1}), 0.2 L ha^{-1} – 31 May, 7 June.

Amount of leaf litter

Assessment of fallen leaves was done on 13 April 2012 in control and treatment with a urea application. Leaves were counted in 0.5 × 0.5 m frame, 1 m distant from a tree, in randomly selected four sites in a treatment.

Amount of pseudothecia

Fallen leaf samples for laboratory analysis were collected on 13 April (2012) - 15 leaves from a non-sanitized control and 15 from a treatment with urea application. From each leaf four discs (each 0.25 cm^2) were cut out. The number of pseudothecia per each leaf disc was determined using a binocular Olympus SZ X7 at four times magnification. Data were analyzed with statistical software R (version 2.15.1), boxplot graphic method (R Core Team, 2012).

Disease incidence

Scab assessments were done on leaves and fruits in the autumn 2011 and in the following vegetation season 2012, on June 7, June 15, June 29, July 5 and August 3. In the summer 2012 a scab incidence (infected objects, %) was assessed on four trees located in the center of each replicate, 25 leaves per tree. All data sets were subjected to analysis of variance using the Genstat 15 statistical package. Data were transformed and then significant F-tests were followed by the Least Significance Difference (LSD)-test for comparing the treatment means.

Weather conditions

The autumn 2011 was comparatively warm, air temperature exceeded long term average. The first sustainable snow cover developed in the middle of January 2012. February 2012 was snowy; in the first decade air temperature was below long term average. Weather conditions from 4 April 2012 were recorded with a portable Lufft weather station placed in apple orchard approximately 2 km distant from the trial site.

The spring in 2012 was late with a comparably low temperature. In the beginning of April the experimental orchard was still covered with snow. The average air temperature and precipitation in 2012, and long-term observations are displayed in Figure 1. The average

amount of precipitation during summer months was over long-time observations; the rain is the main influencing factor for a pear scab development.

Results and Discussion

Application with a urea solution in the autumn 2011 reduced the amount of leaf litter before bud break. An average amount of leaf litter was 127 leaves per 0.25 m^2 in control and 89 leaves in treatment with urea application. For PAD (potential ascospore dose) a calculation number of pseudothecia per lesion is usually used (Gadoury and MacHardy, 1986). In this research, pseudothecia were distributed on the whole leaf surface; therefore, they were counted on leaf discs. The number of pseudothecia per leaf in the trial was high; it reached 250 pseudothecia per one leaf disc in control (untreated) and 160 pseudothecia in treatment with the urea application. Data variance is showed in Figure 2. There was a tendency of pseudothecia reduction in treatment with the urea application, but difference between the number of pseudothecia in the control and in the treatment with urea application was not significant ($p>0.05$), and according to statistical analysis 67% of difference can be explained with the factor 'treatment type'.

The green tip stage (BBCH 07) was observed on 25 April and the first ascospore discharge started nine days later on 3 May. Rainy weather conditions in the end of May (Figure 1.) favored a development of the first scab lesions on pear leaves.

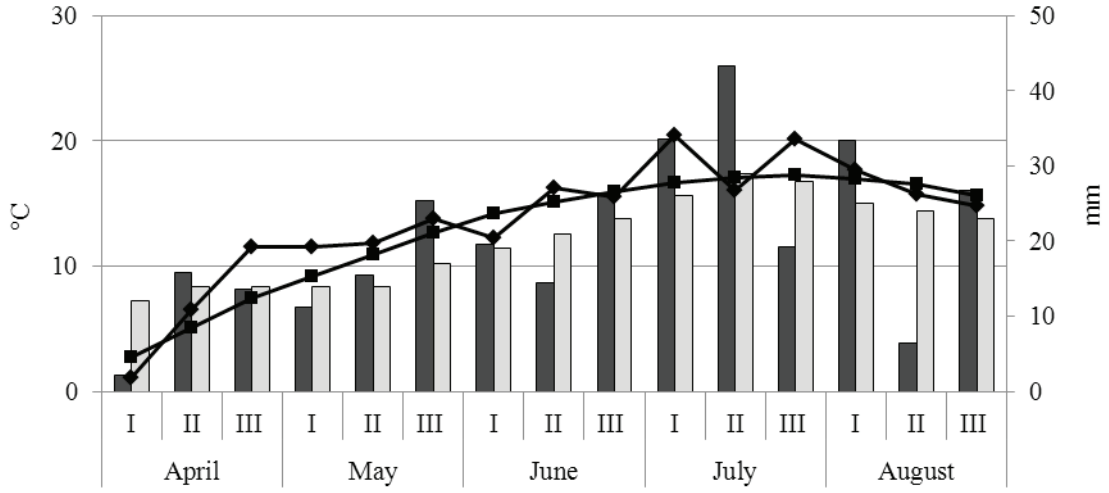

Figure 1. Average air temperature and sum of precipitation:
■ Long-term average, °C; ▲Temperature in 2012, °C; Long-term average, mm;
Precipitation in 2012, mm.

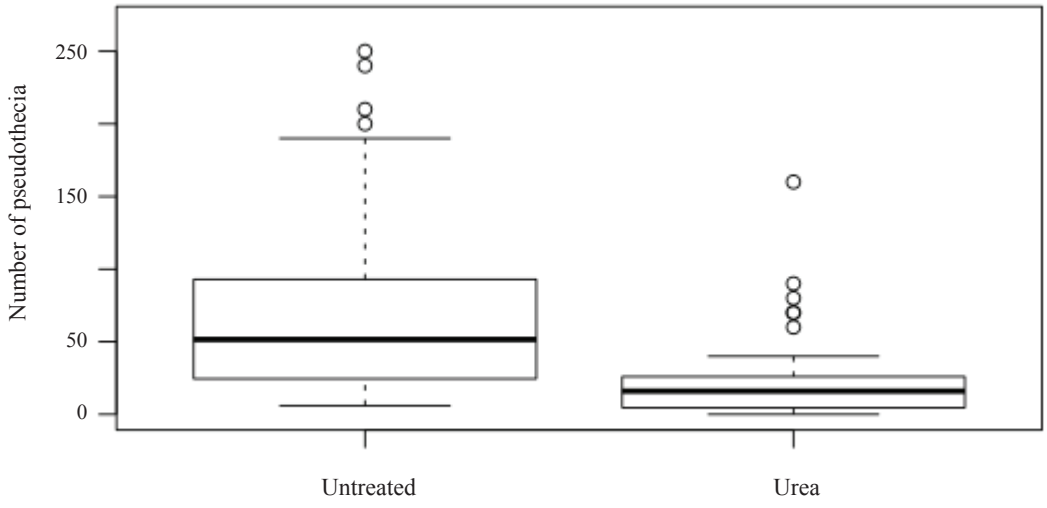

Figure 2. Number of pseudothecia on leaf discs in untreated control and after a treatment with a urea solution.

Table 1

Incidence level of pear scab in sanitation trial in 2012, %

Treatments	Leaves			Fruits	
	June 7	June 15	June 29	July 5	August 3
1. Control	**9.67 a**	7.67 a	6.67 a	5.33 a	10.0 a
2. RIMpro	5.67 b	3.00 a	2.33 b	5.00 a	0.00 b
3. Urea + RIMpro	**1.67 c**	3.67 a	3.00 b	3.00 ab	0.67 b
4. Leaves collection + RIMpro	4.33 bc	3.67 a	2.00 b	3.00 ab	0.00 b
5. Urea + copper + RIMpro	**2.33 c**	2.33 a	1.00 b	1.67 ab	0.33 b
6. Conventional fungicide applications	3.67 bc	3.00 a	1.11 b	0.67 b	0.00 b
$LSD_{0.05}$	2.91	5.78	3.09	3.91	2.69

[a,b,c] – Values marked with the same letter in column, are not significantly different at $p<0.05$.

Pear scab incidence did not exceed 10% in the control. The level of disease did not reach expected level. Nevertheless, statistically significant differences among treatments were observed.

Application with a urea solution in autumn significantly ($p<0.05$) reduced foliar lesions on trees in the first assessment during the primary scab infection period compared with untreated control and treatments followed only RIMpro (Table 1). In the following assessments there was no difference between treatments with urea application and without it. It is explained by the development of conidial stage and regular fungicide applications. Some differences were observed on leaves at the end of June and on fruits in August compared to control. The incidence level, except control, was not different between treatments. There are only some studies that considered the potential of a urea treatment to reduce primary apple scab lesions (Burchill et al., 1965; Sutton et al., 2000). R.T. Burchill et al. (1965) first showed that application of a urea to English orchards in the autumn completely suppressed ascospore production the following spring, and scab lesions on leaves were reduced by 56% and 46%, respectively, compared to the untreated control. Similarly, in France a urea spray applied to trees after harvest, reduced scab in the following spring (Sutton et al., 2000). The main potential of sanitation methods is to reduce the overwintering stage of the scab pathogen in the leaf litter.

Despite the effectiveness of urea in reducing an ascospore survival, the need for spring-summer fungicide applications could not be eliminated in orchards with a high inoculum (MacHardy, 2000) because there is always a strong chance of infection during the growing season if viable spores are present (Holb, 2006a). The main importance of the sanitation is to reduce an infection pressure in orchards with a high inoculum potential and to increase a fungicide efficacy to control scab.

The cultivar 'Belorusskaya Pozdnaya' is moderately resistant (Kārkliņš, 2004). Probably the influence of control measures could be demonstrated more clearly if more susceptible cultivars were grown. The results are preliminary, because the trial demonstrates only one infection period. Investigations should be continued in a pear orchard with a higher disease infection pressure and with special attention to the twig scab control.

Conclusions

1. Urea application in a tree canopy in autumn showed a tendency of pseudothecia number reduction in the treatment with the urea application, but the difference was not significant ($p>0.05$) in comparison with the untreated control.
2. Application with a urea solution in autumn significantly reduced ($p<0.05$) foliar lesions on trees during the primary scab infection period compared with untreated control and treatment followed only RIMpro.
3. The difference between treatments with the urea application and treatment with leaves collection was not significant ($p>0.05$), but the results are preliminary and trial demonstrates only one infection period; thus, further investigations are needed to investigate sanitation practices more in details.

Acknowledgements

The study was supported by the Ministry of Agriculture and the European Structural Fund, No. 211211/c-120.

References

1. Burchill R.T., Cook A.T.R. (1971) The interaction of urea and micro-organisms in suppressing the development of perithecia of *Venturia inaequalis* (Cke.) Wint. In: Preece T.F., Dickinson C.H. (eds) *Ecology of Leaf Surface Microorganism*, Academic Press, London, pp. 471-483.

2. Burchill R.T., Hutton K.E., Crosse J.E., Garrett C.M.E. (1965) Inhibition of the perfect stage of *Venturia inaequalis* (Cooke) Wint. by urea. *Nature*, 205, pp. 520-521.
3. Curtis M.K. (1924) Black spot of apple and pear. *Agriculture*, 28, pp. 21-28.
4. Gadoury M.D., MacHardy E.W. (1986) Forecasting ascospore dose of *Venturia inaequalis* in commercial apple orchards. *Phytopathology*, 76, pp. 112-118.
5. Haynes R.J. (1981) Effect of soil management practice on soil physical properties, earthworm population and tree rot distribution in a commercial apple orchard. *Soil and Tillage Research*, 1(3), pp. 269-280.
6. Heitefuss R. (1989) *Crop and Plant protection: The Practical Foundation*, Ellis Horwood Ltd, Chichester, UK, 261 p.
7. Holb J.I. (2006) Effect of six sanitation treatments on leaf litter density, ascospore production of *Venturia inaequalis* and scab incidence in integrated and organic apple orchards. *European Journal of Plant Pathology*, 115, pp. 293-307.
8. Holb J.I. (2006a) Scab control management strategies in environmentally-benign apple production systems. *Phytopathologia Polonica*, 39, pp. 31-39.
9. Jesperson G. (1995) Sanitation for apple scab control. *Tree Fruit Leader*, 4, pp. 5-8.
10. Kārkliņš J. (2004) *Bumbieru šķirnes (Pear cultivars)*. Dobeles Dārzkopības un izmēģinājumu stacija, Dobele, 112 lpp. (in Latvian).
11. MacHardy E.W. (1994) A 'PAD' action threshold: the key to integrating practices for managing apple scab. *Norwegian Journal of Agricultural Sciences*, 17, pp. 75-82.
12. MacHardy E.W. (2000) Current status of IPM in apple orchards. *Crop Protection*, 19, pp. 801-806.
13. R Core Team (2012) R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. Available at: http://www.r-project.org/, 19 December 2012.
14. Shabi E. (1990) Pear scab. In: Jones A.L., Aldwinkle H.S. (eds) *Compendium of Apple and Pear Diseases*, APS Press, USA, pp. 22-23.
15. Spotts A.R., Cervantes A.L., Niederholzer A.J.F. (1997) Effect of dolomitic lime on production of asci and pseudothecia of *Venturia inaequalis* and *V. pirina*. *Plant Disease*, Vol. 81, pp. 96-98.
16. Stensvand A., Amundsen T., Sem L. (1996) Observations on wood scab caused by *Venturia inaequalis* and *V. pirina* in apple and pear in Norway. *Wageningen Journal of Life Sciences*, Vol. 10, No. 4, pp. 533-540.
17. Sutton D.K., MacHardy W.E., Lord W.G. (2000) Effects of shredding or treating apple leaf litter with urea on ascospore dose of *Venturia inaequalis* and disease buildup. *Plant Disease*, Vol. 84, No. 12, pp. 1319-1326.
18. Vincent C., Rancourt B., Carisse O. (2004) Apple leaf shredding as non-chemical tool to manage apple scab and spotted tentiform leafminer. *Agriculture, Ecosystems and Environment*, 104, pp. 595-604.