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Integrated aproach of apple scab management using iMETOS warning system

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In 2007–2008 in field trials two different apple scab control strategies were compared: the current strategy – conventional disease management (CDM) and integrated disease management (IDM), according to scab infection periods. A new internet based scab warning system iMETOS was used for detection of infection periods and forecast of disease intensity at three levels: light, moderate and severe. According to CDM, apple-trees were sprayed 9 times per season. Scab warning system gave a possibility to optimize the use of fungicides against scab and to reduce to 7–8 instead 9 the total spray applications per season. CDM and IDM gave high scab control in apple-trees and there were not found any essential difference in scab incidence between two control strategies. An efficiency of IDM and CDM against disease incidence on leaves was 90.5–95.1 and 88.5–94.1 %, respectively. Efficiency against disease incidence on fruits raged from 95.1 to 95.6 and from 91.2 to 94.1 %, respectively.

Key words: ascospores, conidia, conventional disease management, efficacy, infection, iMETOS warning system, integrated, .

Introduction. *Venturia inaequalis* causal agent of apple scab is the most important apple disease and its control depends almost exclusively on frequent use of fungicides. 75 % of the pesticide use in apple production is related to control of fungal diseases, in which apple scab has a share of 70 % (Creemers, Laer, 2006). European agriculture faced the strict demands to decrease the use of pesticides in order to reduce any human or environmental hazards; therefore, the need for evaluation and reduction of the use of pesticides is expressed. To obtain the reduction of the use of fungicides without any significant damage to the crop, the control of apple scab should be based on registration of climatic data, scouting of biotic parameters, infection risks and simulation disease models. The bioecology of *V. inaequalis* has been widely studied in many countries. The development of infection risks of apple scab highly depends on apple cultivar susceptibility, inoculum of the pathogen in orchards, ascospore release and the influence of such parameters as air temperature, duration of leaf wetness, relative humidity or light (Gadoury et al., 1998; Stensvand et al., 1998;

Li, Xu, 2002; Rossi et al., 2003; Holb et al., 2004; Holb et al., 2005; Carisse et al., 2007). Based on air temperature duration of leaf wetness and other parameters apple scab models have been developed, evaluated and recently successfully used for the disease control in apple orchards. Met stations are equipped with sensors for registration and transmission of data about temperature, relative humidity, rainfall, leaf wetness and others for prediction of apple scab infection risks (Berrie, 1994; Butt, Xu, 1994; Bühler, Gesle, 1994; Rossi et al., 1999; Raudonis, 2002; Raudonis et al., 2003; Holb et al., 2003; Xu, Robinson, 2005; Atlamaz et al., 2007; Rossi, Bugiani, 2007). However, little is known about the effect of recently introduced iMETOS scab warning system. Therefore, the objective of this study was to evaluate the effects of iMETOS scab warning system for the use in integrated disease management.

Object, methods and conditions. In 2007–2008 field trials were carried out in the orchards of Lithuanian Institute of Horticulture to compare the current apple scab control strategy – conventional disease management (CDM) and integrated disease management (IDM), according to scab infection periods. Internet based pest and disease of horticultural plants warning system iMETOS (G. Pessl, Austria) recorded rainfall, air temperature, relative humidity, leaf wetness and calculated infection periods according to Mills and Laplante at three levels. At the beginning of the season iMETOS calculates release of scab ascospores, later infection and conidia infection when degree-day accumulation (base = 0 °C) was 500 °C. Susceptible to scab apple variety 'Lobo' was sprayed when release of ascospores, ascospores or conidia light infection risk reached more than 70–80 %. CDM was based on prophylactic applications and apple-trees were sprayed at 10–14 days intervals. Plot size consisted at least of 5 trees, 4 replications at random plot distribution. Fastac 50 EC 0.4 l ha^{-1} at 09 and 73 growth stages according to BBCH scale (Meier, 1997) was used for control of insect pests.

Disease incidence was calculated: P = n/N · 100. (P – disease incidence, %, n – number of attacked leaves or fruits, N – total number of investigated leaves or fruits). Disease intensity was calculated: R = ∑ab × 100/NK; R – disease intensity; a – the number of leaves or fruits damaged the same level, b – score of the scale; ∑ – the sum numbers of damaged leaves or fruits of different scores; K – the highest score of the scale (5). Injures caused by fungal diseases were evaluated according to a 6 point scale: 0 – no disease symptoms detected on leaves or fruits, 5 – injured more 75 % of leaf or fruit area.

Scab incidence and intensity on leaves and fruits was compared among treatments in this study with a single factor analysis of variance (ANOVA). Specific differences were identified with Duncan's multiple range test.

The trial was carried out according to trial plan as presented in Table 1.

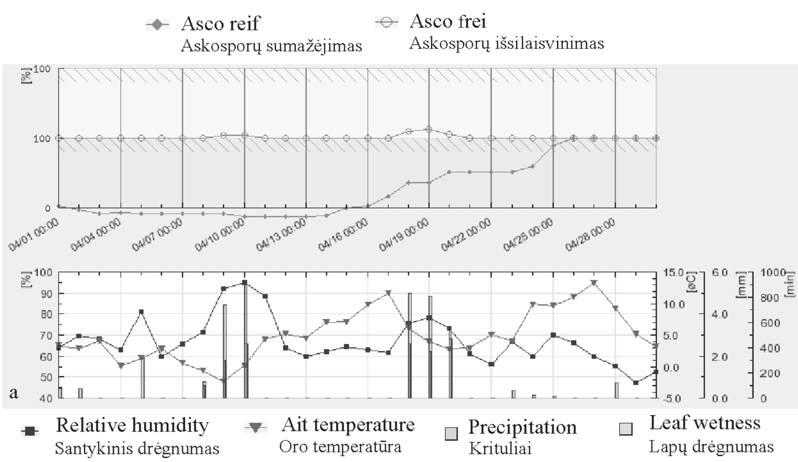
Table 1. Trial plan
1 lentelė. Bandymo planas

IDM				CDM		
rate g, AI ha^{-1} of fungicides fungicidų v. m. norma g ha^{-1}	infection risk infekcijos laipsnis	date data	BBCH growth stage augimo tarpsnis	rate g, AI ha^{-1} of fungicides fungicidų v. m. norma g ha^{-1}	date data	BBCH growth stage augimo tarpsnis
1	*2*	*3*	*4*	*5*	*6*	*7*
			2007			
Cyprodinil 750 g kg^{-1}, 150 g ha^{-1}	100 % asco-spore release askosporų plitimas	IV.28	07	Cyprodinil 750 g kg^{-1}, 150 g ha^{-1}	IV.28	07
Cyprodinil 750 g kg^{-1}, 150 g ha^{-1}	85 % ascospore infection užsikrėtimas askosporomis	V.14	59	Cyprodinil 750 g kg^{-1}, 150 g ha^{-1}	V.10	57
Trifloxistrobin 500 g kg^{-1}, 75 g ha^{-1}	100 % conidia infection užsikrėtimas konidijomis	V.28	69	Trifloxistrobin 500 g kg^{-1}, 75 g ha^{-1}	V.22	67
Trifloxistrobin 500 g kg^{-1}, 75 g ha^{-1}	__ " __	VI.14	73	Trifloxistrobin 500 g kg^{-1}, 75 g ha^{-1}	VI.04	71
Krezoksim-methyl 500 g kg^{-1}, 100 g ha^{-1}	__ " __	VI.29	75	Krezoksim-methyl 500 g kg^{-1}, 100 g ha^{-1}	VI.18	73
Dithianon 700 g kg^{-1}, 70 g ha^{-1}	__ " __	VII.12	77	Dithianon 700 g kg^{-1}, 70 g ha^{-1}	VII.02	76
Dithianon 700 g kg^{-1}, 70 g ha^{-1}	__ " __	VII.29	81	Dithianon 700 g kg^{-1}, 70 g ha^{-1}	VII.12	77
Dithianon 700 g kg^{-1}, 70 g ha^{-1}	__ " __	VIII.12	85	Dithianon 700 g kg^{-1}, 70 g ha^{-1}	VII.26	81
–	–	–	–	Dithianon 700 g kg^{-1}, 70 g ha^{-1}	VIII.08	85
			2008			
Cyprodinil 750 g kg^{-1}, 150 g ha^{-1}	100 % ascospo-re release askosporų plitimas	IV.18	07	Cyprodinil 750 g kg^{-1}, 150 g ha^{-1}	IV.18	07
Cyprodinil 750 g kg^{-1}, 150 g ha^{-1}	79 % ascospore infection užsikrėtimas askosporomis	V.02	57	Cyprodinil 750 g kg^{-1}, 150 g ha^{-1}	V.2	57
Trifloxistrobin 500 g kg^{-1}, 75 g ha^{-1}	100 % ascospo-re infection užsikrėtimas askosporomis	V.23	69	Trifloxistrobin 500 g kg^{-1}, 75 g ha^{-1}	V.16	67

Table 1 continued
1 lentelės tęsinys

1	*2*	*3*	*4*	*5*	*6*	*7*
Trifloxistrobin 500 g kg^{-1}, 75 g ha^{-1}	100 % conidia infection užsikrėtimas konidijomis	VI.16	75	Trifloxistrobin 500 g kg^{-1}, 75 g ha^{-1}	V.29	71
Krezoksim-methyl 500 g kg^{-1}, 100 g ha^{-1}	— “ —	VI.30	77	Krezoksim-methyl 500 g kg^{-1}, 100 g ha^{-1}	VI.12	73
Dithianon 700 g kg^{-1}, 70 g ha^{-1}	— “ —	VII.14	79	Dithianon 700 g kg^{-1}, 70 g ha^{-1}	VII.02	77
Dithianon 700 g kg^{-1}, 70 g ha^{-1}	— “ —	VII.31	85	Dithianon 700 g kg^{-1}, 70 g ha^{-1}	VII.12	79
–	–	–	–	Dithianon 700 g kg^{-1}, 70 g ha^{-1}	VII.25	81
–	–	–	–	Dithianon 700 g kg^{-1}, 70 g ha^{-1}	VII.08	85

Results. Apple scab ascospore release, ascospore and conidia infection periods, depending on air temperature, duration of leaf wetness and relative humidity in 2007–2008 are presented in Fig. 1 and 2. Apple trees were sprayed when release of ascospores, ascospores or conidia light infection risk reached more than 70–80 %, according to IDM using iMETOS warning system. In 2007 conditions for ascospore release reached 100 % on 26th of April (Fig. 1 a) and first fungicide application was made. Second application was made just after ascospore infection when it reached more than 85 % (Fig. 1 b).



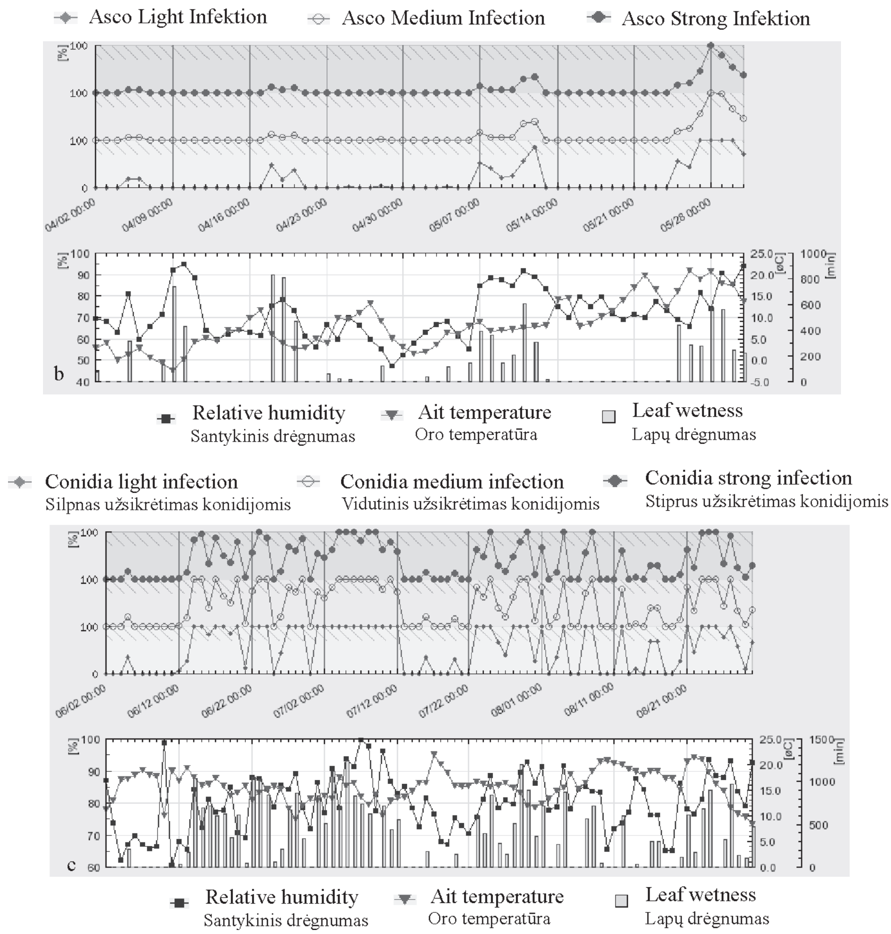
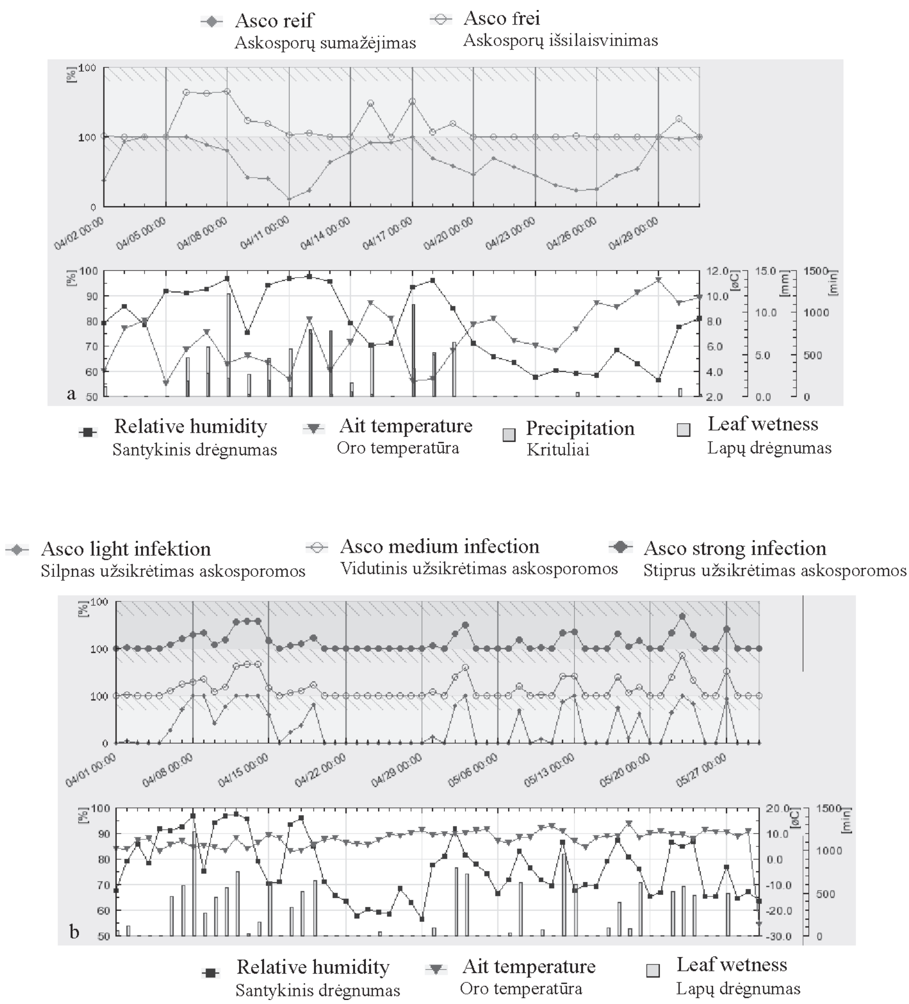


Fig. 1. Scab ascospore release (a), ascospore infections (b) and conidia infections (c) depending on climatic parameters in 2007 according to iMETOS.
1 pav. Rauplių askosporų plitimas (a), užsikrėtimas askosporomis (b) bei konidijomis (c) priklausomai nuo oro sąlygų, pagal iMETOS prognozavimo sistemą 2007 m.

Longer duration of leaf wetness resulted in more favourable conditions for ascospore release and infection in 2008. The duration of leaf wetness in April–May lasted 9 055 and 14 015 min in 2007 and 2008, respectively (Fig. 1 a, b, 2 a, b). After flowering, when degree-day accumulation (base = 0 °C) was over 500 °C, scab conidia infections were led by next sprays. Warm weather and continuously lasting duration of leaf wetness often caused severe conidia infections during the summer of 2007 (Fig. 1 c). Only from the end of May till the middle of June and from the middle till the end of July there was no conidia infection observed. Less favourable weather conditions for conidia infections were in 2008. It can be explained by shorter duration of leaf wetness. The duration of leaf wetness in June–July lasted for 24 795 min in 2007 and near two times less (13 725 min) in 2008 (Fig. 1 c, 2 c). CDM was based on prophylactic applications and apple-trees were sprayed at 10–14 days intervals, depending only on growth stages. Higher number of sprays was made in CDM comparing with IDM strategy, when fungicides were applied only depending on scab infection. Nine fungicide treatments were applied in CDM strategy during both experimental years. Meanwhile, treatments were reduced to eight and seven in 2007 and 2008, respectively according IDM. Nevertheless, significant difference in scab incidence and intensity was not found on leaves and on fruits at harvest between both spray programmes (Table 2). In 2007 there were 8.2 and 3.7 % scabbed leaves and fruits in IDM strategy and 9.5 and 6.7 % in CDM, respectively. In 2008 the damage on leaves and fruits was 2.0 and 3.75 % in IDM and 4.0 and 8.2 % in CDM, accordingly. Meanwhile, the leaves and fruits were damaged by 85 and 97.7 in 2007 and by 49.0–91.5 % in 2008 in unsprayed orchard. An efficiency of IDM strategy against apple scab incidence on leaves/fruits ranged from 90.5/95.6 to 95.1/98.6 % and intensity from 90.4/95.9 to 95.9/96.2 %, respectively during 2007–2008. Similar efficiency results were obtained in CMD.



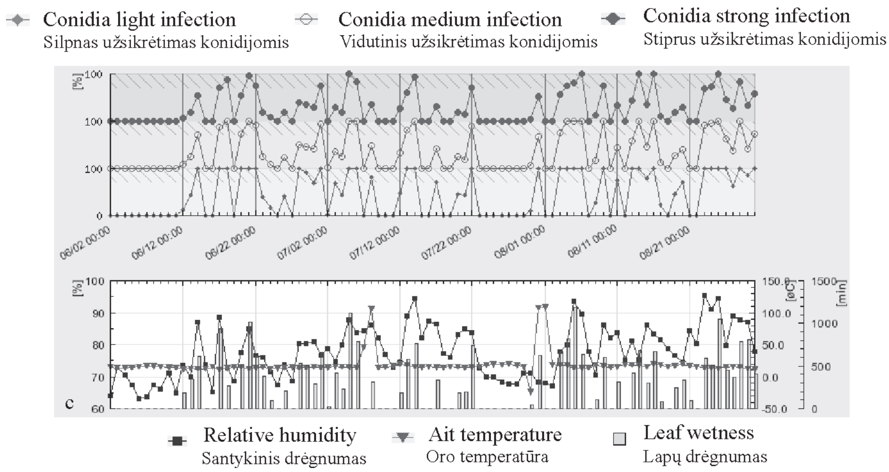


Fig. 2. Scab ascospore release (a), ascospore infections (b) and conidia infections (c) depending on climatic parameters in 2008 according to iMETOS.
2 pav. Rauplių askosporų plitimas (a), užsikrėtimas askosporomis (b) bei konidijomis (c) priklausomai nuo oro sąlygų, pagal iMETOS prognozavimo sistemą 2008 m.

Table 2. Scab incidence and intensity under Integrated and Conventional Disease Management
2 lentelė. Rauplių paplitimas ir intensyvumas taikant integruotą ir įprastinę apsaugą nuo ligų

Treatments Variantai	Apple scab Obelų rauplės (%)			
	leaves lapai		fruits vaisiai	
	incidence paplitimas	intensity intensyvumas	incidence paplitimas	intensity intensyvumas
		2007		
Untreated Nepurkšta	85.0 b	50.4 b	97.7 b	77.9 b
IDM	8.2 a	2.5 a	3.7 a	1.1 a
CDM	9.5 a	3.0 a	6.7 a	2.2 a
		2008		
Untreated Nepurkšta	49.0 b	24.3 b	91.5 b	68.3 b
IDM	2.0 a	2.3 a	3.75 a	3.0 a
CDM	4.0 a	2.8 a	8.2 a	6.0 a

Means followed by the same letter are not different significantly (P = 0.05) according to Duncan's multiple range test
Tomis pačiomis raidėmis pažymėtos reikšmės pagal Dunkano kriterijų (P = 0,05) iš esmės nesiskiria

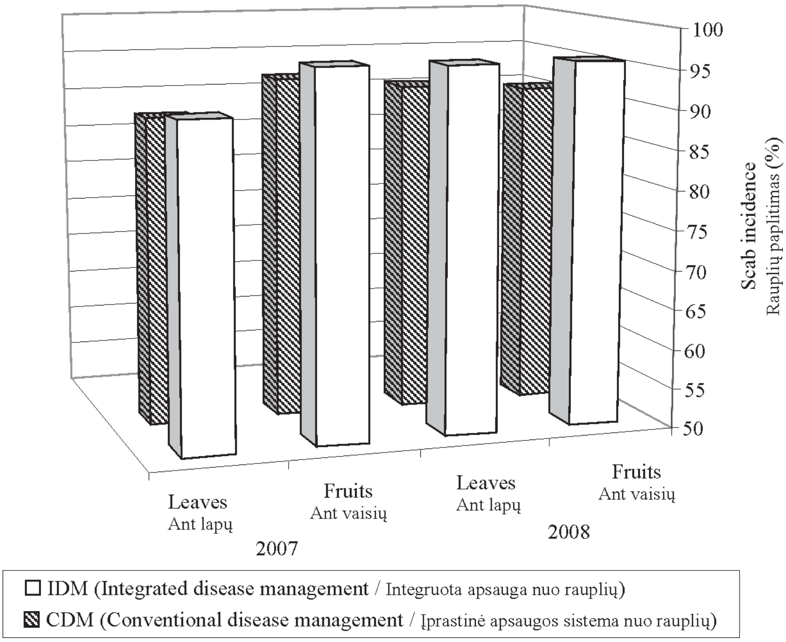


Fig. 3. Impact of Integrated and Conventional Disease Management on Apple scab incidence
3 pav. Integruotos ir įprastinės apsaugos sistemų įtaka rauplių paplitimui

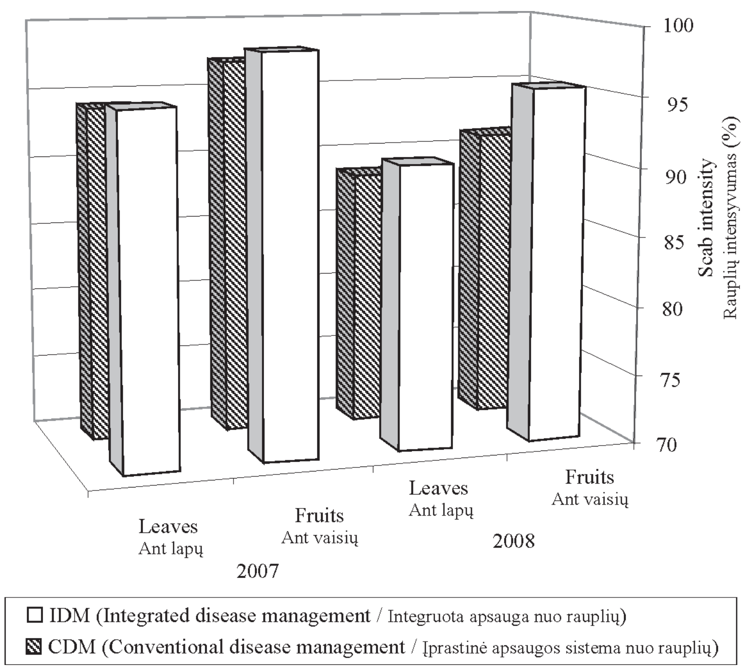


Fig. 4. Impact of Integrated and Conventional Disease Management on Apple scab intensity
4 pav. Integruotos ir įprastinės apsaugos sistemų įtaka rauplių intensyvumui

Discussion. Air temperature, relative humidity and leaf wetness are the factors, which mostly influence the development of apple scab infections (Gadoury et al., 1998; Hartman et al., 1999; Rossi, Bugiani, 2007; Laer, Creemers, 2004; Hamada, 2005; Fröhling et al., 2005; Xu, Robinson, 2005). Refereeing these factors, scab warning systems for prediction of ascospores or conidia infection and scab control are developed (Berrie, 1994; Bühler, Gesle, 1994; Butt, Xu, 1994; Atlamaz et al., 2007). In the orchards of the Lithuanian Institute of Horticulture IDM strategy was successful during experimental years, though climatically conditions for disease development were favourable. Scab incidence on fruits was increasing in unsprayed plots to 97.7 and 91.5 % in 2007 and 2008. With the improved apple scab warning system of the IDM, which is based on iMETOS scab warning system, it was possible to avoid one fungicide application in 2007 and two in 2008, comparing with CDM. Totally IDM strategy gave a possibility to optimize the use of fungicides against scab and to reduce on average to 7–8, instead 9 the total spray applications per season without any significant increase of damage to the fruits and their quality. High effect of the use of different apple scab warning systems have been reported in other studies (Berrie, 1994; Bühler, Gesle, 1994; Butt, Xu, 1994; Grauslund, Loshenkohl, 1994; Pessl, 1994; Raudonis, 2002; Holb et al., 2003; Raudonis et al., 2003; Atlamaz et al., 2007; Rossi, Bugiani, 2007).

Conclusions. A new internet based scab warning system iMETOS was used for detection of infection periods and forecast of disease intensity at three levels: light, moderate and severe. According to CDM apple-trees were sprayed 9 times per season. Scab warning system gave a possibility to optimize the use of fungicides against scab and to reduce to 7–8 instead 9 the total spray applications per season. CDM and IDM gave high scab control (88.5–95.1 %) in apple-trees and there were not found any essential difference in scab incidence between two control strategies.

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Integruotas obelų rauplių valdymas naudojant iMETOS prognozavimo sistemą

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Santrauka

2007–2008m. buvo palygintos dvi skirtingos obelų apsaugos nuo rauplių strategijos: įprastinė ir integruota obelų apsaugos sistema. Pastaroji pagrįsta nauja iMETOS prognozavimo sistema, kuri parodo obelų rauplių mažą, vidutinį ir didelį infekcijos rizikos lygį.

Pagal tradicinę apsaugos nuo rauplių sistemą obelys buvo purkštos devynis kartus per sezoną.

Rauplių prognozavimo sistema leido optimizuoti fungicidų panaudojimą nuo rauplių ir purškimų skaičių sumažinti iki septynių – aštuonių. Obelų rauplių paplitimas nesiskyrė panaudojus tiek tradicinę, tiek ir integruotą obelų apsaugos sistemą. Nustatytas integruotos ir tradicinės obelų apsaugos sistemų efektyvumas, rauplių plitimas ant lapų atitinkamai sumažėjo 90,5 – 95,1 ir 88,5 – 94,1 %. Sistemų efektyvumas nuo rauplių ant vaisių atitinkamai buvo 95,1 – 95,6 ir 91,2 – 94,1.

Reikšminiai žodžiai: askosporos, infekcija, iMETOS, integruota ir tradicinė apsaugos sistema, konidijos.