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CONTROL OF GREY MOULD AND WHITE LEAF SPOT IN STRAWBERRY

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Abstract

A two year trial examined control of different rates of Cyprodinil + Fludioxonil 625 g kg^{-1} against grey mould (*Botrytis cinerea*), white leaf spot (*Mycosphaerrella fragariae*) and estimated their effects on strawberry yields.

The efficacy of Cyprodinil + Fludioxonil 625 g kg^{-1} 0.75 kg AI ha^{-1} against grey mould and white leaf spot ranged from 58.0 to 73.3% and 46.0–70.4%, respectively. Lower rate 0.625 kg AI ha^{-1} of Cyprodinil + Fludioxonil was effective by 56.5–58.4% and 46.0–66.7% against grey mould and white leaf spot accordingly. Cyprodinil + Fludioxonil 625 g kg^{-1} 0.5 kg AI ha^{-1} gave the lowest effect against grey mould and white leaf spot. The efficacy of Vinclozolin 500 g kg^{-1} 0.75 kg AI ha^{-1} was 30.4–62.8% against grey mould and 22.7–37% against white leaf spot. The higher effect of Cyprodinil + Fludioxonil and Vinclozolin was found when disease pressure of grey mould was high and lower effect when disease pressure of white leaf spot was high.

The highest marketable yield (143–146%) of strawberry was obtained in Cyprodinil + Fludioxonil 625 g kg^{-1} 0.75 kg AI ha^{-1} treatment. Cyprodinil + Fludioxonil 625 g kg^{-1} 0.625 and 0.5 kg AI ha^{-1} increased the marketable yield by 123–139%.

Chemical control of these diseases can be difficult as several effective fungicides are no longer sold on the market or have lost their registration for use on strawberries, and some of the pathogens have developed resistance to the more commonly used fungicides. Cyprodinil + Fludioxonil have different modes of action and it could be recommended to provide strawberry growers with more options for controlling diseases, managing fungicide resistance.

Key words: *Botrytis cinerea*, Cyprodinil + Fludioxonil, efficiency, *Mycosphaerrella fragariae*.

Introduction

Strawberry production is affected by a number of pathogens. Grey mould (*Botrytis cinerea*) is a universal and major cause of fruit rot. Grey mould rarely infects flower buds, but open flowers are rapidly colonized and necrotic stamens and styles are an important source of infection for the developing fruit /Dashwood, Fox, 1988; Boff et al., 2003/. The losses due to fungal diseases can cost up to 20% of the crop value per annum /Timudo-Torrevilla et al., 2005/. The most effective strawberry protection against pathogens is chemical control, though frequent use of limited spectrum of fungicides against diseases stimulates development of new races of the pathogen /Katan, 1982; Elad et al., 1988/. Therefore the experiments looking for new effective fungicides to protect

strawberry against pathogens are carried out /Bascón et al., 2003; Constantin et al., 2003; Meszka, Bielenin, 2004 a b; Wedge et al., 2007/.

Experiments on disease evaluation of different strawberry varieties were conducted and some fungicides were tested against grey mould and white leaf spot in Lithuania /Uselis, Rašinskienė, 1995; Rašinskienė, 1997; Uselis, Rašinskienė, 2001/. Several effective fungicides are no longer sold in the Lithuania or have lost their registration for use on strawberries therefore chemical control of grey mould and white leaf spot can be difficult. On the other hand, to reduce the resistance of pathogens to fungicides there is a demand for new effective chemical compounds that could be safely used in strawberry.

As a result, experiments performed in 2003–2004 were designed to clarify how the new fungicides Cyprodinil + Fludioxonil affect grey mould (*Botrytis cinerea*) and white leaf spot (*Mycosphaerrella fragariae*) compared with Vinclozolin in strawberry.

Materials and Methods

The trials were carried out in the open field of strawberries of the Lithuanian Institute of Horticulture in 2003–2004. The strawberries (variety 'Dukat') were planted in 2002, 62500 seedlings per hectare. The soil was fertilised with N – 40 kg ha^{-1} before flowering. Fungicides were applied for the control of harmful strawberry diseases – grey mould and white leaf spot – during flowering at 61, 65 and 69 growth stages. Growth stages are described according to BBCH scale /Meier, 1997/. Plot size was at least 12 m^2. The trial was replicated 4 times at random plot distribution. A Hardi sprayer was used for spraying, spray volume – 1000 l ha^{-1}.

Table 1. Trial design

Treatment	Trade name	[A]Rate (kg AI ha^{-1})
1. Untreated		–
2. Cyprodinil + Fludioxonil 625 g kg^{-1}	Switch 62.5 WG	0.75
3. Cyprodinil + Fludioxonil 625 g kg^{-1}	Switch 62.5 WG	0.625
4. Cyprodinil + Fludioxonil 625 g kg^{-1}	Switch 62.5 WG	0.5
5. Vinclozolin 500 g kg^{-1}	Ronilan DF	0.75

[A] AI – active ingredient

In 2003 there were made 4 assessments (VI.25, VI.30, VII.02, and VII.07) of grey mould during harvest. 5 assessments (VI.28, VII.01, VII.05; VII. 08; VII. 12) were made in 2004. The yield and the number of infected fruits of strawberry were assessed. Assessment of leaf spot was made after harvest (VIII.13) in 2003 and on 08 07 and 08 25 in 2004.

Meteorological data (air temperature and amount of precipitation) were recorded using scab warning equipment Metos D.

The efficacy of fungicides was calculated: $x = (a – b/a)\ 100$ (x – efficacy of fungicide %, a – disease incidence (%) in untreated plot, b – disease incidence (%) in treated plot).

Disease incidence was calculated: P = n/N·100. (P – disease incidence, %, n – number of attacked leaves, berries, N – total number of investigated leaves, berries).

R = ∑ab×100/NK; A – the number of assessed leaves or fruits, B – the number of damaged leaves or fruits, a – the number of leaves or fruits damaged the same level, K – highest score of the scale (5), ∑ – the sum numbers of damaged leaves or fruits of different scores.

The number of damaged leaves or 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.

Table 2. Meteorological conditions

Month	Air temperature °C			Precipitation mm		
	2003	2004	average of 1924–2000	2003	2004	average of 1924–2000
April	7.5	9.6	5.8	11.2	4.4	42.0
May	15.7	10.7	11.9	37.2	46.2	43.7
June	15.4	13.7	16.6	54.2	77.4	50.4
July	20.1	16.1	17.6	60.1	50.4	71.8
August	17.5	16.7	16.3	0.0	123.6	75.8
September	12.8	11,6	12.0	0.0	36,2	30.0

Results and Discussion

There was damaged 6.9 and 13.7% of strawberry berries in unsprayed plots of this study in 2003 and 2004 respectively (Table 3). It could be explained, that conditions for development of grey mould during flowering were not favourable, because the mean air temperature was higher (15.7^{o} C) and there was lower amount of precipitation in May in 2003. Better environmental conditions during flowering and harvesting for disease development were in 2004 compared with 2003 (Table 2). Other experiments show that grey mould development highly depends on the weather conditions /Wilcox, Seem, 1994/. Similar results were obtained for white leaf spot. The efficacy of Cyprodinil + Fludioxonil 625 g kg^{-1} 0.75, 0.625 and 0.5 kg AI ha^{-1} against grey mould was 58.0, 56.5 and 56.7% in 2003 accordingly. There were not found any statistical differences of damaged berries among the treatments (Table 3). Different results of efficacy were obtained in 2004 (Table 3). The number of damaged berries was statistically different among the different rates of Cyprodinil + Fludioxonil. Meanwhile the efficacy of Cyprodinil + Fludioxonil 625 g kg^{-1} 0.75, 0.625 and 0.5 kg AI ha^{-1} against grey mould was 73.7, 58.4 and 27.0% respectively. The efficacy of Vinclozolin 500 g kg^{-1} 0.75 g kg^{-1} was 30.4 and 62.8% in 2003 and 2004. Different variation of the efficacy of Cyprodinil + Fludioxonil and other fungicides was obtained from the trials in the USA /Wedge et al., 2007/. Meanwhile other studies show only high efficacy of Cyprodinil + Fludioxonil against grey mould compared with other fungicides /Bascón et al., 2003; Meszka, Bielenin, 2004 a b/.

Table 3. The impact of Cyprodinil + Fludioxonil 625 g kg^{-1} on grey mould (*Botrytis cinerea*) in 2003 and 2004

Treatment	[A]Rate kg AI ha^{-1}	Grey mould							
		undamaged berries kg $plot^{-1}$		damaged berries				Efficacy %	
				kg $plot^{-1}$		%			
		2003	2004	2003	2004	2003	2004	2003	2004
Untreated	–	39.3 a	17.0 a	2.9b	2.7 e	6.9	13.7	–	–
Switch 62.5 WG	0.75	57.7 d	24.3 e	1.7 a	0.9 a	2.9	3.6	13.7	73.7
Switch 62.5 WG	0.625	57.6 bcd	21.6 d	1.8 a	1.3 c	3.0	5,7	3.6	58.4
Switch 62.5 WG	0.5	53.2 bcd	20.8 c	1.9 a	2.3 d	3.4	10.0	5.7	27.0
Ronilan DF	0.75	43.7 ab	20.6 b	2.2 a	1.1 b	4.8	5.1	10.0	62.8

[A] AI – active ingredient
Means in the column followed by the same letter are not different significantly (P=0.05) Duncan's multiple range test.

Table 4. The impact of Cyprodinil + Fludioxonil 625 g kg^{-1} on white leaf spot (*Mycosphaerrella fragariae*) in 2003 and 2004

Treatment	[A]Rate kg AI ha^{-1}	White leaf spot					
		incidence %		severity %		efficacy %	
		2003	2004	2003	2004	2003	2004
Untreated	–	27.0 d	42.5 e	7.8 c	15.0 d	–	–
Switch 62.5 WG	0.75	8.0 a	27.5 a	2.2 a	8.1 a	70.4	46.0
Switch 62.5 WG	0.625	9.0 b	32.5 b	3.0 b	8.1 a	66.7	46.0
Switch 62.5 WG	0.5	10.0 bc	36.3 c	3.0 b	10.6 b	63.0	29.3
Ronilan DF	0.75	17.0 c	38.8 d	5.0 b	11.6 c	37.0	22.7

[A] AI – active ingredient
Means in the column followed by the same letter are not different significantly (P=0.05) Duncan's multiple range test.

In the first season, untreated plants of strawberry showed low level of white leaf spot, meanwhile more severely infected plants were in 2004 (Table 4). The efficacy of Cyprodinil + Fludioxonil 625 g kg^{-1} 0.75, 0.625 and 0.5 kg AI ha^{-1} against white leaf spot was 70.4, 66.7 and 63.0% in 2003 accordingly. In 2004 the efficacy of Cyprodinil + Fludioxonil 625 g kg^{-1} 0.75, 0.625 and 0.5 kg AI ha^{-1} against white leaf spot was 46.0, 46.0 and 29.3% respectively. Cyprodinil + Fludioxonil showed different results of disease incidence and severity in other trials. It depends on climate factors, spray time,

etc. /Holland et al., 1985/. Previous field tests showed that the most favourable conditions for the development of common leaf spot is during wet flowering period and later the season of strawberry /Uselis, Rašinskienė, 2001/. Statistically lowest disease incidence was shown by the highest rate of Cyprodinil + Fludioxonil in 2003–2004. The highest rate of Cyprodinil + Fludioxonil resulted in the lowest disease severity in 2003 and highest or medium rate in 2004. Vinclozolin gave the lowest effect on white leaf spot during both experimental years compared with all rates of Cyprodinil + Fludioxonil and showed a slight white leaf spot control.

The mean total and marketable yields of strawberry for the two years are given in Table 5. Cyprodinil + Fludioxonil 625 g kg^{-1} 0.75 kg AI ha^{-1} increased marketable yield by 43 – 46%. Statistically lower yield was obtained when lower rates of Cyprodinil + Fludioxonil and Vinclozolin had been used.

Table 5. The impact of Cyprodinil+Fludioxonil 625 g kg^{-1} on the yield of strawberries in 2003 – 2004

Treatment	[A]Rate kg AI ha^{-1}	Yield t ha^{-1}					
		Total t ha^{-1}		Marketable t ha^{-1}		Marketable %	
		2003	2004	2003	2004	2003	2004
Untreated	–	8.8 a	4.1 a	8.2 a	3.5 a	100	100
Switch 62.5 WG	0.75	12.4 d	5.5 e	12.0 d	5.0 d	146	143
Switch 62.5 WG	0.625	11.8 c	4.7 d	11.4 c	4.5 c	139	129
Switch 62.5 WG	0.5	11.5 c	4.6 c	11.1 c	4.3 b	135	123
Ronilan DF	0.75	9.6 b	4.5 b	9.1 b	4.3 b	111	123

[A] AI – active ingredient

Means in the column followed by the same letter are not different significantly (P=0.05) Duncan's multiple range test.

Conclusions

1. The efficacy of Cyprodinil + Fludioxonil 625 g kg^{-1} 0.75 kg AI ha^{-1} against grey mould and white leaf spot ranged from 58.0 to 73.3% and 46.0–70.4% respectively. The lower rate 0.625 kg AI ha^{-1} of Cyprodinil + Fludioxonil was effective by 56.5–58.4% and 46.0–66.7% against grey mould and white leaf spot accordingly. Cyprodinil + Fludioxonil 625 g kg^{-1} 0.5 kg AI ha^{-1} gave the lowest effect against grey mould and white leaf spot.

2. The efficacy of Vinclozolin 500 g kg^{-1} 0.75 kg AI ha^{-1} was 30.4–62.8% against grey mould and 22.7–37% against white leaf spot.

3. The higher effect of Cyprodinil + Fludioxonil and Vinclozolin was found when disease pressure of grey mould was high and lower effect when disease pressure of white leaf spot was high.

4. The highest marketable yield (143–146%) of strawberry was obtained in Cyprodinil + Fludioxonil 625 g kg^{-1} 0.75 kg AI ha^{-1} treatment. Cyprodinil + Fludioxonil 625 g kg^{-1} 0.625 and 0.5 kg AI ha^{-1} increased the marketable yield by 123–139%.

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