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FUNGICIDE APPLICATION TIMING AGAINST SCLEROTINIA STEM ROT ON WINTER AND SPRING OILSEED RAPE IN LITHUANIA

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Abstract

The present study provides the data of research into the fungicide application timing against Sclerotinia stem rot on winter and spring oilseed rape during the 2011-2012 cropping seasons in Lithuania. The fungicides (boscalid and prothioconazole+tebuconazole) were applied once at different flowering stages. The application time according to GS was associated with ascospores production peak. The peak of ascospores on the petals was recorded at the full flowering stage of winter oilseed rape in 2011-2012 and in spring oilseed rape in 2011. High infection was established at end of flowering in 2012 in spring oilseed rape. Application of fungicides at peak of ascospores gave the best control of the disease. However, non-significant differences in incidence and severity were identified between fungicide application times in both crops. Fungicides application at ascospores release peak gave the best control of Sclerotinia stem rot and yield increase.

Key words: *Sclerotinia sclerotiorum*, winter and spring oilseed rape, fungicides

INTRODUCTION

Sclerotinia stem rot (*Sclerotinia sclerotiorum* Lib. De Bary) is a major and devastating disease of winter and spring oilseed rape in many areas of the world (Dueck, Morrall & McKenzie 1983, Mueller, Hartman & Pedersen 1999; Danielson, Nelson & Helms 2004; Kuang et al. 2011); however, the spread of the disease is different. Infection of the disease can occur on various plant parts at different oilseed rape growth stages (Dai et al. 2006). High incidence and severity of Sclerotinia stem rot cause a 50 % oilseed rape seed yield loss (Porter & Melouk 1997). In China, the seed yield losses of oilseed rape caused by Sclerotinia stem rot amounted to 10-80 % and the disease deteriorated seed quality (Kuang et al. 2011). In Canada, the seed yield losses may exceed 30 % in several fields, although average losses are around 5 % annually (Rimmer et al. 2007). Researchers of various countries provide a lot of evidence on Sclerotinia stem rot occurrence in various countries (Dueck, Morrall & McKenzie 1983; Bardin & Huang 2001; Kuang et al. 2011), effects of meteorological factors on the etiology and epidemiology of the disease (Mueller et al. 2002; Bae & Knudsen 2007; Loffredo, Berloco & Senesi 2008), harmfulness of Sclerotinia stem rot and efficacy of various control measures (Fernando et al. 2007; Stammler, Benzinger & Speakman 2007) and fungicide resistance to *Sclerotinia sclerotiorum* in oilseed rape (Ma & Michailides 2005; Stammler, Benzinger & Speakman 2007; Kuang et al. 2011). According to the researchers, this fungal disease is difficult to manage and control in winter and spring oilseed rape. To estimate possible incidence of Sclerotinia stem rot is rather complicated, because its spread is governed by many factors and various combinations of these factors. Different foresting models have been employed in the control of Sclerotinia stem rot in winter and spring oilseed rape (Young et al. 2004; Koch et al. 2007), but none of them are completely effective (Clarkson et al. 2004; Koch et al. 2007; Huang & Erickson 2008).

In recent years, a significant increase in winter and spring oilseed rape crop area in Lithuania, introduction of new cultivars and growing technologies have resulted in a wide range of fungal diseases. Since 2007, when heavy epidemic of Sclerotinia stem rot was recorded, the incidence and severity of Sclerotinia stem rot have increased considerably in winter and spring oilseed rape crops. Therefore Sclerotinia stem rot could be considered as one of the most dangerous fungal diseases in oilseed rape crops in Lithuania, whose control requires a special attention. This paper presents the data from the field experiments on the effects of fungicide application timing against Sclerotinia stem rot in winter and spring oilseed rape crops.

MATERIALS AND METHODS

Field experiments were done in 2011 and 2012 on a winter oilseed rape cv. 'Cult' and spring oilseed rape cv. 'Landmark' at the Institute of Agriculture, Lithuanian Research Centre for Agriculture and Forestry, located in the central part of the country. Winter and spring oilseed rape was cultivated according to the conventional technology. Plant growth stages were assessed according to the scale (Lancashire et al. 1991). Meteorological data (air temperature, rainfall, relative air humidity) were taken from the Dotnuva weather station located 1 km away from the experimental field. The degree of infection of winter and spring oilseed rape petals by *Sclerotinia sclerotiorum* ascospores was assessed using a flower testing method (Turkington, Morrall & Gugel 1991). In 2011 – 2012, field experiments were conducted in a randomised block design with four replications in winter and spring oilseed rape crops. Two fungicides boscalid 500 g a.i. ha^{-1} (Cantus 0.5 kg ha^{-1}) and prothioconazole+tebuconazole 125+125 g a.i. ha^{-1} (Prosaro 1.0 l ha^{-1}) were tested for the control of Sclerotinia stem rot. All field experiments had a control treatment with no fungicides. The fungicides were sprayed with a trial bicycle sprayer (pressure 2.4 bars, nozzle type flat-fan and boom length 2.5 m) at 300 l ha^{-1} spray volume. The time of single application of fungicides was chosen according to the beginning of flowering (GS 63), full flowering (GS 65), end of flowering (GS 67) and that of twice application according to beginning (GS 63) and end (GS 67) of flowering of winter and spring oilseed rape. Assessments of Sclerotinia stem rot on the stems were made before harvesting (GS 85) on 50 plants per each plot (200 plants per each treatment). The mean disease incidence (% of plants with Sclerotinia stem rot on the stems) was calculated. The severity of Sclerotinia stem rot was assessed using a 1-4 score scale (Krüger 1991). The seed yield from each plot was harvested separately by a small-plot harvester. Moisture and oil contents were estimated using a grain analyser Infratec. Average seed yield as t ha^{-1} was calculated and adjusted to 9 % moisture content. The experimental data were analysed and subjected to analysis of variance (ANOVA) for each year. Statistical analysis was performed using the software Statistica, version 5.5.

RESULTS

Ascospores are considered the primary inoculum for diseases caused by fungus *Sclerotinia sclerotiorum* in oilseed rape (Jamaux, Gelie & Lamarque 1995). Some authors have reported that relative humidity had greater influence on peak ascospore release during the oilseed rape flowering period than air temperature and precipitation (Qandah & Mendoza 2011). Ascospores of *Sclerotinia sclerotiorum* could be released at an air temperature of around 22 °C and relative humidity of 65-75% (Clarkson et al. 2003). Within the first two ten-day periods of May in 2011 there was little rainfall, relative air humidity was about 60-70 %, and 10.0 % of infected petals by ascospores of *Sclerotinia sclerotiorum* were established at the beginning of winter oilseed rape flowering (GS 63). Infected petals were identified at this growth stage in both experimental years in winter and spring oilseed rape at relatively low level (10.0-20.0 % of infected petals). Beginning of flowering (GS 63) can be considered as the time when *Sclerotinia sclerotiorum* infection begins. The peak of ascospores of *Sclerotinia sclerotiorum* on the petals (60.0 % infected petals) was recorded at the full flowering stage (GS 65) of winter oilseed rape in 2011 (Figure 1). Frequent rainfall, quite high relative air humidity and air temperature prevailed during mid of flowering of spring oilseed rape. A total of 48.0 % petals were infected by *Sclerotinia sclerotiorum* ascospores. It is known that rainfall could play an indirect effect on *Sclerotinia sclerotiorum* ascospore release by altering the duration of high relative humidity and influencing air temperature (Qandah & Mendoza 2011). In 2012, the highest amount of rainfall and relative air humidity occurred in mid May, which created conducive conditions to the release of ascospores on winter oilseed rape (Figure 2). A total of 42.0 % of the infected petals were recorded in winter oilseed rape at GS 65. In the end of June, the meteorological conditions were very favourable for the peak concentration of *Sclerotinia sclerotiorum* ascospores on the petals of spring oilseed rape plants. As high as 80.0 % infection rate on petals was established at the end of flowering (GS 67). At mid flowering, the infection of petals was low – 20.0 %.

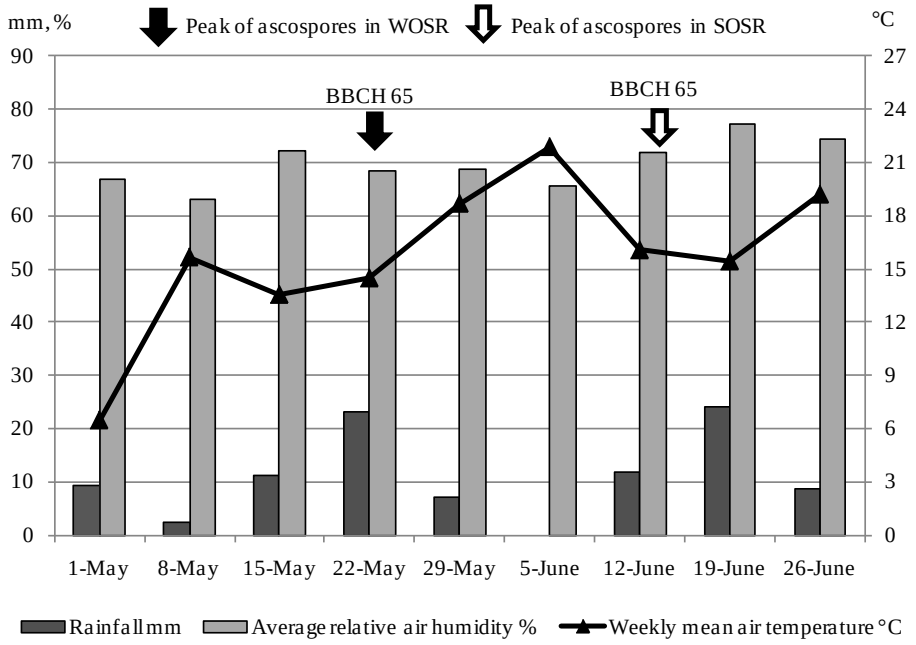


Figure 1. Meteorological factors during the period of *Sclerotinia sclerotiorum* ascospore release on winter (WOSR) and spring (SOSR) oilseed rape at flowering stage (GS 60-67), 2011

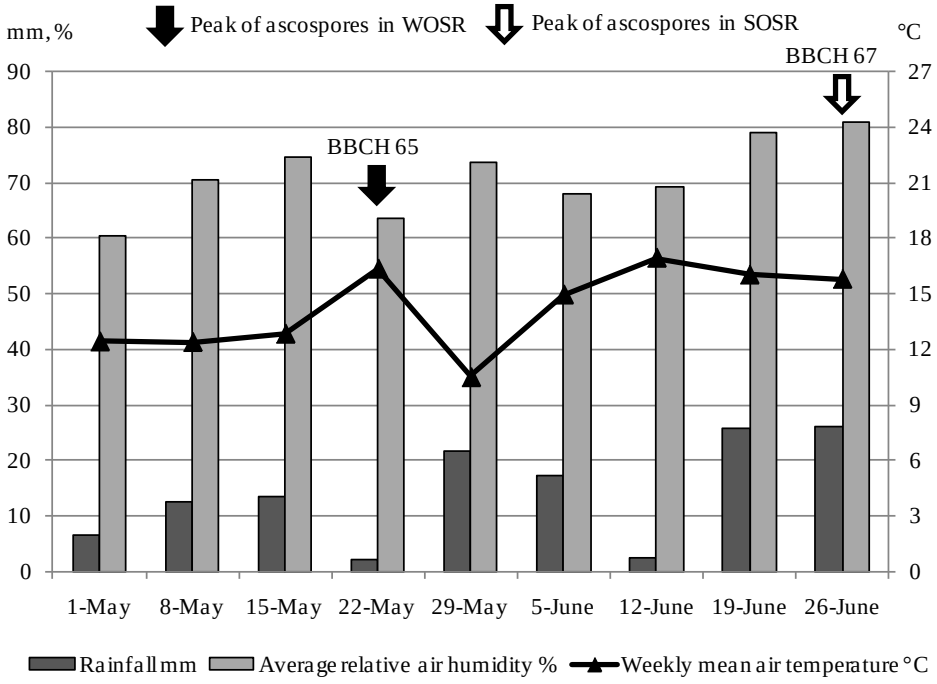


Figure 2. Meteorological factors during the period of *Sclerotinia sclerotiorum* ascospore release on winter (WOSR) and spring (SOSR) oilseed rape flowering stage (GS 60-67), 2012

Table 1. The effect of fungicide application timing on the incidence of Sclerotinia stem rot on winter and spring oilseed rape stems at GS 85, 2011-2012

Treatment		Disease incidence, %			
		Winter oilseed rape		Spring oilseed rape	
		2011	2012	2011	2012
Untreated		62 Ab[a]	60 Ac	54 Ab	62 Ae
Beginning of flowering, GS 63	boscalid 500 g a.i. ha^{-1}	29 Ba	21 Bab	29 Ba	38 Bbc
	prothioconazole+tebuconazole 125+125 g a.i. ha^{-1}	24 Ba	18 Ba	27 Ba	44 Bcd
Full flowering, GS 65	boscalid 500 g a.i. ha^{-1}	27 Ba	18 Ba	23 Ba	42 Bc
	prothioconazole+tebuconazole 125+125 g a.i. ha^{-1}	27 Ba	16 Ba	29 Ba	49 Bd
End of flowering, GS 67	boscalid 500 g a.i. ha^{-1}	27 Ba	26 Bb	24 Ba	32 Bb
	prothioconazole+tebuconazole 125+125 g a.i. ha^{-1}	36 Ba	20 Bab	24 Ba	38 Bbc
Beginning of flowering, GS 63 and end of flowering, GS 67	boscalid 500 g a.i. ha^{-1}	25 Ba	16 Ba	31 Ba	19 Ba
	prothioconazole+tebuconazole 125+125 g a.i. ha^{-1}	30 Ba	20 Bab	25 Ba	25 Ba

[a] – values followed by the same capital letter in the same row untreated versus fungicide-treated and the same lower-case letter in the same column are not significantly different (Duncan's Multiple Range Test, $P<0.05$)

Table 2. The effect of fungicide application timing on the severity of Sclerotinia stem rot on winter and spring oilseed rape stems at GS 85, 2011-2012

Treatment		Disease severity, score			
		Winter oilseed rape		Spring oilseed rape	
		2011	2012	2011	2012
Untreated		1.74 Ac[a]	1.71 Ac	1.56 Ab	1.74 Ab
Beginning of flowering, GS 63	boscalid 500 g a.i. ha^{-1}	0.76 Bab	0.42 Bab	0.74 Ba	0.54 Ba
	prothioconazole+tebuconazole 125+125 g a.i. ha^{-1}	0.65 Bab	0.44 Bab	0.72 Ba	0.47 Ba
Full flowering, GS 65	boscalid 500 g a.i. ha^{-1}	0.66 Bab	0.36 Ba	0.56 Ba	0.52 Ba
	prothioconazole+tebuconazole 125+125 g a.i. ha^{-1}	0.67 Bab	0.34 Ba	0.76 Ba	0.50 Ba
End of flowering, GS 67	boscalid 500 g a.i. ha^{-1}	0.70 Bab	0.57 Bb	0.65 Ba	0.40 Ba
	prothioconazole+tebuconazole 125+125 g a.i. ha^{-1}	1.00 Bb	0.44 Bab	0.68 Ba	0.48 Ba
Beginning of flowering, GS 63 and end of flowering, GS 67	boscalid 500 g a.i. ha^{-1}	0.59 Ba	0.34 Ba	0.81 Ba	0.38 Ba
	prothioconazole+tebuconazole 125+125 g a.i. ha^{-1}	0.77 Bab	0.44 Bab	0.64 Ba	0.38 Ba

[a] – values followed by the same capital letter in the same row untreated versus fungicide-treated and the same lower-case letter in the same column are not significantly different (Duncan's Multiple Range Test, $P<0.05$)

Table 3. The effect of fungicide application timing on the seed yield and thousand seed weight (TSW) of winter and spring oilseed rape, 2011-2012

Treatment		Winter oilseed rape			
		Seed yield, t ha^{-1}		TSW, g	
		2011	2012	2011	2012
Untreated		2.85 Aa[a]	4.21 Aa	4.89 Aa	4.26 Aa
Beginning of flowering, GS 63	boscalid 500 g a.i. ha^{-1}	3.27 Bbcd	4.51 Bc	5.04 Bb	4.38 Bb
	prothioconazole+tebuconazole 125+125 g a.i. ha^{-1}	3.20 Bbc	4.45 Bb	5.03 Bb	4.36 Bb
Full flowering, GS 65	boscalid 500 g a.i. ha^{-1}	3.38 Bde	4.50 Bbc	5.15 Bbc	4.43 Bbc
	prothioconazole+tebuconazole 125+125 g a.i. ha^{-1}	3.34 Bcde	4.48 Bbc	5.15 Bbc	4.42 Bbc
End of flowering, GS 67	boscalid 500 g a.i. ha^{-1}	3.45 Be	4.51 Bc	5.17 Bc	4.47 Bc
	prothioconazole+tebuconazole 125+125 g a.i. ha^{-1}	3.19 Bb	4.46 Bbc	5.04 Bb	4.46 Bc
Beginning of flowering, GS 63 and end of flowering, GS 67	boscalid 500 g a.i. ha^{-1}	3.41 Bde	4.65 Bd	5.19 Bc	4.48 Bc
	prothioconazole+tebuconazole 125+125 g a.i. ha^{-1}	3.15 Bb	4.69 Bd	5.18 Bc	4.44 Bc
		Spring oilseed rape			
Untreated		2.86 Aa	2.42 Aa	4.50 Aa	4.66 Aa
Beginning of flowering, GS 63	boscalid 500 g a.i. ha^{-1}	3.01 Bb	2.54 Bc	4.79 Bb	4.77 Bb
	prothioconazole+tebuconazole 125+125 g a.i. ha^{-1}	3.04 Bb	2.51 Bb	4.77 Bb	4.76 Bb
Full flowering, GS 65	boscalid 500 g a.i. ha^{-1}	3.29 Be	2.57 Bd	4.78 Bb	4.89 Bc
	prothioconazole+tebuconazole 125+125 g a.i. ha^{-1}	3.32 Be	2.50 Bb	4.78 Bb	4.75 Bb
End of flowering, GS 67	boscalid 500 g a.i. ha^{-1}	3.15 Bd	2.71 Be	4.79 Bb	5.02 Bd
	prothioconazole+tebuconazole 125+125 g a.i. ha^{-1}	3.09 Bc	2.50 Bb	4.79 Bb	4.79 Bb
Beginning of flowering, GS 63 and end of flowering, GS 67	boscalid 500 g a.i. ha^{-1}	3.09 Bc	2.54 Bc	4.79 Bb	4.79 Bb
	prothioconazole+tebuconazole 125+125 g a.i. ha^{-1}	3.12 Bc	2.52 Bbc	4.78 Bb	4.77 Bb

[a] – values followed by the same capital letter in the same row untreated versus fungicide-treated and the same lower-case letter in the same column are not significantly different (Duncan's Multiple Range Test, $P<0.05$)

Some authors have reported that meteorological conditions favourable for ascospore release influence the relationship between the incidence of Sclerotinia stem rot and petal infestation (Turkington, Morrall & Gugel 1991; Turkington & Morrall 1993), therefore it is likely that the use of fungicides during the peak infection will give the best effect. Fungicide efficacy is dependent on the timing of applications to match plant development and environmental conditions that favour infection (Turkington & Morrall 1993).

SHD fungicide boscalid and commercial triazoles mixture prothioconazole+tebuconazole were used at the beginning of flowering (GS 63), full flowering (GS 65), end of flowering (GS 67) and twice at GS 63 and GS 67

in 2011-2012. The both fungicides significantly reduced Sclerotinia stem rot incidence and severity on stems in winter and spring oilseed rape, compared with the untreated control (Tables 1, 2). Other authors have reported that fungicides gave good control of Sclerotinia stem rot in oilseed rape crops and stem lesions declined by 93 % (Gladders, Ritchie & Berry 2011).

The lower severity of the disease in our experiments was recorded in the plots treated with the test fungicides at mid of flowering (GS 65) in winter oilseed rape in 2011-2012 and in spring oilseed rape in 2011. Twice application (at the beginning of flowering GS 63 and end of flowering GS 67) significantly better reduced the incidence and severity of Sclerotinia stem rot on spring oilseed rape stems in 2012 only. In our experiments, application of fungicides at peak ascospore release gave the best control of Sclerotinia stem rot. However, in most cases, non-significant differences in the incidence and severity were identified between fungicide application times in winter and spring oilseed rape. In both experimental years, Sclerotinia stem rot highly infected the stems of winter and spring oilseed rape crops. In the two experimental years, at GS 85 disease-infected winter and spring oilseed rape stems accounted for 62.0 %, severity score was 1.74 in untreated plots. Some authors consider that the flower testing and the forecasts based on petal infection at the beginning of flowering were relatively accurate when Sclerotinia stem rot incidence was low (Turkington, Morrall & Gugel 1991; Bardin & Huang 2001).

A significant winter and spring oilseed rape seed yield increase was obtained at all fungicide application times in 2011-2012 (Table 3). A comparison of the four application times of fungicides suggests that in 2011 seed yield increased slightly more when fungicides had been applied at full flowering GS 65, and in 2012 when fungicides had been applied twice (beginning of flowering GS 63 and end of flowering GS 67). A thousand seed weight increase was recorded for winter and spring oilseed rape in 2011 and 2012, having used fungicides at all application times, compared with the untreated control. The seed yield increase is in line with Sclerotinia stem rot control. Applying fungicides is currently major method of controlling this disease (Hao et al. 2007). In the surveys across England, 48 % of oilseed rape crops were sprayed to protect against Sclerotinia stem rot and the disease incidence was reduced by 32 % (Young et al. 2007). Fungicide treatments are very cost-effective when optimized for product, dose and timing (Gladders, Ritchie & Berry 2011). Our experiments support this finding, because fungicide application at ascospore release peak gave the best control of Sclerotinia stem rot and yield increase.

CONCLUSIONS

The beginning of infection of *Sclerotinia sclerotiorum* (10-20 % of the infected petals) was established at the onset of flowering (GS 63) in both experimental years. The peak of ascospores of *Sclerotinia sclerotiorum* on the petals (42-60 % of the infected petals) was recorded at the full flowering stage (GS 65) of winter oilseed rape in 2011-2012 and in spring oilseed rape only in 2011. High infection (80 % of the infected petals) was established at the end of flowering (GS 67) in 2012 in spring oilseed rape.

Application of fungicides at peak ascospore release (GS 65 and 67) gave the best control of Sclerotinia stem rot. However, in most cases, non-significant differences in the incidence and severity were identified between fungicide application times in winter and spring oilseed rape.

The highest seed yield of winter and spring oilseed rape was produced when fungicides had been applied once at full flowering stage GS 65 and twice at GS 63 and GS 67. Fungicide application at ascospore release peak gave the best control of Sclerotinia stem rot and yield increase.

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