EFFECT OF ADJUVANTS, SPRAY VOLUME AND NOZZLE TYPE ON METCONAZOLE ACTIVITY AGAINST *LEPTOSPHAERIA BIGLOBOSA* AND *L. MACULANS* DURING LATE SPRING TREATMENTS IN WINTER OILSEED RAPE

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Abstract: In two seasons 2005–2006 the metconazole (Caramba 60 SL at the dose of 0.75 l/ha) was applicated by spraying at the beginning of flowering against phoma stem canker (*Leptosphaeria biglobosa* and *L. maculans*) in winter oilseed rape. The effect of water volume (200 and 400 l/ha), adjuvant type (Break Thru S 240 – 0.1% and Atpolan 80 EC – 0.5%), and nozzle type (XR11002 – fine droplet size and DB11002 – course droplets at pressure 0.4 MPa) on the biological efficacy of fungicide spraying was investigated in the studies.
The results showed that adjuvants did not significantly influence biological efficacy of fungicide treatments against *L. biglobosa* and *L. maculans.* Generally, control of both pathogens on the leaves and stem did not depend on spray characteristics (nozzle types-droplet size). However, positive effect of air induction nozzles DB 11002 (course spray quality) on fungicide treatments against *L. biglobosa*, particularly with addition of adjuvant Atpolan 80 EC was observed. Two different volumes of water tested (200 and 400 l/ha) did not influence efficacy of metconazole in control *L. maculans* and *L. biglobosa*. The above suggests a possibility of decrease the volume of water used with fungicide to 200 l/ha, without a negative biological effects on fungicidal activity.

Key words: adjuvants, spray volume, nozzle type, metconazole, fungicide, winter rape, *Leptosphaeria biglobosa, L. maculans*

INTRODUCTION

Phoma stem canker caused by two pathogens, *Leptosphaeria biglobosa* and *L. maculans*, is a worldwide disease of oilseed rape, including Poland (Fitt *et al.* 2006; Jędryczka 2006). Amongst methods for control of the disease, spraying plants with fungicides is one of the most important. According to recommendations made by the Institute of Plant Protection – National Research Institute, Poznań, Poland there are two possible terms for fungicide application. The first one should be done in autumn, at phase of 4 leaves occurring until rosette stage or when first symptoms are observed. The second spraying is recommended in spring after start of a plant vegetation or when first symptoms are observed.

The application of fungicides in spring might be connected with two problems. The first one is a possible occurrence of plants already infected in autumn and early spring, as ascospores of pathogens can be realeased for many months e.i. from September to May (Jędryczka 2006). Also winter oilseed rape plants treated with fungicides are usually high this time, so it can make difficulties in precise achievement by droplets of these stem parts and leaves located near soil surface. However, the later spraying in spring should allow to remain an active ingredient in plant, which protects them against later infections, caused in Poland mainly by *L. biglobosa* (Jędryczka 2006).

There are several active ingredients which can be used for phoma stem canker control. Majority of them belong to triazoles and benzimidazoles, which are systemic and can be transported inside plants. However, the efficacy of such application depends on precise covering of plants by chemicals, retention, deposition and ability of fungicide penetration into plant tissue. Those features can be modified by an addition of adjuvants, spray volume and a droplets size (Gaskin *et al*. 2000; Holloway *et al*. 2000).

The aim of the study was to assess the efficacy of metconazole (Caramba 60 SL) in control of phoma stem canker (*L. biglobosa* and *L. maculans)* in winter oilseed rape as affected by adjuvants, volume of liquid per hectare and size of spray droplets.

MATERIALS AND METHODS

The experiment was carried out in Wielkopolska province on winter oilseed rape cv. Lisek in two seasons:

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2005–2006 at Skórzewo and 2006–2007 at Złotniki. A randomized block design in 4 replications with dimension of plots 2x10 m was used. The previous crop was also winter oilseed rape in both seasons, to increase the infection pressure of *Leptosphaeria* sp. The fungicide Caramba 60 SL was applied at the dose of 0.75 l/ha using knapsack sprayer at BBCH 59–61 (beginning of flowering). Spray boom was established 25–30 cm above plant the canopy. In both seasons the wind velocity during treatments did not exceed 2 m/s and the temperature was not higher than 25 °C. The height of plants differed between years. In 2005 the mean height was 71 cm but in 2006 – 130 cm. The effect of 3 factors: i) volume of water (200 and 400 l/ha), ii) adjuvant type (Break Thru S 240 at concentration 0.1% and Atpolan 80 EC at concentration 0.5%), and iii) nozzle type (XR11002 – fine droplet size and DB11002 – course droplets at pressure 0.4 MPa) was investigated in the studies. The control variant consisted of untreated plots. Control of weeds, pests and other agrotechnical treatments was carried out according to the respective recommendations in the same way on the whole plantation.

The assessment of infection caused by pathogens was done on 25 plants collected from each plot. Leaves infection was measured using a 5-degree scale:

0 – healthy
1 – 1–2
2 – 3–4
3 – 5–6
4 – 7 or more
} spots on plant

For assessment of *L. maculans* stem infection 6 degree scale was used (Aubertot *et al.* 2004):

1 – healthy
2 – < 25%
3 – 25–50%
4 – 50–75%
5 – 75–90%
6 – 90–100%
} of infected stem section area

For assessment of *L.biglobosa* stem infection 6 degree scale was used

1 – healthy
2 – 0–25%
3 – 25–50%
4 – 50–75%
5 – 75–90%
6 – 90–100%
} of infected stem surface

Sampling of plants was done once in 2005 at the pod ripening (BBCH 87 – stem infection), whilst in 2006 there were three assessments: at the BBCH 67–68 (25.05 – leaves infection), 77 (27.06 – stem infection) and 87 (17.07 – stem infection).

Statistical analysis of the experiments was carried out using Duncan test at significance level $\alpha = 0.05$.

RESULTS

The level of infection caused by *L. maculans* on stems (untreated plots) was higher in 2005 than in 2006, whilst the occurrence of *L. biglobosa* on stems was similar in both seasons (Table 2).

Spraying with Caramba 60 SL decreased in 2005 the degree of stem infection caused by *L. maculans* as assessed before harvest (BBCH 87). The significant differences in comparison to untreated plots were found for both type of nozzles when adjuvant Atpolan 80 EC was added to the fungicide in water volume of 200 l/ha and when adjuvant Break Thru was used in the same volume of water but using XR type nozzle. The lower incidence of *L. maculans* was also found for 400 l/ha of water volume when plants were sprayed with Atpolan 80 EC addition using XR nozzles or sprayed with Break Thru using DB nozzles. However, in stem infection no significant difference between treatments for interaction of nozzle type, spray volume and adjuvants was observed.

There were not significant differences between the occurrence of *L. biglobosa* on winter oilseed rape stems (BBCH 87) in 2005 on treated with fungicide and untreated plots. In that case the efficacy of fungicide treatments was not influenced by nozzle type (droplet size), spray volume and addition of adjuvants.

The application done in 2006 was efficient in control of *L. maculans* on winter oilseed rape leaves, when the assessment was made at BBCH 67–68 (Table 3). Obtained data showed that the lower level of leaf infection was observed for fungicide treatments without addition of adjuvants, especially at spray volume of 400 l/ha. However there were no differences between treated and untreated plots in stem infection (BBCH 77 and 87) caused by this fungus.

Spraying plants with fungicide metconazole did not reduce leaf and stem infection caused by *L. biglobosa* in 2006 (see results for treated and untreated plots) (Table 3).

Interaction of adjuvants, nozzles type and volume water had no effect on the level of winter oilseed rape leaves infection caused by *L. biglobosa* in 2006 (BBCH – 67–68). In the next assessment done on stems (BBCH 77) similar tendency was observed. No significant differences between tested objects were observed in the latest assessment (BBCH 87) done on winter oilseed rape stems just before harvest (Table 2).

DISCUSSION

Chemical control of phoma stem canker (*L. maculans*) in winter oilseed rape can be done in autumn and/or in spring. However, the fungicide spraying in spring at the beginning of plant flowering might be more yield producing than those done in autumn (Gwiazdowski 2002).

L. maculans can infect oilseed rape leaves in autumn via airborne ascospores and then it grows through petioles to stems (Fitt *et al*. 2006, Jędryczka 2006). On the contrary, the majority of *L. biglobosa* infections occur usually in spring. In May 2005 rainfall was 36% higher than in 2006 (Table 1), which could increase *Leptosphaeria* spp. infections. At the latest assessment of stems, the degree of

Table 1. Meteorological conditions during field experiments

Month	Decade	2005 (Skórzewo)			2006 (Złotniki)		
		sum	mean		sum	mean	
		rainfall [mm]	temperature [°C]	relative humidity %	rainfall [mm]	temperature [°C]	relative humidity [%]
April	I	9	9.29	65.15	0.6	7.32	77.40
	II	0	11.15	74.47	6	9.04	77.89
	III	7.4	8.35	61.67	23.4	11.47	84.44
	sum/mean	16.40	9.59	67.10	30.00	9.28	79.91
May	I	29.2	11.49	86.04	11.6	14.80	61.00
	II	21.8	10.10	79.77	13.6	14.87	75.33
	III	11.2	19.20	67.51	20.4	12.59	80.73
	sum/mean	62.20	13.59	77.77	45.60	14.09	72.35
June	I	8.6	13.33	75.85	6.8	12.80	80.36
	II	8	16.94	73.02	0.4	20.83	67.91
	III	0.2	19.71	63.28	14.4	21.92	64.60
	sum/mean	16.80	16.66	70.72	21.60	18.52	70.96
July	I	9.4	19.98	69.51	0.0	22.44	44.02
	II	3.6	21.08	63.07	20.2	22.73	62.80
	sum/mean	108.40	14.60	70.85	117.40	15.53	70.59

Table 2. Influence of Caramba 60 SL spraying (0.75 l/ha) on the winter oilseed rape stem infection caused by *L. biglobosa* and *L. maculans* at BBCH 87 (before harvest) depending on spray volume, adjuvant and nozzle type

Spray volume [l/ha]	Adjuvant	Nozzle type	*Leptosphaeria biglobosa*				*Leptosphaeria maculans*			
			2005		2006		2005		2006	
				mean		mean		mean		mean
200	–	XR 11002	1.65 a	1.59 a	1.54 a	1.53 a	1.68 a	1.74 a	1.62 a	1.66 a
		DB 11002	1.53 a		1.52 a		1.79 a		1.70 a	
	Atpolan 80 EC	XR 11002	1.79 a	1.75 a	1.60 a	1.58 a	1.57* a	1.52 a	1.61 a	1.63 a
		DB 11002	1.68 a		1.56 a		1.46* a		1.64 a	
	Break Thru S 240	XR 11002	1.78 a	1.79 a	1.53 a	1.54 a	1.55* a	1.62 a	1.62 a	1.60 a
		DB 11002	1.79 a	1.71 A	1.55 a	1.55 A	1.68 a	1.62 A	1.57 a	1.63 A
	mean									
400	–	XR 11002	1.86 a	1.80 a	1.58 a	1.61 a	1.65 a	1.68 a	1.60 a	1.61 a
		DB 11002	1.73 a		1.63 a		1.70 a		1.62 a	
	Atpolan 80 EC	XR 11002	1.69 a	1.69 a	1.61 a	1.59 a	1.55* a	1.65 a	1.58 a	1.60 a
		DB 11002	1.71 a		1.56 a		1.75 a		1.61 a	
	Break Thru S 240	XR 11002	1.79 a	1.72 a	1.55 a	1.61 a	1.65 a	1.62 a	1.64 a	1.62 a
		DB 11002	1.65 a		1.67 a		1.59* a		1.59 a	
	mean			1.73 A	A	1.60 A		1.64 A		1.61 A
Control (Untreated plots)			1.82		1.77		2.07		1.67	
Mean	–	XR 11002		1.76 a		1.56 a		1.67 a		1.61 a
		DB 11002		1.63 a		1.58 a		1.75 a		1.66 a
	Atpolan 80 EC	XR 11002		1.74 a		1.61 a		1.56 a		1.60 a
		DB 11002		1.60 a		1.56 a		1.61 a		1.63 a
	Break Thru S 240	XR 11002		1.79 a		1.54 a		1.60 a		1.63 a
		DB 11002		1.72 a		1.61 a		1.64 a		1.58 a
	mean			1.76 a		1.56 a		1.67 a		1.61 a

a, b or A – entries followed by the same letter were not significantly different using Duncan test at $\alpha = 0.05$
* mean significantly different from control (untreated) using Duncan test at $\alpha = 0.05$

Table 3. Influence of Caramba 60 SL spraying (0.75l/ha) on the winter oilseed rape infection in 2006 caused by *L. biglobosa* and *L. maculans* at BBCH 67–68 (leaf infection) and 77 (stem infection) depending on spray volume, adjuvant and nozzle type

Spray volume [dm^3 ha^{-1}]	Adjuvant	Nozzle type	*Leptosphaeria biglobosa*				*Leptosphaeria maculans*			
			leaves (BBCH – 67–68)		stems (BBCH 77)		leaves (BBCH – 67–68)		stems (BBCH 77)	
			25.05	mean	27.06	mean	25.05	mean	27.06	mean
200	–	XR 11002	0.19 a	0.21 a	1.52 ab	1.48 a	0.55* a	0.49 a	1.46 a	1.47 a
		DB 11002	0.22 a		1.43 ab		0.42* a		1.47 a	
	Atpolan 80 EC	XR 11002	0.21 a	0.17 a	1.44 ab	1.47 a	0.57 a	0.56 a	1.38 a	1.33 a
		DB 11002	0.12 a		1.50 ab		0.55* a		1.27 a	
	Break Thru S 240	XR 11002	0.25 a	0.24 a	1.55 b	1.52 a	0.54* a	0.51 a	1.55 a	1.54 a
	mean	DB 11002	0.23 a	0.20 A	1.49 ab	1.49 A	0.48* a	0.52 A	1.52 a	1.44 A
400	–	XR 11002	0.22 a	0.21 a	1.36 ab	1.38 a	0.41* a	0.42 a	1.44 a	1.47 a
		DB 11002	0.19 a		1.40 ab		0.42* a		1.50 a	
	Atpolan 80 EC	XR 11002	0.19 a	0.22 a	1.49 ab	1.40 a	0.41* a	0.52 a	1.57 a	1.47 a
		DB 11002	0.14 a		1.30 a		0.62 a		1.36 a	
	Break Thru S 240	XR 11002	0.27 a	0.17 a	1.43 ab	1.46 a	0.68 a	0.56 a	1.24 a	1.39 a
		DB 11002	0.16 a		1.48 ab		0.43* a		1.54 a	
	mean			0.20 A		1.41 A		0.50 A		1.44 A
Control (untreated plots)			0.29		1.52		0.9		1.4	
Mean	–	XR 11002		0.21 ab		1.44 a		0.48 a		1.45 a
		DB 11002		0.21 ab		1.42 a		0.42 a		1.49 a
	Atpolan 80 EC	XR 11002		0.20 ab		1.47 a		0.49 a		1.48 a
		DB 11002		0.13 a		1.40 a		0.59 a		1.32 a
	Break Thru S 240	XR 11002		0.26 b		1.49 a		0.61 a		1.40 a
		DB 11002		0.20 ab		1.49 a		0.46 a		1.53 a

a, b or A – entries followed by the same letter were not significantly different using Duncan test at $\alpha = 0.05$
*mean significantly different from control (untreated) using Duncan test at $\alpha = 0.05$

infection caused by *L. maculans* on untreated plots in 2005 reached 2.07, whilst in 2006 only 1.67 (Table 2).

In the experiment done in 2005 at Skórzewo and in 2006 at Złotniki the fungicide Caramba 60 SL was applied in spring at the beginning of flowering. The used dose (0.75l/ha) was lower than it was recommended by the producer (1–1.25l/ha). The active ingredient (metconazole) did not reduce significantly the level of infection of winter oilseed rape plants caused by *L. biglobosa*. It suggested that the tested dose was too little and the date of application did not match the pathogen spore release. The fungicide spraying was efficient against *L. maculans* infections, however, the positive effect of metconazole application concerned oilseed rape leaves only. The level of stem infection was similar on treated and untreated plots. It seemed, that the efficacy of fungicide was decreased by plant development as a concentration of active ingredient in plant became too low to inhibit *L. maculans* development in stem base.

Addition of adjuvants to fungicide did not increase the efficacy of spraying against *L. maculans,* regardless of water volume and nozzle type application. However, oil adjuvant Atpolan 80 EC had good effect on fungicide activity against stem infection caused by *L. maculans* for both nozzle types (droplet size) and, especially at spray volume of 200l/ha. Results indicate a possibility of using lower volume of water to metconazole treatment with or without addition of adjuvants even when spray must penetrate dense plant conopy (in spring, winter rape at the beginning of flowering). The above confirmed Kutcher and Wolfs̀ (2006) conclusions that using conventional nozzles with higher volume of water and low drift nozzles with lower volume are both appropriate for control of Brassica stem diseases.

In general, biological activity of fungicide against *L. biglobosa* was not depended on addition of adjuvants to spray solution and nozzle type (droplet size). Although the control with metconazole against *L. biglobosa* was not fully efficient, spraying using air induction nozzle DB 11002 with or without addition of adjuvants, gave similar efficacy of pathogen control as compared with the spraying using XR 11002. It indicated that the air induction nozzle DB 11002 producing larger droplets could be recommended in winter oilseed rape, especially if the spraying was done at high velocity wind. In crops such oilseed rape larger droplets may penetrate deeper than small ones. However, in other crops e.g. muskmelon, where Alternaria leaf blight affects leaves only, using of nozzles with high pressure was not necessary (Egel and Harmon 2001). Grayson *et al.* (1996) and Kierzek and Wachowiak (2003) suggested that addition of adjuvants could not improve the efficacy of fungicide spraying without taking into consideration other parameters of the application. If spraying was performed in less favourable climatic conditions (stronger wind, lower humidity, higher temperature) application of fungicide with DB 11002 nozzle against *L. biglobosa* should be helpful.

Two different amounts of water tested (200 and 400 l/ha) for spraying against *L. maculans* and *L. biglobosa* did not influence the efficacy of metconazole. It indicates a possibility of decrease the volume of water to 200 l/ha, without any negative effect on fungicide efficacy.

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POLISH SUMMARY

WPŁYW ADIUWANTÓW, ILOŚCI CIECZY UŻYTKOWEJ I TYPU ROZPYLACZA NA SKUTECZNOŚĆ DZIAŁANIA METKONAZOLU W WIOSENNEJ OCHRONIE RZEPAKU OZIMEGO PRZED *LEPTOSPHAERIA BIGLOBOSA* I *L. MACULANS*

W latach 2005 i 2006 na początku kwitnienia rzepaku ozimego zastosowano metkonazol (Caramba 60 SL w dawce 0,75 l/ha) przeciwko suchej zgniliźnie kapustnych (*Leptosphaeria biglobosa* i *L. maculans*). W badaniach oceniono znaczenie ilości wody (200 i 400 l/ha), rodzaju adiuwanta (Break Thru S 240 – 0,1% i Atpolan 80 EC – 0,5%) oraz rodzaju rozpylacza (XR 11002 – drobnokroplisty i DB11002 – grubokroplisty przy ciśnieniu 0,4 MPa) dla biologicznej skuteczności opryskiwania fungicydem.

Wyniki badań wskazują, że dodatek adiuwantów do metkonazolu nie wpływał istotnie na skuteczność zwalczania sprawców suchej zgniliźny kapustnych (*L. biglobosa* i *L. maculans*). Generalnie efektywność zwalczania obydwóch patogenów na liściach i łodygach rzepaku nie była uzależnona od użytych do zabiegu typów rozpylaczy (wielkości kropel). Stwierdzono, że zastosowanie rozpylaczy eżektorowych DB 12002, wytwarzających krople grube, w korzystny sposób wpłynęło na skuteczność zwalczania *L. biglobsa*, szczególnie gdy metkonazol stosowano z dodatkiem adiuwanta olejowego Atpolan 80 EC.

Obie oceniane ilości wody nie wpływały istotnie na skuteczność metkonazolu przeciwko *L. maculans* jak i *L. biglobosa*. Wskazuje to na możliwość zmniejszenia objętości wody używanej do rozcieńczania fungicydu do 200 l/ha, bez negatywnego wpływu na jego biologiczną skuteczność.