Modern fungicides in control of early and late blight in Polish experiments

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INTRODUCTION

Late blight caused by *Phytophthora infestans* is a very serious economic threat in the vast majority of potato production systems. Two recent studies put the total loss (direct and through fungicides) at between $3 and $5 billion per year (Judelson and Blanco, 2005; Haldar *et al.,* 2006). After *P. infestans*, *Alternaria* is the second most important foliar fungal pathogen of potato crops world-wide. Early blight occurs in many parts of the world but is a problem mainly under the weather warm and dry with short periods of high moisture (Venette, Harrison 1973). According to Johnson *et al.* (1986) and Fry (1994), maximum documented yield reductions in USA are usually 20-30%. In Polish climatic conditions there were recorded high regional losses caused by the early blight, however, most related to cultivars with recognized susceptibility to this disease. The use of fungicides is necessary in controlling both early and late blights, but it is important to use fungicides that effectively protect potato plants against the diseases.

MATERIALS

Twelve field experiments to compare the fungicide effectiveness against early blight (EB) and eight against late blight (LB) were set up in the years 2005, 2007-2009. Studies were conducted in the Department of Protection and Seed Sciences of PBAI- NRI in Bonin with the emphasis on:
Comparison of time of the incidence and severity level of the early and late blight of potato in two/three different locations: trials with LB in Bonin and Mierzym (north-west region of Poland) and trials with EB in Bonin, Mierzym (north-west region of Poland) and Stare Olesno (south region of Poland).
Evaluation to rate efficacy of selected fungicides (including newly registered in potato) in limiting the development of the early blight and late blight.
Fungicides tested in the different studies are listed in table 1. All fungicides were tested in all experiments.

Posters

Table 1. *Fungicides used in the field trials*

Fungicide	Active ingredient	Dose rate Kg or L / ha
Amistar 250 SC[1)]	azoxystrobine	0,5
Infinito 687,5 SC	fluopicolide + propamocarb-HCl	1,2-1,6 l
Tattoo C 750 SC	propamocarb-HCl + mancozeb	2,0 l
Ridomil Gold MZ 68 WG	mefenoxam + mancozeb	2,0 kg
Acrobat MZ 69 WG	dimethomorph + mancozeb	2,0 kg
Tanos 50 WG	cymoxanil + famoxate	0,5-0,7 kg
Revus 250 SC	mandipropamid	0,6 l
Altima 500 SC	fluazinam	0,4 l
Ranman 400 SC TwinPack*	cyazofamid + (adjuvant)	0,2 + 0,15 l

1) not registered in Poland for potato crops
** not in trials to control EB*

Field trials for early blight control were carried out in 3 localities (Bonin, Mierzym and Stare Olesno) on cv. Bard (susceptible to the disease). Three sprayings were performed throughout the growing season against EB, beginning with the occurrence of the very first symptoms of the disease on the experimental plots. The next sprays were continued with the same program on all plots against late blight.

Evaluation of fungicide efficacy to late blight control was performed in 2 localities (Bonin and Mierzym) on cv. Irga (very susceptible to the disease). Control of the LB began based on DSS NegFry system. Six to seven sprayings were applied throughout the growing season, with intervals 7-10 days and 10-14 days.

All trials were carried out in four replicates; each size plot = 25 m2. The field trials were carried out in accordance with GEP.

The criteria for pathogen infection pressure assessment were evaluated on untreated plots (control) and assumed to be foliar blight severity at the end of growing season and relative area under the disease progress curve (rAUDPC).

The criteria for fungicide effectiveness assessment on protected plots was assumed to be the percentage of disease severity at the end of growing season, efficacy of tested fungicides compared to untreated control, relative area under the diseases progress curve (rAUDPC) , the diseases development rate defining the increase of destruction of above ground plant parts in unit time and also tuber yield and its healthiness.

The results were analyzed in a 2-factorial ANOVA, the factors being years of experiments and the fungicides applied.

RESULTS AND DISCUSSION

Results of pathogen infection pressure assessment are presented in tab 2 and 3. The observations carried out at Bonin, Mierzym & Stare Olesno revealed that both time of occurrence and severity of early and late blight differed and were dependent upon meteorological conditions and upon the year. Generally, early blight appeared earlier in the South of Poland (exception season 2008). It was connected probably not only with weather conditions but also with viruses' infections. In this area (the South of Poland) climatic conditions also favor greater infection pressure of the viruses. Virus infections enlarged additionally early blight pressure under Stare Olesno conditions. Potato plants infected with some viruses are more susceptible to the early blight infection (Hooker 1990). This refers mainly to viruses PVY and PLRV (Dorożkin *et al.* 1979) and PVX (Nagaich, Prased 1971).

In the field experiments early blight occurred the earliest at Stare Olesno in 2009 (at 10th June). The highest disease pressure, described as rAUDPC was observed in season 2005 and 2007 in Bonin, in 2007 in Mierzym and in 2005 in Stare Olesno (tab.2).

Table 2. *Time of occurrence of the early blight in the years 2005, 2007-2008*

Years	Bonin			Mierzym			St.Olesno		
	Data of disease appearance	Infected leaf area - %	rAUDPC	Data of disease appearance	Infected leaf area - %	rAUDPC	Data of disease appearance	Infected leaf area - %	rAUDPC
2005	27.06.	50,0	0,68	29.06.	33,1	0,33	24.06.	57,9	0,41
2007	19.06.	95,3	0,63	18.06.	98,2	0,61	16.06.	99,5	0,19
2008	20.06.	91,7	0,28	26.06.	95,3	0,16	24.06.	98,0	0,16
2009	19.06.	95,3	0,14	04.07.	71,4	0,28	10.06.	98,6	0,30

Time of the natural late blight epidemic start depended upon the year and differed between years up to 35 days in Bonin and up to 34 days in Mierzym. The disease occurred the earliest in Bonin in 2009 (at 20th June), followed 5 days later in Mierzym. The late blight epidemic started relatively late in both locations in 2005. The highest pressure of the disease was noted in Bonin in the years 2005 and 2007 with the highest foliar blight severity at the end of the season and highest level of rAUDPC. The differences of these factors were not so clear in Mierzym (tab.3).

Table 3. *Time of occurrence of the late blight in the years 2005, 2007-2008*

Years	Bonin			Mierzym		
	Data of disease appearance	Infected leaf area - %	rAUDPC	Data of disease appearance	Infected leaf area - %	rAUDPC
2005	25.07.	97,1	0,68	29.07.	98,9	0,33
2007	29.06.	99,5	0,63	25.06.	73,8	0,61
2008	17.07.	93,9	0,47	03.07.	99,8	0,01
2009	20.06.	81,7	0,14	25.06.	98,6	0,28

Generally speaking meteorological elements and their course during a growing season are the basic elements affecting occurrence of the diseases in the field and variability of infection pressure of *P. infestans* and *Alternaria* spp.

The carried out trials showed also, that all fungicides limited the early blight development compared to the untreated control but at different level (Fig.1). The best results were obtained for Infinito 687,5 SC (dose rate 1,2 l/ha) and the "old" fungicides Altima 500 SC, Antracol 70 WG, Bravo 500 SC. In Polish experiences (12 trials in 3 locations), Amistar 250 SC and Revus 250 SC were the least effective in control of EB.

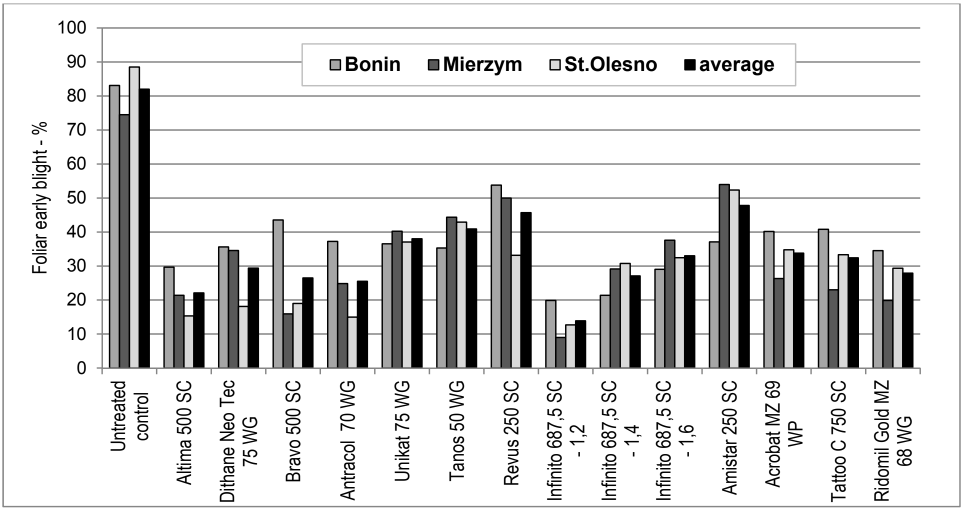

Fig.1. *Efficiency of selected fungicides in potato protection against early blight (12 field trials)*

The effectiveness of fungicides to control potato late blight epidemic for each experiments is given in table 4. The conducted trials showed that all fungicides, applied each 7-10 days, limited the LB development compared to the untreated control. Under climatic conditions in Mierzym, all tested fungicides revealed similar efficiency in inhibition of the late blight development, without any significant statistic differences. The lowest effectiveness in control of late blight was observed for Dithane Neo Tec 75 WG. In Mierzym, relative area under the disease progress curve (rAUDPC) for all fungicides was not too high and differences were not significant.

In Bonin the best effect of late blight control was observed after applications of fungicides Revus 250 SC and Infinito 687,5 SC; less effective in inhibition of LB development were Dithane Neo Tec 75 WG and Acrobat MZ 69 WP. The ranking of the fungicides' efficacy was very similar to the ranking based on rAUDPC index.

Similar good control of LB was observed when fungicides were applied each 10-14 days. Effectiveness of all tested fungicides was assessed above 80% (except for Acrobat MZ 69 WP in Bonin).

Over all years potato late and early blight were monitored as a destructive diseases, which caused significant yield losses due to premature defoliation.

The first priority for farmers and advisors is fungicide efficacy. Sometimes dose rates can be reduced in relation to weather conditions or cultivar resistance. In Poland it is not allowed to use lower dose rates than registered in the country.

Table 4. *Effectiveness of fungicides to control late blight during the whole season*

Treatment	Dose rate Kg, L /ha	Year	BONIN						MIERZYM					
			Foliar blight - %	Fungicide efficacy %	Rate of LB development	rAUDPC	Yield t/ha	Tuber blight - %	Foliar blight - %	Fungicide efficacy %	Rate of LB development	rAUDPC	Yield t/ha	Tuber blight - %
Unprotected control	-	2005	97,1		0.373	0,68	31,4	1,3	98,9		0.428	0,33	27,3	4,7
		2007	99,5		0.377	0,63	20,7	0,1	73,8		0.357	0,61	18,8	0,7
		2008	93,9		0.273	0,47	29,4	0,8	99,8		0.364	0,01	37,0	1,9
		2009	81,7		0.445	0,14	27,5	0,3	98,6		0.325	0,28	26,2	0,3
		mean	**93,1**		**0.367**	**0,48**	**27,3**	**0,6**	**92,8**		**0.369**	**0,31**	**27,3**	**1,9**
Altima 500 SC	0,4	2005	22,8	76,6	0.200	0,20	45,4	2,2	5,9	94,0	0.128	0,01	37,7	1,5
		2007	7,1	92,9	0.222	0,18	31,0	0,0	19,6	73,5	0.193	0,26	27,8	0,0
		2008	3,8	96,0	0.161	0,01	37,9	0,0	11,5	88,5	0.120	0,00	52,0	0,4
		2009	8,1	90,1	0.182	0,02	42,3	0,5	14,9	84,9	0.132	0,02	36,3	0,0
		mean	**10,5**	**88,9**	**0.191**	**0,10**	**39,2**	**0,7**	**13,0**	**85,2**	**0.143**	**0,07**	**38,5**	**0,5**
Dithane Neo Tec 75 WG	2,0	2005	57,9	40,4	0.248	0,39	42,4	1,5	32,1	67,5	0.219	0,05	35,5	3,5
		2007	29,7	70,2	0.280	0,31	25,9	0,0	36,5	50,4	0.232	0,38	23,0	0,0
		2008	2,9	96,9	0.225	0,01	37,2	0,7	37,6	62,3	0.177	0,00	46,0	0,7
		2009	28,7	64,9	0.225	0,04	37,5	0,5	33,1	66,4	0.177	0,06	37,7	0,0
		mean	**29,8**	**68,1**	**0.245**	**0,19**	**35,8**	**0,7**	**34,8**	**61,7**	**0.201**	**0,12**	**35,6**	**1,1**
Acrobat MZ 69 WP	2,0	2005	18,3	81,2	0.200	0,18	39,1	0,0	21,8	78,0	0.189	0,03	34,9	0,0
		2007	25,2	74,7	0.256	0,28	28,3	0,4	11,7	84,1	0.168	0,19	30,3	0,0
		2008	4,7	95,0	0.170	0,02	39,0	0,1	14,9	85,1	0.132	0,00	46,9	1,3
		2009	50,0	38,8	0.310	0,07	38,3	0,4	4,1	95,8	0.097	0,01	36,1	1,2
		mean	**24,6**	**72,4**	**0.234**	**0,14**	**36,2**	**0,2**	**13,1**	**85,8**	**0.147**	**0,06**	**37,1**	**0,6**
Ranman 400 SC	0,2+ 0,15	2005	4,7	95,2	0.128	0,05	46,6	0,5	11,7	88,2	0.159	0,02	44,1	2,1
		2007	13,9	86,0	0.364	0,34	27,4	0,0	11,7	84,1	0.206	0,27	28,9	0,3
		2008	1,1	98,8	0.187	0,00	40,6	0,0	14,9	85,1	0.132	0,00	47,6	0,0
		2009	18,3	77,6	0.237	0,03	38,1	0,0	21,8	77,9	0.155	0,08	39,0	0,0
		mean	**9,5**	**89,4**	**0.229**	**0,10**	**38,2**	**0,1**	**15,0**	**83,8**	**0.163**	**0,09**	**39,9**	**0,6**
Revus 250 SC	0,6	2005	2,9	97,0	0.128	0,04	45,1	0,2	25,2	74,5	0.189	0,04	41,3	4,9
		2007	9,5	90,5	0.233	0,21	34,5	0,0	17,4	82,5	0.151	0,02	41,7	1,6
		2008	3,9	96,0	0.216	0,01	39,3	0,0	18,3	81,7	0.144	0,00	45,0	0,0
		2009	4,1	95,0	0.168	0,01	41,4	4,2	8,7	91,2	0.120	0,01	38,8	0,0
		mean	**5,1**	**94,6**	**0.186**	**0,07**	**40,1**	**1,1**	**17,4**	**82,5**	**0.151**	**0,02**	**41,7**	**1,6**
Infinito 687,5 SC	1,2	2005	0,5	99,5	0.067	0,01	49,0	2,6	1,7	98,3	0.189	0,03	41,3	4,9
		2007	9,5	90,5	0.280	0,23	32,3	0,4	14,7	85,2	0.158	0,02	45,7	1,7
		2008	11,5	87,8	0.206	0,03	49,3	0,3	34,2	65,8	0.166	0,00	47,7	0,2
		2009	5,1	93,9	0.153	0,01	41,2	0,4	8,3	91,6	0.120	0,02	47,3	0,0
		mean	**6,7**	**92,9**	**0.177**	**0,07**	**43,0**	**0,9**	**14,7**	**85,2**	**0.158**	**0,02**	**45,5**	**1,7**
Infinito 687,5 SC	1,4	2005	0,7	99,3	0.055	0,01	47,6	0,7	1,1	98,9	0.128	0,01	35,8	0,8
		2007	8,3	91,7	0.211	0,17	35,8	0,0	8,0	91,7	0.123	0,01	40,9	0,3
		2008	1,1	98,8	0.152	0,00	40,4	0,0	18,3	81,7	0.144	0,00	40,0	0,0
		2009	4,1	95,0	0.138	0,01	45,3	0,5	4,7	95,2	0.097	0,01	46,9	0,0
		mean	**3,6**	**96,2**	**0.139**	**0,05**	**42,3**	**0,3**	**8,0**	**91,9**	**0.123**	**0,01**	**40,9**	**0,3**
Infinito 687,5 SC	1,6	2005	0,3	99,7	0.055	0,00	43,6	2,6	1,7	98,3	0.113	0,01	35,4	3,3
		2007	4,7	95,3	0.185	0,12	40,1	0,0	2,6	96,5	0.117	0,21	35,6	0,0
		2008	3,8	96,0	0.187	0,01	40,8	0,0	18,3	81,7	0.144	0,00	48,7	0,7
		2009	3,5	95,7	0.138	0,01	45,4	0,3	4,7	95,2	0.155	0,01	42,8	0,5
		mean	**3,1**	**96,7**	**0.141**	**0,04**	**42,5**	**0,7**	**6,8**	**92,9**	**0.132**	**0,06**	**40,6**	**1,1**
LSD (p=0,1) for treatments (mean of 4 year)			14,4	15,8	0.067	0.13	6,5	1,4	14,4	15,8	0.067	0.13	6,5	1,4

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