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VARIETAL RESISTANCE OF POTATOES TO LATE BLIGHT AND CHEMICAL PROTECTION STRATEGY

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Abstract: The genetic resistance of potato varieties can be utilized to lower the fungicide rates used for plant protection against late blight. The very resistant varieties can be protected with half the rate of fungicide without negative effect on efficiency of the control.

Key words: potato, late blight, chemical control, genetic resistance

INTRODUCTION

The great variability and wide spread of *Phytophthora infestans* fungus are the reasons why late blight is still a problem in potato production. Worldwide, the losses caused by late blight are estimated at 8–10% (Schlenzig et al. 1999). Yield reduction in unprotected fields is estimated at 70% (Hoffman and Schmutterer 1983).

There are cases described in which early and severe epidemics resulted in total destruction of the yield (Fry 1994). The average yield losses in Poland (long time observations), due to late blight, amount to 20–25% (Pietkiewicz 1989).

The intensive plant protection against late blight is one of the main elements of potato production technology. Under climatic conditions of Poland, the average period of necessary protection is 2.5–3 months what means 8–12 fungicide treatments.

So intensive protection is expensive and, more important, has negative effects on environment.

One of the more cost-effective elements of potato protection against the late blight is the utilization of the genetic resistance. In the areas where the disease is most common and severe, the use of resistant varieties reduces the risk of early occurrence and quick development in the field. The advantage of using the resistance is also the possibility of reducing chemical protection. The genetic resistance of varieties to the late blight can supplement the fungicide action, facilitating thus the reduction of fungicide rates and extension of intervals between treatments (Fry 1975; 1978).

The purpose of the study undertaken at PBAI Bonin was the assessment how much the rates of fungicides used for potato protection against late blight can be reduced by the utilization of the genetic resistance, without compromising the protection efficiency.

MATERIAL AND METHODS

The experiments on the possibility of fungicide rate reduction in plant protection against the late blight were carried out at Bonin in 1998–2000. The experiments were done on 3 potato varieties of various resistance degrees to the late blight. The following varieties were included: Karlena (foliage resistance of 3), intermediately resistant Panda (foliage resistance of 5), and a resistant variety Meduza (foliage resistance of 8). The plot size was 25 sq. meters. The experimental design was completely randomized with 4 replications.

The same protection schedule was applied each year (6 sprayings): S + T + C + C + C + C (where: S means systemic fungicide, T – translaminar fungicide, C – contact fungicides). Each year the same fungicides were used:

propamocarb hydrochloride + chlorothalonil (Tattoo C 750 SC) - 2.5 l/ha,
cymoxanil + mancozeb (Curzate M 72,5 WP) - 2.0 kg/ha,
chlorotalonil + Zn (Bravo Plus 500 SC) - 2.0 l/ha,
mancozeb (Dithane M-45 80 WP) - 2.0 kg/ha,
fluazinam (Altima 500 SC) - 0.3 l/ha,
fentin hydroxide (Brestanid 502 SC) - 0.5 l/ha.

The four combinations of the same schedule (S+T+C+C+C+C), applying the various rates of fungicides, were compared in the experiments: recommended rate (100%) and two treatments of rates reduced to 75 and 50%. An unprotected plot was included as a control.

The infection degree was estimated once a week since the date of first disease appearance, on the base of 9-degree scale, 1 meaning the lack of symptoms or sporadic necrotic spots, and 9 – plants completely destroyed (with the single healthy stem parts). As a criterion of fungicide efficiency, the rate of late blight development was accepted – infection regression coefficient against time (Van der Plank 1963) and tuber yield.

The results were analyzed in a 3-factorial ANOVA, the factors being varieties, years of experiments, and the fungicide rates applied.

RESULTS

The different weather conditions in 1998–2000 resulted in different severity and potential threat of late blight to potatoes (Tab. 1).

The data in table 1, depicting the development of late blight, indicate that the season of 1998 was intermediate in respect to the disease intensity. The late blight appeared at Bonin 62 days after planting. The curve illustrating the disease development in 1999 was quite different. The late blight appeared very early (57 days after planting), but due to the weather conditions, its development was very slow. The disease started to develop only during the third decade of August. Even at the end of growing season the plants in unprotected plots were not completely destroyed.

Table 1. Severity of late blight on the check variety Atol in 1998–2000

Year	Date of planting	Weather conditions in VI–VIII		Date of late blight appearance (days from planting)	Rate of late blight spread
		Mean temp. (°C)	Sum of rainfall (mm)		
1998	08.05.	16.3	354.1	62	0.226
1999	28.04.	17.6	183.9	57	0.194
2000	28.04.	16.4	192.8	81	0.387

The rate of disease development remained moderate. The growing season of 2000 was characterized by the highest pathogen infection pressure. The disease appeared relatively late, but developed quickly. The total destruction of plants in unprotected plots was observed about August 20. Despite late appearance (81 days after planting), the rate of development was very high in that year.

The conducted experiments confirmed that the significant factor affecting the rate of disease spread in experimental plots was the resistance of variety used. It was particularly visible on the varieties extremely resistant to the pathogen (LSD=0.044 at α=0.01). In all years, regardless of the pathogen infection pressure, the lowest increase of destruction during a time unit was observed on the Meduza variety, while the largest one – on Karlena.

In the conducted study, using varieties of different resistance to late blight, the intensity of the disease in particular years was similar to that on standard variety. The rate of disease spread on all varieties studied was the highest during the season of 2000 (Tab. 2, Fig. 1.). The rate of disease development was significantly higher in comparison both to 1998 and 1999 (LSD=0.011 at α>0.01). Significant differences in the rate of disease development between 1998 and 1999 were observed only on the very susceptible variety Karlena. On the other varieties, the disease developed at similar rate in both years.

The factor mostly affecting the rate of late blight development in the plots of less resistant varieties studied was the combination of chemical protection applied, i.e.

Table 2. The intensity of late blight development on potato varieties of different genetic resistance to the pathogen

Year	Protection variant	Potato variety (resistance to late blight)			LSD (α=0.01)
		Karlena (3)	Panda (5)	Meduza (8)	
1998	control	0.257 a	0.181 a	0.031 a	0.020
	50%	0.220 b	0.124 b	0.031 a	
	75%	0.212 b	0.047 c	0.023 a	
	100%	0.183 c	0.032 c	0.008 a	
1999	control	0.213 a	0.181 a	0.031 a	0.020
	50%	0.219 a	0.068 b	0.023 a	
	75%	0.211 a	0.047 b	0.016 a	
	100%	0.183 b	0.032 bc	0.0 ab	
2000	control	0.355 a	0.254 a	0.042 a	0.030
	50%	0.331 b	0.159 b	0.043 a	
	75%	0.318 b	0.143 b	0.052 a	
	100%	0.220 c	0.104 c	0.034 a	

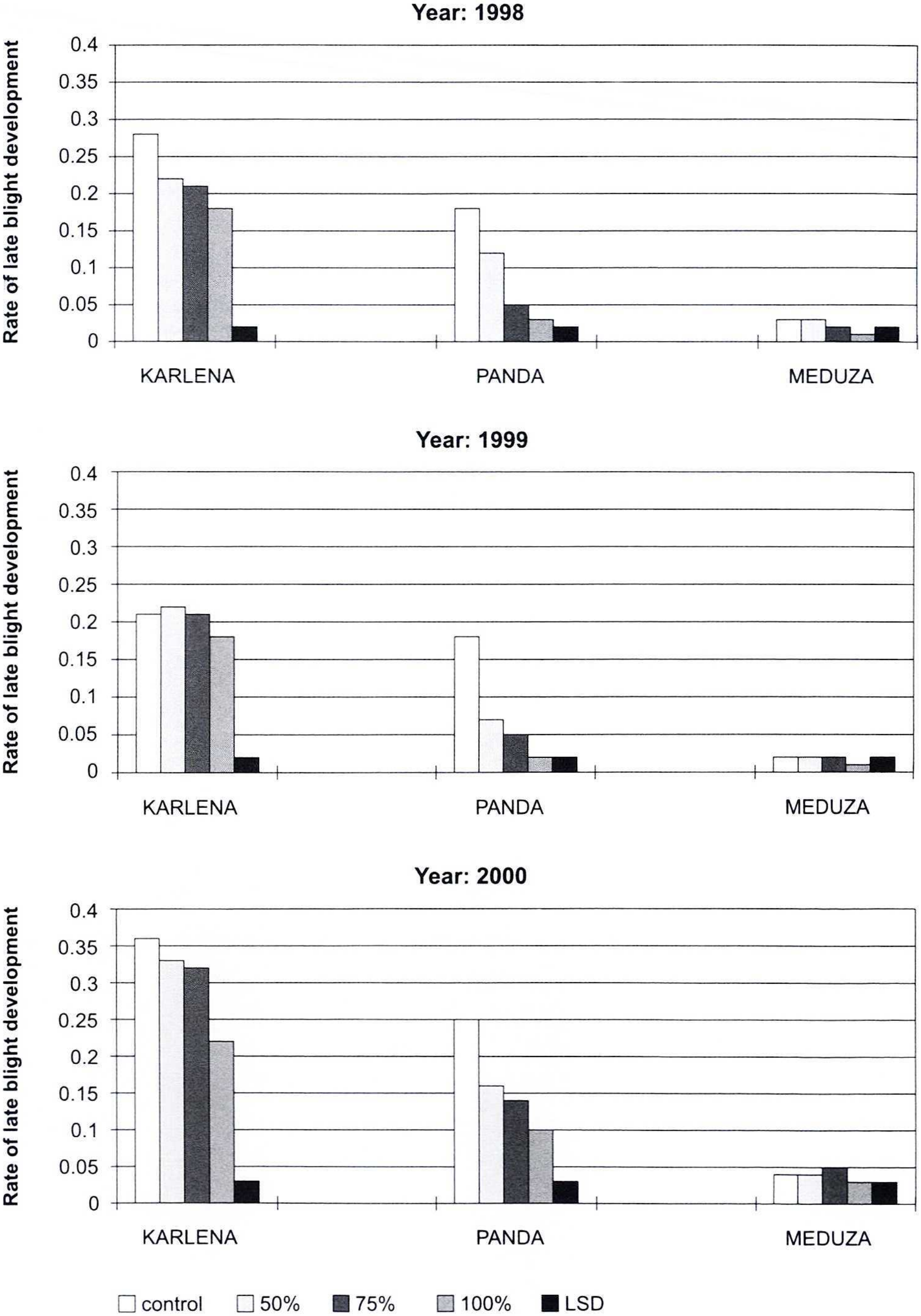

Fig. 1. Changes in the late blight development rate on varietes of different resistance degree in dependence on the protection combination

the rates of fungicides (LSD=0.017 at α=0.01). The effect of applied protection on the rate of plant destruction was different and depended on variety. The significant factor in this case was the interaction of varieties and fungicide rates (LSD=0.021 at α=0.01). On the more susceptible varieties, particularly on the most susceptible Karlena, the change of rate of disease development was observed after each change of fungicide rate applied: between full protection, reduced doses and unprotected variant (particularly in 1998 and 2000) – table 2. On the resistant variety Meduza, there were no observed the significant differences in the rate of disease development neither in plots protected with different fungicides nor in unprotected control.

The data concerning the level of yield obtained each year, from the plots of different varieties protected according to various combinations, are presented in table 3.

On the level of tuber yield produced, the seasons had highly significant influence (LSD=13.41 at α=0.01). Generally the highest yield was obtained in 2000, despite the high intensity of the disease. The late blight appeared late in 2000 (81 days after planting), but before the epidemics developed in the field, the majority of varieties produced the yield already. It was particularly the case with the medium early, susceptible to late blight Karlena variety. In case of late variety Meduza, its genetic resistance to the pathogen prevented the late blight development to such an extent that the disease had little impact on the yield. The lowest tuber yield was obtained at Bonin in 1999. The meteorological conditions during the early growing season (drought in May and June) were unfavorable both for late blight development and for yield production.

On the level of yield produced, the significant effect had also variety factor (LSD=36.96 at α=0.05) and interaction of varieties and years (LSD=26.82 at α=0.01). The different meteorological conditions of a given year variously affected the yield of varieties of different earliness.

No direct significant effect of the protection combination (rates) on the tuber yield was observed. In 1999, no significant differences in the yield level of all varieties either protected with different fungicide rates or unprotected at all. Among other things, it was due to the mild pathogen infection pressure. The plants even in unprotected plots were not destroyed to such an extent as to cause a large yield re-

Table 3. The change of yield of different potato varieties in comparison to control in %

Variety	Year	Combination of protection (rates)				LSD
		Control (dt/ha)	50%	75%	100%	
Karlena	1998	**167.3**	+37.1	+35.9	+59.8	15.8
	1999	**156.0**	-6.1	+10.9	-5.8	13.7
	2000	**327.0**	+ 1.8	+8.6	+13.5	10.1
Panda	1998	**239.3**	+19.2	+25.9	+6.7	11.1
	1999	**203.0**	+10.8	+8.1	+1.5	10.5
	2000	**255.0**	+62.4	+81.6	+74.3	12.9
Meduza	1998	**302.0**	-15.5	-13.8	-14.3	8.8
	1999	**191.5**	-3.1	+2.9	-1.3	11.1
	2000	**393.0**	+9.7	+5.3	+4.3	8.4

duction. In 1998, no differences were observed in the yield of such variety like Meduza. On this resistant variety, there was no observed such foliage destruction as to cause the reduction of the yield produced.

In some years, however, a significant effect of interaction of such factors like variety and fungicide rates on the yield level was observed. It was particularly visible in 2000, when the chemical protection of Karlena, conducted at full recommended fungicide rates, allowed saving the yield. In case of Panda variety, the significant differences in tuber yield were observed in protected and unprotected plots, regardless of fungicide rate used.

DISCUSSION AND CONCLUSIONS

On the ground of conducted study one can say that the resistance of varieties to the late blight is an important element to be used in plant protection from that disease. The obtained results indicate that susceptible to late blight varieties (Karlena) require protection at full recommended fungicide rates each year, regardless of pathogen infection pressure. Highly resistant varieties (Meduza) can be unprotected in some years (late appearance of the disease) or protected at fungicide rates reduced even to 50% (to avoid problems when pathogen infection pressure is changing during growing season). Similar results obtained Bus et al. (1995). The varieties of resistance to late blight of 8 on 9-degree scale (varieties Kartel and Texla) were sufficiently protected from the disease at half of recommended rate. The authors believe these recommendations are right also for commercial production.

The rates of fungicide for the protection of medium resistant or medium susceptible varieties depend on the infection pressure in a given year. At a high fungus infection pressure (high rate of disease development), the effective protection can be provided by the full recommended fungicide rates. At a lower disease intensity, the protection can be effective with the rates reduced to 50–75% (results of Panda variety in 1999). Similar recommendations in respect to protection of medium resistant varieties (degree 5–7) were given in the papers of other authors (Bus et al. 1995). Different varieties can react in various ways to the reduction of fungicide rates. In this study, a significant interaction of varieties and fungicide rates was observed. Similar relationship was found before (Gans et al. 1995).

The level of yield produced is modified by many factors. Plant protection from late blight is not a yield generating factor, of course. However, at high disease intensity and its destructive action on potato plants, the protection can often extend tuber bulking period. At a foliage destruction of 50–75% (depending on variety), the tuber bulking is reduced (Van der Plank 1963). Properly done chemical protection allows saving part of the yield. The effect of protection is particularly high in respect to very susceptible to late blight varieties. This type of relationship was not observed on highly resistant varieties.

Taking into account the genetic resistance of potato varieties to the late blight allows the reduction of fungicides applied, without compromising the protection efficiency, and this can be important for the environment.

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POLISH SUMMARY

ODPORNOŚĆ GENETYCZNA ODMIAN WAŻNYM ELEMENTEM W STRATEGII OCHRONY PLANTACJI ZIEMNIAKA PRZED ZARAZĄ

Odporność genetyczna odmian ziemniaka może być wykorzystana do zmniejszania dawek fungicydów, stosowanych w ochronie plantacji ziemniaka przed zarazą.

Odmiany bardzo odporne (Meduza) mogą pozostawać niechronione lub mogą być chronione fungicydami, stosowanymi w dawkach zmniejszonych o połowę (dla uniknięcia problemów ewentualnie zwiększonej presji infekcyjnej patogena w ciągu okresu wegetacji).

Uzyskane wyniki wskazują, że odmiany podatne na zarazę (Karlena) wymagają ochrony prowadzonej w pełnych zalecanych dawkach fungicydów w każdym roku, niezależnie od presji infekcyjnej patogenu.

Dla niektórych odmian, nawet o średniej odporności (Panda) wystarczające są dawki zmniejszone do 50–75% by skutecznie hamowały rozwój zarazy w niektóre lata. Różne odmiany mogą reagować w różny sposób na zmniejszanie dawek fungicydów. W przeprowadzonych badaniach stwierdzono istotne współdziałanie odmian i dawek fungicydowych.

Uwzględnienie genetycznej odporności odmian ziemniaka na zarazę pozwala obniżać dawki stosowanych fungicydów, z zachowaniem zadawalajacej skuteczności ochrony, co może być ważne ze względu na ochronę środowiska.