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The economical benefit of potato late blight control

ABSTRACT. The economical benefit of controlling potato late blight, caused by *Phytophthora infestans* (Mont.) de Bary, depends on both the quantitative increases in the yield and its effects on quality. The late blight was effectively controlled to combine resistance of varieties, proper cultivation measures and appropriate use of fungicides. The average number of fungicide application in Latvia has been between 2 and 4 times. Mostly, the first field treatment was made during the row closing or according to prognoses of development of potato late blight. Field trials to compare different potato late blight control models were carried out at 5 different sites in Latvia in the years 2001 and 2002. A computer based model was compared with untreated control and routine application of fungicides. Replicated 4-row plots in randomised block design were used in each treatment. The year 2001 was favourable for the development potato late blight. Both variants with fungicide treatments gave a significantly higher yield compare with untreated control. There were not significant differences between the variant of computer based model and the routine. On the other hand, the growing season 2002 was very hot and not favourable for disease development and there were not significant differences between untreated control and variants with fungicide application. The use of computer based model reduced fungicide application and the total amount of fungicide l ha^{-1}. The outlay of routine fungicide treatments was 37% higher than with computer based models in the growing season 2001 and 58% higher in the growing season 2002.

KEY WORDS: potato late blight, *Phytophthora infestans*, fungicide application, routine

The overall objective in controlling potato late blight is to completely protect the crop from attack throughout the growing season, but this is not easy to realize. When weather, conditions are favorable, the fungus can spread rapidly through the foliage and is capable of causing complete destruction of foliage in a very short time. The fungus can infect tubers while they are in the soil or at harvesting [Andersson et al. 2000].

Late blight is over-wintering year to year from the infected tubers. Infected tubers are the most important source of primary infection in spring. Secondary infection of late blight occurs when spores are produced on the infected potato leaves. The spores can be dispersed on wind currents or splashed in raindrops to neighboring plants [Fry, Mizubuti 1998].

In the case of acute potato late blight attack in different countries, up to 25–50% of the harvest may be lost [Fry, Mizubuti 1998; Turka 1998]. Effective control of late blight includes many strategies and tactics. Control strategies are grouped into those that limit or reduce the source of primary infection and those that slow down the pathogen growth rates. Important cultivation measures that can limit or reduce the size of the *P. infestans* population at the beginning of the season are as follows: selection certified seed potatoes; planting only healthy tubers; destruction of cull piles and volunteers; harvest during dry weather [Fry, Doster 1991; Andersson et al. 2000].

Strategies that limit pathogen growth rates include the usage of cultivars with field resistance and application of protective or systemic fungicides. If conditions are favorable for *P. infestans* development the first fungicide applications can be made at the time of row closing. The spraying intervals should be determined by the variety, the kind of fungicide used and weather conditions. Short intervals are used when weather conditions are warm and humid, whereas intervals should be longer if the weather is dry and if resistant varieties are cultivated [Fry, Doster 1991; Andersson et al. 2000]. *P. infestans* is strongly weather dependent. It is assumed that weather is the most important factor determining the incidence and development of the late blight. Forecasting with regard to *P. infestans* is often based on the temperature during periods with high relative humidity [Fry, Doster 1991; Koppel et al. 2003].

Recent developments in weather recording technology and advances in computer programming have led to the development of decision support systems which create late blight control programmes. This system is a computer based programme which records and analyzes historical weather data and will predict the date of the first and subsequent fungicide applications [Dowley, Leonard 2000; Koppel et al. 2003].

Most fungicide applications against potato late blight are still done according to more or less fixed schedule. The most important reason for introducting decision support systems is a possibility to minimize fungicide application without a risk of decreasing the potato yield.

METHODS

Field trials to compare different potato late blight control models were carried out at 5 different sites in Latvia in the years 2001 and 2002. Institutions involved in the experiment were Latvia University of Agriculture Study and Training farm "Vecauce", Stende Plant Breeding and Experimental Station and Latvia State Plant Protection Service, Unit of Prognosis and Diagnostics in Priekuli, Saldus and Bauska.

A moderately susceptible cultivar 'Sante' was used. Replicated 4-row plots in randomised block design were used in each treatment. Disease assessment, tuber infection and yield estimation was done in two central rows only.

Computer based model was compared with untreated control and routine applications of the fungicide. All trials were based on the earlier arranged scheme and the same fungicides were used. Scheme of fungicide application: 1. Untreated control. 2. Computer based model – treatments according to the recommendations of prognosis model with protective fungicide. 3. Routine – two first treatments with systemic fungicide and subsequent treatments with protective fungicide. The first treatment was made during the row closing or according to a prognosis when late blight was recorded in the region. The following fungicide doses were used: protective fungicide Shirlan 500 – 0.3 l ha^{-1} in and systemic fungicide Tattoo 550 – 3 to 3.5 l ha^{-1}.

The weather conditions were different in both growing seasons. The year 2001 was favourable for the development of potato late blight. The end of June, July and August was rainy and warm. The precipitation in some of trial sites was more than 200% of the long-term average. On the other hand, the growing season 2002 was very hot and was not favourable for the development of late blight. August was dry and the air temperature in some days exceeded 30°C.

The price of fungicides and outlay of the treatment were not similar in both years. The price of Tattoo 550 was 10.59 and that of Shirlan 500 – 75.34 EUR per litre in 2001. In the year 2002, the price was higher for Tattoo 550 – 10.93 and Shirlan 500 – 96.12 EUR per litre. The outlay of treatments was 7.0 LVL and 7.73 LVL in 2001 and 2002, respectively.

RESULTS

In 2001 the first treatment of fungicides was made on the 27th–30th of June using routine treatments and on the 2nd–7th of July using a computer-based model. Mostly, fungicide application was performed before observing the first symptoms, except Bauska. In Bauska first potato late blight symptoms were observed on the 25th of June and it was one or two weeks earlier than in other trial sites (Tab. 1). According to the routine variant there were made 6–4 treatments but the computer based model recommended 5–3 treatments. It is 20–25% less than in the routine variant (Fig. 1).

Table 1. Appearance of first symptoms of potato late blight

Trial site	The first symptoms of late blight in 2001	The first symptoms of late blight in 2002
Vecauce	10 July	12 July
Stende	04 July	14 July
Priekuli	12 July	02 July
Saldus	17 July	02 July
Bauska	25 July	31 July

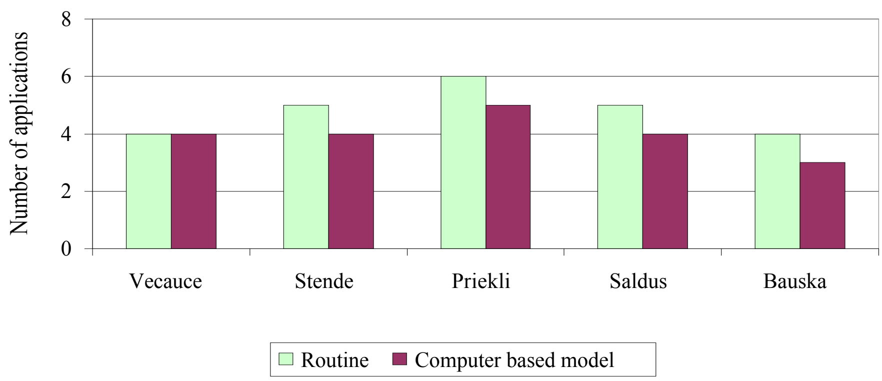

Figure 1. Number of fungicide applications, 2001

In 2002 the fungicide application in all trials was made in time, before observing the first symptoms (2nd of July) (Tab. 1). The growing season 2002 was not favourable for the development of late blight and therefore the number of treatments was lower than in the growing season 2001, respectively 5–3 in routine variant and 3–2 in computer based variant. Using the computer based model gave 25–60% reduction in fungicide amount application (Fig. 2).

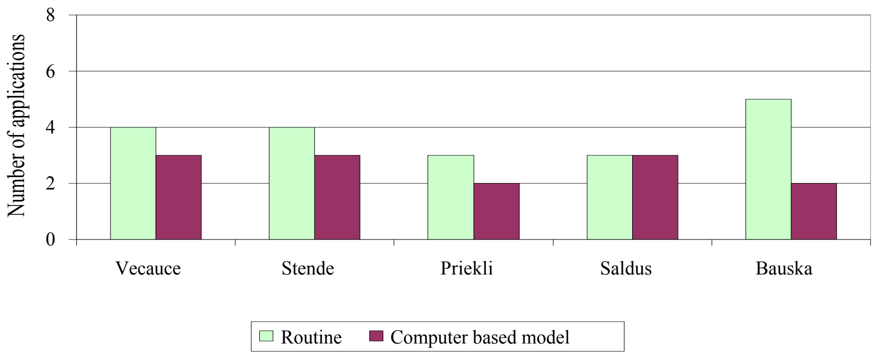

Figure 2. Number of fungicide applications, 2002

Table 2. The influence of fungicide application on potato yield, t ha^{-1}

Trial site	Control	Computer based model		Routine		LSD 0.05
		Yield	Increase of yield	Yield	Increase of yield	
Year 2001						
Vecauce	24.60	34.00	+ 9.40	35.57	+ 10.97	5.89
Stende	27.55	38.27	+ 10.72	40.35	+ 12.80	3.89
Priekuli	36.52	38.55	+ 2.03	40.03	+ 3.51	4.65
Saldus	16.30	25.30	+ 9.00	22.30	+ 6.00	3.80
Bauska	12.16	25.95	+ 13.79	17.02	+ 4.86	3.69
Mean	23.43	32.41	+ 8.98	31.05	7.62	
Year 2002						
Vecauce	44.41	48.05	+ 3.64	47.49	+ 3.09	3.95
Stende	27.64	28.28	+ 0.64	29.64	+ 1.89	0.58
Priekuli	34.62	36.03	+ 1.41	34.64	+ 0.02	6.72
Saldus	25.48	31.80	+ 6.32	31.76	+ 6.28	8.57
Bauska	48.77	48.09	- 0.68	49.36	+ 0.59	4.79
Mean	36.18	38.45	+ 2.27	38.58	+ 2.40	

The tuber yield varied between the years and trial sites. In the year 2002 there was a 54.4% higher yield compared to untreated control variant and 18.6%–24.25% higher in variants with fungicide treatments. The increase of the yield demonstrated that if the weather conditions were not favourable for the development of potato late blight, it was possible to get remarkably higher yield (Tab. 2).

In the year 2001 both variants with fungicide treatments gave a significantly higher yield compared with untreated control. There were not significant differences between variants of computer based model and routine. However, the growing season 2002 was different and there were not significant differences between untreated control and variants with fungicide treatments. The yield increase was low but in the variant with computer based model in Bauska a reduction of yield was observed compared with the untreated control (Tab. 2).

The usie of computer based model not only reduced fungicide application but also the total amount of fungicides l ha^{-1}. The reduction in total fungicide amount could be explained with the use of only protective fungicide. Routine fungicide treatments enlarged the average total amount of fungicides by about 6 l ha^{-1} (Tab. 3).

Overall, in Latvia the outlay of fungicide application made out more than 109–139 EUR per ha with computer based model and 175–192 EUR per ha with routine treatments. The outlay of routine fungicide treatment was 37% higher than that with computer based models in the growing season 2001 and 58% higher in the growing season 2002 (Tab. 3).

Table 3. Outlay of fungicide application with different potato late blight control models

Trial site	Computer based model			Routine		
	Amount of fungicides used in season, l ha^{-1}	Outlay of fungicides application EUR per ha	Increase of yield t ha^{-1} on each EUR of fungicide application	Amount of fungicides used in season, l ha^{-1}	Outlay of fungicides application EUR per ha	Increase of yield t ha^{-1} on each EUR of fungicide application
Year 2001						
Vecauce	1.20	139.77	0.21	7.60	168.66	0.19
Stende	1.20	139.77	0.23	7.90	203.60	0.19
Priekuli	1.50	174.73	0.04	6.90	227.95	0.05
Saldus	1.20	139.77	0.19	7.90	203.60	0.09
Bauska	0.90	104.83	0.41	6.60	158.06	0.07
Mean	1.20	139.77	0.21	7.38	192.37	0.12
Year 2002						
Vecauce	0.90	127.43	0.09	7.60	188.71	0.05
Stende	0.90	127.43	0.02	7.60	188.71	0.04
Priekuli	0.60	85.01	0.05	3.60	131.39	0.0005
Saldus	0.90	127.43	0.16	6.30	135.45	0.14
Bauska	0.60	85.01	- 0.02	7.90	231.39	0.007
Mean	0.78	110.46	0.05	6.60	175.13	0.05

Each EUR spent for fungicide application gave an increase in the tuber yield. In the growing season 2001, the increase was 0.07 t ha^{-1} with routine treatments and it was 45% less with computer based model, where the average increase was 0.12 t ha^{-1}. In the year 2002, the yield increase was the same in both variants (Tab. 3).

Conclusions

1. Computer based model provided 20% reduction in fungicide application in 2001 and 60% reduction in 2002.

2. The use of the computer based model reduced the total amount of fungicide liter per ha and outlay of fungicide application by 73% in the year 2001 and 42% in the 2002 year.

3. The yield increases demonstrate that it is possible to get a higher yield without fungicide application if weather conditions are not favorable for the development of potato late blight.

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