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NEGFRY – DECISION SUPPORT SYSTEM FOR LATE BLIGHT CONTROL IN POTATO CROPS – RESULTS OF VALIDATION TRIALS IN NORTH POLAND

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Abstract: The NegFry model used for timing the chemical control of potato late blight was validated in field trials at Bonin in the years 2001–2002 (4 trials). In these trials the number of fungicide treatments recommended by NegFry was about 34.5% lower (on average) than the number of treatments in a routine spraying scheme. This reduction was mostly the results of a delay in the time of the initial fungicide application and longer spraying intervals recommended by NegFry.

Key words: potato, late blight control, decision support, NegFry

INTRODUCTION

One of the major principles in potato protection against potato late blight is chemical protection of crops throughout the growing season. Chemical protection can comprise the intensive usage of fungicides starting from potato emergence or as sustainable protection based on forecasting of pathogen occurrence and utilizing decision support systems that could help to predict the date of disease outbreak and to determine the timing of first treatment and the most suitable intervals between sprays.

In the majority of European countries with high potato production there is conducted a very intensive chemical protection of potato crops against potato late blight (Tab. 1).

Decision Support Systems (DSSs) used in control of potato late blight in potato crop protection help to determine an accurate date of first treatment and the following applications. This allows decreasing the number of fungicide treatments that plays a significant role in cost-effectiveness of chemical protection and also in environment protection.

Table 1. The estimated use of fungicides for *Phytophthora infestans* control on potato in a few European countries (years:1997–2001) In Schepers (2002)

Country	Years				
	1997	1998	1999	2000	2001
Belgium	14–15	12–14	10	12–20	11–13
Denmark	5.5	8	7.5	7–8	8–9
France	10–14	?	15	16–17	15–23
Germany	7–9	3–10	4–5	2–14	2–16
United Kingdom	4–18	8–15	4–16	?	8–12
Netherlands	7–15	7–15	7–16	15–20	10–18
Poland	1.7	1.7	2	2	1–8

One of the decision support systems used in some European countries is NegFry developed in Denmark in the years 1992–1993 (Hansen 1993; Hansen et al. 1995). The NegFry model is based on two existing earlier models, the "negative prognosis" for forecasting the risk of primary attacks (Ullrich & Schrodter 1966) and a model for timing subsequent fungicide applications during the season (Fry et al. 1983).

In a collaborative project between Poland and Denmark "Development of an Internet based DSS for Cereal Diseases and Potato Late Blight in Poland, 201–2002", in the Plant Breeding and Acclimatization Institute at Bonin there were conducted field experiments on usefulness of the NegFry in potato protection against late blight in the northern part of Poland.

MATERIALS AND METHODS

Field experiments utilizing the NegFry system in potato protection were conducted at PBAI at Bonin in the years 2001–2002. The effectiveness of potato protection was compared with a routine program protection carried out from the end of June until mid of August, treatments at 7–10 day intervals and one according to the NegFry system. Additionally in 2002 there was set up an experiment that included protection according to Polish standards i.e. 2 chemical treatments during the growing season.

In 2001 the experiments were carried out at Bonin on plots (size 60 m^2) sown with the cultivar Rywal (mid susceptibility to the late blight) and at Raduszka (3 km from Bonin) on commercial fields (size 0.54 ha) with cv. Danusia (mid resistance to the disease). In 2002 at Bonin experiments were conducted on plots (size 30 m^2) with 2 cultivars Bekas (cv. susceptible) and Łucja (mid resistance). The criteria for potato protection effectiveness utilizing different systems were assumed to be

- the percentage of haulm destruction at the end of growing season,
- the late blight development rate defining as increase of destruction of above ground parts in unit time (Van der Plank 1963),
- AUDCP= area under disease progress curve (Fry 1978; Shaner & Finney 1977),
- tuber yield and its health status.

The data from plots with chemical treatments were compared with results collected from control plots (unprotected).

RESULTS

Time of occurrence and severity of late blight in northern Poland

Climatic conditions in growing season of 2001 and 2002 favored development of the late blight (Fig. 1, Tab. 2).

In 2001 the first symptoms of late blight at Bonin were recorded in mid of June (June 15) on early cultivars what resulted from warm weather in May and abundant precipitation at the beginning of June. The first late blight symptoms on reference cultivar Rywal (also listed as intermediate late cv.) were observed later (July 7) and probably the cause was high precipitation at the end of June and the beginning of July. The late blight outbreak was observed following the first occurrence of symptoms. At the end of July slight inhibition in development of disease was observed due to lower precipitation. However, in the following months abrupt development of late blight was recorded again (precipitation in August 143.2 mm, in September – 196.2 mm). The infection pressure of pathogen was higher than in former years. The late blight destroyed totally plants on unprotected plots within 1–2 weeks (the late blight development rate r=0.249).

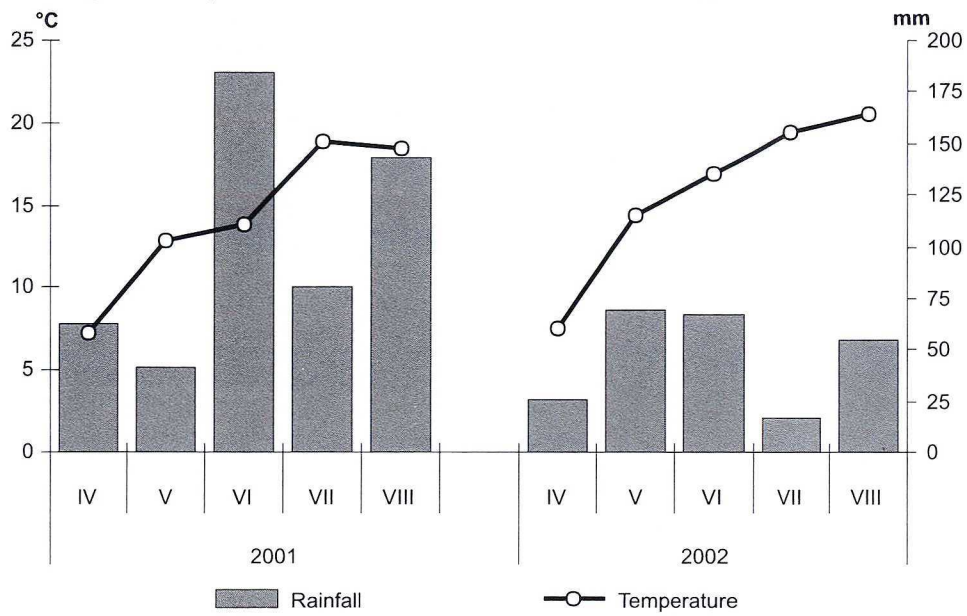

Fig. 1. Climatic conditions during growing seasons 2001 and 2002

Table 2. Late blight development on reference cultivar Rywal (Bonin, years 2001–2002)

Year	Emergence date	Precipitation (mm)				Late blight occurrence		Late blight incidence on reference cv.		
		VI	VII	VIII	Σ	Bonin	Reference cv.	Infection (%)	r *	AUDPC
2001	04.06.	184.2	80.2	143.2	407.6	15.06.	07.07.	96.3	0.249	0.423
2002	15.05.	128.0	68.0	54.2	122.2	26.06.	15.07.	77.5	0.224	0.205

r = the late blight development rate = an increase of destruction of above ground parts in unit time

Climatic conditions in 2002 (mid temperatures in May and low precipitation in May and at the beginning of June) did not favor an early occurrence of late blight. The risk of disease outbreak was after the period of higher rainfalls in mid June and particularly at the end of month. The first symptoms of late blight were found in Bonin area on early and susceptible cultivars of potatoes (June 26). On reference cultivar the disease was diagnosed fairly late i.e. July 15. The following periods of dry weather in July and August caused slow development of the late blight. The plant infection with late blight on unprotected reference the cultivar Rywal at the end of growing season did not exceed 77.5% and the area under the disease progress curve was not high (AUDPC=0.205). This value points to rather weak infection pressure of the pathogen in climatic conditions at Bonin.

Timing of first fungicide application

Recommendations of NegFry system regarding beginning of plant protection in reference to first reports of late blight symptoms occurring on potato crops are presented in table 3. In the NegFry model the initial fungicide application is recommended when the accumulated risk value (ARV) has exceeded 130 and the daily risk value (DRV), calculated according to the "negative prognosis" is above 7.

In 3 out of 4 conducted trials at Bonin in the years 2001–2002 the NegFry system quite exactly set up the date of first treatment against the late blight (0–16 days before actual disease occurrence). Only in one case a fungicide application was late (2001). On a plot with reference cultivar Rywal the single spot caused by casual agent of late blight was found 2 days before the NegFry system would have informed.

Table 3. Time of late blight occurrence and recommended date of first treatment

Year	Cultivar	Time of late blight occurrence		Date of Ist treatment according to NegFry
		at Bonin	on cultivar	
2001	Rywal	15.06.	07.07.	09.07.
	Danusia		20.07.	04.07.
2002	Bekas	26.06.	27.06.	16.07.
	Łucja		27.06.	27.06.

Effect of protection systems on control efficacy of late blight

Progress curves of late blight in 2001 at Bonin and Raduszka on experimental plots protected according to different systems and also on control plots are presented in figure 2. In both sites, the used systems of potato protection against late blight (NegFry and routine) provided good efficiency in controlling disease development as compared with the unprotected control. It was particularly clear on mid susceptible cultivar Rywal. At the end of growing season destruction of potato plants on control plots amounted to 66.7%, protected with the routine system 8% and with the NegFry model 3.5%.

Figure 3 provides information on development of the late blight on experimental plots with different protection systems in 2002. Great control efficiency was recorded on two cvs. (Bekas, Łucja) on plots protected with the routine system as

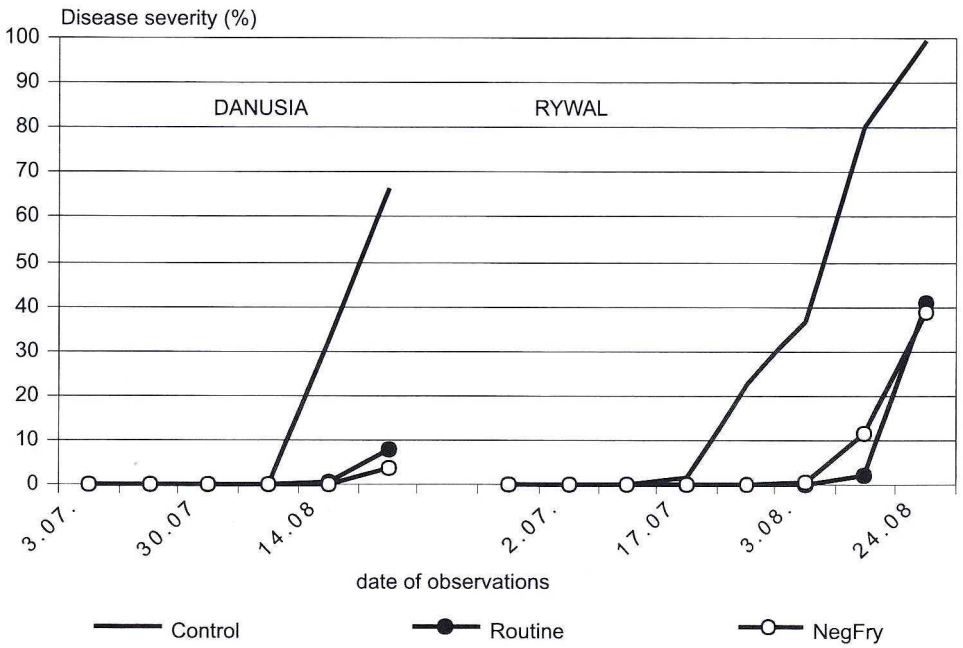

Fig. 2. Development of late blight on the plots with different protection program in 2001 trials

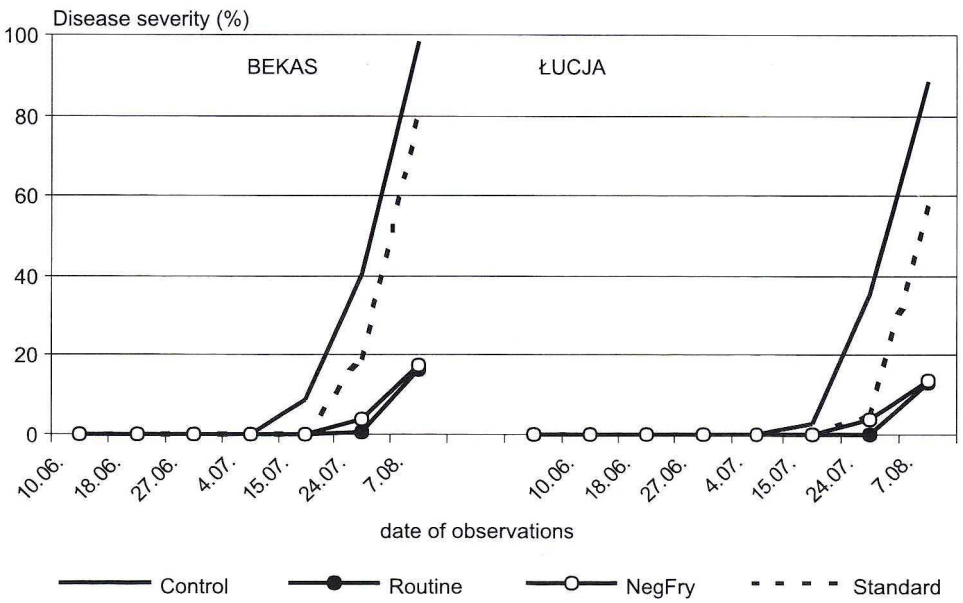

Fig. 3. Development of late blight on the plots with different protection program in 2002 trials

well as with the NegFry model as compared to either the unprotected control or the standard protection (2 fungicide treatments). The disease incidence at the end of season on cv. Bekas for routine and NegFry treatment was 16.5–17.5%, on cv. Łucja

Table 4. Influence of protection systems on control efficacy of late blight development

Year	Cultivar (*)	Treatment	Number of sprays	Disease severity (%)	AUDPC	Yield t/ha	Tuber blight (%)
2001	Rywal (B2)	Untreated	–	99.5	0.361	33.3 a	11.7
		Routine	6	38.7	0.060	41.6 b	10.7
		NegFry	4	40.6	0.042	44.1 b	8.0
	Danusia (B3)	Untreated	–	66.7	0.093	49.8	2.0
		Routine	6	8.0	0.006	52.0	11.4
		NegFry	4	3.5	0.003	41.2	9.8
2002	Bekas (B1)	Untreated	–	98.5	0.254	42.6	0.6
		Routine	7	16.5	0.025	46.2	0.0
		NegFry	5	17.5	0.035	47.8	0.0
		Standard	2	80.0	0.160	46.1	0.0
	Łucja (B2)	Untreated	–	88.5	0.216	45.2	0.3
		Routine	7	13.1	0.019	47.9	0.0
		NegFry	4	13.4	0.033	46.7	0.0
		Standard	2	56.8	0.094	46.6	0.0

Means followed by the same letter are not significantly different at the $\alpha=0.05$ according to t-student test
(*) cultivar resistance: B1 – very susceptible
B2 – mid susceptible
B3 – mid resistant

was 13.1–13.4%. The differences were not significant between NegFry and the routine systems.

The influence of various plant protection systems on other factors proving good efficacy in late blight control are shown in table 4.

Comparing values of the area under disease progress curve (AUDPC) for control plots and protected with different systems there are noticed clear differences. These data provide sufficient information on control efficiency and inhibition of disease development.

In growing season of 2001 tuber yields of cv. Rywal collected from plots protected with different systems were statistically significantly higher that the yield collected from unprotected plots. However, there were no significant differences found between yields obtained from protected plots. There were found no significant differences in infection of tubers with the late blight between protected plots and control, despite that tuber infection rate was rather high.

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Tuber yield of cv. Danusia was generally high. No significant differences were found for yields obtained from all examined plots. There was recorded lower tuber infection for control plots than protected ones but the differences were insignificant.

In 2002 on both tested cultivars there were not significant differences in tuber yield between all experimental treatments. Late occurrence of the disease and fairly

low infection pressure of pathogen in Bonin climatic conditions caused minimum tuber infection with the late blight in the control and the was no evidence of tuber infection in yield collected from protected plots.

In all carried out trials, in both growing seasons, the control efficacy for the routine system and for DSS NegFry model was similar. Protection performed according to NegFry model resulted in a decrease number of chemical treatments from 6 to 4 in 2001 (for both cvs.) and from 7 to 5 (cv. Bekas) and from 7 to 4 (cv. Łucja) in 2002.

DISCUSSION AND CONCLUSIONS

Results of conducted protection against the late blight depend upon disease incidence and infection pressure of the pathogen throughout growing season. Climatic conditions in northern Poland favored occurrence of late blight in 2001. First symptoms of late blight at Bonin were found in mid-June (June 15th). The infection pressure of the pathogen was higher than in previous years. The disease destroyed potato plants on untreated plots entirely within 1–2 weeks. The final infection of the reference cultivar was ca. 96.3%. There were also conducted studies comparing efficacy of decision systems in potato protection against late blight in European countries and the disease incidence varied in 2001. Final disease incidence on untreated plots ranged from 0.2–4.5 in Austria till 80–100% in Ireland, France, Belgium and Switzerland (Hansen et al. 2002).

In 2002, climatic conditions in Bonin did not favor an early occurrence of the late blight. The disease appeared on the reference cultivar late, i.e. on July 15th. Long periods of dry weather in July and August caused slow disease development. Infection on plants of reference cv. Rywal on untreated plots did not exceed 77.5% at the end of growing season. In other European countries the late blight occurred generally very early (April, May). Latter disease development was restrained due to dry weather in July and August (Austria, Belgium, Estonia, the Netherlands, Latvia, Poland, Italy and Switzerland) but in some regions the disease developed again and quite intensively in August. In other countries after early late blight attack there was observed high infection pressure throughout entire growing season (Great Britain, France, Ireland, Germany, Scotland and Wales) (Schepers 2003).

Although the NegFry model was developed for Danish conditions, the results of the validation trials from other countries were similar.

Under Bonin climatic conditions, the NegFry system recommended the first spray 0–16 days before the late blight was found at the trial site (in 3 trials). Under favorable for late blight conditions, the time from infection to appearance of symptoms is about 3–5 days. Therefore, the first spray must be recommended 3–5 days before the first symptoms appear in the field. But, the first spray was frequently recommended much earlier (15–44 days) than first observations at the trial sites and the recommendations differed considerably between various DSSs tested in Europe (Hansen et al. 2002). The importance and role of different inoculum sources for first outbreak is not yet well estimated and DDS models need to be improved in this area.

In Bonin, the late blight incidence at the end of the season was at the same level or lower when compared plant protection with the NegFry and the routine scheme. In 2001 plant infection on reference cv. Rywal protected according to NegFry recom-

mendations amounted to 3.5 %, while for routine program 8%. Protection of cv. Danusia was not so efficient. Plant infection with late blight a week following the last fungicide treatment was 40.6% for the NegFry and 38.7% for the routine system.

In 2002 protection efficiency conducted according to the NegFry, the routine system was similar, and plant infection reached 17.5 and 16.5 for susceptible cv. and 13.4 and 13.1% for mid resistant cultivar.

Tuber yield and risk of tuber infection with late blight are dependent upon many various factors, mainly climatic conditions – especially rainfalls and temperature during growing season. Also the length of active foliar blight period, tuber resistance, type of fungicide applied and soil type have an impact of tuber infection.

In presented results from Bonin trials, there seems not to be the clear correlation between efficacy of various protection systems, the disease incidence on haulm and degree of tuber blight infections.

Compared with routine treatment schemes, the number of fungicide applications was reduced significantly by using the NegFry: in Denmark, Sweden and Norway about 50% (Hansen et al 1995), in Estonia, Latvia and Lithuania from 25% to 50% (Hansen et al 2000). In Bonin trials, the use of fungicides was significantly lower in plots treated according to NegFry compared to routine treatment from 33.3% in 2001 to 29%–43% in 2002. Using other similar decision systems also allows reducing fungicide input by 8%–62% compared to routine treatments (Hansen et al. 2002).

Using NegFry, it is possible to obtain satisfactory control against the late blight and at the same time to reduce the number of fungicide treatments compared to routine protection model.

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POLISH SUMMARY

NEGFRY – SYSTEM WSPOMAGANIA DECYZJI W ZWALCZANIU ZARAZY W UPRAWACH ZIEMNIAKA – WYNIKI DOŚWIADCZEŃ W POLSCE PÓŁNOCNEJ

Model NegFry stosowany w ochronie upraw ziemniaka przed zarazą, dla wyznaczenia terminów pierwszego i kolejnych zabiegów fungicydowych był oceniany w doświadczeniach polowych w Boninie w latach 2001–2002 (4 doświadczenia). W warunkach klimatycznych Bonina system NegFry rekomendował terminy pierwszego zabiegu 0–16 dni przed wystąpieniem zarazy (3 doświadczenia). W jednym doświadczeniu termin ten był o 2 dni spóźniony. Rola różnych źródeł inokulum dla pierwszych infekcji zarazy nie jest jeszcze dobrze poznana, stąd potrzeba poprawienia modeli wspomagania podejmowania decyzji w tej dziedzinie.

We wszystkich wykonanych doświadczeniach skuteczność ochrony prowadzonej wg systemu rutynowego i NegFry była podobna. System NegFry pozwolił obniżyć liczbę zabiegów chemicznych o 33,3% w 2001 roku i o 29%–43% w 2002. Ta obniżka spowodowana była głównie przez opóźnienie terminu pierwszej aplikacji w porównaniu do kontroli prowadzonej rutynowo i dłuższych przerwach między kolejnymi zabiegami.

Zastosowanie modelu NegFry, pozwoliło na zachowaniu skutecznej ochrony pomimo obniżonej liczby zabiegów chemicznych.