Practical Experience with Antiresistance Strategies in the Fungicides Control of Potato Late Blight

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Abstract

Pathogens with rapid reproductive cycles, producing large number wind-spread dispersed infection propagules like sporangiospores, are more likely to pose problems of resistance than slowly reproducing pathogens, which are dispersed over only short distances. *Phytophthora infestans*, is highly adaptable pathogen capable of exerting high disease pressure on crop, and develop resistance to phenylamid fungicide methalaxyl in the potato crop in Europe (1981–1984). Metalaxyl was then reintroduced for use in mixtures coformulated with multisite compounds, and the proportion of resistance strains "subpopulations" rose again, and albeit to a level lower than at the outset. The use of metalaxyl on seed crops, with the possibility of resistance being carried over the next season. Current recommendations are to use alternative multiside fungicides on potato crops. Our results illustrate the importance of understanding pathogen epidemiology in the management of fungicide resistance.

Keywords: chemical control; *Phytophthora infestans*; cost/benefits

INTRODUCTION

The foliar disease of potato called late blight, caused by *Phytophthora infestans*, is covered in the greatest detail because of the relativity greater amount of research that has been aimed on resistance to this disease. Host specific resistance in potato to late blight has been identified in wild potato and incorporated into commercial cultivars. At present we recognised three components of general resistance to *P. infestans*: (1) resistance to penetration of the pathogen, (2) resistance of growth of the pathogen in the host tissue, and (3) reduce capacity of pathogen sporulation on host (GISI 2002). Field population may contain individuals with sensitive, intermediate and resistant responses to PAs and the sensitivity range can be over 1000 fold.

Pathogen resistance to fungicides describes the presence of resistant individuals "isolates" naturally occurring in pathogen populations and their increase in frequency over time (cropping season, from year to year) to extend that disease control may be reduced. At the start of fungicide use, this increase is due to a selection process imposed by the fungicide, which reduced the sensitive sub-population and allows less sensitive and resistant individuals to multiply. Resistant individuals may become dominant in the population as long as the selection process persists. Mutations for the resistance, and resistance build-up through fungicide selection may happen locally and resistance is then distributed to the other potato crops by migration of the pathogen. The aim of so-called "anti-resistance strategies" (SOZZI *et al.* 1992) is the delay of this selection process before the resistant part of the population has become dominant and thus affecting diseases control.

Aims of these experiments are monitoring of an efficiency chemical control potato late blight in the most important potato-seed region in the Czech Republic.

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MATERIAL AND METHODS

Location

Experiments were carried out using location of the Field Experimental Station Valečov of Potato Research Institute at Havlíčkův Brod.

Characterisation of site highlands: altitude 460 m; crop production area: potato seed area; soil type light with stone; mean of the year temperature 6.99°C; mean of the temperature of cropping season: 13.2°C; total rainfall per year: 652 mm; total rainfall of cropping time: 425 ml.

Table 1. Size of the experimental plot (length of the plots = 7.5 m)

Area of the plot (m^2)	Wide (m)	Total plants
Total area 22.5	3	100
Total treatment 22.5	3	mean number 100
Area of evaluation 11.3	1.5	mean number 50
Area of harvest 11.3	1.5	mean number

Table 2. Data of agronomy of experimental technology 2000, 2001

Cropping systems technology	General	Stone-free-ridges
Cultivars	Dali	Lenka
Time of planting	3. 5. 2001	22. 5. 2001
Deep of planting	8 cm	8 cm
Seedbed	good	good
Distant between ridges	75 cm	75 cm
Tuber spacing in rows	30 cm	30 cm

Plot design

Experimental design according EPPO No. 152: the randomised complete blocks; each treatment was replicated four times; orientation of the rows were lengthways; not treatment control plots are including in to blocks.

Assessment of potato late blight

Potato late blight on the leaves. Potato late blight has been determined according HORSFALL and BARRATT (1945). Percentage of disease control have been calculated according to the following formula:

$$PDC = \frac{DIC - DIT}{DIC} \times 100$$

where: PDC – percentage of disease control
DIC – disease incidence in control (no-fungicide)
DIT – disease incidence in treatment

Yield. Yield-data were obtained by harvesting the tubers from the centre of rows of each plot, and are expressed as metric tons per hectare.

Tuber rot. The amount of late blight tuber rot that develops depends on the amount of fungicidal residue on the soil surface, the persistence of the residue, soil type, depth at which the tubers develop, amount of rainfall, and the amount of fungicide used.

RESULTS AND DISCUSSION

Warning number. Delimitate period from the beginning of the grown period of the potatoes crop, in which the potato late blight are not outbreak. Negative

Table 3. Experimental programme of fungicides 2000, 2001

Variants	Formulation of fungicides	Rate/ha	Note
1	not treatment control	–	
2	Altima 500 SC (a.i. fluazinam 500 g/l)	0.4 l	
3	Acrobat MZ (a.i. dimethomorph 60 g/kg + mancozeb 600 g/kg)	2 kg	
4	Bravo 75 WG (a.i. chlorothalonil)	2 kg	
5	Caosar (a.i. propamocarb HCl 375 g and a.i. chlorothalonil 375 g)	2 kg	
6	Dithane M 45. Dithane DG (a.i. mancozeb)	2 kg	2000/2001
7	Galben M (a.i. benalaxyl 8% + mancozeb 65T%)	2.5 kg	
8	Ridomil MZ 72 WP + Ridomil Gold 68 WP (a.i. metalaxyl 8% + 4% + mancozeb 64%)	2.5 kg	2000/2001
9	Tatoo (a.i. mancozeb 302 g/l + propamocarb 248 g)	4 l	

Number of application in 2000 were 5 times, and in 2001 6 times; rate of water per ha 600 l

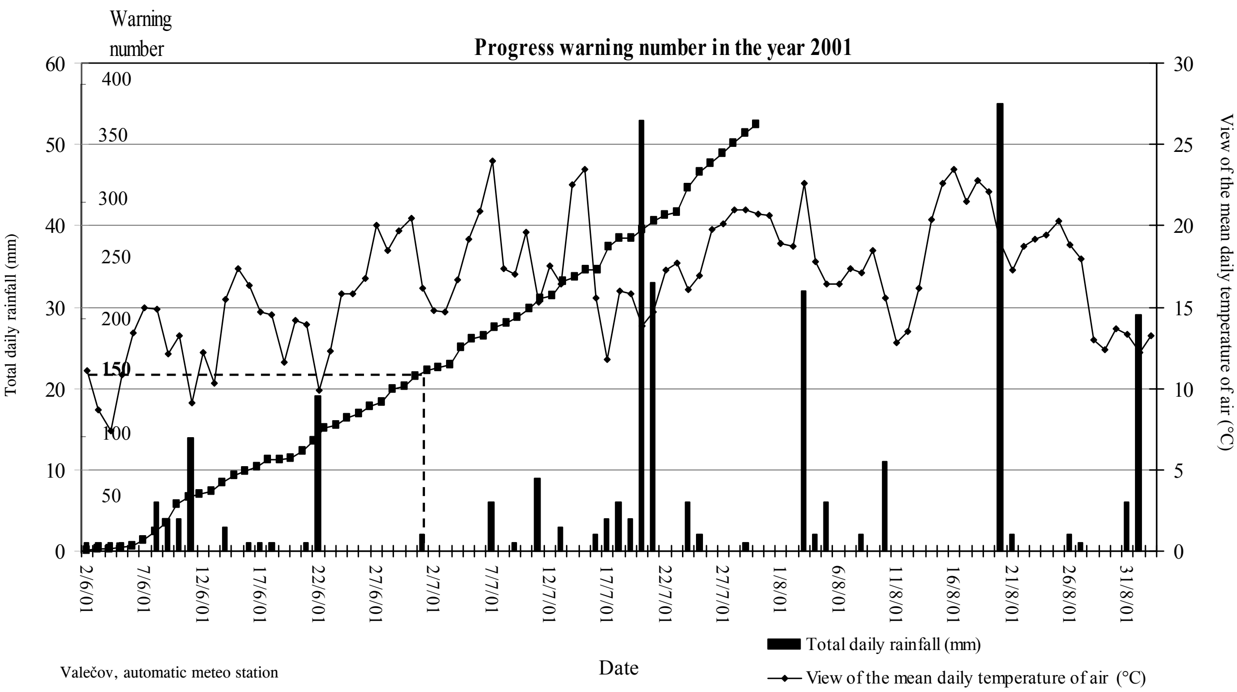

Figure 1. View of the mean daily temperature (°C) of air and total rainfall (mm) in the growth period in 2001

Table 4. Date of fungicides application and evaluation of their effect on potato late blight

Year of experimental programme	2000	2001
Date of application fungicides	3. 7., 13. 7., 25. 7., 9. 8., 17. 8.	4. 7., 18. 7., 25. 7., 3. 8., 14. 8., 24. 8.
Date of application sequences scheme of fungicides	3. 7., 13. 7., 24. 7., 8. 8., 18. 8.	10. 7., 18. 7., 25. 7., 3. 8., 14. 8., 24. 8.
Date of evaluation fungicides effect	4. 8., 14. 8., 21. 8., 29. 8.	30. 7., 6. 8., 15. 8., 27. 8.
Date of evaluation effect scheme of fungicides sequences	27. 7., 6. 8., 15. 8., 27. 8	30. 7., 6. 8., 15. 8., 27. 8.

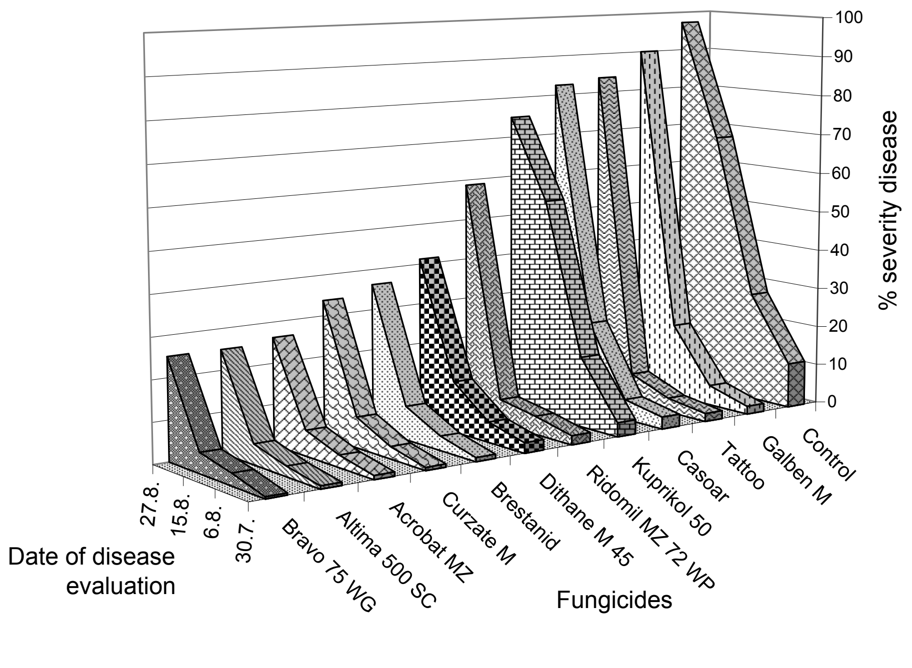

Figure 2. Increase of the severity potato late blight on the leaves after 6 treatment of fungicides in Valečov 2001, cultivar Dali

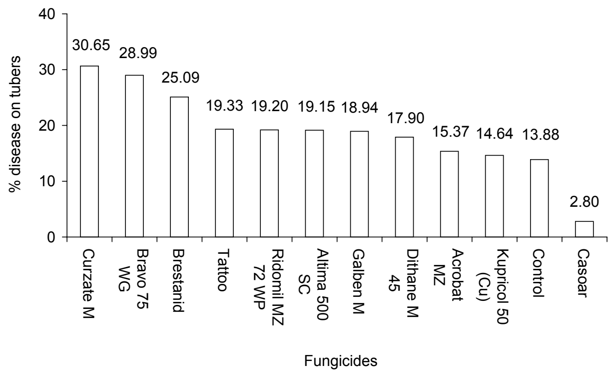

Figure 3. Percentage of incidence of potato late blight on tubers cultivar Dali after 6 treatment of different fungicides in Valečov 2001

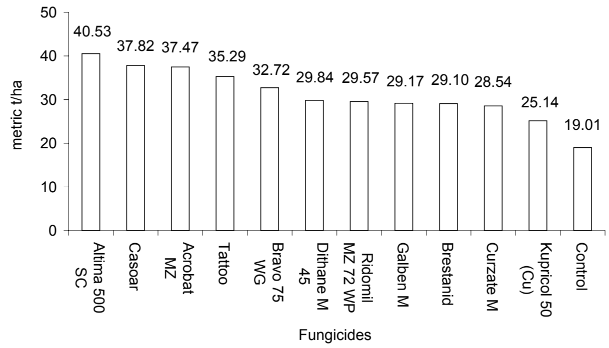

Figure 4. Yield of tubers from 1 ha after 6 treatment of different fungicides in Valečov 2001, cultivar Dali

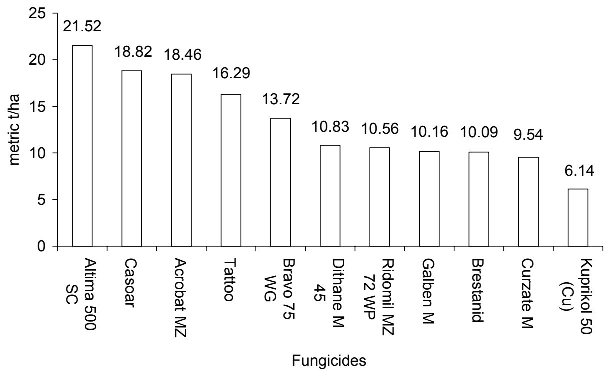

Figure 5. Increase of the tubers production after 6 treatment of different fungicides in Valečov 2001, cultivar Dali

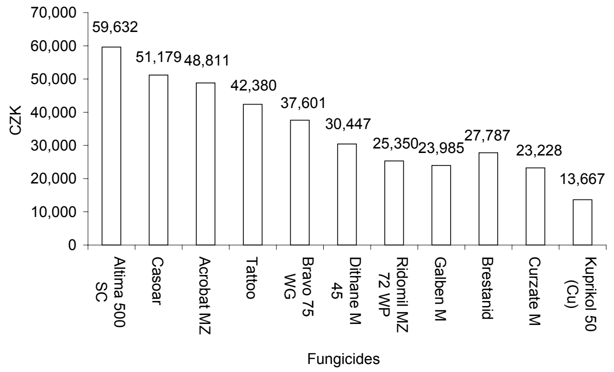

Figure 6. Cost/benefit of the control potato late blight after 6 treatment of different fungicides from 1 ha in Valečov 2001, cultivar Dali

forecast of potato late blight is a function between the first outbreak on potato leaves and on environment: temperature, and relative moisture of air. Utilise regress equations for calculations factor *r*.

There are several forecast models to predict the onset and progress of potato late blight. Generally, in each country specific simulation model has been developed for forecasting of potato late blight. In the Czech Republic, Potato Extension Service by advisors utilise the model, which we have presented in this paper, for special potato seed region. On the other hand State Phytosanitary Administration on web site give the presentation of the forecast outbreak of the potato late blight for whole Czech Republic and recommendation for the treatment potato crops according purpose planting and utilisation of the tubers (seed, early and late harvesting for and starch industry). In spite of specific fungicides and in the near future for the control of potato late blight will remain major tools for effective control and are an integral part of modern agriculture. Their effectiveness depends on combination with other important agronomical practices such as the choice of less susceptible cultivars, a balanced fertilizer input, careful sanitation programmes and the use of forecasting systems and diagnostics.

Anti-resistant strategies are designed according to current knowledge on biological mode of action and activity profiles compounds as well as agronomic practices (GISI 2002). Field trials involving defined mixtures of adequate or not adequate disease control over several cycles help to validate of fungicide mixtures or alternations for the control of both the disease progress and the dynamics of resistant subpopulations.

According our results Figures 2–7 there are different level of the control of potato late blight and we can for each following cropping season give real-time actual level of efficacy different fungicides programme and scheme of fungicides sequences for the growers. Growers can extend adequate control of potato late

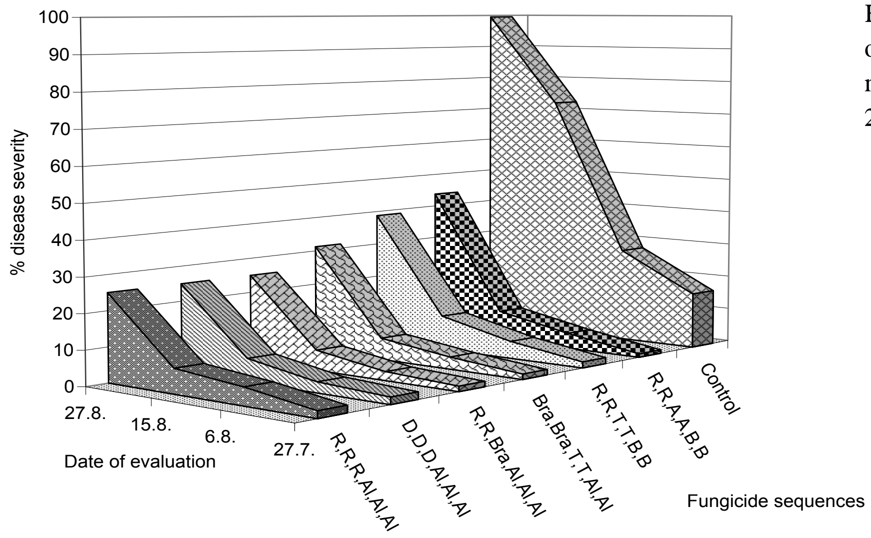

Figure 7. Increase of potato late blight on the leaves after 6 treatment of scheme sequences of fungicides in Valečov 2001, cultivar Lenka

blight by a modification of sequences or by the change of use type of fungicide (Figures 2–7).

Pathogen *P. infestans* populations, however, can adapt very rapidly to both new resistance genes in potato plants and novel anti-fungal compounds, growers can utilise the most effective and durable disease control by the combination of resistance genes (less susceptible cultivars) and anti-fungal compounds. The successful control of potato late blight through development of adapted cultivars and balanced treatment programmes will only be achieved, however, if recommendation are agreed and followed by industry, government, advisors and end users as a co-ordinated strategy (GISI 2002).

CONCLUSION

An accepted strategy to cope with fungicide resistance is to combine high-resistance-risk with low-resistance-risk fungicides. The strategy has led to the development of many mixtures of single site and multi-site inhibitors. An additionally advantage of such mixtures is that multi-site inhibitor may act as an insurance against unacceptable losses in yield or profit in the locality, where resistance to fungicide develops. Evident examples in this respect are mixtures of phenylamides with protectant fungicides and with local systemic or translaminar fungicides (cymoxanil or propamocarb HCl) to control potato late blight (SCHWINN & STAUB 1995). The use of the mix of modern systemic fungicides and the older protectant fungicides are under permanent field-testing control as anti-resistant strategies. Phenylamid Working Group of FRAC maintains in associations with adwisory services, field experimental stations and universities, a monitoring programme that has proved invaluable in assessing the scope of the problem and in helping to define strategies.

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