Control of *Phytophthora infestans* in organic potato production

Hans-Rudolf Forrer, Tomke Musa, Heinz Krebs and Brigitte Dorn

***Abstract - Phytophthora infestans*, the cause of late blight, is the most devastating pathogen in potatoes world-wide. To replace copper fungicides in organic potato production, we examined preparations based on plant extracts, micro-organisms, and other natural compounds for their effect on late blight in field trials as well as *in vitro* and *in vivo*. Most of this work we realised as participants of the EU project Blight-MOP. The majority of the preparations effectively inhibited *P. infestans in vitro* or *in vivo* on tomato plants. However, under field conditions and with applications once a week, commercial and experimental copper-free preparations failed to sufficiently control late blight. In contrast, copper fungicides applied according to the decision support system Bio-PhytoPRE or in regular intervals consistently reduced foliar blight and prevented significant yield losses. Results from an *in vitro* test and from a detached leaf test indicate that a main cause of the failure of copper-free preparations could be low stability towards rain or dew.**[1]

INTRODUCTION

Since 1990 and in collaboration with the Swiss cantonal plant protection services and farmers we recorded the initial disease outbreaks in Swiss potato fields and monitored late blight (LB) epidemics. With a network of 50 to 150 untreated potato plots or organic potato fields, we measured the course and the severity of the LB epidemics (Fig. 1). In 12 out of 16 years, more than 50% of the LB monitoring plots were attacked (Musa-Steenblock and Forrer, 2006). The disease monitoring is part of our LB information and decision support system (DSS) PhytoPRE (Forrer et al., 1993). Since 2005, Bio-PhytoPRE a DSS for organic farmers is operational (Musa-Steenblock and Forrer, 2005). The aim of Bio-PhytoPRE is to optimise the input of both copper fungicides and copper-free preparations (CFP). Since 2000, our LB research is focusing on the development of CFP. Within the EU project Blight-MOP (2001 to 2004) we assumed the task to develop and examine commercial and experimental CFP under field conditions. The aim of Blight-MOP was to develop a systems approach to control potato late blight with an integrated use of disease preventing methods and, based on recommendations of blight forecasting systems, the use of alternative treatments instead of copper.

[1] All authors from Agroscope FAL Reckenholz
Swiss Federal Research Station for Agroecology and Agriculture
Reckenholzstrasse 191, 8046 Zurich (hans-rudolf. forrer @fal.admin.ch, tomke.musa@fal.admin.ch, heinz.krebs@fal.admin,ch brigitte.dorn@fal.admin.ch).

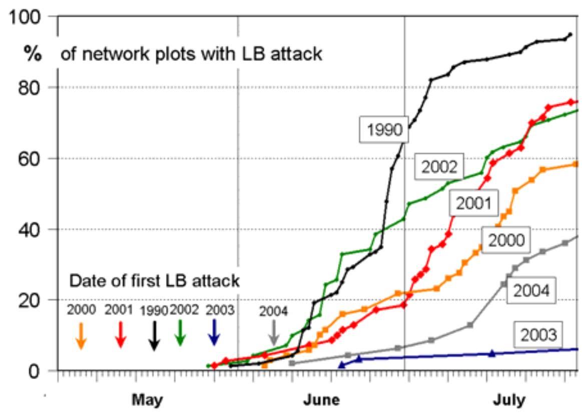

Figure 1. Late blight epidemics in Switzerland monitored with a network of untreated potato plots since 1990.

SEARCH FOR COPPER FUNGICIDE ALTERNATIVES

Commercial and experimental preparations were chosen based on literature, reports of research stations and industry, as well as recommendations of colleagues and organic farmers. Primarily, antifungal preparations with a reported activity in laboratory, greenhouse or in field trials against *P. infestans* or other downy mildew fungi such as *Plasmopara viticola* were selected. In addition, CFP that were selected *in vitro* and *in vivo* trials and recommended by other partners of Blight-MOP were integrated in our experiments. In our search we considered all types of CFP. Hence, we selected CFP containing plant preparations, bio-control agents (BCA), natural compounds such as sulphuric clays and minerals, organic acids, and agents with plant strengthening or resistance inducing properties.

FIELD TRIALS IN 2000

In 2000, the efficacy of 26 CFP was examined with 29 different treatments in four field trials at Zurich-Reckenholz. The trials had four replications and plots with 4 m^2. Each plot was divided in two subplots with each 10 plants of the potato varieties Agria or Bintje. Each trial contained an untreated control and a reference treatment with copper hydroxide (375 g Cu ha^{-1}). CFP and copper preparations were applied once to twice a week with a knapsack sprayer. The first application was conducted according to the recommendation of the DSS PhytoPRE and before LB symptoms appeared in trial plots. To ensure a homogenous disease distribution, leaves infested with LB were spread in the trials at the end of June. After the detection of first symptoms in the plots, the percentage of diseased leaf area was rated once to twice a week. To compare the efficacy of the preparations, the area under the disease progress curve (AUDPC) was calculated.

With the exception of Robus, a product based on phosphonates, none of the CFP had a significant effect on late blight. Since residues with such compounds were observed (Speiser et al., 2000), no efforts were done to further develop this product. In all four trials, the copper reference performed well and reduced foliar blight by 75%. Moreover, a product with a low dosage of copper (135 g Cu ha^{-1}) reduced it by 35% (Bassin and Forrer, 2001).

FROM FIELD TRIALS TO THE LABORATORY

In 2001, the size of the sub-plots was enlarged to 9 m^2 to enhance the sensibility of the field test system and to allow yield assessments. All small-plot trials had a rectangular square design with each 10 treatments and five replications. The plots with the varieties Agria and Ditta (2001) or Nicola (2002, 2004) were bordered by the low susceptible variety Appell and with additional rows with the high susceptible variety Bintje, which served as disease spreader rows.

Table 1. Effect of copper-free preparations and on late blight in small-plot field trials at Zurich-Reckenholz, 2000-2004

Year	Number of CFP tested	Reduction of foliar blight (AUDPC) ≥ 75 %	≥ 50 %	≥ 25 %
2000	26 (2)*	0 (1)**	0	1 (1)
2001	11 (2)	0 (2)	0	0
2002	14 (1)	0 (1)	0	4
2004	12 (3)	0 (1)	0 (1)	0 (1)

* in brackets number of copper preparations (150-375 g Cu ha^{-1})
** mean reduction of the varieties Bintje and Agria was 74%

From 2001 to 2002, 25 CFP were assayed with 43 different treatments in field trials at Zurich Reckenholz. In 2001, 12 out of 27 treatments with CFP were dedicated to various formulations and combinations of *Salvia officinalis* and *Potentilla erecta* preparations. Preparations of these two plants proved to be efficient against *P. infestans* in laboratory and field trials (Blaeser et al., 2002), but failed in our field trials. In contrast to 2001, in 2002 with Mycosin, two other sulphuric clays, the organic acid C-2000 and two BCA's significant efficacies were observed. However, only four of them had an efficacy above 25% (table 1). Since we did not know if the disappointing results of our field trials were due to missing activity of the CFP per se, the effect against *P. infestans* of the 20 CFP tested in 2001 and 2002 was assessed *in vitro* and *in vivo*. In either of these assays, two thirds of the CFP showed a high efficacy, thus the hypothesis of missing activity was rejected. In 2003, a year with an extremely dry and hot summer (Fig. 1), we failed to achieve LB in our trials despite artificial infections.

In 2004, and based on the assumption that the bad performance could rely on insufficient stability of the CFP to adverse environmental conditions, the field testing procedure was modified. The efficacy of 15 pre-selected CFP was analysed in micro-plot field. To ensure an almost complete coverage of the potato foliage, preparations were applied twice a week on the upper and lower side of the leaves. With this approach, six out of 15 CFP significantly reduced foliar blight by more than 25%. However, and with the exception of a phosphonate-compound, none of them reached an efficacy of 50%. In addition, 12 CFP and three copper preparations were examined with 24 different treatments in small-plot trials. Though all CFP-treatments reduced LB significantly, none of them reached the 25% efficacy level (table 1). First results from an *in vitro* test to examine the persistence of the inhibitory effect of preparations to environmental stress indicate that a main cause of the failure could be a low stability towards rain or dew. This hypothesis is in line with results of a semi-field study with detached leaves (Cao et al., 2003).

In contrast to CFP, copper treatments had efficacies between 24% to 78% and significant effects on yield up to 29%. The products were applied with dosages of 150-375 g Cu ha^{-1} per treatment according to Bio-PhytoPRE or in regular intervals.

CONCLUSIONS

Until now no commercial or experimental CFP with a reliable activity for LB control could be found. Until stable formulations are developed, copper fungicides applied according to a DSS and with low dosages could help to control LB and to reduce copper input into the environment in organic potato production.

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