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Öko-SIMPHYT (= Organic-SIMPHYT): A forecasting system for specific scheduling of copper fungicides against late blight

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SUMMARY
During a 4-year project a fungicide strategy against late blight in organic potatoes based on the use of copper was developed resulting in the decision support system (DSS) Öko-SIMPHYT. Öko-SIMPHYT is based on SIMPHYT1 model which recommends first treatment and SIMPHYT3 model which recommends treatment interval and application rate. The aim of Öko-SIMPHYT is to reduce the number of treatments and the application rate. In phases with very low disease pressure calculated by SIMPHYT3 a break of the spraying schedule is recommended. In phases with high disease pressure the aim of the DSS is to achieve best antifungal activity based on the maximum allowed application rate (3 kg/ha copper). 49 nationwide demonstration trials were carried out to validate Öko-SIMPHYT. By timing the treatment interval and adjusting the application rate with the help of the decision support system Öko-SIMPHYT it was possible to get results comparable to standardized weekly applications, applying less copper. In certain cases it was possible to save up to 1000g/ha of copper. On average 0.6 applications were saved and the reduction of copper was 535g/ha.

KEYWORDS
Phytophthora infestans, Decision support system, SIMPHYT, simulation model, infection pressure, copper

INTRODUCTION

In organic potato farming the control of late blight disease is a problem because a range of highly effective fungicides does not exist. So it is very important to use every preventive method to delay the outbreak of late blight. Such preventive methods are choice of location and variety, pregermination, nutrient supply and the use of plant resistance improvers. Moreover the use of protective copper fungicides is allowed. The maximum allowable application rate is 6 kg/ha Cu given by EU Organic Regulation. The German Grower's associations allow maximal 3 kg/ha with special approval (Bioland, Naturland) or prohibit the use of copper (Demeter). On the market there are different copper fungicides with following active ingredients: copper hydroxide, copper octanoate and copper oxychloride. In conventional farming the simulation models SIMPHYT1 and SIMPHYT3 are successfully used for years (Gutsche, 1999; Kleinhenz and Jörg, 2000). Based

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on these experiences, models were developed to the conditions of organic farming and the DSS was named Öko-SIMPHYT.

MATERIAL AND METHODS

Different application strategies were examined by the Bavarian State Research Centre for Agriculture (LfL) and the Julius Kühn-Institut, Federal Research Centre for Cultivated Plants (JKI). Based on the experiments the DSS Öko-SIMPHYT was developed. It is based on the use of copper hydroxide and a maximum application rate of 3000 g copper per ha and year. Copper hydroxide showed the best results concerning rainfastness.

For testing the DSS, Öko-SIMPHYT was programmed by the Information System for Integrated Plant Production (ISIP) in the internet portal www.isip.de.

Öko-SIMPHYT-Input

To run Öko-SIMPHYT some plot-specific information like field name, variety and date of emergence are needed. Moreover a weather station representative for the site has to be chosen from a list. For each model run the input parameters potato growth and rainfall have to be considered since last application. They influence the treatment interval and have to be updated at times. The model requires additionally hourly measurements of air temperature and relative humidity (2m) and sums of precipitation. Figure 1 shows the input form of Öko-SIMPHYT.

Öko-SIMPHYT-Output

SIMPHYT1 predicts the date for the expected start of the late blight epidemic (first outbreak). The date is calculated with a predictive time span of 8 days. The first application should be done within this period.

After the treatment start is predicted, the calculation continues with SIMPHYT3. Based on the variable input data and a calculated weather dependent infection pressure, SIMPHYT3 delivers three results: Treatment interval in days based on last application, recommended application rate and the possibility of an interruption of copper treatments. The infection pressure is grouped into 5 classes from very low to very high. From this infection pressure, recommendations of treatment interval and application rate can be derived (Figure 2). A very low infection pressure corresponds with a treatment interval of 12 days and an application rate of 250 g copper per ha and a very high infection pressure means a short treatment interval of 4 days and a corresponding application rate of 750 g per ha. Dependent on the individual input data of potato growth and rainfall since last application, the treatment interval is calculated. So the maximum treatment interval is 13 days and minimum 4 days.

Moreover a daily Phytophthora efficiency value is calculated by SIMPHYT3. The value ranges from 0 to 1 and gives information about how favourable the day was for late blight infections. If there are 7 consecutive days with Phytophthora-efficiency-value = 0 Öko-SIMPHYT recommends an interruption of copper treatments until two consecutive days with pev > 0 appear.

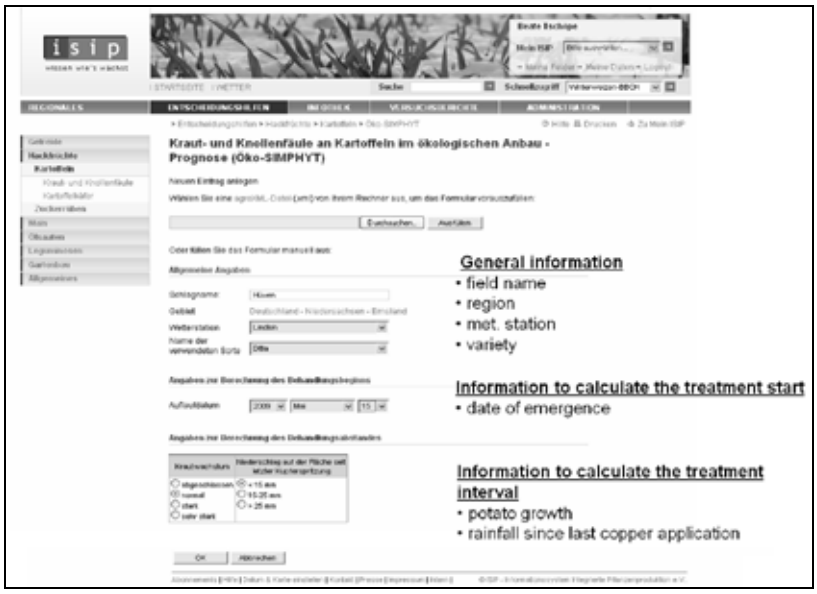

Figure 1: *Input form of the DSS Öko-SIMPHYT*

Öko-SIMPHYT-Scheme

Infection pressure	Treatment interval	Variable application rate
very low	12 days	250 g/ha
low	10 days	250 g/ha
medium	8 days	500 g/ha
high	6 days	750 g/ha
very high	4 days	750 g/ha

Potato growth	Addition/Reduction (days)
completed	1
normal	0
strong	-1
very strong	-2

Rainfall (mm) since last application	Reduction (days)
< 15	1
15-25	0
> 25	-1

Figure 2: *Öko-SIMPHYT scheme*

Öko-SIMPHYT-Trials

Validation of Öko-SIMPHYT was done by 49 nationwide trials carried out from 2006 to 2009 in Germany, 17 of which had 4 trial elements, 20 with 3 trial elements and 12 on-Farm-trials. Table 1 shows the different elements. The trials were designed as a block system with four replications. The disease incidence and severity was examined weekly (Tschöpe, B. *et al.*, 2008).

Table 1: *Trial variants for Öko-SIMPHYT validation*

No. element	Description
1	Untreated control
2	500 g/ha Cu, weekly
3	Variable rate and interval (Öko-SIMPHYT)
4	500 g/ha Cu, variable interval (Öko-SIMPHYT)

RESULTS AND DISCUSSION

Validation of SIMPHYT1

For validation of SIMPHYT1 the hit rate of correct forecasts was calculated. Therefore the difference between recommendation and first outbreak of late blight was evaluated. A forecast was rated as correct if the predicted date of outbreak was before the first observations in the field. During the four years (2006-2009) a hit rate of 72% correct forecasts was achieved on average.

Moreover the data were validated with an additional model to predict first appearance of late blight called SIMBLIGHT1 (Kleinhenz *et al.*, 2007). This model includes soil moisture and crop prevalence. In average the model achieved a hit rate of 81%, so it fits better than SIMPHYT1 but some forecast were considerable to early.

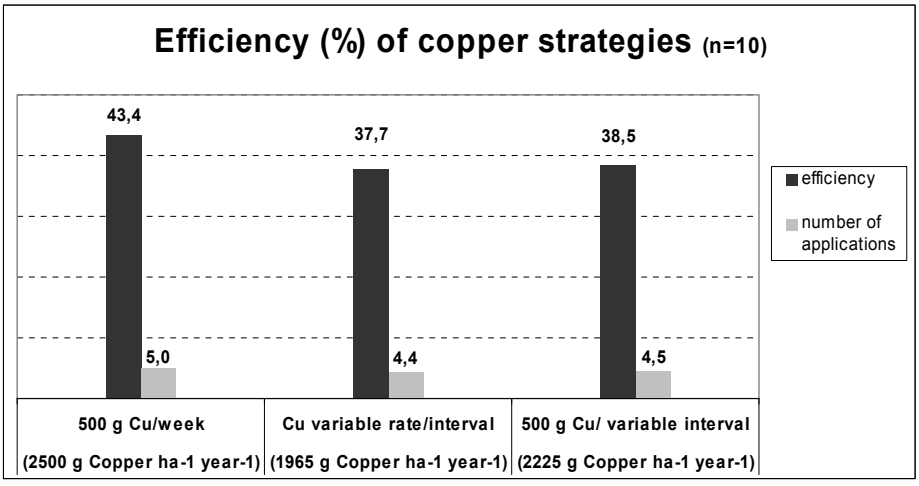

Figure 3: *Efficiency (%) of copper strategies, n= 10*

Validation of SIMPHYT3

For validation of SIMPHYT3 the disease severity curves of the variants were converted into an AUDPC. Then the efficiency of the copper applications was calculated by comparing the AUDPC of the copper treated trial elements to the untreated control element. Figure 3 shows the results of 10 trials with 4 elements in the years 2006-2009. Using Öko-SIMPHYT it was possible to get an efficiency of about 40% which is comparable to standardized weekly applications. On 5 trial sites Öko-SIMPHYT saved up to 1500g/ha copper. On average the number of applications was reduced by 0.6 and the reduction of copper was about 535g/ha.

CONCLUSIONS

The forecasting system Öko-SIMPHYT serves as an important tool for site specific scheduling of copper fungicides against potato late blight. Based on the daily calculated infection pressure the spray interval was adjusted. An optimized control of late blight is possible and the use of copper fungicides can be minimized. The DSS is available for farmers and extension officers via the internet on the homepage www.isip.de

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