DECISION SUPPORT SYSTEMS FOR THE CONTROL OF LATE BLIGHT (*Phytophthora infestans*) OF POTATO

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ABSTRACT

In the nineties a complex, weather-based decision support system (DSS) to aid control of *Phytophthora infestans* in German growing regions has been developed. The DSS consists of three modules. SIMPHYT 1 forecasts the first occurrence of *P. infestans* depending on date of crop emergence and a risk categorisation. SIMPHYT 2 is a highly complex expert system which simulates *P. infestans* epidemics on a plot-specific scale taking into consideration weather, crop data and fungicide properties for its recommendations. SIMPHYT 3 is an infection pressure model that is used to calculate length of spraying intervals on a regional level. All models are validated over several years and helped in reducing the fungicide load of potato crops. Due to the good results the SIMPHYT – models have been introduced into practice via warning services in Germany, Austria and Luxemburg.

Key words: *Phytophthora infestans*, decision support systems, forecasting models, potato, warning service

IZVLEČEK

SISTEM ZA PODPORO ODLOČANJA ZA VARSTVO PRED KROMPIRJEVO PLESNIJO (*Phytophthora infestans*)

V devetdesetih letih prejšnjega stoletja je bil v Nemčiji razvit kompleksen sistem za podporo odločanja za varstvo krompirja pred krompirjevo plesnijo (*Phytophthora infestans*). Sistem je sestavljen iz treh modulov. SIMPHYT 1 napoveduje prvi pojav glive *P. infestans* v odvisnosti vznika rastlin in kategorizacije tveganja. SIMPHYT 2 je zelo kompleksen sistem, ki simulira pojav bolezni, pri čemer upošteva vremenske razmere, podatke o gostitelju glive in lastnosti fungicidov. SIMPHYT 3 je model infekcijskega pritiska in se uporablja za izračunavanje dolžine intervalov med škropljenji na regionalnem nivoju. Vsi modeli so pokazali uporabnost v večletnih testiranjih in so lahko v veliko pomoč pri zmanjševanju uporabe fungicidov pri varovanju krompirja pred glivičnimi boleznimi. Zaradi dobrih rezultatov so bili modeli SIMPHYT prek prognostičnih služb vpeljani v prakso v Nemčiji, Avstriji in Luksemburgu.

Ključne besede: *Phytophthora infestans*, sistem za podporo odločanja, prognostični modeli, krompir, prognostična služba

1 INTRODUCTION

The first successful forecasting model in crop protection practice of arable crops was the "negative prognosis" of *P. infestans* by Schrödter & Ullrich in 1966. Since that time many efforts have been taken to improve the prediction of late blight epidemics of potato. In the former German Democratic Republic an improved model to predict the first occurrence of *P. infestans* has been elaborated by Gutsche & Kluge (1983). Also in the eighties the first simulation model for *P. infestans* epidemics was developed (Stephan & Gutsche, 1980). Based on this work more complex decision support systems (DSS) to assist in the planning of fungicide schedules for the control of *P. infestans* were elaborated (Gutsche, 1988; Gutsche & Kluge, 1995). They combine all knowledge available on late blight epidemiology, crop properties and fungicide efficacy. Recently the SIMPHYT models are introduced into agricultural practice. They are essential tools in integrated crop protection of potato.

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2 The SIMPHYT – Models

In Germany the models of the SIMPHYT – family have been developed by the governmental crop protection services (incl. Federal Biological Research Centre for Agriculture and Forestry; ZEPP; Gutsche, 1999; Roßberg *et al.,* 2001). The **SIMPHYT – DSS** consist of three models which basically are using temperature and relative humidity as meteorological input parameters. They are included into the PASO – system, a complex software combining all available DSSs for crop protection used by governmental crop protection officers (Kleinhenz & Jörg, 1998). In the following an overview is given on the models and their validation.

2.1 SIMPHYT 1

SIMPHYT 1 predicts the date of first appearance of late blight for eight crop emergence - date classes and two risk levels for the production sites (Fig. 1). The emergence – date classes cover all relevant potato growing regions in Germany. Sites with a high moisture impact (close to lakes or rivers, waterlogged soils, highly susceptible cultivars) are considered to be of “high risk”(risk level 1), i.e. the disease is likely to occur earlier. Risk level 2 characterises sites with a lower risk (dry conditions, medium susceptibility). Furthermore it is possible to insert information on seed poatato infestation into the model. Forecasts are given with a prognostic time span of eight days. The aim of SIMPHYT 1 is to signalise the date of the first fungicide treatment (start of the spraying schedule) and to avoid superfluous sprayings before this date. Spraying should be started a few days before the signalised start of the epidemic.

2.2 SIMPHYT 2

SIMPHYT 2 is a complex DSS which monitors epidemic progress of late blight (calculation of a disease progress curve and daily increase of disease severities; Fig. 2) and gives recommendations on timing and choice of fungicides on a plot-specific scale (Fig. 3). The choice of active ingredients and the length of spraying intervals is varied by SIMPHYT 2 according to internally calculated infection rates for the plot. The models includes several functions for curative and protective efficacy of contact, translaminar and systemic fungicides over time (Gutsche *et al.,* 1994). SIMPHYT 2 detects dry periods during which a fungicide treatment is not necessary. Fungicide choice and frequency of applications are varied also according to the aim of potato production (i.e. starch production or consume potato). And lastly SIMPHYT 2 takes into consideration the fungicide resistance status of regional *P. infestans* – populations. SIMPHYT 2 requires a strict documentation of all agronomical data of the potato plot and all fungicide uses.

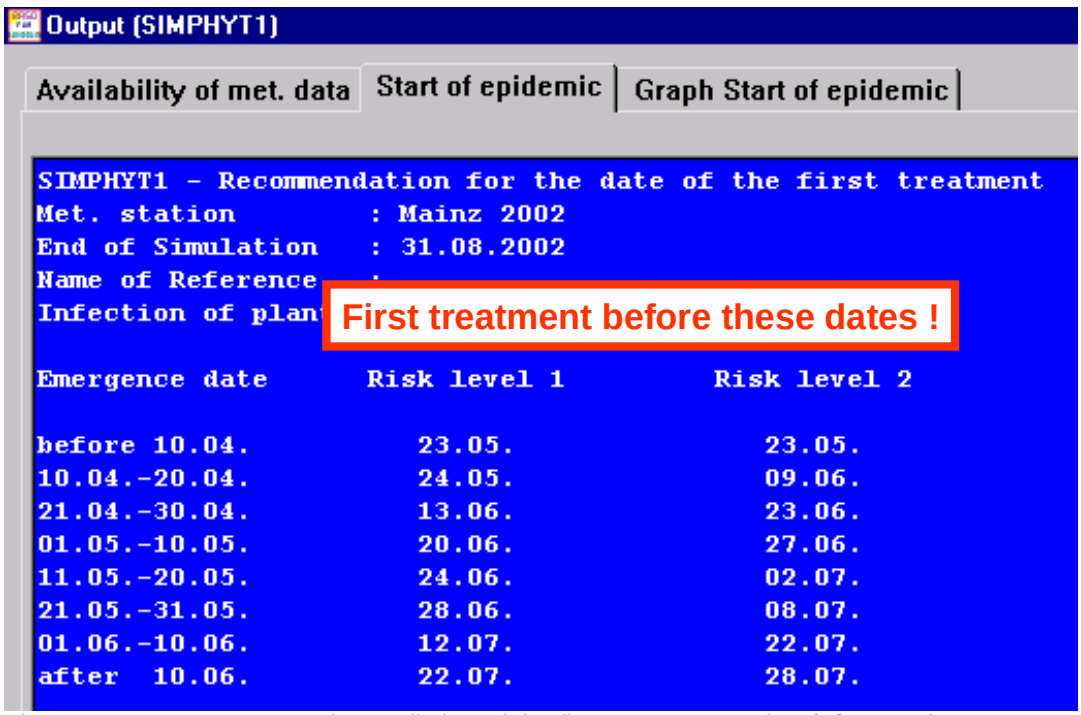

Fig. 1: SIMPHYT 1 – Result: Prediction of the first occurrence of *P. infestans* for 8 emergence date classes and two risk levels (2002)

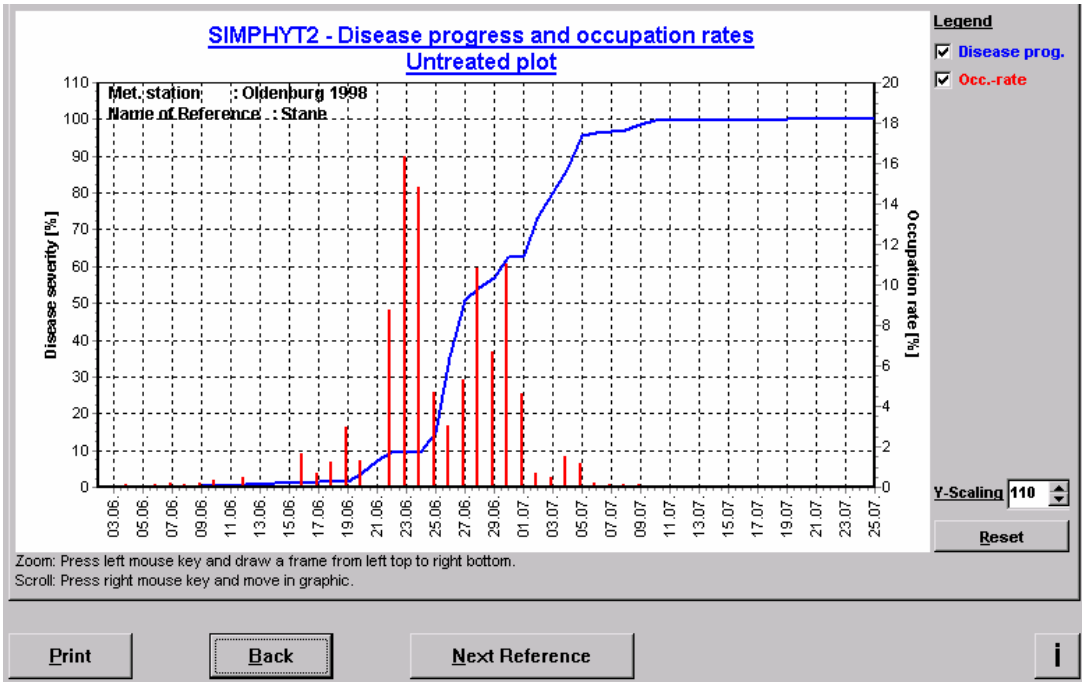

Fig. 2: SIMPHYT 2 – Results: Simulation of the disease progress curve (disease severitiy; line) and daily increase in dieased leaf area (bars) in an untreated field; Northern Germany, 1998

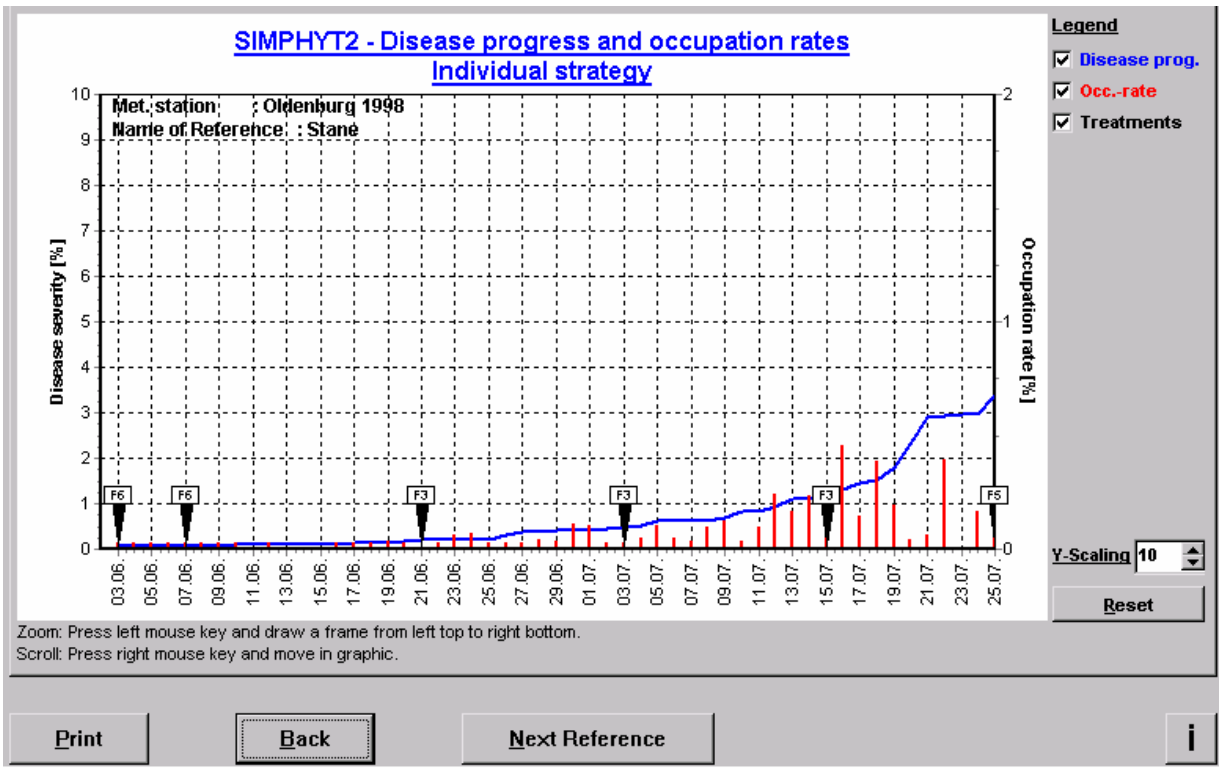

Fig. 3: SIMPHYT 2 – Results: Simulation of the disease progress curve (disease severitiy; line) and daily increase in dieased leaf area (bars) in a treated field (fungicide applications indicated); Northern Germany, 1998

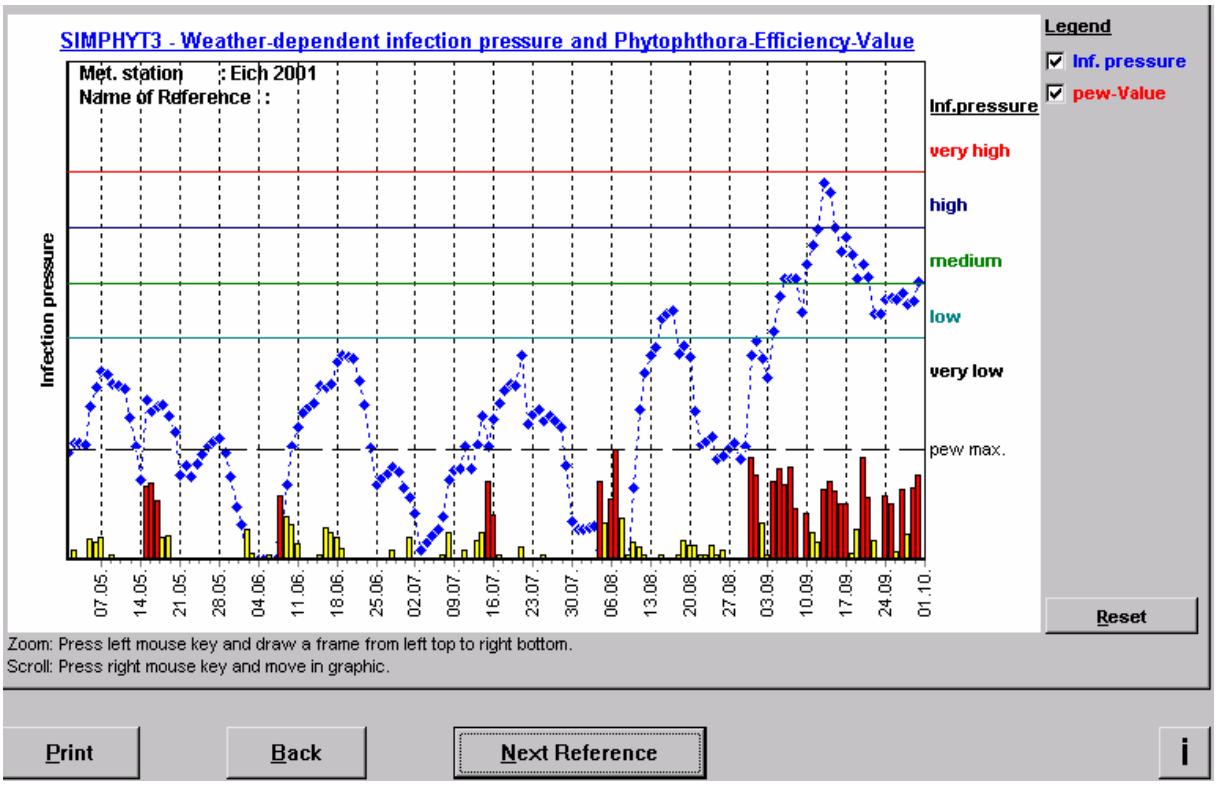

Fig. 4: SIMPHYT 3 – Results: Weather dependant infection pressure (points) and *Phytophthora* effiency value (bars)

2.3 SIMPHYT 3

SIMPHYT 3 is a simplification of the SIMPHYT 2 model which works on a regional level. It is solely weather – dependent and calculates an actual infection pressure taking into consideration temperature and relative humidity of the last two weeks (Fig. 4). In addition SIMPHYT 3 quantifies the daily risk for new infections (*Phytophthora* efficiency value, pew, Fig. 4). From SIMPHYT 3 rather general fungicide strategies can be derived. In periods of high infection pressure curative fungicides should be used in short spraying intervals whereas contact fungicides sprayed in longer intervals control late blight sufficiently in periods with lower infection pressure.

3 Validation and Introduction into Practice

During the last nine years intensive efforts have been taken to validate the SIMPHYT – models. Most experience is available on SIMPHYT 1.

SIMPHYT 1 validation period ranges from 1994 to 2002 (Fig. 5). In most of the years the share of correct predictions of first occurrence ranged from 87 % to 97 %. The predicted first occurrence of *P. infestans* in these cases was earlier than the observed one. In three years (1997, 1999 and 2002) SIMPHYT 1 with a considerable share predicted the very early occurrences too late.

From 1994 to 1998 in Germany trials were laid out to compare conventional fungicide strategies to strategies recommended by SIMPHYT 2 (Fig. 6). The results showed that according to SIMPHYT 2 – strategy it was possible to save two fungicide treatments without losing control efficacy compared to routine treatments or conventional spraying schedules (Kleinhenz & Jörg, 1998). During a joint action throughout Europe it was shown that compared to other DSSs SIMPHYT 2 needed less fungicide input to suffiently control *P. infestans (*Kleinhenz & Jörg, 2000).

Validation of SIMPHYT 3 in Germany and Austria in 2001 and 2002 gave good results thus leading to a high acceptance of the model`s strategy.

Meanwhile the control strategy for late blight is essentially based on the SIMPHYT – models. SIMPHYT 1 and 3 results are presented via warning service. The latest development is ISIP, the internet warning service of the governmental crop protection services of Austria, Luxemburg and Germany. The potato warning service within ISIP is the most successful part. Per day in the average 1000 to 1200 visits were recorded which means about 80000 to 90000 visits per vegetation period. Several ten thousand SIMPHYT – simulations are run each growing season based on data of 110 meteorological stations located in the growing regions.

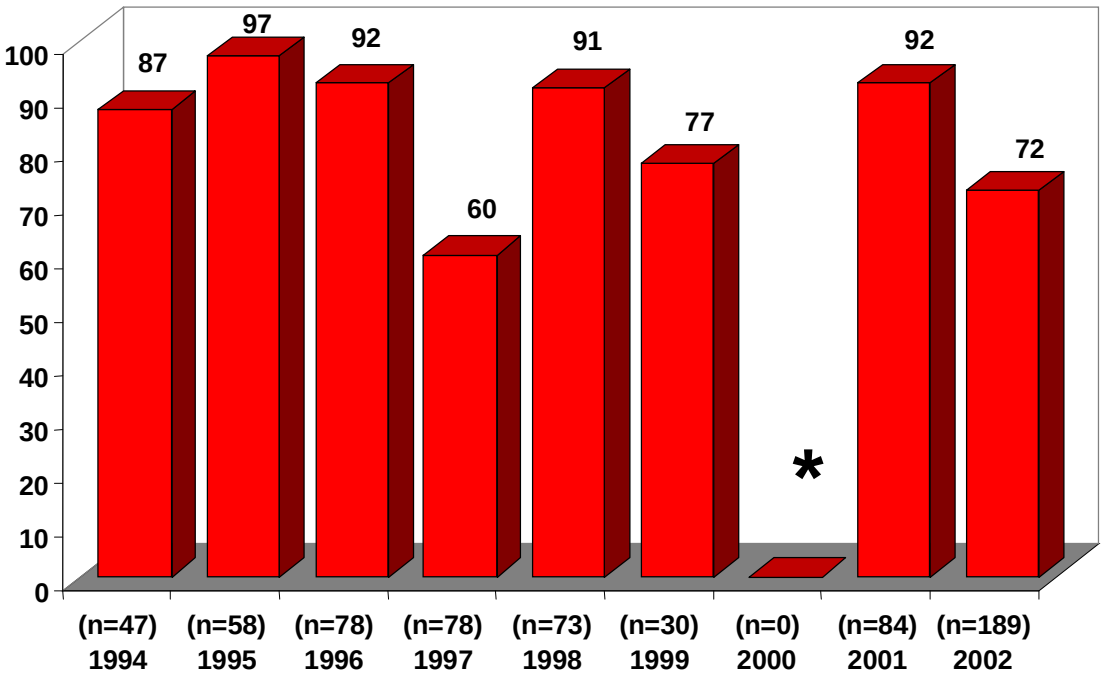

Fig. 5: Validation of SIMPHYT 1: Share of timely forecasts 1994 – 2002 in Germany (* = no data available)

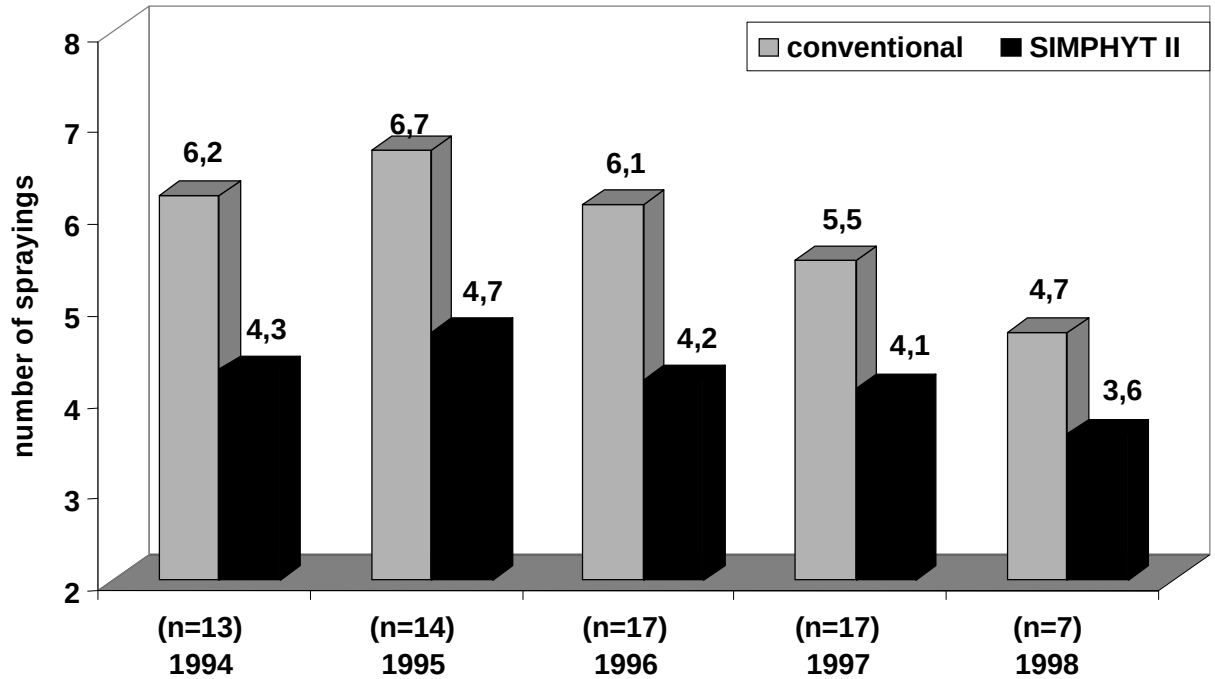

Fig. 6: Validation of SIMPHYT 2: Comparison of conventional and SIMPHYT 2 spraying strategies; number of *Phytophthora* treatments (1994 – 1998; Germany)

4 Problems and Further Work

Main problems occurred with SIMPHYT 1 forecasts. In cases of severe rainfall during April and May the model gave too late forecasts for the first occurrence. *P. infestans* first appearance then was registered within the first four weeks after crop emergence and far before canopy closure or even row closure. It is likely that the wet soil conditions are the cause. Work has been started to include soil properties and precipitation after planting til crop emergence into SIMPHYT 1 in order to improve the forecast.

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