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FORECASTING MODELS FOR THE PREDICTION OF CERCOSPORA LEAF SPOT DISEASE (*Cercospora beticola*) OF SUGAR BEET

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ABSTRACT

Based on an Italian expert system (CERCOESY) forecasting models for *Cercospora* leaf spot disease of sugar beet have been developed. Using temperature and relative humidity and a rough categorisation of regional inoculum as input CERCBET 1 predicts the first occurrence and the spread of the disease in a region. CERCBET 1 has been introduced into practice via warning services and signalises the start of monitoring and field inspection activities. CERCBET 3 is a model for the plot-specific prediction of fungicide treatments based on weather parameters. Validation gave promising results. Further agronomical parameters will be included into the model to improve precision of the forecasts.

Key words: *Cercospora beticola*, epidemiology, forecasting models, sugar beet, warning service

IZVLEČEK

PROGNOSTIČNI MODELI ZA NAPOVEDOVANJE PESNE LISTNE PEGAVOSTI (*Cercospora beticola*) NA SLADKORNI PESI

Na podlagi italijanskega sistema CERCOESY smo razvili prognostični model za napovedovanje pojava pesne listne pegavosti (*Cercospora beticola*) na sladkorni pesi. Prognostični model CERCBET 1 napoveduje prvi pojav in širjenje bolezni, pri čemer upošteva temperaturo in relativno vlažnost zraka, kot tudi zastopanost inokuluma glive na obravnavanem območju. CERCBET 1 je bil vpeljan v kmetijsko prakso prek prognostične službe in je znanilec monitoringa in ostalih nadzorovalnih aktivnosti. CERCBET 3 je model za specifično napovedovanje škropljenja s fungicidi in temelji na vremenskih parametrih. Njegova uporaba zagotavlja obetavne rezultate. Zaradi povečanja natančnosti prognoze, bodo v ta model v prihodnosti vključeni tudi drugi agronomski parametri.

Ključne besede: *Cercospora beticola*, epidemiologija, prognostični modeli, sladkorna pesa, prognostična služba

1 INTRODUCTION

Cercospora beticola is the most damaging leaf disease in German sugar beet growing regions. In the average losses in sugar yield vary from 5 % to 15 % (Maier & Bürcky, 1999). In cases of extremely strong epidemics losses can reach 50 %. Such epidemics are reported from warm and moist regions (e. g. river valleys) (Maier & Bürcky, 1999). Irrigation in warm areas accelerates the epidemic disease process substantially (Jörg & Krauthausen, 1996). In drier regions epidemics start later and disease severities remain on a low level (Jörg & Krauthausen, 1996). Since the mid-nineties the disease is controlled regularly by applying one or two fungicide treatments. Action thresholds have been elaborated which are based on disease incidence counts and which vary according to the start of the epidemic (Maier & Lang, 2001*)*. In order to aid decision-making in controlling the disease a comprehensive and laborious monitoring was organised by governmental crop protection services, growers` unions and sugar industry.

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2 The CERCBET – Models

In 1999 work was started on the development of forecasting models which reflect the influence of weather on the epidemic development of *C. beticola.* Based on the CERCOESY expert system developed at the University of Piacenza (Italy) (Rossi & Battilani, 1991; Rossi *et al.,* 1994) the CERCBET models were elaborated for German growing conditions. The intention was to obtain robust, analytical predictive models rather than complex simulation models. Main aims were to forecast regional first occurrence of *C. beticola* including subsequent spread of the disease and to predict the timing of fungicide applications in the case that action thresholds are overridden (Tab. 1).

Table 1: CERCBET – Model output and –use

Module	Output	Use in practice
CERCBET 1	First occurrence in a region (share of infested fields)	Warning service: a) start of monitoring (ext.) b) field inspections (grow.)
CERCBET 2	Disease progress curves (disease severity)	Scientific model: a) cultivar susceptibility b) fungicide efficacy
CERCBET 3	Infection pressure Disease progress curve (disease incidence)	Warning service: a) infection risk b) dates of treatments

2.1 CERCBET 1

Based on the Italian CERCOPRI-model (Rossi & Battilani, 1991) CERCBET 1 was developed. CERCBET 1 is an empirical statistical model to forecast the first occurrence of *C. beticola* in a region. As input parameters CERCBET 1 uses meteorological data (temperature, relative humidity) and agronomical parameters (sugar beet prevalence, length of crop rotation, average *C. beticola* disease severity of the previous year).

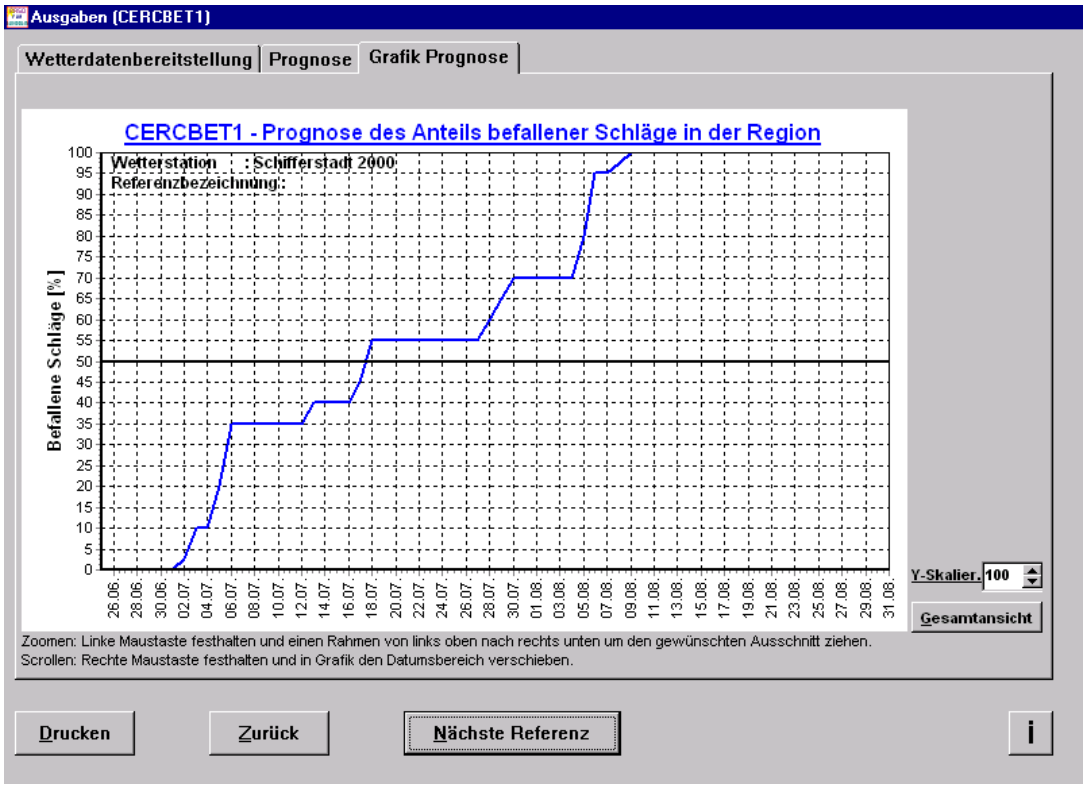

Fig. 1: CERCBET 1 – Result: Prediction of the first occurrence (2. July) and spread of *Cercospora beticola* within a region in the Rhine valley in 2000

Agronomical parameters are used to classify regions according to the availability of inoculum into three risk categories. CERCBET 1 calculates sums of temperature and relative humidity. Once certain thresholds are overridden *C. beticola* is likely to occur. For each day the share of infested fields in a region represented by a meteorological station is predicted (Fig. 1).

2.2 CERCBET 2

CERCBET 2 is a complex simulation model for the disease progress curve of *C. beticola* (see Rossi *et al.*, 1994). Input parameters are temperature, relative humidity and precipitation. In addition cultivar susceptibility may be introduced as a factor. The essential target variable of CERCBET 2 is the infection rate from which several other disease parameters are calculated. CERCBET 2 is a scientific model employed to acquire knowledge on the epidemic behaviour of *C.beticola* a practical use in crop protection is not intended.

2.3 CERCBET 3

The latest development in the CERCBET model family is CERCBET 3. CERCBET 3 is an empirical regression model which has been derived from CERCBET 2. Using temperature and relative humidity as input CERCBET 3 calculates the daily infection rate (Fig. 2). In a second step these infection rates are summed up over a certain period in order to characterise the infection pressure during this period (Fig. 3). Finally *C. beticola* disease incidences are calculated by employing a regression model. CERCBET 3 is used to predict the date of the first treatment on a plot-specific scale with a predictive time-span of seven days. Recently the influence of cultivar susceptibility and irrigation is introduced into CERCBET 3.

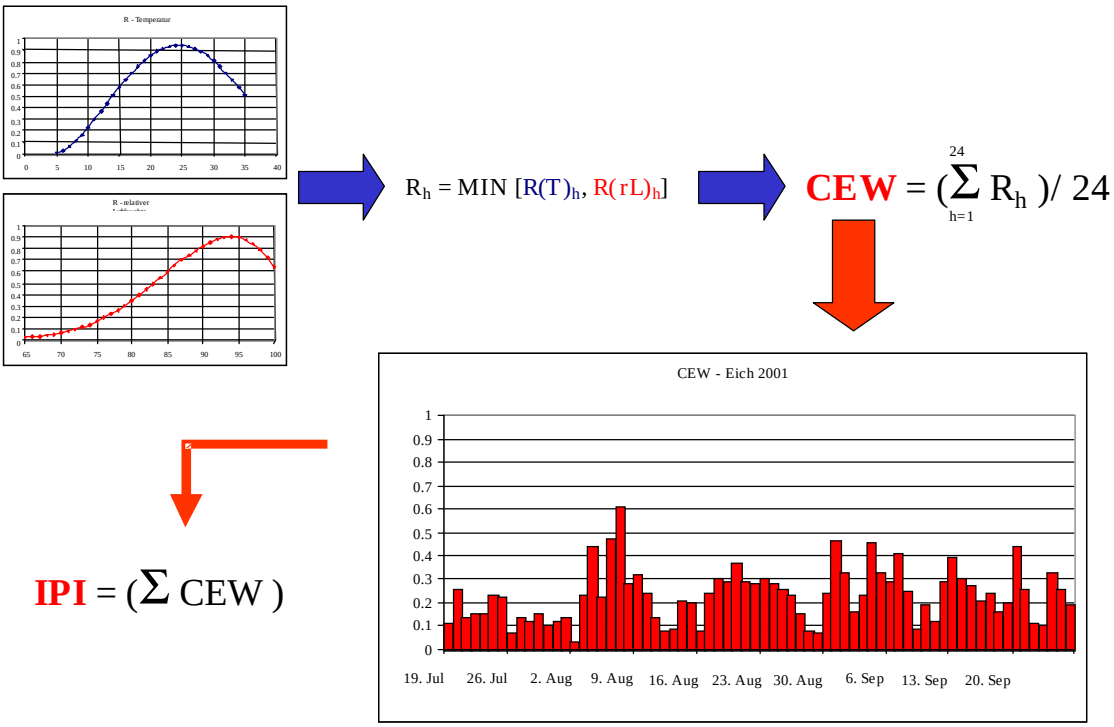

Fig. 2: CERCBET 3: Calculation of hourly and daily (CEW) infection rates and an infection pressure index (IPI) based on temperature and relative humidity

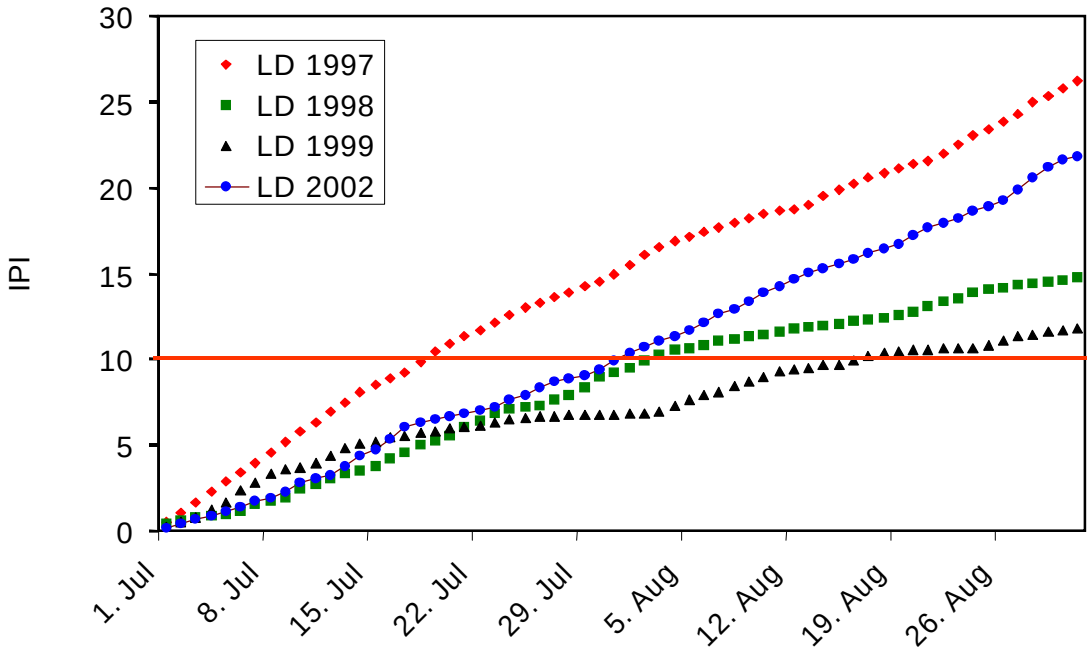

Fig. 3: CERCBET 3: Infection pressure index (IPI) for a site in the Rhine valley in 1997-1999 and 2002 (*C. beticola* - risk: high in 1997 and very low in 2002)

3 Model Validation and Use

Before introduction into practice the models have to be validated at least during a three years testing period and if necessary improved.

3.1 Validation of CERCBET 1

During an eight years period (1995 – 2002) CERCBET 1 has been validated in practice. A comparison was made of the dates predicted by CERCBET 1 and the corresponding dates observed in farmers` fields in many regions throughout Germany. With a few exceptions the model proved to be very precise.

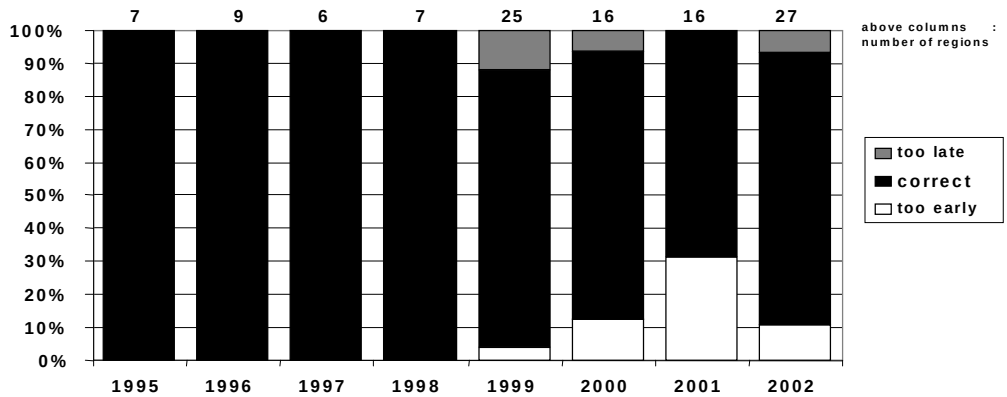

Fig. 4: CERCBET 1 – Validation: Share of too early, correct and too late forecasts of the dates when 50% of the fields are infested with C. beticola (1995 – 2002)

The predicted dates of first occurrence and the respective ones observed in the field in most of the cases differed by less than a week. In addition we found the same precision for the dates when 50% of the fields in a region were infested (Fig. 4) by *C. beticola*. Then in fields with a high risk the first action threshold is reached. With the exception of 2001, when the forecasts tended to be about one week to early, CERCBET1 gave correct predictions.
In 2000 CERCBET 1 successfully has been introduced into practice and is used to steer the *Cercospora* monitoring and for signalising the dates for the first fungicide treatments on a regional scale.

3.2 Validation of CERCBET 3

Since 2001 disease incidence curves recorded in the field are compared with curves simulated by CERCBET 3. First results obtained revealed greater differences (Racca ***et al.***, 2002). In most of the cases CERCBET 3 underestimated the disease progress. This lead to a modification of the model. Standard weather parameters measured in 2 m height were transformed into such for the crop canopy. For the prediction of disease incidence from IPI a non-linear regression function was preferred to a linear model.
The modified CERCBET 3 model gave very promising results. With a tolerable deviation of +/- 10 % of disease incidence CERCBET 3 correctly predicted the date when the threshold was reached in 72 % of the cases in 2001 and resp. 82 % in 2002 (Fig. 4). In some fields CERCBET 3 predictions were too late. This especially occurred in high risk areas with irrigation. To improve predictions in such cases the influence of irrigation on epidemic progress will be reflected in a future version of CERCBET 3. Recently the share of *Cercospora* – tolerant cultivars is increasing in German sugar beet production.

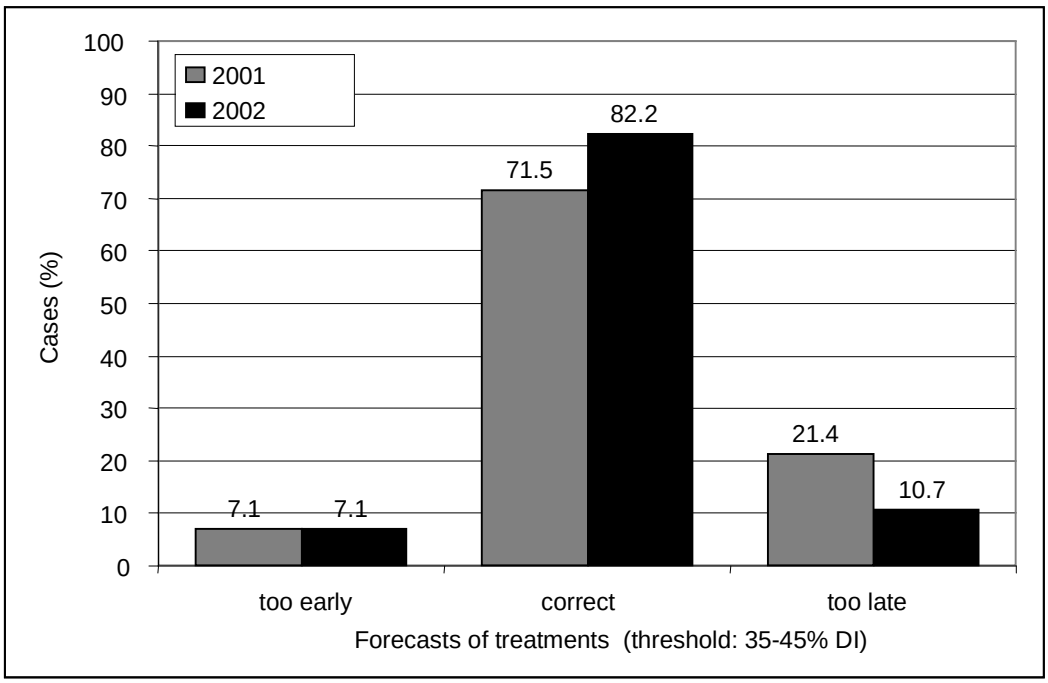

Fig. 5: CERCBET 3 – Validation: Share of correct forecasts of the treatment dates in 2001 (n= 36) and 2002 (n= 28)

The influence of reduced susceptibility on epidemic progress is under investigation and will be included into the model. The same holds for the efficacy of fungicides. In some regions the need for a second treatment has to be estimated and thus CERCBET 3 must take into consideration how disease incidence progress is affected by the first fungicide application.

4 Outlook

Based on the forecasting approach developed for *C. beticola* predictive models for other sugar beet leaf diseases are elaborated. For powdery mildew and rust of sugar beet models for the first occurrence and infection pressure models similar to CERCBET 1 and 3 have been created (Racca *et al.,* 2000; 2002). An introduction into practice is planned for 2005. Recently the approaches are transferred to forecasting work on fungal diseases of cereals.

5 ACKNOWLEDGEMENTS

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