Practical Application of Integrated Disease Management

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Abstract

A decision support system for cereal diseases and late blight of potatoes has been developed at the Chair of Phytopathology, Technische Universität München. The Wheat and Barley Prognosis System has been in use for many years by the Bavarian official advisory service. It is based on an exact diagnosis and established biological thresholds influenced by weather. Certain fungicides are recommended also covering diseases which have not reached the threshold. Diseases under consideration are eye spot disease, powdery mildew, Septoria leaf blotch, Septoria leaf and glume blotch, tan spot, brown and yellow rusts.The PhytophthoraModel Weihenstephan consists of two parts, weather based prognosis and monitoring in the unsprayed control plots. Spraying recommendations are given based on the results of the above-mentioned parts and considering cultivar behaviour and blight development in the field. The first spraying in the season as well as the timing of the following ones are crucial. This model does not give any recommendations regarding which active ingredient should applied. However there is a distinction made with regard to contact (protective) fungicides and systemic fungicides. The PhytophthoraModel Weihenstephan has been in use for several years in Germany as well as in Austria.

Keywords: decision support systems; cereal diseases; potato late blight; control thresholds

INTRODUCTION

The integrated plant production turned out to be the only economic way of crop production in modern agriculture. This must be seen in context with the increase of agricultural running costs, especially fertilizers and pesticides. Therefore it has been necessary to reflect on decreasing running costs as well as to considerate the effects of these materials used on the environment. Horror scenarios on damages on the environment by these materials vanished, however, concern about possible environmental influences remained.

Certainly it is an error to assume that chemical measures were carried out if the farmer felt it necessary to have them. Normally a farmer takes in consideration what his crop will be worth and how his expenses for this crop will be. So, the integrated plant production was one way to solve problems. But there were some obstacles, for example the farmer himself was mostly unable to decide at which time a pesticide application was necessary and when not. Scientific institutions will help him. Meanwhile many decision support systems exist.

For more than 15 years a close cooperation took place between the Bavarian Agricultural Administration, the industry for pesticide production and the Chair of Phytopathology at Weihenstephan concerning the development of these decision support system and its use in practice.

The advisory services

At present there are some advisory services working on an official or on a private basis including some deriving from experiences from the Chair of Phytopathology at Weihenstephan. As crop production in agriculture should be environmentally compatible, some requirements and presuppositions are necessary

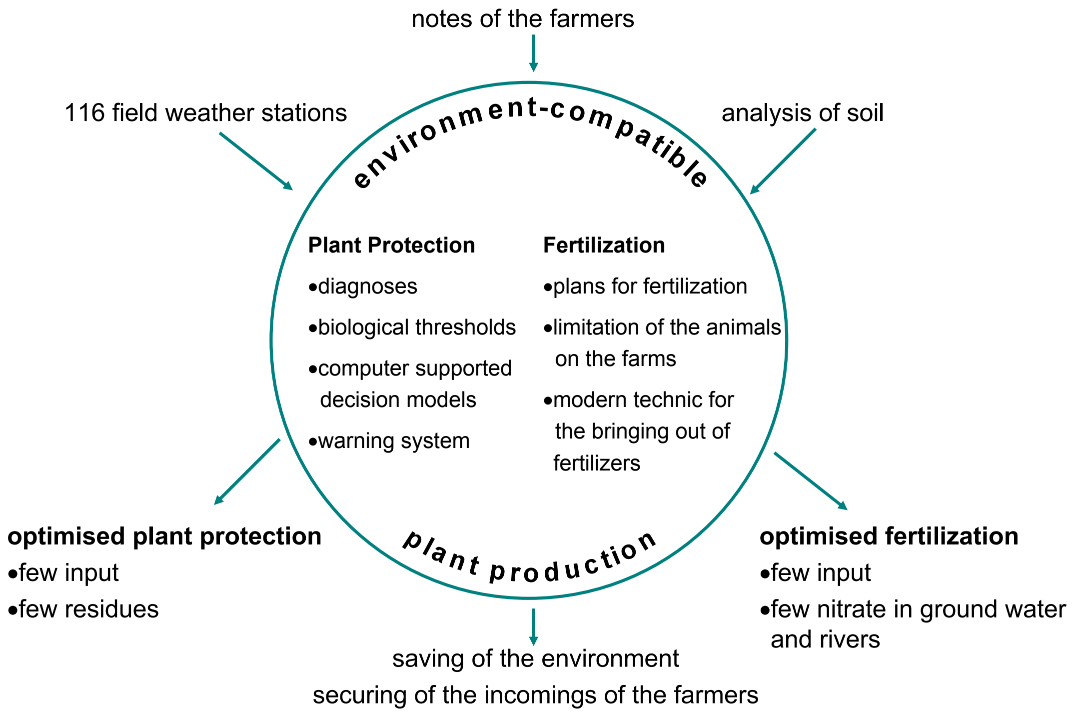

Figure 1. Program Environment-Compatible Plant Production in Bavaria

(Figure 1). First of all one should know the weather conditions. For this reason weather stations are necessary in the main growing areas.

The optimal plant production also includes optimized plant protection and optimized fertilization, including knowledge on the nutrients in the soil, the varieties grown and the exact cultivation of the crops. But the main point is the knowledge about the weather conditions. From the weather stations all important data will be recorded like as temperature in the air and in the soil, relative humidity, rainfall, leaf wetness, global radiation, wind velocity etc. All these data will be transmissioned by computers to a central institution, processed and information will be sent to official or private advisors and, of course, to the farmers. This is the framework for the information of advisory services and of farmers (Figure 2).

Wheat and Barley Prognosis System (IPS = Integrated Plant Protection)

The system is mostly based on the Bavarian Wheat and Barley Prognosis System which is meanwhile paralleled by some privately established institutions.

It is relatively easy to get records on weather conditions which means no outbreak of plant diseases, although the bad weather would favour plant diseases. For this reason the main principles of the Wheat and Barley Prognosis System are presented in the following way (Figure 3):

- At first an exact diagnosis has to be done using, if necessary, magnifiers and stereomicroscopes.
- Second, an exact infestation has to be recorded. This is fundamental for establishing biological thresholds.
- Third, fungicide applications should be recommended only after transgressing these biological thresholds taking into consideration the influence of weather.
- Fourth, special fungicides should be recommended and used with special target effects.
- Last but not least, the effects of such control measures should be monitored and, if loss of fungicidal effects occurs and in case of a new transgress of the biological threshold, control measures have to be repeated.

The thresholds of the Bavarian wheat model are based on the observation of

- eye spot (*Pseudocercosporella herpotrichoides*)
- powdery mildew (*Blumeria graminis*)
- leaf blotch (*Septoria tritici*)
- leaf and glume blotch (*Septoria nodorum*)

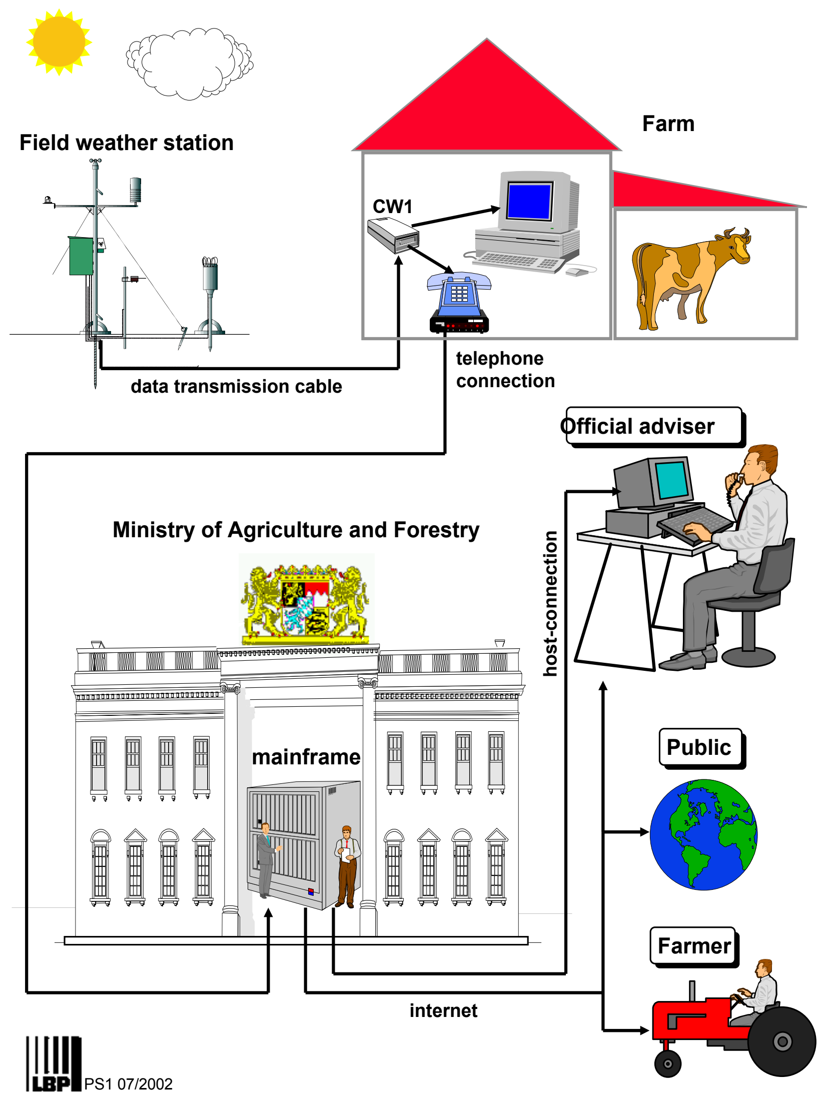

Figure 2. Data Transmission in the Bavarian Network of Field Weather Stations

– tan spot (*Drechslera tritici repentis*)
– brown rust (*Puccinia recondita*)
– yellow rust (*Puccinia striiformis*).

The threshold for *Septoria* leaf and glume blotch will be fixed in the following way:

30 plants as samples should be taken out of the control plot. In the growth stage EC 37–39 the fifth or the fourth leaf beneath the flag leaf should be examined for the presence of pycnidia of *Septoria nodorum*. 12% infection frequency is equal to one pycnidium per indication leaf of one out of 30 plants. In this case a control measure is necessary with a target fungicide.

In case of presence of further cereal diseases which had appeared without transgressing the control threshold another fungicide should be used with side effects against those diseases.

It has to point out that a second control measure should not be applied earlier than 21 days after the first fungicide application. However, this depends on

Important principles:

- Exact diagnosis of diseases
- Quantitative registering of the infestation
- Application of fungicides only after transgressing of the biological thresholds by having regard to the weather.
- Selection of fungicide in regard to the parasites in the field
- Several controls for monitoring the success of the treatment

Figure 3. Wheat and Barley Prognosis System of Bavaria

Eye Spot Disease (*Pseudocercosporella herpotrichoides*)			**BBCH 32–37**
Dye-test according to Mauler-Machnik and Nass			
Control threshold	20% IF of the main stems		
1. sample	BBCH 32, in case of negative		
2. sample	BBCH 34/37		
Powdery Mildew (*Erysiphe graminis*)			**BBCH 31–69**
Control threshold	BBCH 31–39	60% IF of the whole plant, in case of a 2. application F-3	
	BBCH 41–69	60% IF/indication leaf stage	
	BBCH 41–55	F-2	
	BBCH 59–69	F-1	
Septoria Leaf Blotch (*Septoria tritici*)			**BBCH 33–65**
Control threshold	40% IF/indication leaf stage		
	BBCH 33–43	F-4	
	BBCH 47–65	F-3	
Septoria Leaf and Glume Blotch (*Septoria nodorum*)			**BBCH 37–71**
Control threshold	12% IF/indication leaf stage		
	BBCH 37–39	F-5 or F-4	
	BBCH 41–49	F-4 or F-3	
	BBCH 51–71	F-3 or F-2	
Tan Spot (*Drechslera tritici repentis*)			**BBCH 32–71**
1. Control threshold	5% SF/indication leaf stage		
	(BBCH 32	F-6 or F-5, but only in case of wheat not being the precrop)	
	BBCH 33–39	F-5 or F-4	
	BBCH 41–49	F-4 or F-3	
	BBCH 51–71	F-3 or F-2	
2. Control threshold	5% IF on F-2 or F-1 or F		
Brown Rust (*Puccinia recondita*)			**BBCH 37–71**
Control threshold	30% IF on the main stems		
Yellow Rust (*Puccinia striiformis*)			**BBCH 31–71**
1. Control threshold	First infection nests in the plot		
2. Control threshold	First pustules on one of the upper three leaves		
A second control measure should not be done earlier than 21 days after the first fungicide application. Exception Powdery mildew 14 days			
IF = Infection frequency SF = Sporulation frequency F = agleaf F-5 = the fifth leaf beneath the agleaf			

Figure 4. Control thresholds for parasitic fungi in wheat (included in the Bavarian Wheat Model)

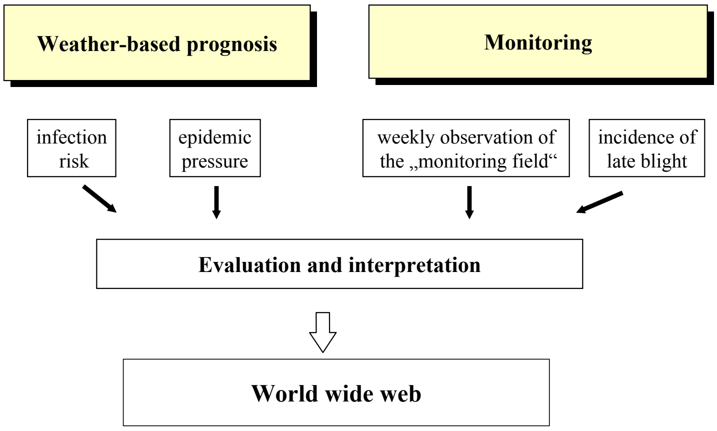

Figure 5. PhytophthoraModel Weihenstephan

the effects of these fungicides and the permanence of their effectiveness (Figure 4).

There is a very similar situation in the control of barley fungal diseases. The observations are concentrated on

– leaf spots (*Rhynchosporium secalis*)
– net blotch (*Drechslera teres*)
– powdery mildew (*Blumeria graminis*)
– brown rust (*Puccinia hordei*).

The decision support is very similar as in wheat and has had a real positive effect resulting in reduced fungicide applications and from this reason an increase in the farmer's income.

PhytophthoraModel Weihenstephan

Quite different from cereal diseases are potato diseases and with regard to these especially potato late blight and its causing agent *Phytophthora infestans*. This imported parasite is said to pass the winter in the stored tubers. If these tubers are used for seed the fungus grows through the shoots into the leaves and blight occurs especially in cool and rainy weather conditions. But up to now nobody knows at which time sporulation occurs. It is assumed that one infected tuber per hectar in a potato field is able to cause a real epidemic in the whole field if the weather

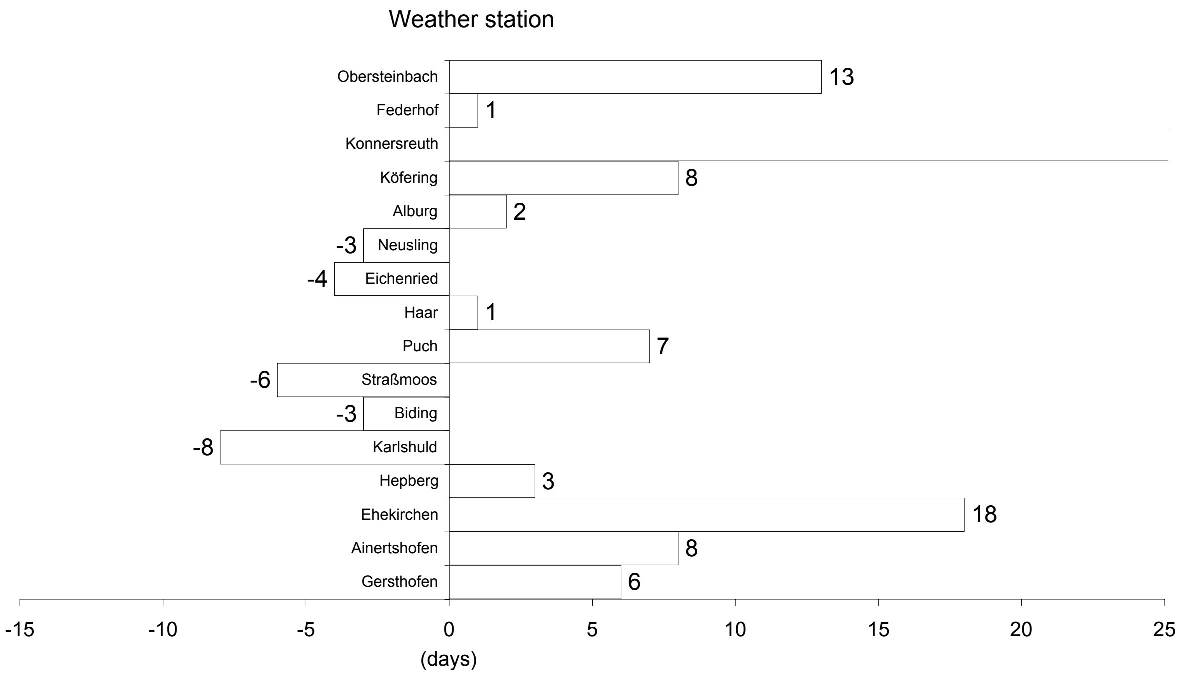

Figure 6. First treatment (Simphyt I) – outbreak 1999 (untreated foliage)

conditions are favourable. There are no totally resistant potato varieties and the degree of destruction is varying depending on weather conditions, infested seed tubers and resistance levels. Therefore it is necessary to use fungicides up to 15 to 20 times a season. These fungicides are preventive and systemic ones, the latter are said to have lost effectiveness because of sensitivity losses of the fungus population. The use of a prognosis model within a regional warning system seems to be the best way to optimize fungicide application and to reduce chemical input. There are already some prognosis systems but they are not sufficiently working.

The PhytophthoraModel Weihenstephan is based on two components (Figure 5):
- on the weather based prognosis and its computer processing
- on actual disease observations in the field (monitoring).

The weather based prognosis has been originally developed by the German Biologische Bundesanstalt (GUTSCHE 1999) some years ago and consists out of two modules: Simphyt I and Simphyt II. At Weihenstephan Simphyt II was used as a basis, however, it was improved and modified in 1998 and is now called Simphyt III. The first predicts the time for the first fungicide application for eight different crop emergence classes and two risk levels. The program requires the input of temperature, relative humidity and rainfall (Figure 6).

Simphyt III provides information on epidemic pressure and dry periods. Additionally information on the development of the blight fungus on a single day is given. Simphyt III does not recommend a fungicide strategy, but by calculating epidemic pressure considering foliage growth, cultivar resistance, blight situation in the field and farmer fungicide usage, spraying intervals are derived (Figures 7 and 8). The decision support system Simphyt in the whole is based on records of temperature, relative humidity and precipitation, which are recorded each hour by (automatically working) weather stations. These local data are transferred online to a server. The data quality is controlled and the data are transformed and processed by the program Simphyt.

The program is run twice a week in the Federal Republic of Germany done by official service and by private ones.

The second element of the PhytophthoraModel Weihenstephan – the monitoring – is carried out weekly. The fields under observation are called "monitoring fields" and they are sown with cultivars most fre-

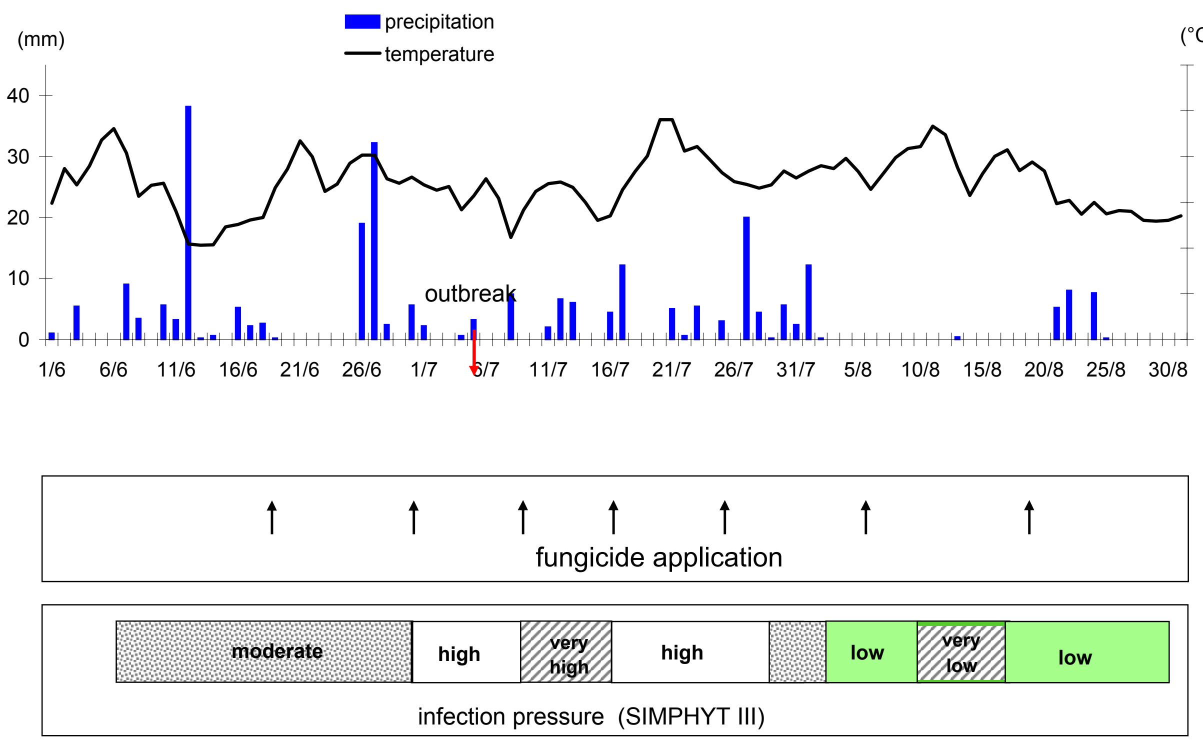

Figure 7. Weather data and infection pressure 1998 (site: Biding, Lkr. Neuburg)

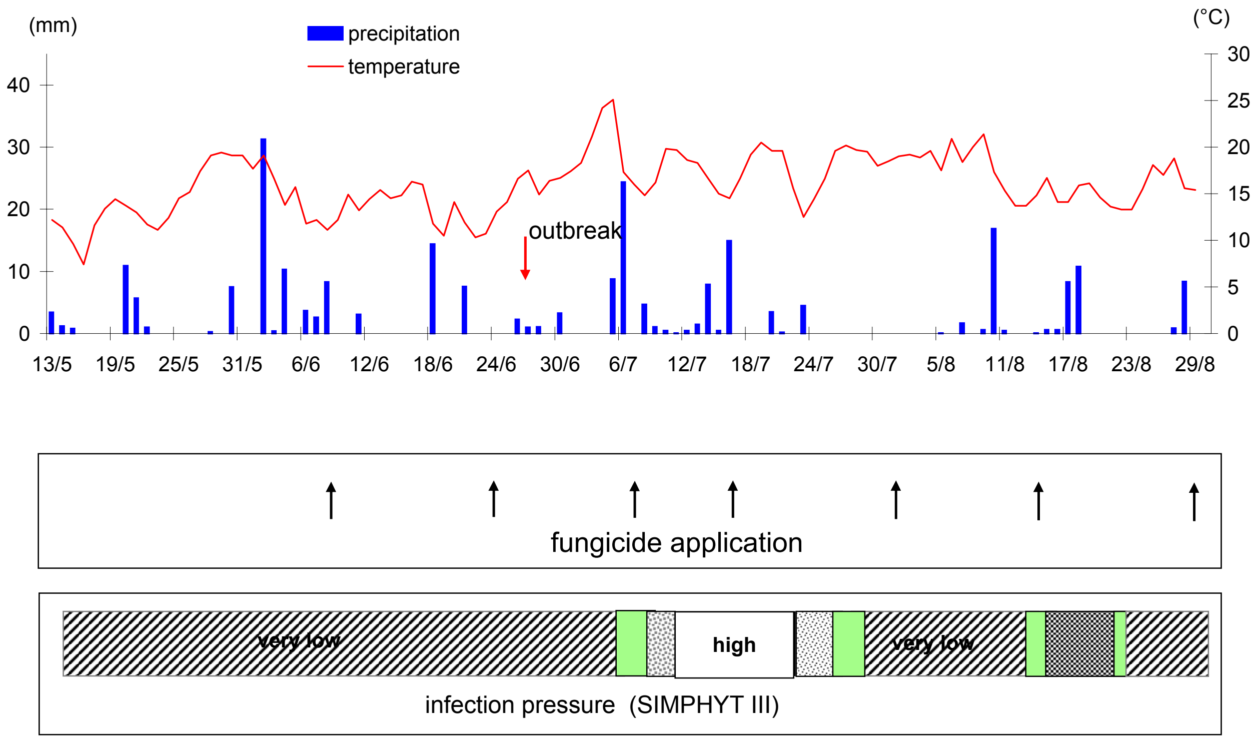

Figure 8. Weather data and infection pressure 1999 (site: Eckendorf, Lkr. Nabburg)

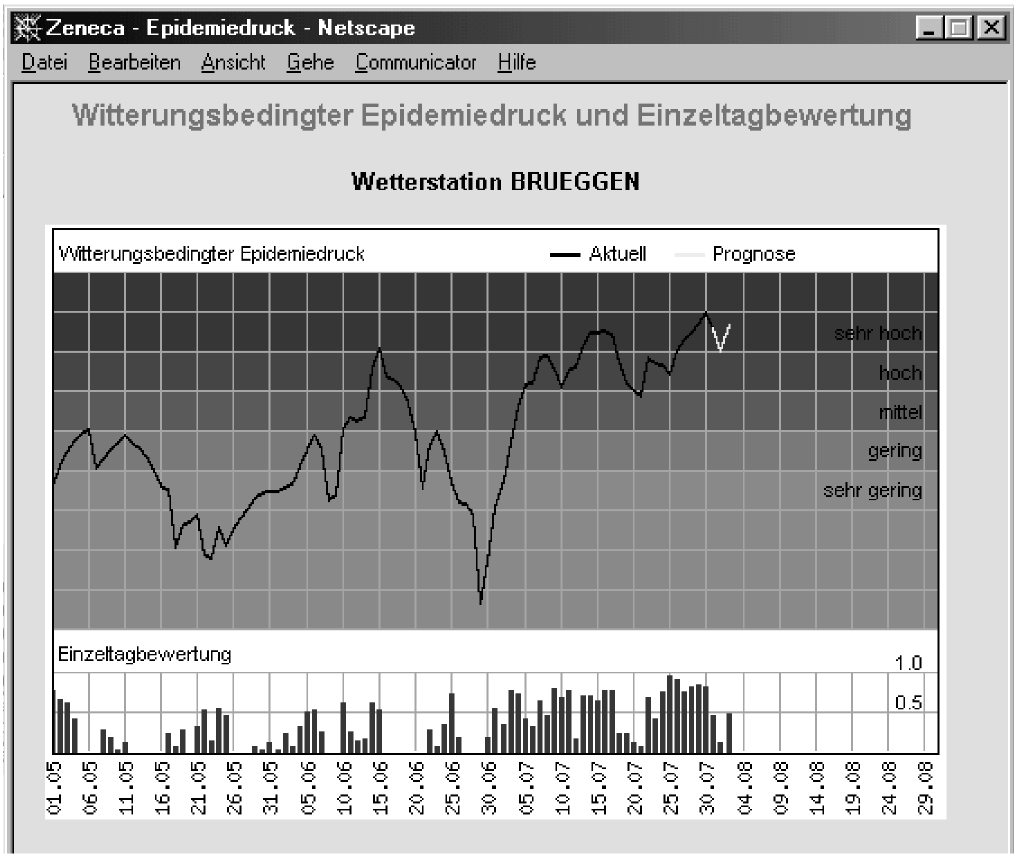

Figure 9. Weather conditioned epidemic pressure and single day evaluation

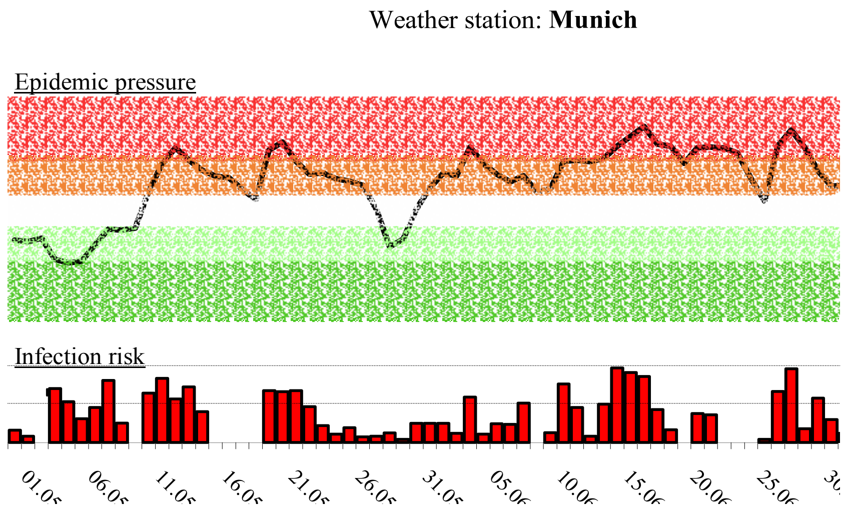

Figure 10. Weather Station Munich

quently grown in the region. These fields belong to potato growing farmers and they contain a fungicide untreated control plot of about 100 sqm. This control plot remains fungicide untreated until first symptoms of blight occur. Control plots and fungicide treated fields will be monitored weekly as mentioned already by recording leaf and stem symptoms. There are at least two or three monitoring fields in the neighbourhood of each weather station.

Both informations – Simphyt results and monitoring – are evaluated and interpreted and after that conclusions concerning fungicide applications are drawn. These conclusions are published weekly in agricultural newspapers. Using the modern communication technology the Phytophthora warning system Weihenstephan is available via World Wide Web. The third way of informing farmers is via official advisors who take the information out of the Internet, record it on an answering machine or send a fax to the potato growers (Figures 9 and 10).

Simphyt I indicating the first fungicide treatment gave good results in 1997 and 1998, but a bit disappointing ones in 1999. The failure in 1999 results from the evidence of heavy rainfalls and high soil moisture after planting the tubers in May, thus providing optimal conditions for early Phytophthora infections by movement of zoosporangia or zoospores in the soil from one infected and sporulating tuber to other noninfected tubers.

These possible infections have not be considered enough in the model!

The following spray program after the outbreak of late blight is recommended according to Simphyt III. Spraying distances should be reduced in times of high epidemic pressure and extended during low infection periods (Figure 11).

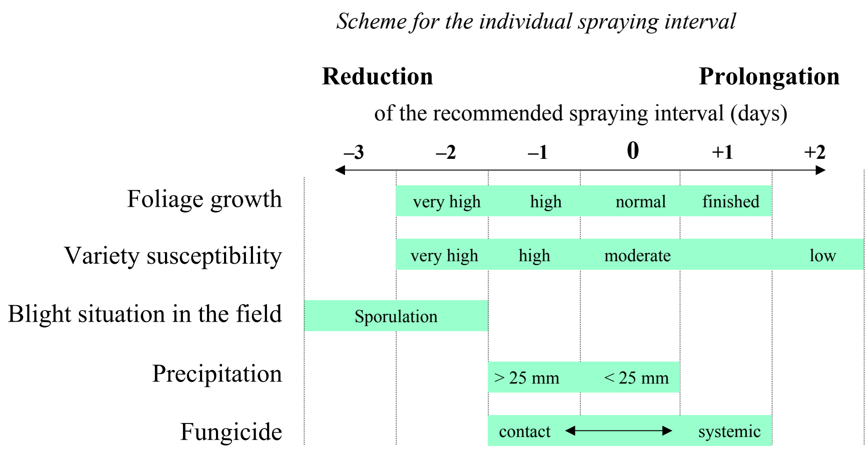

Figure 11. PhytophthoraModel Weihenstephan

As it was mentioned already the Prognosis Model Weihenstephan is extended to the whole of Germany and Austria. The Deutsche Wetterdienst will provide weather stations and weather data, more than 110 farmers from all potato growing regions of Germany participate in the monitoring program which means there are more than 300 fields under observation.

It has to be said that the development of a prognosis model against potato late blight is much more difficult than the one against cereal diseases. The presence of lots of papers concerned with potato late blight is well known. Meanwhile some prognosis models on the late blight are running with differing results. All models need providing to give effective results which may run up to about 95% probability.

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