"PLB-1" ---- A WARNTING SYSTEM ON POTATO LATE BLIGHT IN CHINA

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Abstract Late blight is one of the most important diseases on potato crop. Because most of the varieties in use today are susceptible to the pathogen, spraying chemicals in a routine is the main control measure. In order to save chemicals, improve disease control affectivity and strengthen disease management in a large scale, a warning system "PLB-1" on potato late blight was established. The system includes several subsystems, such as basic knowledge on potato diseases, current situation of late blight, disease forecasting in a near future and feed back of user's information. Disease forecasting was made based on both disease real attacks in surrounding areas and weather forecasting (temperature and precipitation) in the coming 48 hours. In addition, information exchange windows and disease control suggestions are provided. The successful running of the system relies on active participating of disease investigators. As computers are more and more popular, the system will play a more and more important role on spreading knowledge and improve disease control level.

Key words potato late blight, disease forecasting, decision support system

China is the biggest country for its potato production with sowing area of 3.3 million hectares annually. Potato late blight is the most disastrous disease, which causes about one billion dollars in China alone and about 17 billion dollars of economic losses per year in the world (Zhang and Wang, 2001). Because most varieties in use today are susceptible to *P. infestans*, chemical control is necessary to combat the disease (Zeng and Yang, 1986). In central Europe people commonly use 6-8 times of chemical during the growing season. In special wet year, people even spray 20 times of chemical to control the disease (Schepers *et. al.*, 1996). In China, 2-4 times of sprays each year are popular except some companies which spray 8-10 times intensively per year in order to get large amount of commercial potato tubers or seed potatoes. Although there is much difference on chemical use between different countries and in different years, to use chemical as a routine of every week or every two weeks is the common way for most farmers. As a result of this unscientific way of disease control, in the dry year people

are easily to use too much chemical resulting in environment pollution and economic losses, while in wet year the protection for the plants is not enough. In order to save the chemical usage and at the same time to improve the controlling efficiency, some decision support systems have been developed in different countries to guide the chemical use (Keane, 1995; Hansen *et. al.*, 1995).

PhytoPRE is a decision support system, which was developed and used in Switzerland in 1989 (Forrer *et. al.*, 1993). After several years of application, it has been proved that PhytoPRE did give a correct time for the first chemical treatment. However, the number of following treatments is often more than necessary. Detailed research on disease epidemic was carried out during 1995 to 1998 in field (Reckstuhl *et. al.*, 1999). The weather conditions on major infection and sporulation period (MISP) were summarized (Cao *et. al.*, 1996a). Based on MISP conditions, a new version "PhytoPRE+2000" was established and used through Internet in 2000 (Cao *et. al.*, 1996b). Comparing to original PhytoPRE program, it can save about 30-50% of chemical usage in average per year.

Because of the change of agricultural producing structure, potato production in China increases greatly in recent years. However, the level on forecast and control of late blight is much lower than the developed countries. Based on the similar rules of PhytoPRE+2000, a warning system "PLB-1" was developed in 2001. Under the guidance and help of Pest Forecasting Bureau in Agricultural Techniques Extension Center of Chinese Agricultural Ministry, the warning system "PLB-1" will play its function through Internet in 2002.

1. General structure of "PLB-1"

The general structure of "PLB-1" is as follows:

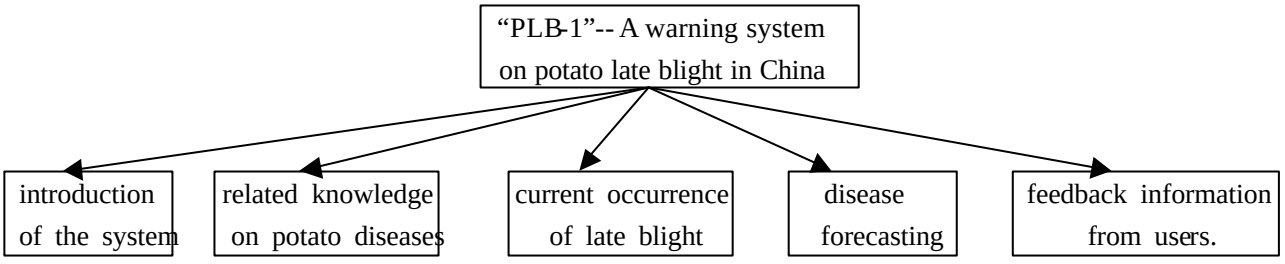

Fig. 1 General structure of the warning system on potato late blight

The whole system is composed of five subsystems. Not only it includes the basic knowledge on late blight, but also it makes disease forecast based on the real attack of the disease and the weather forecast in the near future.

This system in fact is a support decision system, which could help farmers to make decision on whether chemical control is necessary. It helps users to understand the occurrence of late blight in China quickly and also makes it possible for farmers to share experience and valuable information between them.

2 The functions of "PLB-1"

The most important function of the system is to make disease forecast in the near future. The crucial weather conditions for disease infection and sporulation are the principles for making disease forecast. Suitable weather conditions of the near future are the driving force for disease development. Because the pathogen could be transmitted by air, the real occurrence nearby is considered to be the trigger of the epidemic. Only when all the conditions including weather and infection source are met, the disease is supposed to have heavy infection and sporulation. Considering the great differences on agricultural production and the economy situation between China and Switzerland, both disease forecasting and decision making process on "PLB-1" are quite different from those of "PhytoPRE+2000". A common point is that both systems require the active participating of disease inspectors in potato growing areas. A sound disease observing system is the basis for the well performance of the warning system.

2.1 Related knowledge on potato late blight

This subsystem introduces the distribution of potato growing area in the world, the symptoms of potato diseases on different parts of plant, how and when to make disease investigations, some basic knowledge on epidemics and control measures on each potato disease. More than 30 web sites on potato production in the world are listed.

2.2 Current occurrence of late blight

This subsystem includes reporting on the occurrence of late blight and showing the distribution of disease on the map of China.

2.2.1 Reporting on occurrence of late blight

A disease-observing network is necessary for the performance of "PLB-1". Under the help and guidance of Pest Forecasting Bureau in Agricultural Techniques Extension Center of Chinese Agricultural Ministry, a disease observing team of 300 professional people from plant protection stations of different counties in potato growing

area will be organized. The technicians from seed tuber producing farms and companies are the auxiliary source on disease report. At least a nursery of 9 m^2 with susceptible potato variety and without chemical treatment during the whole growing season is required for each observation place. Regular disease investigation is required. The first attack of the disease is a very important signal for the surrounding area, which is a trigger for disease epidemics afterwards. So it is very important to investigate carefully and make report on time. If the disease was found in farmland rather than the observing nursery, the disease attacking report is asked to make immediately also. The contents of the report is as followings.

Table 1 Contents of disease reporting from inspectors

Items	Contents of reporting
Inspector's information	Name_____ Telephone number _____ Communication address _____ Password_____
Disease first attacking time	Year _____ Month_____ Day _____
Place where the disease was found	County _____ Commune _____ Village _____
Current disease incidence	<30%_____ 30-60% _____ >60% _____
The name of potato variety	_____
Reporting time	Year _____ Month_____ Day _____

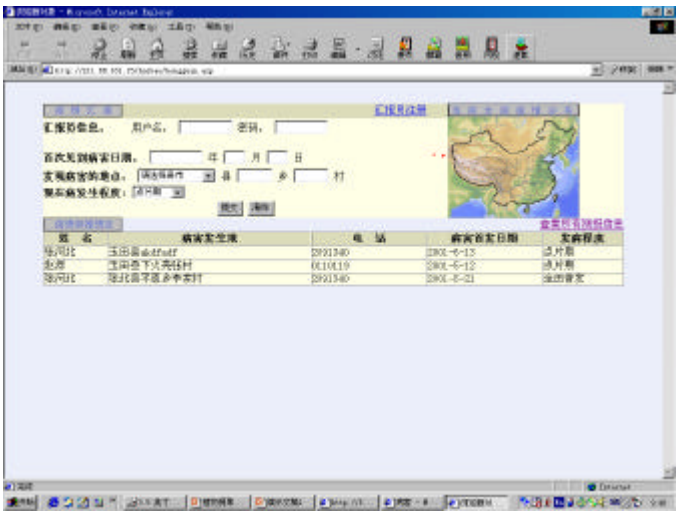

Fig. 2 A web page which shows the way of disease reporting and the information of inspectors

After filled in the above contents, press delivering button. The information above will be transferred automatically to our net center and stored in a database. Inspectors' information and current disease incidence data will be listed on a table in the same web page afterwards (Fig. 2). This table is very helpful for farmers to contact professional disease observers and get something in details. The password will be provided to disease inspectors

in advance. It is just to prevent unrelated people to input wrong message to the system.

2.2.2 Showing the distribution of the disease on a map

If disease is found in a place, a red square will be marked on the corresponding area of the map of China. This is done according to the calculation based on longitude and latitude of the place.

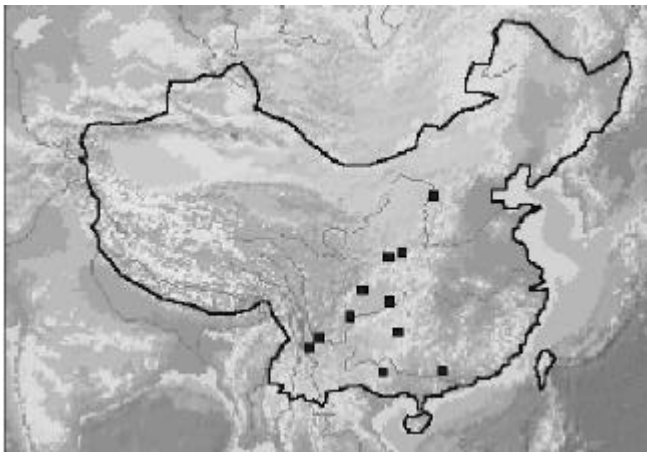

Fig. 3 Current disease occurrence and distribution in China

Fig. 3 shows the occurrence and distribution of late blight in the country. This figure not only helps farmers to know the disease situation in the surrounding area, but also helps leaders in Agricultural Ministry to understand the whole situation in the country. It is very helpful for both farmers and leaders in government to make control decisions at different levels.

2.3 Prediction on Disease trend in the near future

According to our research during 1995 to 1998, the crucial weather conditions for infection and sporulation of the pathogen are:

Periods of 24 hours with
(1) at least 6 hours of precipitation with air temperatures between 10-20?
And
(2) a minimum of 6 successive hours with relative humidity of = 90%

The prediction on disease trend in the near future is based on two aspects. (1) If disease has already occurred in field or in the surrounding area within 100 km. (2) If the weather condition in the near future is favorite for disease infection and sporulation. Squares of different color in a figure will show forecasting results. The yellow color represents “dangerous”; the red color represents “very dangerous” situation; the green color

represents “safe”.

It is possible to get the coming 48 hours of weather forecasting information from television. The contents of the weather forecast include the highest temperature (TH), the lowest temperature (TL) and the possibility of rainfall (P). We use 0, 1 and 2 to represent sunshine, cloudy and rainy climate respectively.

The forecasting process is as follows:

If disease has not occurred in the surrounding area of 100 km, it is very safe for the plants.

If disease has occurred in the surrounding area of 100 km, then check the weather conditions of future 48 hours.

If TL_i= 10? , and TH_i= 20? , and P_i =1, then a yellow square will be shown.

If TL_i= 10? , and TH_i= 20? , and P_i=2, then a red square will be shown.

For the other situations it is safe for plants, a green square will be shown.

Where “$_i$” means date (Fig 4).

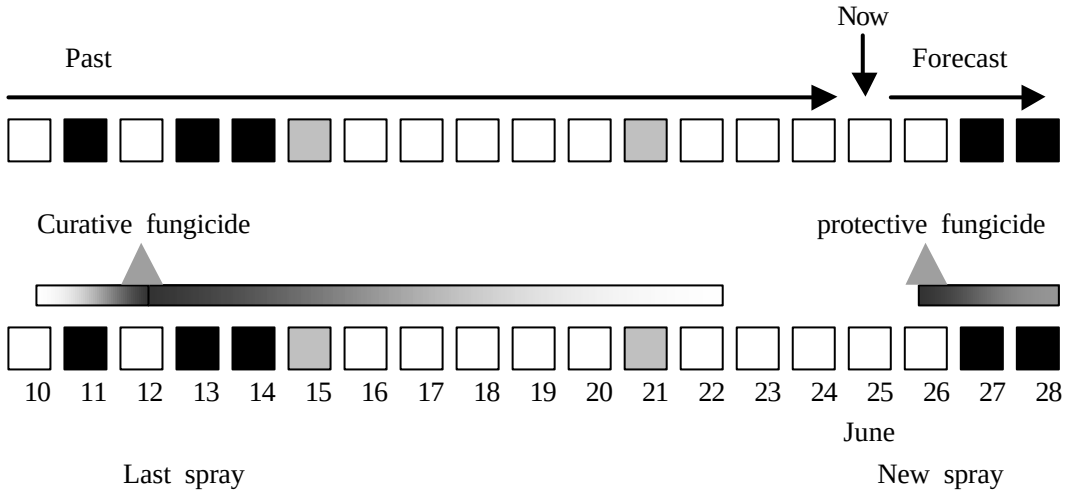

Fig. 4 A desired pattern of chemical protection against *P. infestans*. (The black square here represents the “very dangerous” day, the gray square represents the “dangerous” day, the white square represents “safe” day.)

Because there is weather data logger in field, it is very easy to know if the past weather data have met the crucial weather conditions or not. Relatively it is easy to make decisions on disease control. If the weather conditions were met, which means the pathogens have infected the plants, only curative fungicide is possible to cure the plants.

Considering the current situation in China, the control suggestions are as follows.

Protective fungicide is suggested to use one day before the red alarming day, or curative fungicide should be used as soon as the red alarming day passed. The interval between two sprays is no less than ten days.

2.4 Feedback information

In order to know if the system performed well, a note board is designed for leaving message to all the users. From this information the people of the net center can understand the real situation of the disease, the problems facing to the users. It is a good way to know how to improve the system and make it more reliable and more accurate. For all the users it is also a good way to communicate among them.

3 Problem and prospect

Because China is a big country, the potato-growing season is quite different from south to north and from low altitude to high altitude. In south China potato is planted in autumn and harvested in spring. While in north China potato is normally planted in spring and harvested in autumn. All year round there is potato cultivation in China. However, the infection of surrounding area is the real danger for a special farm. In this warning system, disease attack within 100 km is considered to be the trigger for disease epidemic of the uninfected field. Whether it is correct needs further testing in the future.

At present it is possible for farmers and system users to get weather forecast data from TV and radio. Normally people can get the forecast of temperature and possibility of rainfall 48 hours in advance. After receiving some fees, the meteorological stations also provide special weather forecast of upcoming 7 days. Because no hourly weather forecast is possible in China, here it is supposed that the crucial weather conditions for disease infection and sporulation is met if the coming day is rainy. In another word, if protective fungicide is used following the suggestion of this warning system, people have the possibility to use more chemicals during growing season. This is a difficult point to solve unless the experience of users is very rich.

Because the resistance of different varieties is not under consideration, it is necessary for the users to adjust the control decisions during growing season. Because of the limitation of hard ware, the numbers of users at beginning could be less. However, as the improvement and more popular of computers, the number of users will increase steadily. After application for some periods, modification of the system will be made. It is believed that by the efforts of all the users and participants the system will run well and can improve the scientific level of disease control in large scale.

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