Decision support systems for late blight integrated management in the southern Chile.

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SUMMARY

Potato is an important crop in Chile and represents a vital part of the agriculture. The major potato disease in Chile is late blight. In previous studies Blitecast was calibrated and used to evaluate chemical control strategies and the interaction with cultivar susceptibility and agronomic management season, with big success. With the results and the network of meteorological stations of INIA between the Bio-bio and the Los Lagos regions, has been implemented an late blight early warning system to support decisions of potato farmers in southern Chile, using tools of information and communications technologies such as an application that delivers information to farmers via SMS and e-mail. The early warning system of late blight is inserted in an integrated management strategies for disease control. The use of information technologies (SMS & email) for the late blight early warning system in southern Chile will allow farmers to have better support to decision making. It is expected to increase the number of system users by facilitating the access to information, specially farmers.

KEYWORDS

Early warning system, late blight, agrometeorological station network

INTRODUCTION

Potato is an important crop in Chile and represents a vital part of the agriculture and economy. The major potato disease in Chile is late blight, caused by *Phytophthora infestans*, which spreads fast and attacks vast areas if weather conditions are favorable. The disease can affect plants at any growing stage depending on inoculum and weather. An integrated disease management plan for disease control considers the knowledge of the genetic characteristics of the pathogen population, the relative susceptibility of the host and the proper timing of chemical controls based on weather conditions favorable for the disease. Since 2003, the Agricultural Research Institute of Chile (INIA), associated with public and private institutions, developed a study which main objective is to implement an integrated pest management for late blight based on a disease forecasting system. After studying different late blight models, the Blitecast was calibrated and used to evaluate chemical

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control strategies and the interaction with cultivar susceptibility and agronomic management season, with big success. This forecast system is based in an automatic weather network, late blight model processor and web page information.

Since, wireless communication system begun to be important in rural areas of southern Chile, this season, the INIA forecasting system will use technologies such as Short Messages Service (SMS) and e-mail. With the use of this method the farmers will receive the late blight warning quickly and easily and therefore to make better management decisions. This new system will give access to those who did not have it for internet connectivity problems and also will improve the information access.

MATERIALS AND METHODS

The early warning system of late blight has three components, which allows the generation of information for the users and spread it readily and efficiently. These components include a network of automatic meteorological stations and corresponding database; a processing model, where estimates the conditions for the development of the late blight; and an information system, using tools of information and communications technologies. The model of the system can be seen in figure 1.

Meteorological station network

The network of INIA's meteorological stations are localized in various parts of the Chilean territory, however, for the early warning system of late blight, the data used comes from the stations that are located in the southern Chilean areas, between the Bio-bio and the Los Lagos regions. Here more than 73% of the surface is used for crop cultivation and produces 80% of the potatoes in Chile. This network is composed of 31 automatic meteorological stations, where temperature variables, relative humidity and precipitation on hourly basis were used as an input for the Blitecast model, which was validated under the conditions of Chile (Acuña *et al.* 2009).

Information technology

This system uses tools of information and communications technologies so the users can obtain quickly the warning information. The media used are the e-mails and the short messages service (SMS), which are sent through the system every day when an event of late blight, takes place.
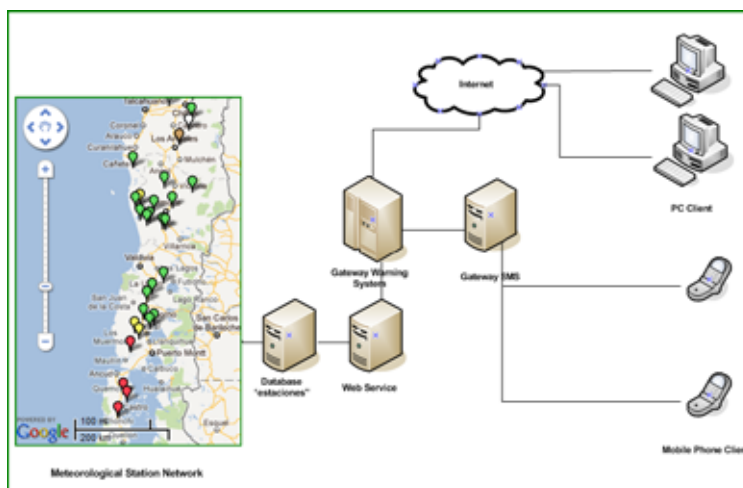

Figure 1. Late blight alert system structure.

RESULTS AND DISCUSSION

The early warning system of late blight is inserted in an integrated management strategies for disease control, minimizing the impact and damage on potatoes. Under these conditions, the web page of the early warning system is a site of information that offers a set of tools for the users that allows an improvement in the decision taking in the control of late blight in the south of Chile. These tools are:

The website

Corresponds to home page of the website (figure 2) and contains sections where users can find information about late blight and *Phytophthora infestans*. Here are present the following sections:
Documents and photographs: corresponding to publications by INIA for the divulgation of different topics for the recognition of symptoms, integrated management, strategies evaluation, etc.

Figure2. Home page the late blight alert system web page (http://tizon.inia.cl)

The objective is that the users can know more about late blight and how the alert system can help them to take better decisions to control late blight.
News and events: facts and events are published and that can be of interest for the system users, like seminars, interviews, etc.

Late blight forecast system
It is where the web page is based, since it is where the information is generated from late blight daily development conditions. The information of the warning system is published in the website and the users can visualize them for the conditions present in all of the monitored sites, through a map where the automatic meteorological stations are located, using the Google Maps® technology (figure 3(a)). In the map, it is indicated with a color the conditions current according the meteorological data measured. The colors indicate the different condition category;

Green: There are NO conditions for the development of late blight.
Yellow: There are LOW conditions, must be alert for the conditions in the next few days.
Orange: Conditions are MID-LEVEL for the development of late blight.
Red: There are HIGH conditions for the development of late blight.

Another way to visualize the information is as indicated in figure 3 (b), where it is possible to observe the conditions for the development of late blight through out the season and for every meteorological station that is chosen. In the bottom axis it can be seen the dates from the start of the season and every color indicates an alert category in the same way as described before.

Figure 3 (a and b). Daily information display in http://tizon.inia.cl.

Through out these two ways the user can have a complete view on the meteorological conditions that have existed in the area where the crop is grown and that allows a correct decision on the crop protection.

Late blight warning messages
By the propagation characteristics of *P. infestans*, it is necessary that the information is delivered as soon as possible to the potato farmers, so this way it can be timely for the decision making. However, in the more rural sectors of Chile, the connectivity to internet is low, but the use of mobile phones is a communication medium that has a great coverage over the Chilean territory. For these reasons, this system has incorporated an application that delivers information to farmers via SMS. This service guarantees that the information can be sent directly to the users and they can see it any time of the day. For this, in registers of system, the farmers must enter their mobile phone number and the meteorological station of which receive late blight warning. If the users register his or her e-mail, they will receive the information also by this medium. Once completed all the steps, the system will send the information through SMS and/or e-mail to all the users according to the meteorological station to which they registered. An example of the message can be observed in table 1.

Table 1. Settings of some messages sent to the users through email and/or SMS.

Alert Category	Message sent by email	Message sent by SMS
Yellow	Dear User: According to the data of the metrological station to which you are associated, there is a YELLOW ALERT. Check the crop the next few days and the state of the other meteorological stations of our network by visiting http://tizon.inia.cl.	YELLOW ALERT. Check the crop the next 3 days. Visit http://tizon.inia.cl.
Orange	Dear User: According to the data of the metrological station to which you are associated, there is an ORANGE ALERT. It is recommended to apply fungicides every 10 days. Check the state of the other meteorological stations of our network by visiting http://tizon.inia.cl	ORANGE ALERT. There are médium conditions for the development of late blight. Visit http://tizon.inia.cl.
Red	Dear User: According to the data of the metrological station to which you are associated, there is an RED ALERT. It is recommended to apply fungicides every 7 days. Check the state of the other meteorological stations of our network by visiting http://tizon.inia.cl	RED ALERT. There are high conditions for the development of late blight. Visit http://tizon.inia.cl.

CONCLUSIONS

INIA late blight forecast system is working very successful since 2006. Today, the system shows a registration of 461 users, however, they have difficulties in access to information because of connectivity problems. The use of information technologies (SMS & email) for the late blight forecast system in southern Chile will allow farmers to have better support to decision making. It is expected to increase the number of system users by facilitating the access to information, specially farmers.

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