FIRE BLIGHT RISK ASSESSMENT IN GIRONA REGION (CATALONIA): COMPARISON OF MARYBLYT AND COUGARBLIGHT MODELS

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SUMMARY

Fire blight is a serious disease of apple and pear in some areas of Catalonia (Northeastern Spain). However, fire blight has only been detected in a few trees of two orchards in Girona region in the last 10 years. The first detection took place in 2007 on pear and the second one occurred in 2013 on apple. All the trees in the affected orchards were eradicated according to the legal measures. Fire blight can quickly become an epidemic in Catalonia, for this reason an intensive surveillance has been done in the last years through rigorous disease monitoring. In order to have a better guidance for inspection, two fire blight predictive models were used: Maryblyt and CougarBlight. The fire blight risk was established during 2013, 2014, 2015 and 2016 on pear (cv. Conference) and apple (cvs Fuji, Gala, Golden and Pink Lady©) using meteorological and phenological data of three representative locations. A detailed analysis was also performed in an apple orchard placed near to the location where the last outbreak had been detected in 2013. Results showed that CougarBlight is more appropriate than Maryblyt when the disease is not present in the area using the scenario 1 (no fire blight in neighborhood orchard last year); according to CougarBlight the overall fire blight risk in Girona was low or moderate. When forecasting models are used to guide the inspections in orchards, Maryblyt or CougarBlight with scenario 3 (fire blight is now active in the neighborhood orchards) are useful.

Keywords: Maryblyt, CougarBlight, Fire blight risk.

INTRODUCTION

Fire blight, caused by the bacterium Erwinia amylovora (Burr.), is an important and destructive disease of apple, pear and other trees and ornamental plants of the Rosaceae family. The disease was first described in North America, but it has been reported in Europe, West Asia and New Zealand (Dewdney et al., 2006). In Europe, Erwinia amylovora is considered a quarantine organism (EPPO, 2016). When a quarantine pathogen is detected for the first time in a new area, eradication is the most effective control method, but in the European Union (EU) the long-term eradication has not been achieved successfully (Bonn and van der Zweet, 2000; Palacio-Bielsa et al., 2012). Despite this, the eradication measures are necessary to delay the outbreak of the epidemics. Erwinia amylovora was detected for the first time in Spain in 1995 (López et al., 1999; Palacio-Bielsa et al., 2012), and since then new outbreaks have been reported in other areas in Spain. Girona is an important apple growing area located in the northeast of Catalonia (3000 ha of apple, 300 ha of pear and 8.5 ha of ornamental plant and fruit on nurseries), where fire blight has only been detected in a few trees of two orchards in the last 10 years. The first detection was in 2007 on cv. Conference pear trees in Bordils (5 ha) and the second one occurred in 2013 on cv. Pink Lady© apple trees in Torroella de Montgrí (1 ha). The entirely trees of the affected orchards were eradicated according to the legal measures. Fire blight can quickly become an epidemic, for this reason an intensive surveillance has been done in the last years through rigorous disease monitoring. Disease forecasting models are tools that can help the guidance for inspections by predicting accurately when infection episodes may have taken place.

Different fire blight warning systems have been developed, and Maryblyt (Steiner and Lightner, 1996) and CougarBlight (Smith, 1999), used in North America, are the best known ones. These two models have been also evaluated in different European countries such as Italy (Bazzi et al., 1996; Casoli et al., 2006). The Maryblyt model was used in Spain for assessing the fire blight risk from 1997 to 2006 in the Aragon region and to relate the risk levels with the symptoms observed in orchards (Llorente et al., 2002; Palacio-Bielsa et al., 2012). CougarBlight and Maryblyt models differ in the way the disease risk is calculated.
Maryblyt uses weather and phenological data to identify the conditions conducive to infection events and symptom development (blossom, canker, shoot and trauma blight) (Shtienberg et al., 2003). CougarBlight also uses weather and phenological data, but only to predict blossom infections. There are some relevant differences between the two forecasting systems: 1) the period in which the fire blight risk is established, as described above; 2) Maryblyt is based on daily mean temperatures and CougarBlight on the daily high temperatures; and 3) Maryblyt assumes that the inoculum is high in the orchard, whereas different levels of inoculum pressure are considered in the CougarBlight model on the basis of the fire blight history and the different scenarios simulated. These differences were included in the CougarBlight model by Smith because the other models performed poor predictions in the Pacific Northwest (Smith, 1999; Dewdney et al., 2007).

The objective of this work was to analyse the fire blight risk assessment in Girona region and to compare Maryblyt and CougarBlight model predictions.

**MATERIALS AND METHODS**

**Description of fire blight prediction systems.** Maryblyt model was developed by Steiner and Lightner (1996). The model predicts specific infection events and symptom development of blossom, canker, shoot and trauma blight, and can be used in apple and pear orchards. Criteria for blossom infections are: 1) the blossom must be open with stigmas and petals intact; 2) epiphytic inoculum potential (EIP) is greater than 100; 3) more than or equal to 2.5 mm of rain on the day or on the previous day; 4) an average daily temperature ≥ 15.6°C. During the blooming and post-blooming period, four levels of risk are obtained: low, moderate, high and infection. Blossom blight symptoms will appear after 57 cumulative degree days above 12.7°C (Steiner and Lighter, 1996; Shtienberg et al., 2003).

Maryblyt runs on computer and needs daily minimum and maximum temperature, rainfall, leaf wetness and trauma. Versions 7.0 and 7.1 of the Maryblyt were used in this study.

CougarBlight forecaster was originally developed by Smith (1999) and has been modified and updated (Smith and Pusey, 2011). The CougarBlight 2010 (Celsius) version 5.0 was used in this work. The model may be used in apples and pears. Temperature data is used by the CougarBlight model to estimate the growth rate of fire blight bacteria (*Erwinia amylovora*) over the past three days plus the present day. The risk of fire blight is calculated daily during the blooming period and considers the blossom wetting from dew or rain. Four levels of risk are generated: low, caution, high and extreme. In the version 5.0 of CougarBlight the fire blight history is used as an indicator of the potential pathogen presence (Smith and Pusey, 2011) and three scenarios are possible: scenario 1) no fire blight in neighborhood orchards last year; scenario 2) fire blight occurred in neighborhood orchards last year; scenario 3) fire blight is now active in the neighborhood orchards. The predicted disease risk level depends on the scenario.
The fire blight risk was established during 2013, 2014, 2015 and 2016 on pear (cv. Conference) and apple (cvs Fuji, Gala, Golden and Pink Lady®) orchards located in three different areas of Girona (northeastern Catalonia, Spain). Phenological data, especially during the bloom and postbloom period, were provided by the orchard cooperators. Daily maximum and minimum temperature, rainfall and dew period were obtained from weather stations of the Agrometeorological Net Services of Plant Health Service (Government of Catalonia). These remote stations (model CR10X, Campbell Scientific Ltd., Leicester, UK) were placed near to the pear and apple orchards in the three areas of study (Fig. 1). The levels of fire blight risk according to Marybltyt and CougarBlight models were calculated daily during the four years of study (2013 to 2016). In CougarBlight model the inoculum potential was the scenario 1 (no fire blight in neighborhood orchard last year). In order to compare the two forecasting models, the risk was classified into four levels according to Marybltyt, named low, moderate, high and infection. These levels corresponded to low, caution, high and extreme, respectively, in CougarBlight model. The number of days corresponding to each risk level during the blossom period for each cultivar and orchard were compared.

As reported previously, *E. amylolea* was detected in few cv. Pink Lady® apple trees from an orchard located in Torroella de Montgrí (Girona) in 2013. The entirely trees of this orchard were eradicated. Considering that the situation of the potential inoculum in this orchard was different from the other ones and with the purpose to determine the evolution of fire blight risk in this area and the efficacy of the eradication method, a detailed risk analysis was performed. Weather data were obtained from a climatic station placed in an apple orchard (cv. Pink Lady®) near where the outbreak was detected, in Torroella de Montgrí (Fig. 1) and the phenological data were also obtained from this orchard. The fire blight risk was calculated for 2012 (using historical data), 2013, 2014, 2015 and 2016 through Marybltyt and CougarBlight forecasters as described previously, but considering the scenario 2 (fire blight occurred in neighborhood orchard last year). The number of days for each risk level during the blossom period was compared.

**RESULTS**

No fire blight symptoms were detected in the orchards evaluated during the years of this study.

The summary of days with each level of fire blight risk according to each forecasting model is presented for each year and cultivar in three different locations: La Tallada d’Empordà (Fig. 2), Torroella de Fluvia (Fig. 3) and Vilobi d’Onyar (Fig. 4). In general, the levels of fire blight risk predicted by Marybltyt were higher than those predicted by CougarBlight when using scenario 1 (no fire blight occurred in neighborhood orchard last year).

The overall fire blight risk based on phenoclimatic conditions in apple and pear tree cultivars evaluated in Girona region was low or moderate according to CougarBlight model in 2013, 2014, 2015 and 2016 (Fig. 2, 3 and 4). No days with high or infection risk (corresponding to high and extreme) were predicted by CougarBlight, and only low or moderate risk indexes were forecasted in the three locations for different cultivars of apple and pear. Marybltyt forecasted an overall risk higher than CougarBlight model. Some days, between 1 to 10, of high infection risk were predicted by Marybltyt model in most apple and pears cultivars in 2013, 2014 and 2016. In 2015, one or two days reached the highest risk level (infection) in cvs Fuji, Gala and Golden apple orchards from La Tallada d’Empordà. In one day, the same high risk level (infection) was achieved in pear (cv. Conference) and apple (cvs Fuji,
Gala, Golden and Pink Lady© orchards from Torroella de Fluvià and in a cv. Conference pear orchard located in Vilobi d’Onyar.

A detailed analysis of fire blight risk performed in a neighboring orchard where the last outbreak had been detected in 2013 (Torroella de Montgrí), showed that the model Maryblyt predicted two days of infection risk in 2013 (Fig. 5). According to this model, the phenoclimatic conditions of this orchard where only favorable to E. amylovora infections in 2013, and no infection risk was predicted for 2012, 2014, 2015 and 2016. On the other hand, CougarBlight forecaster using the scenario 2 (fire blight occurred in neighborhood orchard last year) did not predict infection risk in 2013, only high risk. CougarBlight predicted infection in 2013 only when the scenario 3 (fire blight is now active in the neighborhood orchard) was used (data not shown).

DISCUSSION

The objectives of the work presented herein were to use the fire blight–risk systems to obtain general information about the phenoclimatic fire blight risk in Girona region and to increase the accuracy of inspections for disease monitoring in orchards. The forecasters were not used for timing control measures since the disease is not established in the area of study. In fact, no fire blight was detected during the whole years forecasted in the apple and pear orchards evaluated, except for an orchard which was analyzed individually.

The difference between Maryblyt and CougarBlight systems in relation to the inoculum potential is very important in areas where fire blight disease is not present. Maryblyt assumes that the inoculum is always present in the orchard, so in areas where the disease is not established,
et al. to risk assessment difficult to estimate (Shtienberg pointed out that the disease is sporadic in space and time, making epidemiological studies and orchard trials difficult to plan and the relative value of different approaches to risk assessment difficult to estimate (Shtienberg et al., 2003). The sporadic behavior of fire blight must be taken into consideration when designing inspections in orchards. Guidance inspections in Girona are focused to detect the disease through symptom observations. Although fire blight is not present in the region, and therefore the level of inoculum potential is low, the use of CougarBlight model with scenario 3 is recommended. If scenarios 1 or 2 are used instead, the level of risk will probably be low or moderate and the model will not be useful to predict the days when infections may occur. Maryblyt forecaster is more appropriate for this purpose. The analysis performed in the location where fire blight was detected showed that the dates with infection risk level predicted by Maryblyt and CougarBlight with scenario 3 were similar. Similarly, both forecasters agreed in fire blight high or infection risk predictions under different geographical areas in North America or Hungary, showing only few differences between the forecasters (Dewdney et al., 2007).

In previous studies in Aragon region (Northeastern Spain), a close relationship between the dates when symptoms were predicted by Maryblyt forecaster and the dates when symptoms were observed in the orchard was obtained (Palacio-Bielsa et al., 2012). However, additional studies are necessary to determine accurately when infection periods are likely to happen using Maryblyt and CougarBlight under Girona region conditions.

No symptoms have been observed since 2013 in the neighborhood of the orchards where the disease was observed and trees were completely eradicated. But this fact does not indicate that the pathogen is totally absent in this area, since during the years analyzed there has not been the phenoclimatic conditions necessary for the production of infections according to the two models.

According to results obtained in the present study performed in Girona region, it can be concluded that CougarBlight may be appropriate to determine the overall fire blight risk in large areas. Additionally, the possibility to introduce the disease history in the model increases its accuracy when the disease is not established in the area. Maryblyt seems to be more appropriate to be used as a tool for scheduling the disease surveillance sampling in orchards and for determining the local risk of fire blight, and the prediction of evolution of symptoms increases the information provided. Similar conclusions were obtained in Italy (Casoli et al. 2006). CougarBlight may also be used to guide the inspections in orchards when using the scenario when symptoms were predicted by Maryblyt forecaster and the dates when symptoms were observed in the orchard was obtained (Palacio-Bielsa et al., 2012). However, additional studies are necessary to determine accurately when infection periods are likely to happen using Maryblyt and CougarBlight under Girona region conditions.

Orchard inspection is critical to detect *E. amylovora* infections in order to take measures as eradication, and warning systems such as CougarBlight and Maryblyt can be very efficient tools to achieve it.

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