Control of *Monilinia* spp. and *Rhizopus* spp. in stone fruit using new strategies that do not leave residues when harvested

Summary

The GOMORI Operational Group was created with the main objective of controlling post-harvest diseases in peaches and nectarines, caused by *Monilinia* spp. and *Rhizopus* spp. using strategies that do not leave residue on the fruit when harvested, in order to achieve more sustainable production and gain access to the most demanding markets. Brown rot due to *Monilinia* spp. is the main disease affecting stone fruit in our area of production. *Rhizopus* spp. is another of the major pathogens that affect stone fruit, causing soft rot, and its prevalence in our area of production has increased in recent years. Despite the incidence of stone fruit affected by soft rot, no reliable information is currently available on the effectiveness of fungicides to control it. Furthermore, the design of pest and disease control strategies in the field does not include effective products for the control of this disease. The situation as regards *Monilinia* spp. is very different, as programmes for applying synthetic fungicide products throughout the crop's entire phenological cycle in order to bring the disease under control are being designed. Fruit production is currently facing a scenario in which it must comply with the applicable legislation and meet the requirements and demands of consumers, and as such it is necessary to innovate and redesign the disease control strategies which are applied so that they do not create residue on the end product. In this context, the Operational Group GOMORI "Control of *Monilinia* spp. and *Rhizopus* spp. in stone fruit using new strategies that do not leave residues when they are harvested" was established in 2019. The production and marketing sector is involved in the execution of the project, through the companies Fruits de Ponent d'Alcarràs (Lleida), Agropecuària and the credit section of Soses SCCL and SAT Fruita d'Alcarràs. The scientific and technological sector is involved through the IRTA.

Objectives

The primary objective is to control post-harvest diseases of peaches and nectarines caused by *Monilinia* spp. and *Rhizopus* spp., using strategies that leave no residue when the fruit is harvested.

The following specific objectives were established in order to achieve this overall objective:

Determine the products that leave no residue on the fruit which are most effective for controlling *Monilinia* spp. and *Rhizopus* spp., and: 1) The time frame for their application in the field (by calendar or by model) and/or post-harvest; 2) The effect of applying them as preventive or curative treatments.

Determine the maximum time in which effective synthetic chemicals for the control of *Monilinia* spp. and *Rhizopus* spp. can be applied in the field without any residue appearing on the surface of the fruit when it is harvested.

Determine the field and post-harvest conditions that foster the development of *Monilinia* spp. and *Rhizopus* spp., and determine possible preventive and cultivation measures that limit their development. The volatile compounds emitted by the fungi that cause these rots will also be determined for use as biomarkers to predict their appearance.

Develop and validate an integrated management strategy for the control of diseases caused by *Monilinia* spp. and *Rhizopus* spp. that leaves no residue on the fruit at the time of harvest.

Assess the profile of volatile compounds in fruits inoculated with *Monilinia* spp. and *Rhizopus* spp. and identify possible predictive biomarkers for those diseases.

Description of the actions carried out in the project

The actions carried out are described below:

1- Assessment of the effectiveness of a wide range of alternative products to chemicals to control *Monilinia* spp. and *Rhizopus* spp., and optimisation of their application taking their curative or preventive effectiveness into account.

2- Determine the effectiveness of various zero residue strategies applied in the field at the microplot scale to control *Monilinia* spp. and *Rhizopus* spp. in peaches and nectarines.

3- Compile all available information about when fungicide products should be applied to control *Monilinia* spp. and *Rhizopus* spp. in stone fruit, so that its residues are not detected on the surface of the fruit when harvested.

4- Study the location of the propagules of *Rhizopus* spp. in the field at times close to harvest.

5- Study the eco-physiology of *Rhizopus* spp. depending on the temperature and relative humidity in *in vitro* and *in vivo* conditions.

6- Determine the effect of chlorine on the viability of *Rhizopus* spp. conidia, and the effect of water temperature on the effectiveness of chlorine for controlling *Rhizopus* spp.

7- Determine which cultural methods could help to control the presence of fruit affected by *Rhizopus* spp. in stone fruit and their effectiveness.

8- Evaluate the periods for determining the volatile compounds of inoculated samples and control samples of the stone fruit varieties tested.

9- Based on the results obtained in the actions above, a strategy was designed to control *Monilinia* spp. and *Rhizopus* spp. in peaches and nectarines that does not lead to the presence of residues on the fruit when harvested.

Final results and practical recommendations

The major results obtained with the execution of this project are listed below. The information provided was very useful, and a significant proportion can be applied immediately by stone fruit producers.

Zero residue strategies were designed and assessed in the field based on the results obtained in the laboratory studies in the first year. When used in the field about a month before harvest, the chemicals authorised for use in stone fruit to control *Monilinia* spp. and/or *Rhizopus* spp. were detected in multi-crop residue analyses. The strategies designed by calendar therefore mostly incorporated zero residue products, which were mainly Amylo-X, Serenade Max, Curatio and Julietta.

Cultural methods for the control of *Monilinia* spp. were extensively studied, and green pruning and propagule removal a few days before harvest were found to improve control of the disease. The execution of this project showed that propagules of *Rhizopus* spp. are mainly located in the soil of the farms, which has led to the addition of a third cultivation practice based on maintaining plant cover on the farms, which acts as a physical barrier to the dispersal of propagules from the soil to the fruit on the trees.

Based on all this information, zero residue strategies applied in the field were designed and validated and complemented with post-harvest treatments in the third year of the project. Three different situations were identified:

The level of disease in the field and post-harvest is low in early varieties, and the effectiveness of the zero residue strategy is the same as for the conventional strategy.

For mid-season varieties, in general the level of disease recorded for the zero residue strategy was generally higher than for the conventional strategy. In these cases, the results did not improve when a zero residue product was applied post-harvest to the zero residue fruit from the field. If a chemical (fludioxonil) is applied post-harvest, the effectiveness of the zero residue field strategy is comparable to the conventional strategy.

Finally, there is a risk that the losses for September varieties will be significant, as the application of the post-harvest chemical (fludioxonil) is no longer sufficient to match the level of disease compared to the conventional strategy applied in the field.

This project involved an in-depth study of *Rhizopus* spp. Sodium hypochlorite was found to be effective in controlling this fungus, regardless of water temperature. The optimum growth temperature was also observed to be around 30°C, while for *Monilinia* spp. it was 25°C. These field pathogens therefore require different treatments. Another relevant factor observed was that the fungus was unable to infect fruit inoculated with *Rhizopus* spp. and stored at 0°C, or to develop. In addition, after seven days of storage at 0°C, when the fruit is at 20°C (shelf life) the incidence of affected fruit begins to decline to almost 0% rotten fruit when the fruit has been preserved for up to four weeks at 0°C.

Furthermore, the profile of volatile compounds in the 'Nectatinto' variety artificially inoculated with *Monilinia* spp. and *Rhizopus* spp. was observed over two consecutive campaigns, and compared with their respective controls in 3 conservation periods (harvest, 20 and 40 days at 0°C). The results showed a change in the concentration of certain volatile compounds, which could be used as predictors of both diseases.

Conclusions

Carrying out this project showed the importance of studying the epidemiology of diseases when endeavouring to control them. Cold storage of the stone fruit before sale could help to limit the development of *Rhizopus* spp., and therefore prevent losses caused by this fungus. In this context, it should be remembered that other fungi that also affect stone fruit such as *Monilinia* spp. and *Geotrichum* spp., are able to continue growing, although they grow more slowly in cold storage conditions.

The application of cultural methods during stone fruit production is no guarantee that the final level of disease will be lower, but it increases the likelihood of this. Their implementation must be considered under conditions that are very favourable for the development of the disease or for more sustainable production strategies that include zero residue products. They were therefore included in the zero residue strategies designed and assessed under semi-commercial conditions.

Finally, the semi-commercial validation of the zero residue strategies showed that they have the same level of effectiveness as the conventional strategy if the incidence of the disease in the field is low. However, the level of incidence of the disease was higher than when the conventional strategy was used for late varieties with a higher propagule pressure. In these cases, applying a post-harvest chemical treatment with the Scholar product would restrict the disease to levels similar to those recorded for the conventional strategy. For varieties from late August onwards, the risk of applying a zero residue strategy is high, and other production strategies should be designed in these cases. These must also be sustainable, but contain chemicals when the prediction model indicates a risk of disease.

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Subject area(s) of application

☒	Agricultural production system
☒	Agricultural practice
☐	Agricultural equipment and machinery
☐	Livestock farming and animal welfare
☒	Vegetable production and horticulture
☐	Landscape / Territorial management
☒	Pest and disease control
☐	Fertilisation and nutrient management
☐	Soil management
☐	Genetic resources
☐	Forestry
☐	Water management
☐	Climate and Climate Change
☐	Energy management
☐	Waste and by-product management
☒	Biodiversity and environmental management
☐	Food quality/processing and nutrition
☐	Supply chain, marketing and consumption
☐	Competitiveness and agricultural and forestry diversification
☐	General

Geographical area(s) of application

PROVINCE(S):
Lleida

REGION(S):
El Segrià, La Noguera, El Pla d'Urgell, L'Urgell, La Ribera d'Ebre

Dissemination of the project: publications, seminars, multimedia, etc. (State links)

Poster

Neus Teixidó. 2019. Control of *Monilinia* spp. and *Rhizopus* spp. in stone fruit using new strategies that do not leave residues when they are harvested). Seminar at the IRTA Experimental Station Day in Mollerussa.

Dissemination article

Carla Casals, Pilar Plaza, Laura Vilanova, María Sisquella, Rosario Torres, Neus Teixidó. 2021. *Geotrichum* spp. y *Rhizopus* spp. enfermedades emergentes en fruta de hueso. ¿Qué sabemos de ellas? Horticultura, Dossier: Fruta de hueso, 18-23.

Oral Presentation

Carla Casals. *Geotrichum* spp. and *Rhizopus* spp. – emerging diseases in stone fruit. What do we know about them? XIX Post-Harvest Technical Seminar. 27 May 2021. Online.

Dissemination report

Control de *Monilinia* spp. i *Rhizopus* spp. en fruita de pinyol mitjançant noves estratègies que no deixin residus en el moment de la collita. (https://www.fruitsdeponent.es/node/2164).

More information on the project

PROJECT DATES	TOTAL BUDGET
Starting date: July 2019	Total budget: €178,557.00
End date: September 2021	DARP funding: €72,972.54
Current status: Executed	EU funding: €55,049.46
	Own funding: €50,535.00

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Order ARP/133/2017 of 21 June, approving the regulatory bases for grants for cooperation for innovation by promoting the creation of European Association for Innovation operational groups in the areas of agricultural productivity and sustainability and the execution of innovative pilot projects by those groups, and Resolution ARP/1282/2018, of 8 June, announcing the call for the grant.

Generalitat de Catalunya
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