www.agrimeteo.eu: web platform combining weather data, IoT sensors and modelling for precision management of crops

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Abstract

Newfarm Agriconsult is a network of experts with the main objective of supporting operators to lower inputs in agriculture and coaching them in precision crop management. Over the years, we developed an infrastructure of web services giving access to data of remote sensors and formatting them automatically for integration in most existing decision support systems (DSS). Data are real-time measurements (air and soil sensors), weather forecasts or virtual calculated parameters. Lately, pictures are also used in different tools as insect traps. For orchard and vineyard management, the platform integrates disease and pest models like Rimpro, Fruitweb, Fieldclimate, Cipra, Inoki, etc. A specific tool gives best spraying windows for selected chemicals. The irrigation is managed mainly with profile probes showing comfort and stress levels within the root zone. Insect monitoring is done with automatic traps sending pictures where catches are identified and counted. Phenology and thinning are approached thru pictures and modelling. Results can be seen in real time on https://arboviti.agrimeteo.eu. The platform is running for growers and advisers; it can adapt easily to new developments and remains a tool of progress open to new challenges.

Keywords: DSS, orchard, vineyard, irrigation, insect traps

INTRODUCTION

NewFarm Agriconsult is a network of experts with the main objective of supporting operators to lower inputs in agriculture and coaching them in precision crop management. Members of this network are people involved in developing decision support systems (DSS) for crop management, companies providing sensors for automatic field monitoring, data providers and web developers. All are joining efforts to offer an open platform where farmers and advisers have the possibility to run as many crop DSS as possible with their own data. Agrimeteo.eu, the resulting platform, is gathering various existing tools and is built to make it easy to integrate new developments.

MATERIAL AND METHODS

Over the years, we developed an infrastructure dedicated to web services in agriculture. We tried to make it simple and modular. The architecture allows efficient interactions between databases, servers and web applications. We can get data from partners' databases; basic examples are real-time weather data from remote sensors or numerical hourly weather forecasts. Data formats are transformed to make them compatible with the requirements of the DSS, and then integrated in the tools going to process them. Data or results can be sent to or received from other platforms.

The front-end of the platform is developed in Drupal (open source Content Management System). Users have personal view of the results of the services they subscribe to. Our back-end applications are written in open source languages and run on open source operating systems. We make intensive use of API. Developments are PC and smartphone

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oriented.

Users have unique codes to connect to the platform and data remain their unique property. As we believe that digitizing of agriculture will lead to better decisions in crop management, we are also convinced that the local "field view and experience" are crucial for a good agronomical practice; therefore, the infrastructure is built so that it can be "cloned" for use in other regions and languages. Under one roof (the agrimeteo.eu platform), we want to give access to the multiple DSS the farmer needs.

RESULTS

Weather monitoring in the orchard and vineyard

The weather stations we use are installed in the crop field. We want to monitor the real climate the plants are facing. Temperature, relative humidity, leaf wetness and rain are the main parameters needed to run most disease or pest models. We use scientific accurate sensors on iMetos weather stations (Pessl Instruments, Austria is our partner in this area); the platform is also compatible with other brands and at the moment, the remote sensors are making their measures available on the web or transferred to our databases.

We use also 'virtual weather stations' and 'semi-virtual weather stations' for cheaper investment. The data are computed from an atmospheric simulation and synchronized with radar data and networks of weather stations on the ground around the location of the virtual station. We observe excellent results when used in general DSS, but once higher precision is needed, a mix of virtual and real sensors is offered as most accurate and economical equipment; indeed, measured rain and leaf wetness are quite important for best results.

Concerning the weather forecasts, we work with the Swiss company Meteoblue, which provides excellent hourly updated values for the forecast parameters to be integrated in the DSS.

As a commercial standard, we are proposing what we call the "HubAgrimeteo". The hub is available on one location (coordinates latitude-longitude-altitude); it provides hourly data in real time and 7 days forecast of the following parameters: rainfall, temperature, relative humidity, leaf wetness, wind speed, wind direction, solar radiation, Eto. All our DSS are running on demand with the data from the hub. Many combinations of sensors are available also on a hub.

Frost protection

As first example, the additional wetbulb temperature sensor will be mentioned. A real-time measure of the wetbulb temperature is crucial for frost protection. Our partner Fruitweb (Germany) developed an application to help the grower anticipate and fight more efficiently the frost events. Because of monitoring wet and dry temperatures at sensitive locations in the orchard (or vineyard), the grower sees constantly the measures of his sensors with near future forecasted evolution; he gets a curve of the forecasted temperatures till sunrise in situation of radiation frost; he can set thresholds for alarms (SMS, email or phone). With this application, monitoring and actions with frost protection equipment are made easier (Figure 1).

Spraying decision

When the grower needs to spray, he should consider the climatic situation and choose the best moment for maximum efficiency of the operation. Two complementary tools are available: 1) the assessment of the behaviour of the spray coming out from the sprayer (the spray windows) and; 2) the match between the microclimatic conditions within the orchard/vineyard and the properties of the chemical for best interaction of the product with the plant.

The hourly situation calculated in the spray windows is classified as "favorable – risky – not suitable". It takes into account the following parameters: wind, rain, and deltaT (combining air temperature and humidity). Within the thresholds, it gives the grower a clear view of what is coming ahead. The objective is to avoid drift or risk of crop scorch.

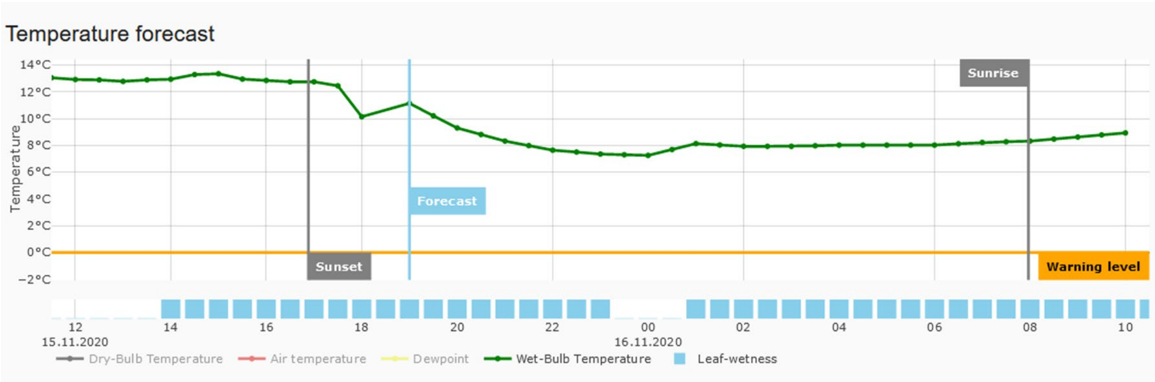

Figure 1. Example of temperature monitoring. The left side of the graph is showing real time updates of measures coming from the sensors; the right side is showing the forecast. All options concerning the settings are available on the interface.

The second tool, called ECO-T, is studying the interaction of the chemical with the plant. For each active ingredient, the system uses models that describe the relationship between product properties, processes and climatic conditions. A climate model calculates the weather conditions in the crop, using the stage of crop and soil moisture as additional information. The DSS developed by our partner Erno Bouma (The Netherlands) runs sub-models resulting in an hourly index showing best chance of efficiency of a given chemical (Figure 2). The behaviour of a chemical on and in the leaf of a plant is changing accordingly to the climatic conditions (wetness, humidity, temperature). A chemical may need to «stick» on the leaf or "penetrate" the leaf using water or lipid channels (Figure 3); its efficiency depends on a list of conditions our DSS is trying to summarize.

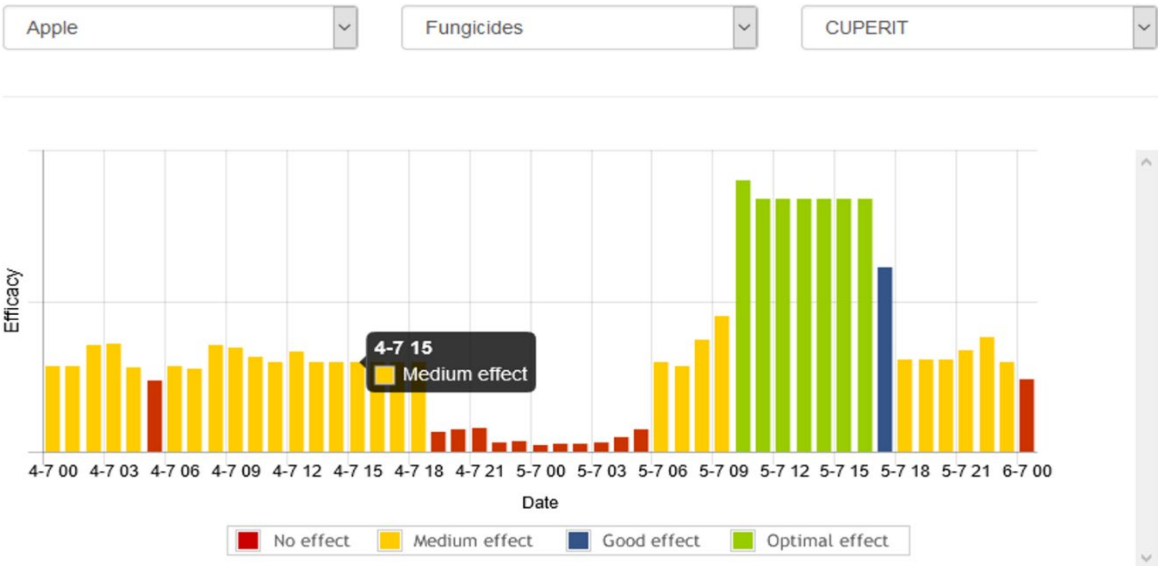

Figure 2. Choice of the best moment for spraying a copper fungicide according to the ECO-T app.

ECO-T allows the growers to choose the best chemical just before doing the job (forecast); they can also check the efficiency afterwards, thanks to the measured data coming from the weather station.

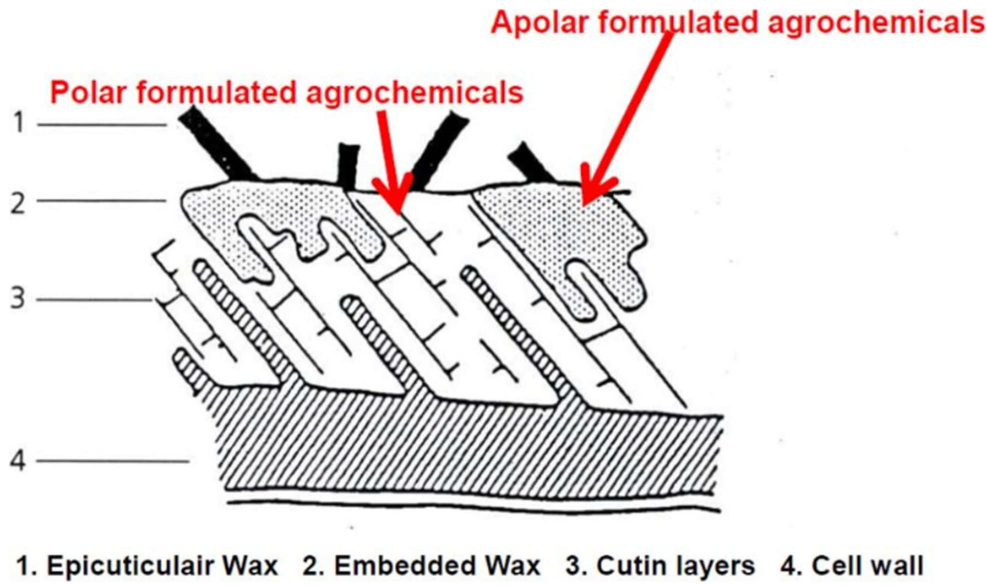

Figure 3. Penetration of agrochemicals in the leaf of plants.

Disease models

The agrimeteo.eu platform is running quite a few disease models in real-time and, very often also, with 7 days forecast: the objective is to help the fruit or the grape grower to anticipate the risk of diseases. We like biological models giving a universal scientific approach of the infection processes and epidemic pressure. The RIMproCloud models from Marc Trapman (the Netherlands) are of this type. Statistical risk models are also available but need some kind of local validation. The long list of models from Pessl Instruments (Austria) or from CIPRA (Canada) belongs to this category.

We are looking for models with clear output for the farmer (Figure 4): "Do I have a risk? Do I need to protect my crop (still protected with previous spray)? What is the best moment to go and spray?". The models should allow checking and comparing situations with observations in the crop: this is the job of experienced farmers and local advisers using the DSS. As a tool of progress, model simulations should also teach better risk evaluation (feeling) by the grower and best intervention practices.

Insect monitoring

Insect monitoring in orchards and vineyards is best done with traps and scouting. As a complement to traditional delta or funnel insect traps, we are giving access to the Trapview internet platform (Figure 5). The Trapview is an automatic insect trap developed by EFOS (Slovenia). Using pheromones just like in conventional insect traps, the Trapview is taking pictures of the daily catches on the sticky plate. Images are sent automatically to the web server where insects are identified and counted. This approach is quite useful for early warnings as we get a daily updating of the flights. It gives also very good logistic financial savings: travelling is now only necessary for pheromone changes; counting catches and self-cleaning of sticky plate (roll) is fully automatic.

Network comparison and statistical approach are easy to perform, giving better value to the "one location catching trap"; the data are automatically saved for seasons.

Other models using temperature sums are also helping the growers with simulation of the development stages of the insects (Pessl Instruments, Inoki, Cipra, etc.). Those are DSS for best positioning of specific insecticides (eggs, larvae, etc.).

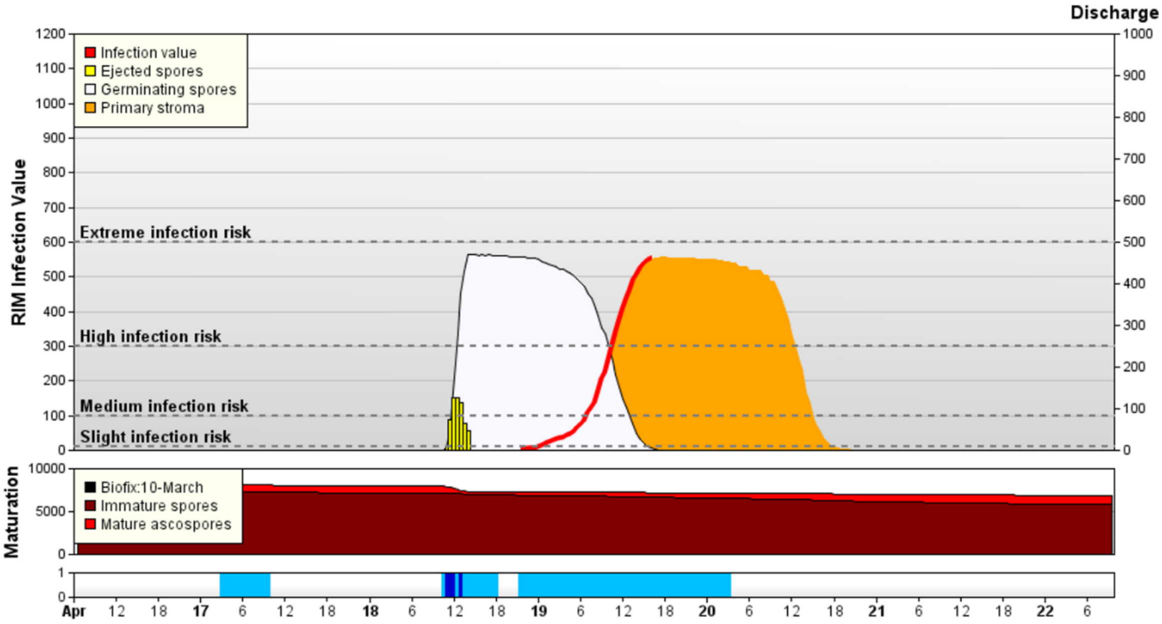

Figure 4. Clear situation of projection and infection in apple scab RIMproCloud.

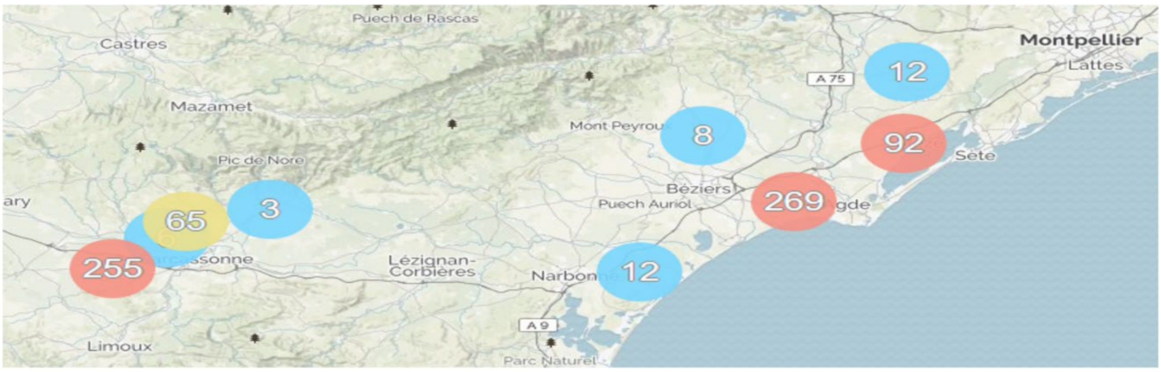

Figure 5. Map of 10 days catches of *Lobesia botrana* in vineyards in south of France.

Irrigation management

With the appropriate sensors on the weather station, the water demand of a crop is well estimated through calculation of ETo and water balance in the soil. We also provide daily ETo estimation in the weather forecast. Today tough probes can be installed in the soil for in situ monitoring of water availability. We like to use 60 cm probes with measurements of water content, temperature and ion concentration in every 10 cm layer of soil (Drill&Drop from Sentek, Australia).

A fully configurable application ("MyIrrigation" from our partner Aquagri in Portugal) is available for easy use and interpretation of the curves (Figure 6). The grower sees the water evolution in the profile every 10 cm according to rain and irrigation events; the use of water by plants is also well detected. Growers will decide to start irrigation in a way to avoid any water stress to the crop and regulate the quantity in order to avoid losses by over-irrigation; the crop is maintained in a healthy condition with correct readily available water in the root zone.

Phenology

Once again the temperature sums from devices placed in the orchard or the vineyard give possibility to run phenology models; CIPRA (Canada) for instance developed several useful tools. The best way to monitor at distance is to use cameras in the field. We use Cropview from Pessl Instruments and we are presently testing the fruit growing application coming with it (Figure 7). On the daily pictures, the system calculates dimensions of the targets.

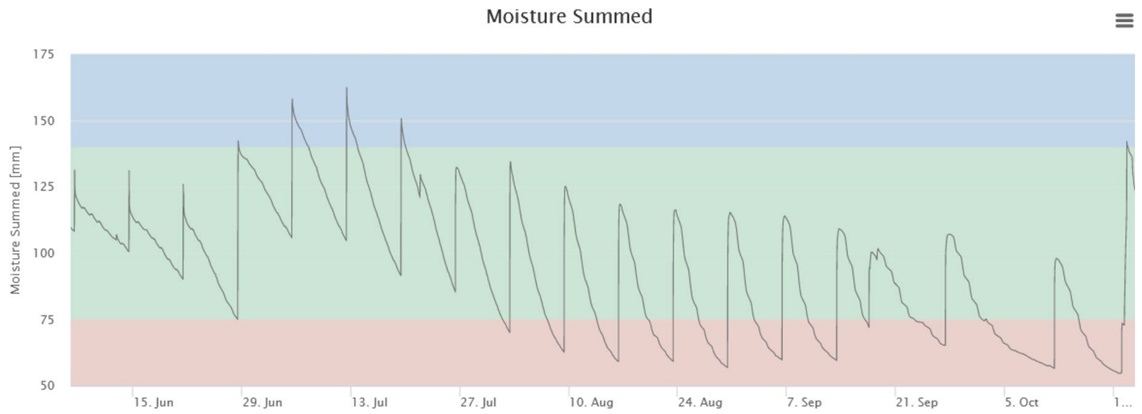

Figure 6. Evolution of total water easily available in the root zone of a crop under sprinkler irrigation.

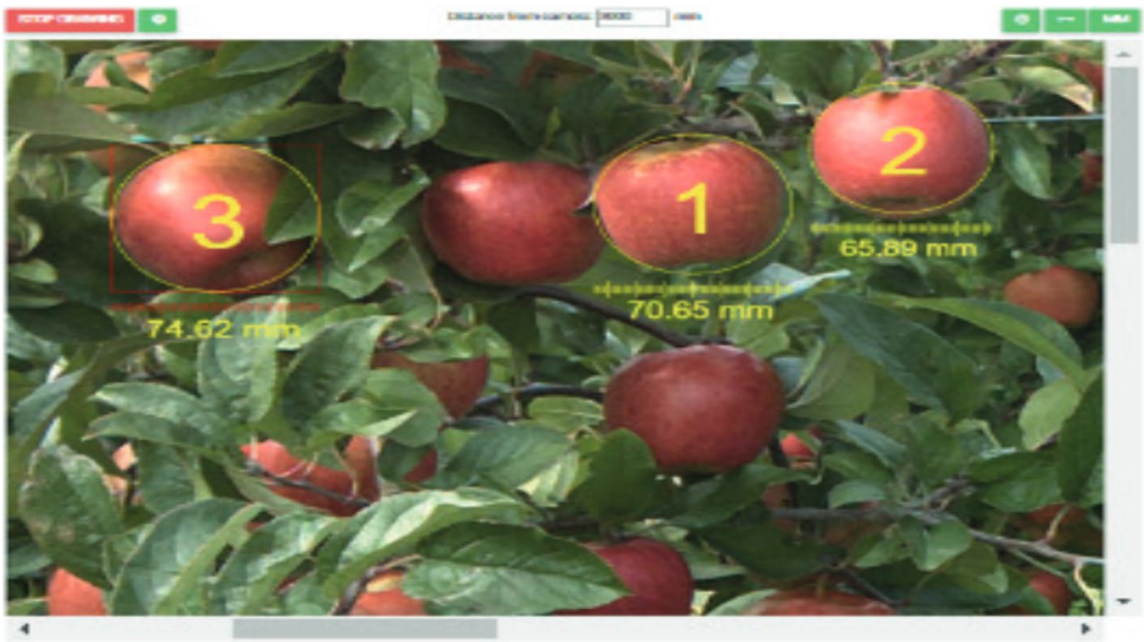

Figure 7. Following fruit size in the Cropview application from Pessl Instruments (under testing).

Also apple and pear growers are learning to use a thinning application integrated in RIMproCloud (Figure 8); it uses carbohydrate balance of the tree and evolution of the young fruits size.

DISCUSSION

In this work, we show that precision management of orchard and vineyard crops is operational with a combination of various tools. IoT sensors and “smart equipment” are available; and more are coming. We make the outputs of specific DSS easy to understand and give value in the decision process. Growers and advisers are really taking advantage of the new technologies and digitizing of their job.

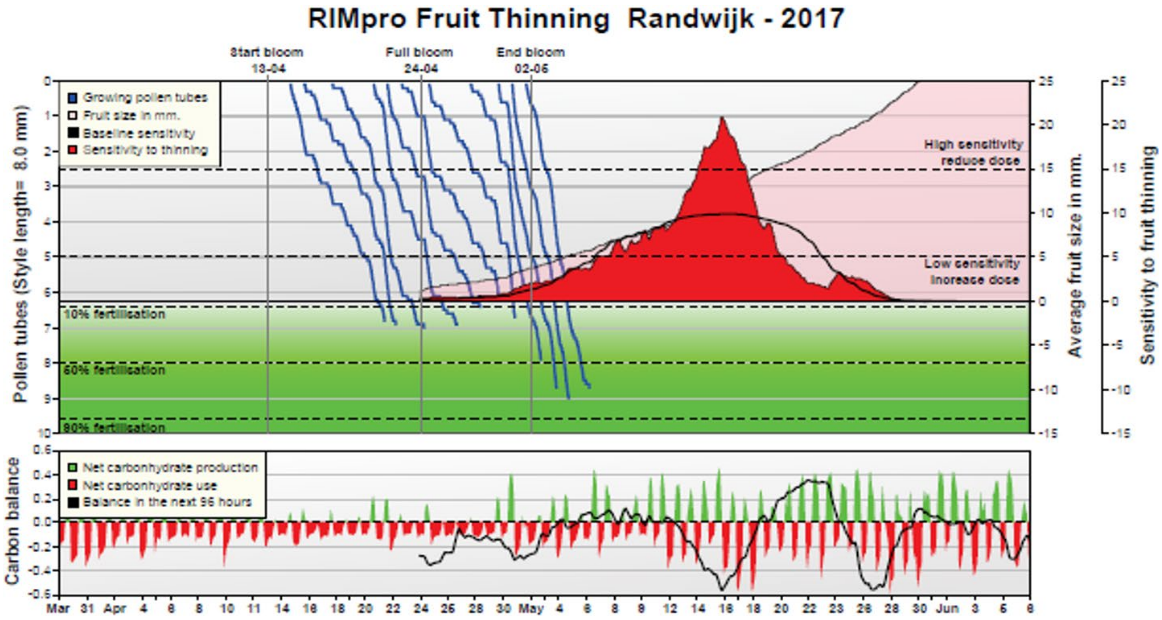

Figure 8. Visualization of the thinning model in an apple orchard (2017).

Agrimeteo.eu has been running for a few years in Belgium and France with around 500 orchards or vineyards under monitoring. We would like to integrate more DSS and make results available to even more fruit and grape growers. The platform remains an open infrastructure for developers to test and validate their tools.