DELIVERABLE 10.3

Digital guide covering the usage of the technology developed for different applications for public dissemination

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Deliverable 10.3 – Digital guide covering the usage of the technology developed for different applications for public dissemination

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EXECUTIVE SUMMARY

This deliverable (D10.3) is a public document intended to serve as a non-technical guide for the use of the ENTOMATIC solution. It focuses on use and maintenance recommendations, and best practices learned from field tests by the ENTOMATIC consortium, and aims to contribute to future developments of automatic IPM systems.

This deliverable can be considered as a compilation of information extracted from other project deliverables.

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1 INTRODUCTION

There are many studies that explain the benefits of the existing methods for mass trapping in olive yards. Many of these studies done in several European countries about the relevance of the mass trapping of the olive fruit fly to reduce the number of damaged fruit, and, hence, the reduction of quality of the production. Their results reveal that, comparing different olive yards without any control system and a yard controlled by traps, the one with controlled by traps reduces, in mean, a 25% less of damaged fruits. Furthermore, other studies reflect that this percentage is increased to values higher than 30%, reaching in some cases a 100 %.

The ENTOMATIC consortium has developed a novel stand-alone field monitoring system comprising: a fully autonomous trap with integrated insect bioacoustic recognition embedded in a wireless sensor network and supported by a spatial decision support system placed in the cloud. With this automatic control of the fly population olive growers, will have real-time data to support the necessary actions to fight against the plagues and be able to react faster than with nowadays manual counting methods.

To summarize, the ability to quantify and make a precise control of Olive fly populations in a cost-effective way, has been a long-desired goal in the Olive sector. The potential offered by ENTOMATIC has SME-AGs and their associated SMEs keen on its development. The benefits are the reduction of damage to olive fruit and oil production and to promote the sustainable use of pesticides. Via ENTOMATIC, olive producers are able to track pest population and geographical status and receive advice on precision pesticide application.

2 BENEFITS

ENTOMATIC system creates a database related to olive fly population, field and owner information, etc. and a Spatial Decision Support System (SDSS) specific for the Olive fly, capable of issuing automated warnings for on-time and precise pesticide application, supported by advanced algorithms, and historical records of insect population, pesticide usage and spraying activities

This system is supported by a multi-accessible database with historical logging, user details, GIS database of regional information such as historical infestation data and impacts. The SDSS has an intelligent warning system which performs calculations based on the data collected from traps, and sends messages to local growers with recommendations for pesticide spraying and providing alerts (e.g. risk of infestations).

The SDSS has an intelligent monitoring system that calculates the effectiveness of pesticides used (or other methods) in real-time. An interactive system will enable the user to inform the system with a simple message about pesticide usage details (quantity, date/time and type). An intelligent pesticides usage module will gather all historical data and compile statistical information that can be used by SMEs in reducing pesticides use and evaluating their effectiveness. The system will provide spraying charts, and this way the operator will know where to spray according to the automatically detected pest densities.

The system acquires pest data daily, and producers have a daily report on the status of the pest, thus preventing that an infestation breaks out unnoticed. The system acquires simultaneously pest data and weather data at each trap and the producer may request the information in real-time.

Since the system acquires daily and accurate information on pest population density, the producers no longer will over-spray their fields.

Pesticide spraying based on accurate pest data updated daily, leading to a very detailed overview of the necessities to manage properly the orchards and proper corrective actions. Spraying charts are issued by the Spatial Decision Support System, providing to the operators a precise guide leading to less pesticide usage, optimal timing and amount.

The above-mentioned advantages lead to an elimination of over-spraying plus other savings, reducing overall costs by 60% (+110 €/ha)

The system enables for SME-AGs to have a common management structure of pest data for the first time. The system is designed to permit full traceability and record reliable pest data, building historical records that can be easily shared with other regional, national or EU authorities.

3 FIELD OPERATION

Installation of ENTOMATIC traps must follow exactly the same approach as traditional traps, as the goal is to simply make the fly counting automatically, without changing any other aspects from traditional country-specific approaches. However, both traditional (manual counting) and ENTOMATIC system (automatic counting) could fairly coexist and complement each other in the same orchard. For instance, the ENTOMATIC system can be used to send alarms to orchards managers to inspect the other traps when fly levels above certain established thresholds appear.

3.1 ENTOMATIC TRAPS

The ENTOMATIC trap units are easily installed in olive trees by the end-users. According to modern IPM procedures for the deployment of Olive fruit fly traps, for small holdings and in fields of uneven topography, a density of 2-4 traps/ha will be used. Once the traps are deployed, they form a low-power mesh network capable of wirelessly with the ENTOMATIC Gateway.

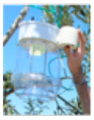
The ENTOMATIC gateway, transmits the field data to the ENTOMATIC Monitoring & Management Central. This central is hosted by a Cloud Provider, which makes the collected data available on internet, as well as the results from processing it, including the IPM recommendation generated. The end-users can use the on-line platform to access the IPM tool, using just a common laptop, a smart-phone or a tablet PC.

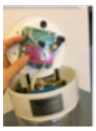
3.1.1 INSTALLATION

The ENTOMATIC consortium has created a plug-and-play solution (see Figure 3.1) easy to be installed in the field to satisfy olive producers' needs. Before initializing the whole system, a proper location for the Gateway should be found. It is highly advisable to place the gateway unit in an elevated position without obstacles in the surroundings, and if possible, with access to a power plug, or alternatively, use a solar panel.


1.- Press the right button of the gateway and wait until a the blue led is on.


2.-Now press the left button and put your gateway in an elevated area.


3.- Place the trap/traps at the olive tree and press the red button until you hear one beep.


4.- Press the right button of the radio module until the green led is on.

Your trap is ready!

Figure 3.1: ENTOMATIC system plug & play installation guide

As for the trap unit, it must be fastened tight on a tree. Swinging is not a problem but a direct hit may cause false alarms due to propagation of vibrations. The trap is designed to be operated in the field; i.e., away from any electromagnetic interference caused by mobiles, routers, and/or tablets, that also may cause interference to the sensor.

Once a trap is placed, the electronics system must be initialized as shown in Figure 3.2 by first activating the B.oleae sensor (by pressing trap's red button for a second), and subsequently the communications module (by pressing device's right button).

Figure 3.2: Detail of the trap's red button

It is worth noting here that in case the B. oleae sensor was not properly initialized, the system would keep working but the communications module would only send data from the rest of sensors (temperature, humidity, and luminance).

3.2 ENTOMATIC CLOUD

A fundamental but invisible part of the ENTOMATIC system is the monitoring & managing central server, where the data is stored and analyzed, as well as tools for data visualization, and generation of alerts & recommendations are executed.

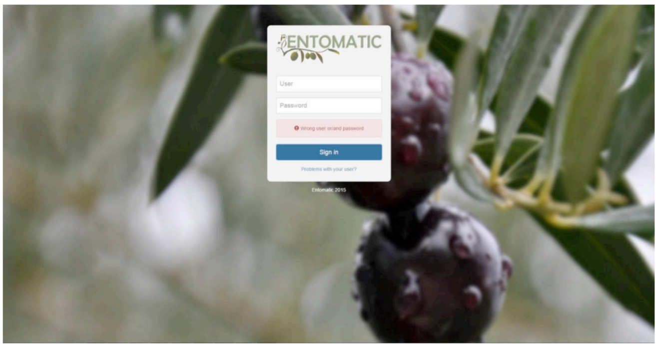


Figure 3.3: Registration as a user in the ENTOMATIC webapp

The ENTOMATIC webapp is designed to be offered as a service for farmers, associations and governments to manage their own ENTOMATIC traps, providing private access and functionalities such as the ones depicted in Figure 3.4

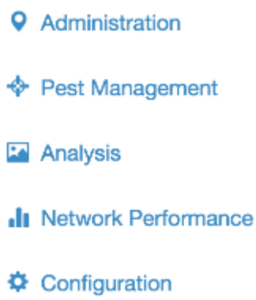
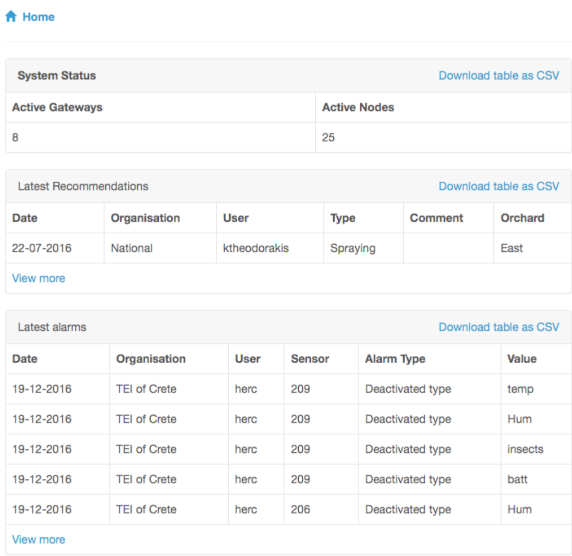


Figure 3.4: Main menu of the ENTOMATIC web app

The web app is divided in 4 main areas: administration, pest management, analysis and network performance. In the following lines, they are further described.

3.2.1 ADMINISTRATION

As a user, you are assigned in one the existing organizations. They are able to visualize (see Figure 3.5) their associated traps and the last collected data, including recommendations to manage their orchards. In addition, any information can be downloaded in *.csv* format for its further visualization or processing in any supported software platform.



Home

System Status — Download table as CSV

Active Gateways	Active Nodes
8	25

Latest Recommendations — Download table as CSV

Date	Organisation	User	Type	Comment	Orchard
22-07-2016	National	ktheodorakis	Spraying		East

View more

Latest alarms — Download table as CSV

Date	Organisation	User	Sensor	Alarm Type	Value
19-12-2016	TEI of Crete	herc	209	Deactivated type	temp
19-12-2016	TEI of Crete	herc	209	Deactivated type	Hum
19-12-2016	TEI of Crete	herc	209	Deactivated type	insects
19-12-2016	TEI of Crete	herc	209	Deactivated type	batt
19-12-2016	TEI of Crete	herc	206	Deactivated type	Hum

View more

Figure 3.5: Administration section of a user

3.2.2 PEST MANAGEMENT

Users can consult the recommendations (Figure 3.6) offered by the SDSS (Spatial Decision Support System). With the data collected and the historical data base, the ENTOMATIC system offer estimations of the plague and the recommended action to be done, i.e. if the system recommends to the grower to spray or not. Moreover, an historic of actions done could be introduced by the user as fr reference.

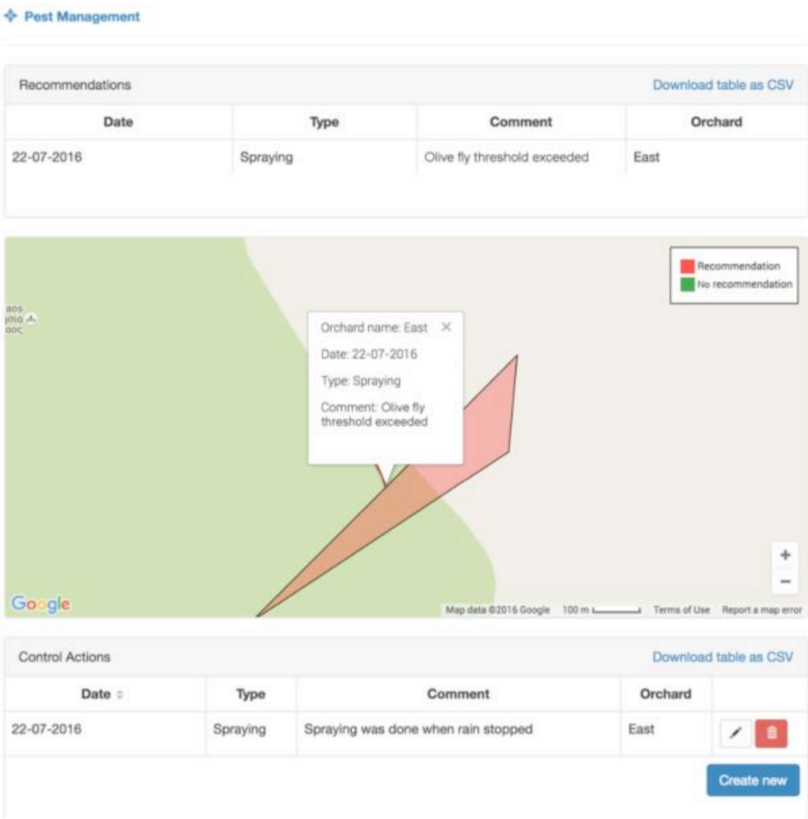


Figure 3.6: The pest management page shows recommendations that are automatically generated by the ENTOMATIC spatial decision support system (SDSS) and control actions that are manually entered by the user

3.2.3 ANALYSIS

To visualize the data collected (see Figure 3.7) during a certain period of time, the user could access analysis submenu. The available functions are:

- Data per sensor or per sector
- Visualize the data over the map
- Graphics with last measurements and comparison with near sensors.

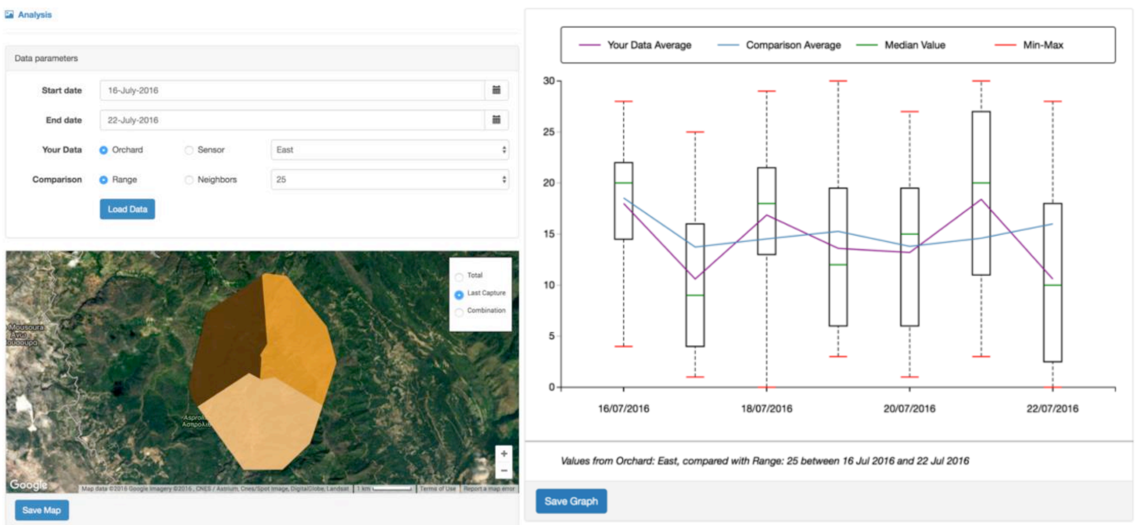


Figure 3.7: The analysis page allows the user to compare data from his own orchards or sensors to data from the nearest sensors

3.2.4 NETWORK PERFORMANCE

The network performance is controlled in this submenu. Users are able to visualize (see Figure 3.8) the configured alarms and the state of the network. Main alarms that are predefined are:

- Low battery
- Broken devices
- Surpass of thresholds (temperature, number of flies, battery)

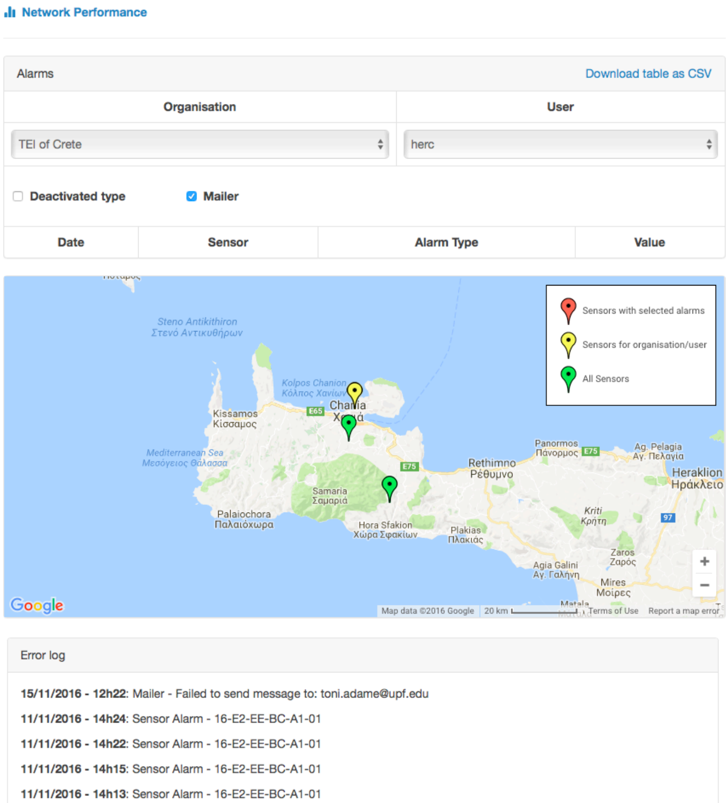


Figure 3.8: Network performance section general view

3.3 USE AND MAINTENANCE

Using ENTOMATIC traps is as easy as other traditional traps. Some general recommendations to keep ENTOMATIC traps in perfect working conditions are:

1. Deploy (collect) the ENTOMATIC traps at the beginning (end) of the B. oleae season to keep them safe when they are not used. Electronics (sensors and communication modules) are sensitive to environmental conditions, and traps' lifetime may be reduced when unnecessarily exposed to adverse environmental conditions (varying temperatures, humidity, rain, wind, etc.)

2. Deploy ENTOMATIC traps following the same approach as in traditional mass trapping using McPhail traps. For example, usually a trap can be placed every 1 ha of olive orchards, or just follow your country guidelines.

3. Replace the attractant as if a standard McPhail trap was used. In case the ENTOMATIC web-app shows a low battery alert, replace the battery of the trap. In general, we recommend the use of a solar panel in all traps to guarantee that the battery will last for a full season.

4. Collect also your measurements directly from the Gateway. Take the data from the SD card of the gateway and, visualize all the data collected with the ENTOMATIC standalone application.

5. Follow all alarms and recommendations suggested by the ENTOMATIC cloud system. They are currently send by mail, but other options (i.e., cellular text messages) can be also added in the future.

6. Follow the alarms from the environmental sensors installed. They generate alarms when a performance error appears.

4 BEST PRACTICES & LESSONS LEARNED

The development of the ENTOMATIC system has allowed the consortium to discover and solve many unexpected issues, learning strategies for using ENTOMATIC in an effective way. In this section, we introduce the most relevant lessons learned and best practices from the expertise gained during the project execution, aiming to contribute to the future development of the automation of the olive sector.

1. **ENTOMATIC traps** (Figure 4.1) are based on standard McPhail traps. It is the most used trap model in Mediterranean countries, and the ENTOMATIC consortium - based also on the market assessment - decided to push for a solution that was well-known for olive producers, thus avoiding any potential reticence if other traps - more suitable to include all electronic parts, but maybe less effective to trap flies - were chosen.

Figure 4.1: ENTOMATIC trap

2. The use of the **adequate attractant** in any of its assorted formats (liquid, gel, pheromones, etc.) is crucial for achieving a successful trapping of insects regardless if a traditional or an ENTOMATIC trap is used (see Figure 4.2 for two demonstrative examples). However, the use of automatic counting opens new considerations in the selection of the attractant. In case the resolution of the sensor is low, we may be interested to help it by using specific attractants for the target insect to increase the accuracy of the sensor. Otherwise, if the sensor is able to differentiate between different insect species and track the desired one, as it is the case of ENTOMATIC, the use of a general attractant -which may have a lower cost- could be an optimal solution.

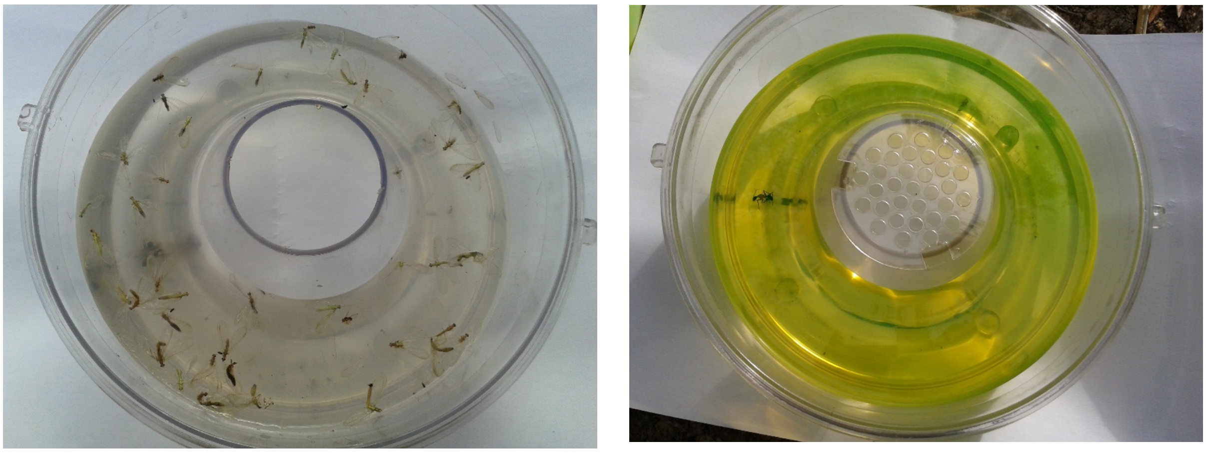


Figure 4.2: Different attractants: ammonium sulphate 2% (left) and AB plastic ring (right)

3. First field tests of ENTOMATIC traps revealed the **presence of unexpected and erroneous number of insect counts**. We discovered that the incidence of UV light affected the sensor accuracy, generating false positives. To solve it, the use of plastics able to filter the UV light was required in the construction of the trap (Figure 4.3). We also observed that the sensor was sensitive to electromagnetic interferences from electronic devices such as mobile phones or WIFI networks. While this last issue is not a problem in the orchards, the use of similar sensors to detect certain types of insects in other scenarios such as cities may not be recommended.

Figure 4.3: ENTOMATIC trap protected with UV filter

4. Traps must be easy to set-up and manage in the field by non-technical people. Ideally, **electronic traps must be plug-and-play**, with no more requirements than pushing one or few buttons to turn them on/off (Figure 4.4). In addition, batteries and other mobile elements such as the solar panels have to be easy to replace. Those aspects have been considered in both the design of both the prototype and the final ENTOMATIC traps.

Figure 4.4: ENTOMATIC trap with detail of the red button to switch on it

5. **Combining automatic counting traps for accurate and real-time sampling the presence of flies in the orchards with other traps for mass trapping** can be an optimal solution to reduce deployment costs but keeping all benefits of the ENTOMATIC system. Depending on the size of the orchard, the use of a single ENTOMATIC trap may be enough to provide the orchard manager with timely information.

6. Automatic monitoring systems such as ENTOMATIC are able to cope with the different policies & requirements used in the different countries for acting against the olive fly plague by simply using different system configurations, such as the rate at which data is collected from the traps, and how often the SDSS system is executed. However, the evolution of automatic monitoring systems goes through the **integration of artificial intelligence techniques able to dynamically adapt the full system operation** to the environmental conditions as well as the knowledge extracted from the data monitored, improving both the system management and the quality of the collected data.

7. While the use of cellular networks may seem a natural solution to collect data from the traps, given there is cellular coverage where the traps must be placed, we have observed they require large amounts of time and energy to establish a connection, thus being a very inefficient solution for sporadic data transmissions. In this situation, **the use of a tailored made wireless network**, such as the ENTOMATIC wireless sensor network (Figure 4.5) offers many advantages, such as a higher reliability and life-time. Therefore, even if cellular operators push to use their technologies everywhere, it may not always be the most suited for solution precision agriculture.

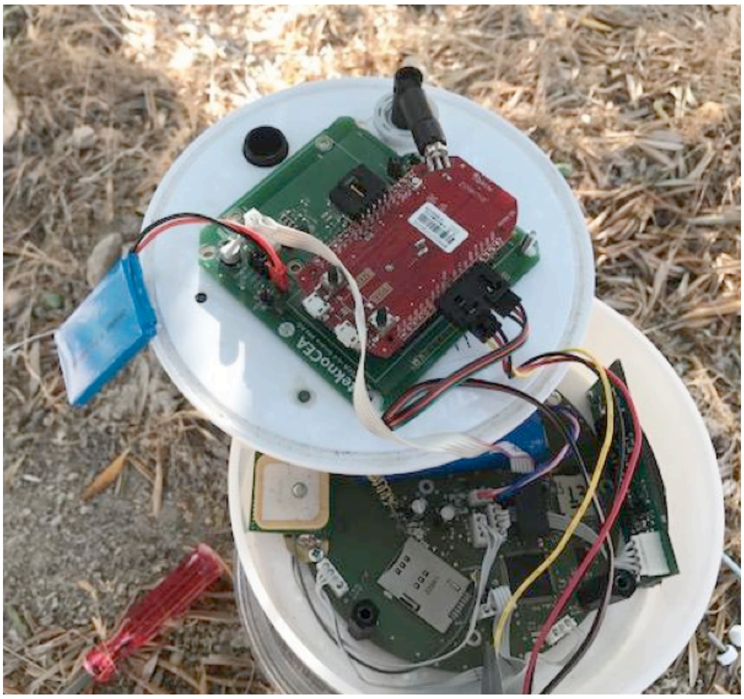


Figure 4.5: Detailed of the radio module used in ENTOMATIC traps

8. The lack of power supplies in olive orchards can be solved using batteries, as well as with other elements to collect clean energy from the environment, such as solar panels (Figure 4.6) or wind turbines. Taking into account that sun rays are hugely available in olive orchards, it seems a logical approach. In such a situation, the ENTOMATIC consortium believes **a fully environmental friendly solution can be also achieved**, harvesting all required energy to operate the network of traps and gateways.


Figure 4.6: Solar panel used in ENTOMATIC

5 SUMMARY

The ENTOMATIC solution improves the traditional olive fly control methods by means of offering a system that automatically collects information from the traps in the orchards, analyses it in the cloud, and provides alerts and recommendations to the orchards managers in a precise and timely manner. This will result in a reduction of the damages to the fruits and a reduction on the use of pesticides, thus reducing both the production costs and increasing the quality of the produced olives.

In this public deliverable, we overview the benefits and best practices. We detail the most relevant lessons and best practices learned during the development of the ENTOMATIC project, as well as some other points we think could be of interest, aiming to contribute to future developments of IPM systems beyond this project.