Development perspectives of electronic systems in pest control strategies

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Abstract

The codling moth, *Cydia pomonella* (L.) (Lepidoptera Tortricidae), is a key pest in apple and pear trees and requires an effective pest management. Integrated pest management (IPM) represents among the pest control strategies adopted in the years one of the most diffused methods and it requires sex pheromone traps regularly checked by the farmer for pest monitoring. IPM is currently applied also in the monitoring and control of stored products insects and in general in the food industry. An automatic electronic trap designed to monitor the flight of codling moths, able to identify the pest and to forward the information on males caught has been developed. The electronic device was designed basing on the commercial Carpocartrap. Modifications carried out on the standard sticky trap did not affect the performance of the trap in catching the male codling moths. The images sent to a remote unit allowed an easy identification of the moth. Current activity is in progress in order to apply the same approach to a standard sticky trap used in the food industry to monitor *Plodia interpunctella* (Hubner) and *Ephestia kuehniella* Zeller, very common pests of dry plant produce, especially cereals, and found around the world.

Keywords: pheromone trap, codling moth, pest management

Introduction

The Integrated Pest Management (IPM) requires the integration of multiple disciplines and control measures to achieve a management aimed at prevention of pest damage before reaching the threshold of economic damage. The implementation of IPM foresees assessment of factors that regulate the systems involved, the monitoring of insect populations and the availability of historical data to define appropriate measures to manage infestations (Trematerra, 2012).

IPM approach is used in orchard crops protection but it starts to be applied also in stored agricultural products and in food industry.

In pest protection of apple fruits impressive progress has been observed in monitoring populations of *Cydia pomonella* (L.) the Codling moth. Pest monitoring allow improving insect control, by using biological, chemical or physical treatments, and decreasing the impact of pesticides on environment, crops, operators and consumers.

Use of sex pheromone traps in IPM refers mainly to the overcoming of the economic damage threshold evaluated by counting the trapped males. In Emilia Romagna region (Italy) the treatments against codling moth are fixed overcoming two males captured per trap in a week (ERMES, 2011). Two/three traps per hectare of orchard surface are the standard in normal operation, checked once or twice per week by technicians to verify the males caught so as to decide the spraying date.
Codling moth (Fig. 1) has been monitored using sex pheromone traps in apple and pear orchards since the beginning of the ‘70s. This was due to the discovery of the Codlemone (Roelofs et al., 1971; McDonough and Moffitt, 1974), component of the natural pheromone released by the codling moth female.

![Figure 1. Codling moth: adult and larvae](image)

The trap shape and the dispenser type, together with the trap opening width, are the key factors for trap efficiency. Various researchers have demonstrated that a reduction of the width allows an increase in the number of captured males (Madsen and Vakenti, 1973; Charmillot et al., 1975). The increase of the effectiveness of the codling moth traps has been achieved obtaining a thin wake of pheromone in output from the trap, combined to a small opening, so as to increase the difficulties in flight out (Accinelli et al., 1998).

Nonetheless the codling moth remains the most damaging pest on apples and, among the control strategies currently evaluated by various researchers, there is a physical system of control, the "Alt'carpo" system (Fig. 2). It consists in a barrier made of nets enclosing the single row or the complete apple orchard for avoiding the contact of the moth with the fruit (Severac and Romet, 2008). In this enclosed environment, mainly when it is extended to all apple orchard, sex pheromone traps could be used as safety system to check the efficiency of the protecting nets.

![Figure 2. Alt’carpo system to protect apple rows and orchards](image)

In addition, new environmental friendly techniques are used to control the codling moth by spraying not only chemical insecticides, but also releasing beneficial insects and microbial preparations, the latter usually less persistent in time with respect to conventional insecticides. Therefore, an efficient monitoring with pheromone traps becomes even more important in order to match the treatment to the flight start (Maini, 2007).

A further application of the sex pheromone traps is in the food industry for monitoring the insects damaging the stored products, either raw products and processed ones. IPM concept applied to stored products requires the definition of the tolerance thresholds for the different pests (Trematerra, 2012). This is due to the fact that in the case of stored raw
products is acceptable the presence of a limited number of pests, on the contrary in the phases of product transforming and preparation of food products, as in their packaging, the economical threshold becomes close to zero. In any case the pheromone traps could be used to check the presence of the insects and to evaluate the dimension of the population to carry out targeted treatments only when strictly necessary. Traps used in stored products monitoring are often similar to the sticky traps applied for the codling moth, but there are also traps differently shaped to prevent the escape of trapped pests. These have been developed based on empirical and their performance are still affected by this factor (Barak et al., 1990).

_Ephestia kuehniella_ Zeller and _Plodia interpunctella_ (Hubner) (Fig. 3), both moths of the family Pyralidae, very common pests of the stored products, are monitored by means of sticky traps similar those used for the codling moth.

![Image](image.png)

**Figure 3. The larvae of Plodia interpunctella Zeller and the damage on a chocolate piece.**

The necessity of higher efficient monitoring of the pests associated with more frequent controls allowed for the development of monitoring systems with different solutions of automation.

Pest detection and monitoring systems, based on acoustic transducers for sensing the sound of the insects, able to send electronic signals to identify the locations of the traps have been developed (Beroza, 2002). Other systems based on an automatic counting of the captured insects were fitted with crossing transducers (Kliewe, 1998). A different approach has been implemented with automatic record systems using a camera designed to record the periodicity of pheromone trap catches (Kondo et al. 1994) or to automatically transfer the images to a computer where an image processing technique counts the insects (Shimoda et al., 2006). Technologies of identification and classification of the insects were also developed as demonstrated by specific researches and patents (Wen, et al., 2009; Landwehr and Agudelo-Silva, 2005).

The availability of electronic technologies on the market and a progressive cost reduction make it possible to adapt commercial solutions to the aims of pest monitoring, in the crop production in open field and in food industry. The paper report the results, already presented (Guarnieri et al., 2011), obtained with a prototype of an automatic electronic trap designed for monitoring the Codling moth.

Currently a new prototype of electronic trap for monitoring the moths damaging the products in the food industry is in development. As first step, the focus are _P. interpunctella_ and _E. kuehniella_. The results will be discussed in a future paper.
Materials and methods

On the basis of the IPM approach a first prototype of the electronic traps has been designed modifying a commercial trap (Pomotrap, Sumitomo Chemical Italia, Milan, Italy) specific for the *C. pomonella*. The Pomotrap consisted of an envelope with a defined shape in which a sticky pad and the pheromone dispenser were inserted. Two side openings in the trap allowed male moths to enter. The Pomotrap was modified for fitting the electronic devices (Fig. 4).

![Figure 4. Layout of the electronic trap.](image)

To realize the electronic trap, a commercial acquisition and data transfer system using wireless technology was selected. The system was composed of a programmable Smartphone, with an integrated camera of 3 Mpixel and the Symbian operating system.

To allow for a sufficient autonomy of the system, the Smartphone was integrated with an external power management unit.

To adapt the system to the monitoring needs, the software modules were realized. A temporized storage of the photos, in order to connect the camera at defined intervals, to fix the parameters in function of the brightness conditions and to memorize the photos was provided. A data sent on an EDGE/GPRS network to periodically transmit the data to a remote server, to save a local copy of the data and to resend the data missed in case of a temporary network breakdown was also realized.

The power management system allowed for a reduction of the Smartphone power consumption.

After a preliminary check of the functionality and the autonomy of the monitoring electronic system, two electronic trap prototypes were built. Field tests were performed in an apple orchard (variety: golden; planting layout: 4.0 x 2.5 m) of the Bologna University Experimental Farm. The traps were placed on the trees at a height of 1.7 m from the soil. On the 3rd row, two traps, one traditional Pomotrap (Trap A) and one electronic trap prototype (Trap B) were placed at a reciprocal distance of 60 m and both at a distance of 10 m from the orchard borders. On the 8th row, in the opposite positions with respect to the previous traps, were placed the second electronic trap prototype (Trap C) and the traditional Pomotrap (Trap
D). All the traps were placed with the openings oriented in the same direction, to reduce the effect of the wind direction on the captured moths (Fig. 5).

The tests were performed between April 12 and August 29, 2010. Treatments against the codling moth were not performed during this period, to assure a high infestation of the moth. The electronic system was set to acquire a daily photo at 8.30 am and to send it immediately to the remote server for a visual evaluation of the captured moths. This adjustment was defined considering a normal operating condition of an electronic trap for the codling moth management. The visual inspection of the traditional traps was performed weekly, as in the normal practice when commercial pheromone traps are used, while the exchange of the sticky pad and pheromone dispenser was carried out monthly in all the four traps.

![Figure 5. Standard Pomotrap and electronic prototype trap.](image)

Basing on the previous experience and taking into consideration the application of the electronic concepts to the monitoring needs of the food industry, the second prototype is currently in development for the control of insects as the *P. interpunctella* H and *E. kuehniella* Z.. The trap is designed on the commercial sticky trap used for the moths. In this second prototype a simplification of the electronic devices and power management unit is foreseen with respect to the typical conditions of the operating environment. Indeed the prototype will not be exposed to environmental conditions and to spray applications.

**Results**

During the field tests the different components, such as software, hardware and the external envelope, worked properly. The exposure to the environmental conditions did not affect the performance observed in the preliminary laboratory checks.

The images of the captured moths arrived daily at the remote server (Fig. 6). The traps captured other insect species as flies and midges, but with a dimension and a shape perfectly identifiable in the images.

The weekly control demonstrated a perfect agreement between the captures registered through the evaluation of the photos transferred to the remote system and those checked during the visual control on the field. The males captured were always located in the cone of vision of the camera. The results of the moths caught in the electronic traps and in the standard ones, cumulated in the test period, show that the modifications introduced on the external envelope of the traps did not influence the capture efficiency of the electronic traps (Fig. 7). In total 325 males of codling moths were trapped in the four traps and in particular Trap A: 94 samples (29 %); Trap B: 88 samples (27 %); Trap C: 69 samples (21 %); Trap D: 74 samples (23 %). In total 325 males of codling moths were trapped in the four traps and in
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**Figure 6. Images of the trapped insects. On the left camera cone of vision with the sticky pad and the pheromone dispenser in evidence. On the right two males trapped.**

The very high number of males captured, as a consequence of the conditions of the test orchard and the absence of specific treatments, allowed for an accurate adjustment of the electronic system.

The moths captures started from the middle of April to the end of August.

**Figure 7. Accumulation of the codling moths captured in the electronic traps (Trap B + C) and in the commercial ones (Trap A + D).**

Electronic monitoring of Codling moth can be a valuable method to obtain effective treatments by means a more accurate choice of the treatment time. The results obtained demonstrate that the electronic trap can also represent a valid support for territorial authorities to better calibrate the forecast models.

**Conclusions**

The electronic trap efficiency, verified on the field with the codling moth in terms of number of insects captured, images transferred and easy identification of the moths, allows to widen the applicability of the system to other kinds of traps, like those used in the food
industry context. The automatic monitoring could permit a reduction of staff costs due to a lower control of the traps.

The system flexibility also permits an increase of the monitoring frequency to use the system not only for field analyses but also for research investigations (as a better identification of hours for male flights in case of application of mating disruption, etc.).

Technical and operating characteristics of the automatic trap allow to consider the development of commercial systems with a wide potential market, also favoured by the continuous updating of electronic technologies, their availability on the market and progressive cost reductions.

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References


