



A Farmer's Toolbox for Integrated Pest Management

AGRI/2020/OP/0003

Case study – ALIEN.STOP in Italy

Abstract

The project ALIEN.STOP investigates the use of multifunctional nets to successfully control several key insects of fruit orchards, such as the codling moth and the threatening brown marmorated stink bug.

Results of the numerous experimental trials performed suggest that the nets are a successful mean to control for a wide range of harmful insects, also showing a wide range of positive side-effects including protection from extreme weather events (e.g. hail and extreme rain) as well as birds attacks.

Further research is required to investigate the influence of the nets on agronomic and physiological aspects, such as pollination and fruit ripening, as well as to optimise the technique thus reducing the associated costs.

1. Introduction

ALIEN.STOP is a research project focused on low-impact strategies and techniques to protect fruit orchards from attacks by the invasive insects, among which the codling moth (*Cydia pomonella*), and the brown marmorated stink bug (*Halyomorpha halys*). The initiative revolves around the concept of “exclusion netting”, i.e. the use of nets to cover the entire tree canopy to *avoid* harmful phytophagous to come in contact with fruits. That being so, it builds on the IPM *Principle 1 - Prevention and suppression*, which entails the prevention and/or suppression of harmful organisms, e.g. by using different cultivation techniques, adopting resistant varieties and enhancing the site conditions.

Specifically, the project aims at optimising the use and combination of different tools available to farmers, focusing on *preventive techniques* such as **anti-insect multifunctional nets**, alongside other direct means of containment (insecticides and products of natural origin). The project focuses on fruit orchards, specifically on pears, apples, kiwifruit and berries). Within the project, mechanisms are being studied to improve the effectiveness and efficiency of the use of nets, as well as their influence on other physiological and agronomic aspects, i.e. pollination, ripening etc. with the overall aim of preventing and mitigating infestations and damage caused by key orchard phytophagous such as the Brown marmorated stink bug.

Context and background information

Pomefruit orchards require the application of many pesticides, including a high proportion of insecticides specifically targeted towards the codling moth: between 10 and 12 sprays are applied yearly on average in South-Eastern France apple orchards and in Emilia Romagna pear orchards¹.

In view of the growing interest of the European Union to reduce the use of plant protection products² and to better protect the environment and the health of operators and consumers, multifunctional nets are an effective strategy enjoying increasing popularity.

In fact, thanks to the features of such technique, they can be fully included among the techniques envisaged in the integrated management of orchards as well as in organic production systems. The results obtained through the ALIEN.STOP initiative indicated that netting represents an efficient way to control the codling moth and other pests, thus enabling a significant reduction in pesticide use without any major risk for fruit production, harvest and quality.

Moreover, these innovative technique appears as particularly interesting in the context of emerging and difficult-to-manage problems such as invasion by alien organisms, climate change and high-intensity weather events (protection from hail, wind, rain etc.). Recent experience shows a protective role of nets also against spring frosts, which have become increasingly worrying in recent years.

In the context of the Pilot Project, the experience of ALIEN.STOP represents an example of a successful story where the application of an IPM practice (anti-insects nets, alone or in

¹ Alaphilippe A., Capowiez Y., Severac G., Simon S., Sandreau M., Caruso S. Vergnani S. (2014) - Codling moth exclusion netting: an overview of French and Italian experiences. Proceeding of IOBC meeting «Pome arthropods and Stone fruits». Vienna (Austria) 6-9 october.

² As stated in the Farm to Fork Strategy, link available at URL: https://ec.europa.eu/food/system/files/2020-05/f2f_action-plan_2020_strategy-info_en.pdf

combination with other agronomic techniques) successfully lead to the reduction of pesticide dependency and as use. Moreover, by reflecting on the costs, limitations and possible pitfalls of said technique, the project provides useful insights on the key barriers and drivers to the application of IPM practices, thus valuably supporting the pilot project. As a matter of fact, the case study can usefully inform the study questions related to:

- Costs of implementation IPM at farm level;
- Risks of yield reduction;
- Link between the level of IPM measures uptake and crops' characteristics;
- Knowledge transfer;
- Other drivers and side effects.

2. Research theme

The objective of this case study is to investigate the practices used in the ALIENSTOP initiative and to reflect on how they are applied to reduce the use and dependency on insecticides in fruit orchards. Throughout interviews with researchers, producers and other actors directly involved in the project, the case study explores the advantages, limitations, mitigation strategies and future developments of the technologies under investigation.

The research questions that guided the investigation in this case study cover the following aspects:

- History and objectives of the initiative (type of practices used, general and specific objectives, phases and evolution of the project);
- Governance and functioning (funds used, actors involved and their role in the implementation of the initiative);
- Results achieved;
- Limitations encountered and mitigation strategies (technical, economic, environmental limitations);
- Barriers.

3. Methodology

In order to gather information about the initiative, direct interviews were organised with the actors involved in different phases of the research project as well as with some producers that are currently using the technology of nets. Several interviews were carried out on a virtual platform (MS Teams), with relevant stakeholders involved in the initiative.

Alongside interviews, desk research has been conducted, based on the material provided by the project coordinators, including relevant studies, brochures, conferences outputs etc. The documents consulted can be found in the source section.

No particular limitations were found in conducting the case study, as all the actors involved were responsive and enthusiastic about the project, allowing for a smooth organisations of the consultation activities.

4. Activities and results

4.1 Objectives

The general objective of the ALIEN.STOP initiative is to reduce the incidence of insect attacks in fruit orchards thus reducing the need, and ultimately the use, of plant protection products (specifically insecticides). The project initially focused on pear and apple cultivation but was extended also to stone fruit (e.g. cherry trees) and other fruit crops such as kiwifruit. Moreover, the project also tackles the growing threat of new emerging and/or alien pests, such as the Brown marmorated stink bug, which have been posed a serious threat to the national fruit production.

The ALIEN.STOP initiative was launched in 2008³, when researchers from the Provincial Plant Protection Consortium of Modena (CFM, *Consorzio fitosanitario provinciale di Modena*) started investigating the potential of using nets to protect agricultural crops from phytophagous insects in Italian territories. The initiative was inspired by another research project implemented in France, where a group of researchers was investigating the use of anti-hail nets to combat *Cydia pomonella*, as part of a project called "ALT CARPO", named after a a non-copyrighted method named 'Alt'Carpo nets'⁴ designed in 2005 to cover the entire tree canopy and protect fruits against codling moth.

That being so, the initiative also represents an example of a fruitful collaboration between research entities across EU MS. Interviews with researchers involved in the early stages of the projects confirmed how working groups with participants from both French and Italian research institutes were keys in the preliminary phases of the project, in that it allowed to build on each other experiences.

Notably, the first experimental phases of the project were funded via regional laws targeting research (from region Emilia Romagna). Interviews also mentioned that in the initial phases, the use of nets was rather limited to organic production, whereas it slowly but steadily grew relevance for integrated management as well.

In 2009 the ALIEN.STOP consortium built the first installations in Italy to study the effects of this technology in the fight against *Cydia pomonella* on pears and other pest insects (gen. *Drosophyla*) on stone fruits (e.g. cherry trees). The initial phase of the initiative continued to see close collaboration between Italian and French researchers, to adapt the use of the nets to the local environmental conditions. In fact, since 2009, the French and Italian Alt'Carpo networks have compared and shared their experiences about the effects of exclusion netting on pests and fruit production.

The first phase of experiments involved the use of nets of different colours and sizes, on structures built on concrete poles and equipped with plastic elastics and attachment plates to keep the nets away from the plants, thus limiting fruit abrasion and hail damage. In the first years of the research, in addition to verifying the effectiveness on *Cydia pomonella*, various measurements were carried out in order to monitor possible influences on other adversities (e.g. Scab, Brown spot, Psyllids, Mealybugs) as well as on microclimatic (temperature and relative humidity) and physiological parameters (shoot development; Brix degrees, acidity, overcolour, olfactory pleasantness; shelf life of the harvested fruit). As a matter of fact, the

³ The initiative was initially named "HALYS" .

⁴ <https://www.alt-carpo.com/5.cfm?p=541-alt-carpo-alt-carpo-protection-carpocapse-severac-pommes-filet>

use of nets can potentially modify the agronomic context of orchards, including microclimate and biological aspects. The initiative immediately achieved positive results, allowing this technology to be disseminated in several regions of Italy (Emilia Romagna, Veneto, Friuli, Piedmont) for further research and application.

Following the successful application of the anti-insect nets against *Cydia pomonella*, the project shifted its focus on the alien species *Halyomorpha halys* (the so-called Brown marmorated stink bug), an alien species detected for the first time in Italy in the province of Modena in 2012, and responsible of serious damage to fruit crops in many areas fruit from Northern Italy. An articulated experimental program was therefore launched which included: tests of laboratory on different orchard layouts (i.e. single block or single rows) and field trials to test of the effectiveness of different types of nets, including generic anti-hail nets as well as anti-insect nets.

To date, the research carried out by ALIEN STOP carries on analysing the potential of the nets on different crops (actinidia, cherry, apple, pear, small fruits) and on different pests, also considering their combination with other pest management strategies (i.e. sexual confusion, attract and kill etc...).

4.2 Governance and functioning of the initiative

The relevant actors that played a role in the initiative are the following:

- **Centro di Ricerca Produzioni Vegetali (CRPV)**

CRPV is a co-operative constituted by the main agricultural production and organisation entities of the Emilia-Romagna region, representing more than 60% of the regional agricultural production. In close agreement with the regional organised production, CRPV promotes and organises every year several projects concerning research activities in the field of plant production. In the context of the ALIEN.STOP project, CRPV deals with organisational aspects, ranging from project preparation to project management.

- **Astra Innovazione e Sviluppo (Agenzia per la Sperimentazione Tecnologica e la Ricerca Agroambientale)**

Astra s.r.l. is a company that offers research, experimentation and dissemination services for public and private entities within the agri-food production chain, in the horticultural, fruit, wine, olive, extensive crops and seed sectors. *Astra* is a component of the CRPV and focuses, in the context of the initiative, on the actual testing of the technology, importing the research, setting up the investigation methods, collecting data and information at farm level and analysing the results.

- **Consorzio fitosanitario provinciale di Modena (CFM)**

“Consorzio fitosanitario provinciale di Modena” (Provincial Plant Protection Consortium of Modena) is a non-economic public body, dependent on the Emilia-Romagna Region, set up with the aim of strengthening plant protection in the province of Modena. The Consortium collaborates, upon stipulation of a specific agreement, with the regional organisational structure in charge of phytosanitary matters, with Research Centres and Universities and can carry out specific activities and project development

in the phytosanitary sector commissioned by public or private bodies and organisations.

Concerning its role within the initiative ALIEN.STOP, the consortium implements the activities of this initiative in a synergic way, both in terms of contacts with producers, management of the experimentation and data collection, as well as promotion and dissemination of the results obtained. Moreover, the "Consorzio fitosanitario provinciale di Modena" acts as a local body in direct contact with the farmers, with which it interacts during the implementation of the research.

Other stakeholders have been actively involved in specific phases of the project, such as the "Fondazione per l'agricoltura fratelli Navarra"⁵, responsible for part of the experimental fields and involved in the interviews for this case studies.

As concern access funding, the initiative benefitted of the support from the second pillar of the CAP, through RDP measure 16.1 (focus area 4.b, on improving water management, including fertiliser and pesticide management) which promotes the establishment of operational groups, i.e. partnerships that carry out an innovation project to seize new opportunities and/or solve particular problems with reference to the objectives of the European Partnership for Innovation in Agriculture (PEI AGRI). The budget allocated to the initiative via M16.1 of Region Emilia Romagna is of 299 623 €.

Alongside the CAP support to the research activity itself, it should be noted that the spread of this technology in Italy has also been supported by the CAP, which has made funds available for co-financing the purchase of nets by farmers under the OCM (when the applicants were Producers Organisations) and RDP measures of the Emilia-Romagna, Friuli Venezia Giulia, Veneto and Piedmont regions.

4.3 Results

Over the years, the ALIEN.STOP initiative has investigated the effectiveness of nets with different characteristics in terms of size, colour and model (single-row vs. single-block) analysing the effects on both target insects but also on other parameters such as moisture under the nets, influence on plant development, fruit ripening, fruit set, fruit drop, protection from weather, birds, presence of pollinators, presence of other pests and diseases.

The results obtained are encouraging in terms of effectiveness of the nets. In general, the use of nets has led to a reduction up to 90% in the use of insecticides against the codling moth according to the interviews, or under certain conditions completely cut their use. For example, the trials against *Cydia pomonella* on pear in both France and Italy on single-row nets resulted in a total reduction of chemical treatments. In fact, the use of nets permitted a significant decrease in insecticide use⁶ in orchards measured by the TFI⁷. The research showed that different types of net showed different performances: whilst the single-row model allows to drastically cut the use of insecticides almost to zero, the single-block model still requires

⁵ <https://www.fondazioneavarrar.it/>

⁶ Alaphilippe A., Capowiez Y., Severac G., Simon S., Sandreau M., Caruso S. Vergnani S. (2014) - Codling moth exclusion netting: an overview of French and Italian experiences. Proceeding of IOBC meeting «Pome arthropods and Stone fruits». Vienna (Austria) 6-9 October.

⁷ The treatment Frequency Index represents the sum across the season of the number of equivalent full -dose applications of pesticide.

targeted chemical interventions. The mode of action of netting was proved to be twofold, first as a physical preventing codling moth from reaching the tree and then, as a behavioural constraint limiting reproduction under the nets.

Investigations have also been performed on cherry trees.⁸ Interestingly, anti-insect nets showed promising performances in the control of *D. suzukii* (key phytophagous for stone fruits) as well as against the “cracking” (condition caused by high precipitation rates), thus reducing the need for chemical treatments in cherry orchards.

As regards the management of the dangerous alien species *H. haly* on pears and apples, the results obtained are promising, although at a somewhat lower degree as compared to those obtained with the codling moth, due to the peculiarities of this specific pest (e.g. harmful in all stages of development and extremely high mobility). The results⁹ show that all the types of nets tested proved to be one an effective barrier to the passage of adult forms of *H. Halys*, although at different degrees depending on the type of net used.

Specifically, simple anti-hail nets show partial effectiveness (about 40% damage reduction) against damage compared to uncovered orchards. However, it has been noted that anti-hail nets can intercept adults which are positioned on the upper part, thus enhancing the effectiveness of any chemical treatments performed because they “trap” individuals during the execution of the latter.

The anti-insect net used in single-block models showed higher effectiveness in the settlement of *H. haly* in the orchard as compared to anti-hail nets, resulting in a damage reduction in the range of 80%, and in a 35% reduction in the use of insecticide. Finally, the single-raw model showed the highest effectiveness with reduction of damages above 80% in organic pear orchards.

It has to be noted that, alongside the different types of nets used, the effectiveness of insect nets against *H. haly* also depends on other factors and must be supported and complemented by careful monitoring of the pest and targeted insecticide interventions. For instance, the use of nets in small orchards surrounded by sources of infestation (e.g. margin strips, hedges, houses, etc.) can result in lower effectiveness, especially in the single-block model.

Other side-effects and results

Alongside the benefits in terms of control of harmful insects such as the codling moth and the fruit fly, the use of nets also revealed a number of other positive side effects, the latter justifying the wording “multifunctional nets”. The main positive externalities observed are the following:

- **Hail protection**, linked to the original purpose of single-block nets, which were initially designed to protect crops from hail nets;
- **Protection from damages caused by birds**, which is particularly relevant for early varieties of pome and stone fruits with bright colours;
- **Protection against Scab disease** (*Venturia inaequalis*), obtained indirectly by limiting dampening of the fruits and avoiding, as a consequence, fungal infections;

⁸ Caruso S. (2021) - *Le reti multifunzionali su ciliegio controllano cracking e D. suzukii* ; L'Informatore Agrario, 9/2021, pp 52.

⁹ Vergnani S., Caruso S. (2019) - Cimice asiatica: buon controllo con le reti multifunzionali L'Informatore Agrario, 24-25/2019, pp 47.

- **Reduction of “cracking” on cherry fruits**, thanks to a protective action against heavy rains.

Further research¹⁰ has highlighted how nets could possibly positively influence the quality level of production. In cherry trees, this can be explained by a delay in ripening of a few days caused by less interception of solar radiation, combined with lower risk of infestation by *D. suzukii* or possible damage from cracking. The combination of these two factors allows for the possibility of waiting for the full ripening of the fruits and therefore the opportunity to obtain high-quality and high-size productions.

However, negative side effects linked to the use of anti-insect nets have been reported as well during the experimentations of ALIEN.STOP, highlighting the need for an integrated approach of the orchards and calling for further research.

First and foremost, it has been observed that the use of nets could somehow affect the pollination processes and consequently the fruit setting, fundamental for both pome and stone fruits. This negative effect can be due to both a physical barrier between the pollinators and the fruits and a shadowing of the flowers that can affect the physiological aspects of fecundation. Given the importance of this particular side-effect, further research in this field is required, in order to optimize the pollination processes in protected orchards.

Finally, unwanted effects have been reported with regard to an increase in population of other harmful pests, such as the red spider mite and the black aphid on cherry trees¹¹.

More broadly speaking, other spill-over effects can be observed along the supply chain interested by the multi-functional nets. In the context of an integrated pest management of the orchards, the nets represent an opportunity for producers, by allowing to save on conventional treatments yet keeping high quantity and quality standards, thus positively effecting their revenue. However, the high costs of this technique must be taken into account (further explored in the barrier section below).

It is difficult to determine whether the use of nets in fruit orchards affects in both positive or negative manner other actors in the agri-food value chain. Certainly, the use of this technology opens the floor to nets manufacturers, who could develop new business models based on the information gathered through research projects such as ALIEN.STOP.

Moreover, it has been mentioned in interviews that the use of nets is increasingly gaining popularity in fruit cooperatives, which oftentimes prescribe their mandatory deployment to their members.

The results of the ALIEN.STOP initiative, as well as the other parallel activities carried out in its framework, are continuously disseminated through different media such as the consortium partners' website, articles and scientific journals, workshops and technical meetings, thus increasing its visibility and outreach among stakeholders.

¹⁰ Ghelfi R., Palmieri A., Francati S., Dindo ML., Muzzi E., Grandi M., Correale R., Maccarone F., Lugli S., 2015. Analisi tecniche ed economiche sulle coperture multifunzionali. Rivista di Frutticoltura n.4/2016.

¹¹ Caruso S. (2021) - *Le reti multifunzionali su ciliegio controllano cracking e D. suzukii* ; L'Informatore Agrario, 9/2021, pp 52.

Taking into account the positive results presented in the section above, it is safe to say that the objectives proposed by the project ALIEN.STOP have been successfully met and that the project represents a successful story where the reduction of pesticide dependency has been reached by applying IPM principles.

4.4 Barriers

The initiative ALIEN.STOP has led to excellent results both in terms of reducing the use of pesticides and improving the quality of products. Nevertheless, some limitations have been encountered in the use of nets, due to the agronomic conditions of the site where they nets are installed (plants on flat land, with a low slope and already using an anti-rain system are the best) as well the reduced accessibility of pollinators, the presence of more aggressive insects and fungi under the nets, the disposal of materials (usually plastic, with a life span of 10 to 15 years) the high cost of the initial investments and the workforce needed to operate the nets (certain agronomic practices require opening and closing of the nets).

On the specific issue of pollinators, interviews with actors involved in experimental trials revealed that trials have been made where pollinators from the gen. *Osmia* were physically introduced in the underneath the nets to facilitate pollination. However, in this case, the occurrence of pollinators escaping once the nets have been open has been reported.

Another factor affecting the effectiveness of the nets is the type and layout of orchard as well as morphology of the land where the nets will be installed. In fact, fairly young plantations with regular layout and small-size plants together with flat lands appear as the most advantageous combination for the new installation in terms of costs. On the contrary, old orchards with big-sized plants in hilly territories are less adapted to this type of technology. Moreover, the specific crop influences the choice of whether or not installing anti-insect nets. In fact, high added value crops such cherries are more likely to justify the high investment of installing the latter.

Beyond these agronomic factors, the cost of purchasing and managing the nets remain the biggest limitation to the diffusion of this technology, especially taking into account the different type of crop and the selling price of agricultural products on the market., which may not justify such investments. As an average range, for a cherry orchard, the installation costs are in the range of 60.000 euros per hectare. Lower yet significant installation costs have been reported for pear orchards, in the range of 20.000 euros/hectares. Partners of the ALIEN.STOP project performed a technical-economic assessment¹² or the feasibility of the nets, focusing on the costs and benefits of this technique and analysing the related return of investment (ROI). Results from this study show ROI is, in fact, only guaranteed if the nets allow for an increase in the production value (achieved either through higher quantity or higher quality of production) in the range of 15%. In such conditions, the ROI is about 7 years.

To overcome the cost barriers, according to the interviewees, the research could soon investigate new means of mechanization capable of reducing the working hours linked to the management of the nets, e.g. installation but also handling of the opening and closing of the nets for routine agronomic practices. Another strategy is to provide financial supports to

¹² Ghelfi R., Palmieri A., Francati S., Dindo ML., Muzzi E., Grandi M., Correale R., Maccarone F., Lugli S., 2015. Analisi tecniche ed economiche sulle coperture multifunzionali. Rivista di Frutticoltura n.4/2016.

producers installing the nets through the CAP instruments, notably through RDP measures targeting the pesticide management (focus area 4.b), as already implemented in the past in some Italian regions. However, interviews revealed that the level of financing possibly obtained through RDP measures (around 50% of the investment costs in the initial phases of the project) is still too low to justify the investment according to farmers.

5. Discussion and conclusions

The experience of ALIEN.STOP explored in this case study allows us to draw useful conclusions that can feed the study themes of the pilot project. In fact, this initiative shows how, despite higher costs for the producers associated with the installation and use of insect nets, these costs can be offset in the medium-long term through the reduction in the purchase of plant protection products accompanied by an increase in the value of production. In fact, experiences from the study suggests that the use of anti-insect nets allows not only to preserve the yield levels thanks to their protective action against insects, but also to improve the commercial characteristics of the products.

The versatility of the nets in terms of target crops, pests, and construction characteristics (e.g. size, colours and thickness) allows this technology to be potentially transferred on different perennial crops and adapted against different plant diseases and insects. Furthermore, the trials performed in the context of the ALIEN.STOP project showed how the nets are particularly beneficial when paired with other tools and techniques, such as monitoring of insect population, use of pheromones and other techniques aimed at reducing the use of pesticide. Another extremely positive outcome of this initiative was linked to the successful control of invasive alien species such as the brown marmorated stinky bug, which would be difficult to control via chemical means. Finally, several positive externalities linked to the use of nets in fruit orchards have been observed, e.g. protection from extreme weather conditions and attacks from birds, justifying the wording “multi-functional nets”. That being so, the use of multi-functional nets fully falls in the framework of IPM practices that can allow the reduction of dependency on pesticides.

However, in the face of the numerous advantages, the adoption of anti-insect nets still represents a considerable economic burden for farmers, with high costs of installation and management. Such inconvenience can be mitigated acting from different angles. From one hand, further research and knowledge-building will improve the technique in order for it to optimally target to the specific context and to achieve an increase of production levels such as to justify the high investment costs. Examples of improvements suggested during interviews include the mechanisation of nets, thus reducing installation and management costs, and the combination with other techniques to maximise their effects. To obtain such improvements of the technique, further research similar to the ALIEN.STOP experience is of paramount importance.

On the other hand, public support via CAP tools (specifically RDP measures) and CMO support in the case of producer organisations can successfully “buffer” the high initial cost.

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