PROJECT DELIVERABLE REPORT

Deliverable D6.1: Report from the introductory stakeholder meetings

Fruit Flies In-silico
Prevention & Management
FF•IPM

Project Title:

In-silico boosted, pest prevention and off-season focused IPM against new and emerging fruit flies ('OFF-Season' FF-IPM)

SFS-2018-2

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1 Summary

The main objective of Work Package 6 is to develop a decision-support modelling system for in-silico design of site-optimised precision IPM for the management of the Mediterranean fruit fly (medfly, *Ceratitis capitata*) that can be adopted by European farmers and applied in heterogeneous landscapes. The validation of the novel OFF- and ON-Season IPM strategies that will be developed will be conducted on farm with the involvement of stakeholders. Hence, this deliverable presents and analyses the outcome of a series of three consultation workshops (which took place in Greece, Italy and Spain) that explored and tried to identify stakeholder needs, perception of precision pest management and expectations. Their input will be used to adapt the FF-IPM developed modelling to their requirements and to particularities of the different production systems in different European countries. Based on stakeholders' recommendations, heuristic guidelines and illustrative case-scenarios, OFF- & ON-Season IPM medfly control approaches will be developed, and their socioeconomic and environmental impacts assessed. The participants of the workshops were growers, local and regional advisors, pest control managers and scientists. The results of the Workshops will be also used to identify a suitable communication platform with the stakeholders (see WP 7 and 8).

The current deliverable provides background information for each pilot site and describes (a) the risk of medfly for fruit growers in Greece, Italy and Spain considering the information gathered during the stakeholders meetings and historic and published data, and (b) stakeholders perspectives and needs identifying also their willingness to adopt alternative pest management strategies. It also thoroughly discusses differences and similarities among the three countries and pilot sites with regard to (a) the production system, (b) medfly importance, (c) the control methods applied, and it identifies challenges in the integration of improved medfly control technology and records stakeholders needs and priorities. Briefly, stakeholders (a) are interested in a range of pests while researchers usually focus their attention on one pest, (b) identify a need for more knowledge about pest identification and damage, (c) seek a more advanced surveillance system and stronger support from public extension services and (d) consider the farmers cooperation as key element of fighting against a notorious pest such as medfly.

Overall, the conducted workshops and stakeholder interviews revealed a substantial dose of interesting information, modified our perspective and improved our understanding of the local conditions where FF-IPM tasks will be performed. The collected information will be further analysed and used to shape project execution.

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2 Introduction

The main objective of Work Package 6 is to develop a decision-support modelling system for in-silico design of site-optimised precision IPM for *Ceratitis capitata* (the Mediterranean fruit fly, medfly) management in heterogeneous landscapes and to develop and validate on-farm novel OFF- & ON-Season precision IPM strategies. The development of these alternative strategies and of the in-silico decision support system (DSS) for fruit fly control will be based on detailed knowledge about stakeholders' needs and expectations and on their active involvement throughout the development process, which is essential in order to solve their problems. With that purpose, an interactive process was built into the project with several steps and methods to facilitate that active engagement of stakeholders. The current deliverable reports on the first stakeholder meetings and their outcome - the description of the medfly problem in the eyes of growers and pest management professionals.

The first stakeholder meetings (SM1) were organised in three countries where the pilot sites will be set up, namely Greece, Italy and Spain. They took place from December 2019 to February 2020 and served to set the basis for engagement with stakeholders for the whole 4-year long program of field work in each country. They aimed at presenting the project goals and concepts and strategies for fruit fly control within the framework of FF-IPM with a focus on the OFF- & ON-Season IPM concepts and strategies and in-silico approach to design and optimisation of local IPM; they also aimed at developing a shared understanding about the fruit fly problem and its control, discuss stakeholder needs regarding fruit fly problem and discuss the possibilities and limitations of the alternative IPM practices. The deliverable describes the methodology followed in the organization of the meetings and the results obtained in each country. It also provides an analysis of what information and knowledge can be used for the subsequent development of the work package.

The meetings engaged a broad range of actors with complementary knowledge including fruit producers, growers' cooperatives and associations, traders, exporters and other business, advisors, cooperatives and NGOs, public administration and research. Two additional series of stakeholders' meetings (SM2 & SM3) are planned (D6.3, M24 and D6.4, M44), each with different objectives as it is described in the Grant Agreement:

- SM-2: presentation of a portfolio of IPM evaluation scenarios for stakeholder approval
- SM-3: stakeholder assessment of the results, and recommendations for technology adoption guidelines.

3 Methodology

3.1 Objectives of the Stakeholder Meetings (SM1)

The main purpose of the first Stakeholder Meeting was:

- to present the fruit fly problem, with a focus on medfly;
- to present WP6 concepts and expected activities;

- to collect feedback from the stakeholders regarding their perception of medfly damage, current IPM practices and pest management practices on the target farms to control medfly and other insect pests, and the limitations of such practices (including critical points);
- to discuss the possibilities of modifying/adapting the usual IPM practices in a manner acceptable to the stakeholders.

3.2 Meeting structure

The structure of the meetings respected generally the following sequence:

- Welcome and short introduction to the meeting
- Short round presentation of participants
- **Presentation of the fruit fly problem in Europe**
- **Overview and goals of the FF-IPM project**: focus on *OFF*- &*ON*-Season IPM concepts and strategies (Work Package 6) and on the need for a sound stakeholder's involvement in the project
- **Interactive discussion with stakeholders.** Focus on fruit fly damage (medfly infestation) in their fruit production area, fruit fly control methods and their efficiency, stakeholder needs for improved pest management and willingness to adopt alternative pest management strategies (including FF-IPM)
- **Completion of the questionnaire by the stakeholders** (see below for more details about the questionnaires).

There were slight variations in the structure of the meetings to adapt to the local context. In Italy, the presentation of FF-IPM was preceded by a presentation on the recent changes in agriculture (traditional, integrated, organic etc.) and the interactions between agriculture, market demands, climate change, emerging insects and a presentation on the good practices for medfly pest management in the fruit orchards and an overview on insects recently arrived in Italy.

The Stakeholder Meetings took place in national languages and had a national facilitator and rapporteur. The rapporteur registered all interventions from the audience and provided the minutes of the meeting.

All participants were asked to complete an Informed Consent Form (as stipulated by GDPR regulations) and a Personal Data Informative Text Form. These standard forms were developed in Work Package 9 (D9.1).

For each meeting the following documents were produced: Power Point presentation of the FF-IPM, meeting concept paper and programmes, meeting minutes, attendance list, consent forms and First Stakeholders Meeting questionnaire translated in national languages.

In Italy, there were also Power Point Presentations on the biological cycle of the Mediterranean fruit fly and the severity of damage to major host fruits as well as on good practices for pest management in orchards. Factsheets and manuals on the management of the main pests in fruit orchards were also made available to participants.

3.3 Questionnaires

To complement the open discussion during the meetings and to ensure a systematic collection of the information, a dedicated questionnaire was developed. The questionnaire was translated into the national languages and offered to the participants in the last session of the meeting. The main objective of the questionnaires was to "harvest" the perspectives of all the participants in the meetings and, as such, the number of questionnaires is limited.

In the follow up to the meetings, the questionnaires have been adapted and used to collect additional information from other group of stakeholders beyond the ones that participated in the meetings. These questionnaires were adapted to the specificities of each country and the respective fruit production system of the area. The follow-up questionnaires were used in Spain to collect data from production and quality technicians.

The questionnaires were structured around four main topics:

- Perception of fruit fly damage
- Fruit fly control practices and challenges faced by stakeholders
- Other key pests in orchards: perception of damage, control strategies and challenges
- Willingness to adopt novel pest management strategies

See Annex for full questionnaires. Questionnaires were translated into the national languages.

3.4 Location of the meetings

The meetings were held in the three countries where the pilot projects will be established: Greece (with stakeholders from the Korinthos region), Italy (with stakeholders from the Latium Region) and Spain (with stakeholders from the Region of Valencia).

Figure 1. Map with the location of the pilot sites in Spain, Italy and Greece marked (red dots). Stakeholders' meetings were conducted in Valencia (Spain), Paliano (Italy) and Korinthos (Greece) close to considered pilot sites.

The meeting in Greece was held in December 2019 and those in Italy and Spain were held in February 2020. They were organized by the national partners of FF-IPM and had the support of national authorities.

Table 1. Location of Stakeholder Meetings, dates and organizers

Country	Location	Date	Organiser, facilitators and rapporteurs
Greece	Agriculture school Velo Corinthians Vela, Korinthos	10 December 2019	Nikolaos Papadopoulos (UTH) Panagiotis Milonas (BPI) Rapporteur: Elma Bali (UTH)
Italy	Sala ex Cinema Esperia Piazza XVII Martiri, Comune di Paliano, Frosinone. *The meeting was sponsored by the Municipality of Paliano*	4 February 2020	Andrea Sciarretta (UNIMOL) and Pasquale Trematerra (UNIMOL) Rapporteur: Lorenzo Goglia (UNIMOL)
Spain	ANECOOP headquarters, Valencia	11 February 2020	The meeting was organized by ANECOOP and facilitated by Nicolas Juste Vidal, who provided the minutes of the meeting

3.5 Stakeholders participation

The meeting in Greece was attended by 10 participants from different groups of stakeholders. There were also various participants from the FF-IPM consortium namely from UTH, BPI and ISCTE-Lisbon.

- Two traders in Plant Protection Products
- Three participants from Research organisations
- Five agronomists from different directorates in the Ministry of Agriculture

The meeting in Italy was attended by 16 participants among different groups of stakeholders. There were also 5 participants from FF-IPM (UNIMOL, UTH and ISCTE-Lisbon).

- Eight producers/owners of private farms (two of them have also an agricultural store for retail)
- One agri-food industry operator
- Two researchers from the Council for Agricultural Research and Economics (CREA)
- Three agronomists (two of them also owners of private farm)
- Two citizens (final consumers[1]).

[1] The meeting was open to public and citizens from the area participated

The meeting in Spain was organised by ANECOOP and was attended only by farmers (27 growers of which 7 from Les Alqueries, 11 from Bèlgida and 9 from Carlet). Feedback from production and quality technicians was collected through follow up questionnaires by 5 agronomists.

Table 2. Meeting participants by stakeholder group.

Stakeholders	Greece	Italy	Spain
Producers/Farm owners		8 producers (including 2 agronomists)	27 producers
Retailers		2 producer/retailers	
Traders Plant protection product	1 person		
Industry (pack houses and exporters)		1 person	
Research Institute/organization	Koniario Institute of Citrus plants in Korinthos (1 person)	Council for Agricultural Research and Economics (CREA) (2 persons)	
	Directorate of Research, Innovation and Education of the Ministry of Rural Development and Foodstuff (1person)		
	Hellenic Agricultural Organization 'DEMETER' (1 person)		
Ministerial/Plant Protection organisations	Directorate of Rural Economics and Veterinary Medicine - Department of Quality and Plant Health Control in Korinthos (1 person)		
	Directorate of Rural Economics and Veterinary Medicine in Argolida (3 persons)		
	Department of Rural Development in Velo, Korinthos (1 person)		
Plant protection advisers (including Production and quality technicians)	Korinthos (1 person)	1 agronomist	5 agronomists
Consumers		2	

4 RESULTS - summary of the information shared by the stakeholders

4.1 Overview of medfly population dynamics and risk in Greece

Medfly, since first record in 1915 in Peloponnese, has expanded its geographic distribution in the past decades from southern coastal areas to the northern most ones (Papadopoulos et al. 2001, Papadopoulos et al. 2012). More recently, established populations of medfly are detected in cooler areas of the country including northern Greece and continental areas of other regions (Papadopoulos et al. 2012). Hence, it currently threatens the fruit production and trading in almost all producing areas of the country.

In southern warmer areas where citrus are cultivated, such as Korinthos, the fly is active all year round, but adult captures are low, close to zero, during winter and early spring. High population densities are recorded in summer and autumn. In northern cooler areas, adult detection ceases late in autumn and resumes in summer, with high populations building up towards autumn. In such areas, medfly overwinters as larvae within infested fruit (usually apples) that remain on the orchards from end of autumn to spring.

Citrus fruits (especially mandarins, sweet and bitter oranges), stone fruits (apricots, peaches, nectarines), pome fruits (pears, quinces, apples), figs, and even table grapes have been recorded to be infested by medfly in different areas of Greece.

In Greece, the economic importance of medfly infestations may be dramatic in specific crops (e.g. proportion of infestation in peaches and figs may reach 100%) (Papadopoulos, 2008). In addition, the economic damage in the so-called non-susceptible hosts, e.g. kiwi, could be high because it may affect trading and exports of fresh produce.

Table 3 gives the list of main medfly hosts in Greece as far as area harvested, total production and yield per ha is concerned for 2018.

Table 3. Main medfly hosts, area harvested and production according to FAO statistics for the year 2018.

Fruit crop	Area harvested(*ha*)	Production(*tonnes*)	yield (tonnes/ha)
Apples	10,350	285,000	27.5
Apricots	7,940	108,600	13.7
Figs	3,700	16,000	4.3
Grapes	100,340	933,150	9.3
Lemons and limes	4,390	88,380	20.1
Oranges	31,600	913,000	28.9
Peaches and nectarines	42,650	968,720	22.7
Pears	4,410	77,020	17.5
Quinces	194	5,186	26.7
Tangerines, mandarins, clementines, satsumas	9,100	174,170	19.1

Overall, the importance of medfly should not be underestimated: it is an established pest, but it exhibits a great capacity for invasions and adaptation to northern climates and these factors should be taken into account thoroughly in terms of alerting for newly recorded infestations/areas/hosts. Since medfly has recently threaten new fruit production areas in Greece, such as peach and apple production in northern continental areas, factors such as (a) determination of economic injury thresholds; (b) recording/mapping newly infested sites and characterization of geo-climatic zones favorable for the pest's expansion, and (c) planning of a state-based integrated management program, taking into account environmentally sound methods and promotion of fresh fruit exports should be considered.

4.2 Overview of medfly population dynamics and risk in Italy

Medfly is one of the key pests of the fruit sector in Italy; however, the damage it causes varies greatly depending on the climatic characteristics of the region and the crops grown.

In the Latium Region (central Italy), medfly has a maximum of four generations per year. Depending on the year, the time of appearance of adults varies from mid-June to the end of July, with a variability that depends on environmental factors (altitude and fruit vocation of the area) and seasonal factors (mild winters and hot spring). In Latium, in general, early peach and apricot cultivars are not attacked by medfly, while those ripening from the second half of July onwards are susceptible to damage, the more serious the later the harvest time is, as they can even reach 100% losses for the fruit harvested in September and October, if not protected.

In Latium, the main crop at risk from fruit flies are peaches, with a total cultivated area of about 2,000 hectares and an annual production of 25,000 tonnes (ISTAT 2019 data). Typically, the farms have multi-varietal orchards with gradually ripening cultivars. The cultivars most at risk of medfly attack, i.e. those harvested from August onwards, represent approximately half of the cultivated area (1,000 ha). Crops with smaller areas but equally at risk are apples, yellow kiwi, pears, pomegranate, oranges (total cultivated area about 1,400 ha). Kiwi (the main fruit crop in the region with 8,000 ha) has a limited attractiveness to the pest. Other susceptible crops such as figs, persimmons, mandarins, clementine and prickly pears are present in the region only as isolated plants.

4.3 Overview of medfly population dynamics and risk in Spain

The Region of Valencia (Comunitat Valenciana) in Spain is one of the Spanish Autonomous Communities where large areas of crops at risk from medfly are concentrated. The largest part of the production is citrus with a wide range of cultivars with different maturation/harvest dates and, accordingly, different susceptibility to medfly. However, there are some areas where citrus orchards are mixed with a mosaic of other fruit crops. The two pilot sites selected for the FF-IPM in Spain are located in two of such areas: La Ribera Alta (Carlet/Algemesí) and La Vall d'Albaida (Bèlgida/La Pobla del Duc).

La Ribera Alta is made of a variety of stone fruit orchards (peaches, nectarines, apricots, plums) mostly mixed with citrus (oranges) and persimmon orchards. La Vall d'Albaida is also a mosaic of stone fruits mostly mixed with persimmon, some vineyards, olives and other vegetable crops, not too much citrus as this valley is located at a higher altitude (264 versus 48 m above sea level) with more severe winters (snow is not a rare event).

In the central part of the Comunitat Valenciana (La Ribera Alta), the first generation of the medfly develops from eggs laid by overwintering adults that can survive up to March. These eggs originate the first generation of adults emerging during late April and May. A second generation appears in June and then up to 7-10 additional generations may follow until the end of the year. In La Vall d'Albaida, the first generation appears about one month later (late May-June) followed by 3-4 additional generations.

4.4 Stakeholder perspectives and needs on fruit fly problems in Greece

Medfly damage in the Korinthos area

During the stakeholder meeting in Korinthos, participants stated that medfly and olive fruit fly (*Bactocera oleae*) are the major pests of their area, which is characterized by high citrus and olive production.

Figure 2. Map indicating the Korinthos area in white. Red dots correspond to the pilot sites (see Figure 1 for perspective).

The main fruit crops identified as medfly hosts by stakeholders were citrus, stone fruits namely peaches, pome fruits, table grapes and pomegranate. Oranges are the crop of most risk from medfly. The percentage of damage without control in oranges and pomegranate reaches 40% (Table 4). However, infestation rates in mandarins were considered by stakeholders to be low. In pome and stone fruits damage is estimated at around 25 to 30%. In recent years there has been some interest in the production of lemons, but these are not usually infested.

Stakeholders pointed out that there are also high infestation rates of medfly on grapes. They estimated that infestation rates in grapes can go as high as 25% in some production areas.

Technicians report that visual inspection is usually not enough because some other pests (e.g., leafhoppers) can also cause damage that is visually similar.

Table 4. Damage caused by medfly in Greece.

Crop	% damage if no control measures are applied	% of damage despite control
Citrus	40	13
Pomegranate	40	25
Pome	30	5
Stone	30	10
Grapes	25	5

Medfly control methods

Medfly is mainly controlled using cover sprays of pesticides. According to the stakeholders, pesticides most commonly used are pyrethroids, namely deltamethrin but the organophosphate phosmet and malathion were also referred in the discussion as an option, which is no longer available or will soon become non-available. One to two applications of pesticides are used for medfly control in citrus, pome, stone and grapes. The number of applications is usually higher in oranges and lower in grapes. In mandarins, no fruit fly control is usually needed however spraying may be necessary in fruit for exports to fulfil export requirements for some destination markets.

Some farmers (around 15 to 30%) use bait sprays. For the bait sprays, growers use the same pesticides applied in cover sprays combined with appropriate food attractants. Stakeholders believe that most producers (>70%) follow the guidelines issued by local Plant Protection authorities on the timing of spray application in their orchards. The local Plant Protection authorities issue guidelines for pest management considering climatic, crop phenology and pest population data. They also indicate the registered pesticides that can be used and give generic guidelines for their application. Table 5 gives the pesticide products that the stakeholders consider being applied for the control of medfly.

Table 5. Pesticides used for medfly control in Greece.

<table>
<tr><th>Crop</th><th colspan="2">Cover</th><th colspan="2">Bait Sprays</th></tr>
<tr><th></th><th>Pesticide</th><th>Number of applications Mean (range)</th><th>Pesticide</th><th>Number of applications Mean, Range</th></tr>
<tr><td rowspan="2">Citrus</td><td>deltamethrin</td><td rowspan="2">1.3 (1-2)</td><td>deltamethrin</td><td rowspan="2">1.3 (1-3)</td></tr>
<tr><td>phosmet</td><td>phosmet</td></tr>
<tr><td>Grapes</td><td>deltamethrin</td><td>1.3 (1-2)</td><td>deltamethrin</td><td>1</td></tr>
<tr><td>Pome</td><td>deltamethrin</td><td>2</td><td>deltamethrin</td><td>1</td></tr>
<tr><td rowspan="2">Stone</td><td>deltamethrin</td><td rowspan="2">1.6 (1-2)</td><td>deltamethrin</td><td>1</td></tr>
<tr><td>Other pyrethroids</td><td></td><td></td></tr>
</table>

Some growers may also use other IPM tools, including mass trapping and other attract-and-kill approaches. These alternative control options seem to be adopted especially by organic growers, which constitute ca. 8% of all fruit growers in the area. Organic farming is estimated to represent

9.32% of the total agricultural area in Greece; approximately 10% of this area are permanent crops such as fruit trees (https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Main_Page).

It was also reported that pesticide sprayings in periods of high insect populations are not effective. In citrus, even after control measures are applied, damage is estimated at more than 10%. In pomegranate, control seems to be more difficult as 25% fruit infestation is often reported despite control. In peaches, pesticides seem to be similarly effective as damage despite control is estimated at 10%. In pome and grapes, damage drops to 5% when control measures are applied (see Table 4).

Stakeholders reported that medfly affects product quality and price and also affects exports. They also expressed concerns about pesticide residues on fruits.

One stakeholder mentioned that mass trapping for medfly control in grapes may be effective in high risk areas. According to his experience, Spinosad in grapes is not a recommended method as it has indirect effects on non-target beneficial insects.

Other key pests and their control

The key pests identified in the questionnaires and their control methods are indicated in Tables 6 and 7. Stakeholders also mentioned the plumpox virus as a problem in apricots.

Table 6. Damage caused by other pests in fruit crops in Greece.

Crop	Pest	Average infestation rates (%)
Pome	*Cacopsylla* sp. (Psyllidae)	20
	Cydia pomonella (Tortricidae)	
	spider mites (Tetranychidae)	
Stone	*Anarsia lineatella* (Gelechiidae)	20
Citrus	scale insects (Diaspididae) mealybugs (Pseudococcidae) leafhoppers (Cicadellidae) spider mites (Tetranychidae) *Aleurothrixus floccosus*(Aleyrodidae)	20
Grapes	*Planococcus citri* and *P. ficus* (Pseudococcidae) *Lobesia botrana* (Tortricidae) *Drepanothrips reuteri*, *Frankliniella occidentalis* (Thripidae)	26.6
Pomegranate	aphids (Aphididae)	20

Table 7. Control of other pests in fruit crops in Greece.

Crop	Pest	Pesticides used	IPM
Pome	*Cacopsylla* sp.	deltamethrin	
Stone	*Anarsia lineatella*	deltamethrin	*Bacillus thuringiensis* Spinosad Cultivation practices
	mites		

Citrus	mealybugs	Paraffin Oil Fatty acid concentrate Sprays	
Grapes	*Planococcus citri* *P. ficus*	Decis fenoxycarb Paraffin Oil cypermethrin	Fatty acids potassium salts Paraffin Oil
	Lobesia botrana		*Bacillus thuringiensis* Spinosad
Pomegranates		Sprays	Cultivation practices

Stakeholder needs

Stakeholders mentioned the limitations of the existing trapping networking in their area. In fact, the Regional Plant Protection Institutes have a rather "loose" adult trapping network in most fruit growing areas and, depending on adult captures and fruit ripening, they issue spraying warnings to growers. McPhail type traps baited with Biolure attractants and Jackson traps baited with trimedlure are often used to monitor medfly populations (Katsoyannos et al. 1999a,b).

Stakeholders have stressed the need to increase the number of traps and training of personnel for fruit fly identification, particularly as far as the identification of exotic fruit fly species is regarded.

Trap efficiency was another issue discussed and especially how to make this trapping grid more efficient instead of just increasing the number of traps, which is not the preferred option due to the time required to service the traps.

The need for better coordination between all the stakeholders in fruit fly monitoring was also stressed. Firstly, representatives of local plant protection authorities mentioned that there could be benefits from coordination and sharing between public institutions and private organizations. Some private sector actors (companies, advisors and producers) have monitoring systems in place in their fruit production areas which could be useful if shared with public organizations. It has been recognised that effective monitoring requires the engagement of all stakeholders.

Even within public authorities, there are also difficulties in the coordination of activities related to monitoring of fruit fly populations and post-invasion practices by different authorities.

Stakeholders also reported some problems in the coordination with research institutions and sustainability of the initiated operations and developed technologies. They referred to examples of the existing research and detection programmes that were implemented for some pests, which were abandoned after the end of the programmes. It is important that these types of partnerships with research do offer not only technical solutions, but also provisions for continuity after the end of the project.

Stakeholders also expressed concerns about the trend towards planting late harvest apricot cultivars, and the impact it may have on the infestation by medfly as well as the control of the pest under such conditions. Warmer springs and the availability of early maturing cultivars promote the above trend and increase the season of apricot with important implications in medfly phenology. Apricot is a preferred medfly host that often consists the main host-bridge between the overwintering generation and that of the summer ones. Thus, the establishment and existence of extensive apricot cultivation in the area increases the risk of medfly infestation, which is expected to escalate over the next few years. A detailed monitoring of the medfly population in apricots is therefore essential. Until now damage on early harvested crops was low but it may increases in later harvest varieties. It seems that FF-IPM approaches are very relevant to the above-mentioned effects of changes in cultivation practices and that of the climate change, since it targets the population of the fly well before it reaches the susceptible ripening season of major crops.

Public authorities report that it is difficult to deal with fruit flies from an area wide IPM perspective due to the high level of fragmentation and large number of farm owners with small production units.

Stakeholders also discussed the effectiveness of pesticide spraying concluding that these give mixed results. According to the questionnaires, damage with control is still significant in some crops. As regards to citrus, in the case of high infestation, sprays do not work well while for low infestation they are efficient. In peaches, sprays are generally less effective. The list of registered pesticides for use against medfly has been reduced in the last few years and growers have lamented in several occasions not having adequate means to protect their crops. This decrease in the range of products available may also contribute to the difficulties in achieving effective control. Stakeholders in the region of Naoussa report that there is no effective pesticide for olive fruit fly control and therefore for the medfly as well.

At the level of the exports, the requirements for some importing countries are very stringent in terms of the presence of medfly in fruits. Local pack-houses implement fruit quality control measures and have an inspection system in place to detect medfly-infested fruits. However, given that these procedures are time consuming and not entirely effective, they expressed the need for an automated and accurate method of fruit inspection to replace or enhance the common practice of visual inspection in production lines. Another problem is that even for crops that are not attacked by medfly, such as plums or specific species/cultivars of mandarins, pesticides still need to be applied to fulfil export requirements. But, at the same time, the level of pesticide residues may also be a barrier to exports. Alternatives, such as risk analysis and pest free areas, were discussed as possible ways to address this problem. Stakeholders noted that oranges are usually exported to countries with no export restrictions and that the problems are mainly with mandarins. For some exports cold treatments are needed.

In the Naoussa region in Northern Greece, a new area of range expansion of medfly, stakeholders (in the framework of another workshop on the importance of fruit fly detection) reported that there are no exports of peaches to Canada due to the presence of medfly. They also report the need for cold treatment in kiwi.

Stakeholders are also concerned about the risks of introduction of other diseases from imports of citrus. The standards should be stricter at import, but inspectors face numerous obstacles due to lack of human and other resources.

Willingness to adopt alternative pest management strategies

It is possible to adopt an alternative control strategy at large scale. The whitefly parasitoid *Cales noaki* (Hymenoptera: Aphelinidae) was mentioned as one example of successful adoption of biological control, a kind of alternative pest management approach. However, stakeholders recognised that farmers are not very open to change. In addition, there are no large groups of famers, which makes the application of new technologies even more difficult.

The main motivation for selecting IPM practices seems to be an increase in market prices and increase in product quality. Some stakeholders also responded that IPM may lead to yield increases.

Stakeholders answered that producers will be interested in changing their pest management practices only if they can really benefit from that. Economic benefits seem to be the drivers of change either in the form of production increase or increase in market prices. Another important requirement of the possible alternative would be that it would bring improvements in terms of organization of work (ease of application). Some stakeholders also mentioned environmental impacts.

The importance of the economic considerations was emphasized by stakeholders which discussed the low prices of citrus. Sometimes they may be so low that they don't even give opportunity to use pesticide, and in the worst cases, not even enough to cover production costs. The latter has very damaging 'after-effect', because the non-harvested fruit which can stay long on the tree, such as citrus, provides excellent overwintering resource for medfly and greatly contributes to the next-year pest population and fruit damage.

Regarding stakeholders' involvement in FF-IPM Project activities (namely for WP6), most of them showed willingness to follow IPM protocols for fruit fly control based on the OFF-Season approach as they strongly believe that significant reduction of spray applications can be guaranteed. In this sense, they considered as a viable strategy the establishment of a trapping network early in season for early detection of fruit flies in their area, which is a prerequisite for taking sound decisions on timing of medfly spray applications.

4.5 Stakeholder perspectives and needs on fruit fly problems in Italy

Medfly damage in the Paliano area

In the area of Paliano, the main crop is olive and thus, stakeholders stressed that the major problem growers face is olive fruit fly (*B. oleae*). However, there are fruit farms scattered in the territory[2] and fruit farm owners from the area pointed out that the presence of the medfly has been constant over the years and has now become one of the key pests. A farmer reported that, in the past, the key pests in peach were the oriental moth (*Cydia molesta*) and the peach twig borer (*Anarsia lineatella*) but these are now largely under control with mating disruption.

[2]Sciarretta and Papadopoulos explained that the reason for selecting the area of Paliano in Italy to run the WP6 experiments of the FF-IPM is precisely because these are isolated fruit farms with a constant, but not too high, presence of medfly.

Figure 3. Map indicating the Latium area in white. Red dots correspond to the pilot sites (see Figure 1 for perspective).

Stakeholders estimated that damage in peaches in the Latium area (Paliano) without control can reach around 75% of the production (Table 8). Note that as most farmers apply control measures, stakeholders expressed difficulties in estimating the percentage of damage in different crops in the absence of control. Although some stakeholders believe that pesticides are effective in control, some report that control is not fully effective. In peaches, around 15% damage can still be observed despite control. In plums, farmers report that they apply control measures and that there is still damage despite control. Plums are usually considered by researchers to be a marginal host in the region; however, it cannot be excluded that in years where conditions are more favourable to medfly, damage may be significant. Stakeholder's responses confirm that kiwi, the main crop in the region, is not usually attacked. No damage was reported in apricots which is in line with what is expected since they are usually harvested before population peaks. They do, however, report high damage in apples.

Stakeholders also reported that fruit fly damage greatly affects fruit quality and these fruits are not commercialized.

Table 8. Damage caused by medfly in Italy.

Crop	% damage if no control measures are applied	% of damage despite control
Peach	75%	15%
Apple	30%	N/D
Plum	N/D	5%
Kiwi	N/D	0%
Apricot	N/D	0%

Medfly control methods

Control of medfly is mainly conducted through the conventional use of pesticides in a routine basis (Table 9). Stakeholders in the meeting referred to two or three pesticide treatments per season in peaches every year. However, according to researchers, in coastal and lowland areas, the number of pesticide applications may reach four to six treatments per year even though it may decrease to two in hilly areas.

Pesticides identified as being the most commonly used for fruit fly control were pyrethroids, and, among those, the most frequent were deltamethrin, cypermethrin, lambda-cyhalothrin and etofenprox. The neonicotinoid imidacloprid was also mentioned, however all outdoor uses of this substance have been banned in the EU due to identified risks to bees[3]. Spinosad was also identified in the discussion as an alternative, with repeated applications during the growing season.

Table 9. Pesticide use for medfly control in Italy.

Crop	Pesticide	Mean number of applications (SD)
Peach	deltamethrin	1.66 (0.57)
	lambda-cyhalothrin	1
	cypermethrin	1
	etofenprox	1
	imidacloprid	1
Apple	lambda-cyhalothrin	1
	deltamethrin	1
Apricot	deltamethrin	1
Plum	deltamethrin	2
	cypermethrin	2
	imidacloprid	2

Stakeholders from Colleferro Municipality (Latium province), a nearby area, also reported that the control measures applied for medfly control are not always effective especially in late peach cultivars. Some also reported decrease in the efficacy of the pesticides available.

Monitoring is not incorporated in pest management strategies. Little use is made of monitoring and of alternatives such as attract-and-kill methods which are limited mainly to organic farms. Alternative tools are not often recommended by experts due to concerns about lack of efficiency.

Other key pests and their control

Control of *Anarsia lineatella* and *Cydia molesta* is the only one where an alternative to pesticides has been widely used (Table 10). Pheromone-based Mating Disruption (MD) has led to a sharp decrease in pesticide use, even though in some area's pesticides are still applied. Monitoring traps are deployed in March and, in April, the mating disruption dispensers are deployed. The threshold for control is reached when the number of adults per trap reaches 8 to 10 from the second generation onward.

Other pesticides are applied in a calendar base, or upon indication from a technician or upon visual inspection as is the case for aphids and scale insects.

[3] https://ec.europa.eu/food/plant/pesticides/approval_active_substances/approval_renewal/neonicotinoids_en

Table 10. Damage caused by other pests in fruit crops and their control (Italy, Paliano area).

Crop	Pest	Damage (%) Mean	Pesticides used
Peach	*Anarsia lineatella*	15.3%	Pyrethroids (deltamethrin, etofenprox) rynaxypyr, indoxacarb
	Cydia molesta	12.4 %	
	Aphids	Few	Neonicotinoids (imidacloprid, acetamiprid) spirotetramat
	Thrips	n.d.	Pyrethroids (cypermethrin, tau-fluvalinate) spinosad
	Scale insects	n.d.	Paraffin oil
Plum	*Anarsia lineatella*	2.5%	
	Aphids	n.d.	imidacloprid, acetamiprid spirotetramat,
	Scale insects	n.d.	
Apple	*Cydia pomonella*	41%	Pyrethroids (deltamethrin, lambda-cyhalotrin) rynaxipyr

Stakeholder needs

Participants stressed the importance of promoting Integrated Pest Management with a strong focus on monitoring of the pests with traps and the identification of the damage and pests. They identified a knowledge gap regarding monitoring tools, which are not routinely used, and pest and damage identification.

Farmers must be kept informed about the pest presence and timing of its control, and also deepen the knowledge on pest identification. Many farmers do not have information or skills on the identification of pests and the damage they cause. One farmer reported a case of intense damage on an early cultivar of pomegranate which he suspected to be medfly, but he was not able to identify the insect.

Farmers reported having little information about alternative medfly management approaches. They also feel abandoned by public institutions in the management of crops and call for the need of more efficient extension services to assist farmers. Finally, farmers expressed concerns about the arrival of new harmful species, such as the brown marmorated stink bug (*Halyomorpha halys*).

Willingness to adopt alternative pest management strategies

As regards to the willingness to change to other control methods, stakeholders are ambivalent as to what extent farmers would be interested in adopting alternative control methods. Willingness to change would be conditioned to a clear economic advantage in using alternative methods; solutions need to be practical and efficient and farmers would need to be provided with appropriate information.

Those who believe farmers are willing to change, mention that for small farmers, changing to other methods would be more difficult. If alternatives imply higher costs for farmers, then the willingness to change would be greatly reduced. The same would be if alternatives imply higher risk of decrease in market value of fruits. Reduction of environmental risks and economic risks are ranking as the most important motivations for adoption of alternative methods. Quite alarmingly, the risks to consumers and to the health of workers rank lower in the motivations for change.

As mentioned earlier, in the area of Paliano, farmers feel left out by the extension services and this could constitute an obstacle to the adoption of alternatives. Note however that the situation is very different in the different regions of Italy.

Despite the abovementioned limitations, evidence was provided for the local potential for technology uptake, provided the novel approaches are efficient and cost or labour effective. Although the results have not been as dramatic as in other regions, MD has also been progressively adopted. In fact, MD was mentioned repeatedly by farmers as an example of successful uptake of alternatives in the Paliano area.

4.6 Stakeholder perspectives and needs on fruit fly problems in Spain

Medfly damage in the Comunitat Valenciana

Due to the damage fruit flies cause (Table 11), medfly is considered as a pest of high interest (plaga de alto interés[4]) in the Comunitat Valenciana, which means that there is an official area-wide control programme in place to deal with this pest in a co-ordinated way in the whole region.

Table 11. Damage caused by medfly in Spain.

Crop	% damage if no control measures are applied	% of damage despite control
Citrus	8	4
Stone Fruit	16	7
Pomegranate	12	6
Persimmon	11	6

Medfly control methods

Medfly management in the Comunitat Valenciana is covered by the Integral Plan for the Control of Medfly (Plan Integral de Actuación contra la Mosca de la Fruta en la Comunidad Valenciana) Figure 4). Both pilot areas, La Ribera Alta (Carlet/Algemesí) and La Vall d'Albaida are included in the area covered by the 'Integral Plan for the control of the medfly'. The red and blue dots in Figure 4 correspond to Carlet/Algemesí and Bèligida/La Pobla del Duc, where the FF-IPM case studies are located.

The programme is the responsibility of the Valencian Government and was initiated in 2003. The programme has several components: the autonomic authorities have a major role in control operations (i.e., the SIT program, the monitoring program, subsidies for co-ordinated mass

[4] http://gipcitricos.ivia.es/area/plagas-principales/dipteros/mosca-de-la-fruta; http://www.agroambient.gva.es/es/web/agricultura/plagas-campanas-oficiales

trapping and pesticide terrestrial treatments) but the farmers also participate in control operations when needed, especially setting traps for mass trapping and terrestrial applications in foci.

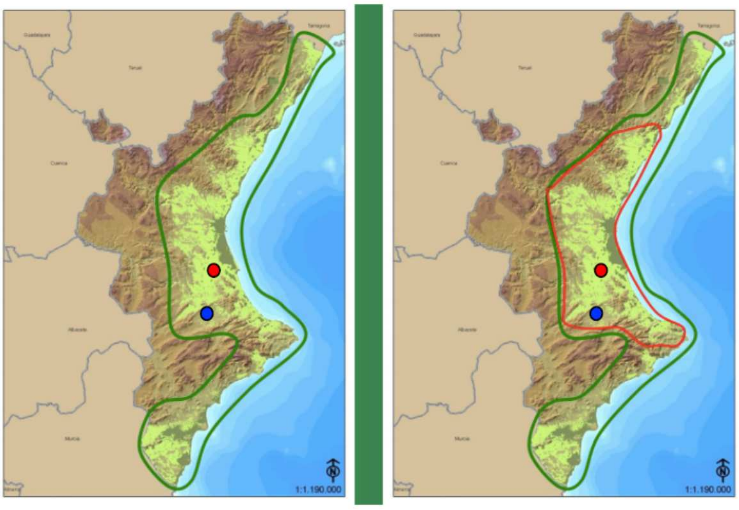

Figure 4. Area covered by the "Integral Area for the control of medfly" in the Region of Valencia (left; green line) and area where the sterile male releases take place (right: red line). Blue and red dots indicate the pilot sites considered (see Figure 1 for perspective).

The medfly control plan is based in the deployment of a combination of "biorational non-contaminating methods" to maintain fruit fly populations below the Economic Injury Level. It includes the monitoring of fruit fly populations (Figure 5), which is performed by TRAGSA, a public company. The monitoring system includes 938 dry Nadel traps with trimedlure to capture male fruit flies and 190 dry Tephri traps with tripack food attractant to capture both sexes and a killing agent. Farmers receive the information about trapping data via email and information is made available to the public at the website of the Department of Agriculture[5].

[5]http://www.agroambient.gva.es/va/web/agricultura/avisos-de-tratamientos

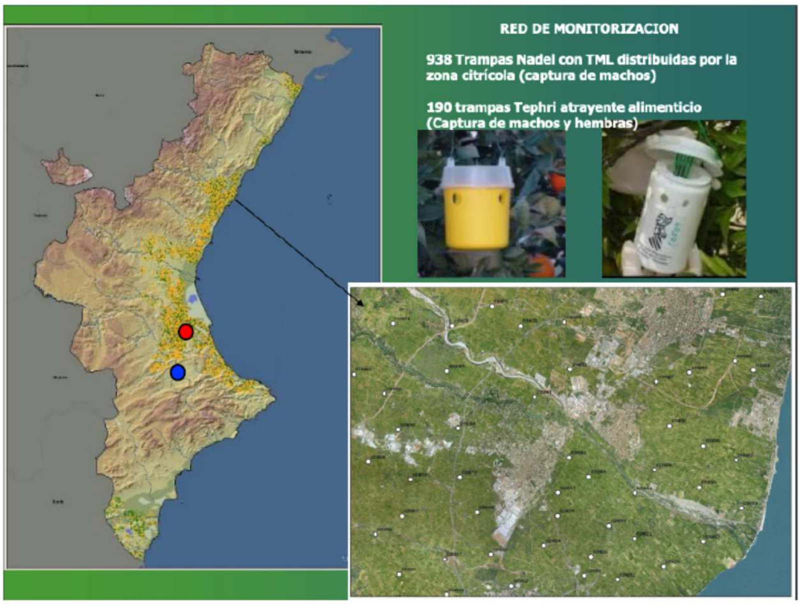

Figure 5. Monitoring network in the "Integral Area for the control of medfly"[6].

The control plan also includes:

- The release of sterile males in an area covering 140,000 hectares of mainly citrus all year round (corresponding to the area limited by the red line; in Figure 4); TRAGSA is also in charge of the releases of sterile insects. Sterile males are produced in a facility located about 60 km inland Valencia (at Caudete de las Fuentes) in an area with cold winters and mostly free of medfly hosts. The use of SIT is possible due to the existence of that facility and a centre for processing and analysis, prior to their release in the field, at the premises of the Valencian Institute for Agricultural Research, IVIA (Montcada, Valencia); both facilities, as well as the sterile males produced, are managed by TRAGSA.
- Aerial collective treatments with Spinosad and hydrolysed protein bait as bait sprays, carried out by the Department of Agriculture.
- The management of fig trees (more than 15000 tress) and other isolated host plants.
- Mass trapping, conducted by farmers and partially subsidised by the Department of Agriculture.
- If adequate levels of control are not achieved, then farmers are recommended to apply bait sprays. Treatments are usually conducted from May to July for stone fruit and from September to December for citrus. According to the questionnaires, the pesticides most used by farmers and the number of applications are indicated in Table 12. Note that farmers reported that almost all farmers follow IPM and so pesticides are used as bait sprays, which are applied according to the warning services ('Butlletí d'avisos fitosanitaris'). Farmers benefit from public support for the purchase of pesticides:

[6] Red and blue dots correspond to Carlet/Algemesí and Bèligida/La Pobla del Duc, where our case studies are located.

Table 12. Pesticides used by farmers for medfly control (farmer's questionnaire).

Crop	Farmers	
	Pesticide in bait sprays	Number of applications Mean, Range
Persimmon	spinosad	N/D
	lambda-cyhalothrin	1
	spirotetramat	1
	chlorpyriphos methyl[7]	1
Stone fruit	acetamirpid	1
Pomegranate	acetamiprid	1
Citrus	spinosad	1
	spirotetramat	1
	lambda-cyhalothrin	1

Other key pests and their control

Farmers identified the following key pests of citrus: (a) the red scale, (b) mealybugs and (c) mites; in persimmon, they identified: (a) mealybugs and (b) whitefly; for pomegranate and stone fruits, the key pest was aphids (Table 13). There are many pesticides that can be used against these pests, but since these insects do not have the same biological cycle, there are times when treatments for one pest are not effective to control the other.

Table 13. Damage caused by other pests in fruit crops and their control.

Crop	Pest	Damage caused (%) Mean
Pomegranate	Aphids (Aphididae)	15
Stonefruit	Aphids (Aphididae)	
Citrus	Red scale (*Aonidiella aurantii*, Diaspididae)	10
	Mealybug (*Planococcus citri*, Pseudococcidae)	10
	Spider mites (Tetranychidae)	10
Persimmon	Mealybugs (Pseudococcidae, *Planococcus citri and others*)	10
	Whitefly (Aleyrodidae)	10

Stakeholder needs

Stakeholders appreciate the support by the Department of Agriculture with the release of sterile males and the ATVs that go through the fields to reduce the fruit fly population.

However, they also commented that there is a need for an integrated control of pests supported by the public authorities. The programme should not be limited to the release of sterile males in the citrus areas because the damage caused by the fly is also of great importance in other crops. At present, the area covered by SIT is only part of the whole area covered by the integral plan (see Figure 4) and it focuses on citrus only. Therefore, only when other fruit crops (stone fruit) coexist

[7] Forbidden (this year)

with citrus, will stone fruits benefit from the releases of sterile males. That means that La Ribera Alta is mostly covered by SIT but La Vall d'Albaida is only marginally touched.

Given that the area of other fruits such as stone fruit or persimmon has greatly expanded and it is reaching an area comparable to that of citrus fruits, this needs to be taken into consideration in the planning of the medfly control plan.

Farmers consider that the support they are receiving to acquire traps is sufficient and that it is not necessary to increase the number of traps. Even though the number of fly catches is very high at the time of the campaign, the damage in fruits with control is not considered a big problem. Despite control, damage is estimated between 5 to 10 % in different crops.

Farmers also stressed the need for coordinating their activities in the field because while one farmer may be trying to adopt environmentally friendly measures such as releasing biological control agents, his neighbour may be using pesticides at the same time, thus killing all of them.

However, most of the interest about FF-IPM was focused on the risk of introduction of new pest species (invasive species). When discussing the threat of *Bactocera dorsalis* and *B. zonata* (Diptera: Tephritidae), farmers expressed their fears as they were unaware of the risk from these fruit flies that may affect their crops. So, they requested that, through entities such as Anecoop, the authorities be urged to carry out fruit checks at customs entry in more detail.

Willingness to adopt alternative pest management strategies

The public authorities in the Comunitat Valenciana are deeply committed to finding alternatives to pesticides as demonstrated by the numerous programmes of biological control.

The Comunitat Valenciana annually allocates 8 million Euros to solve the problem of medfly using alternative control methods by supporting an SIT facility, which produces 300 million flies weekly throughout the year. Research is also carried out by TRAGSA at IVIA premises with collaboration from the Universidad de Córdoba on alternative control options for medfly control employing the entomopathogenic fungus *Beauveria bassiana*.

The Valencian Government has public insectaries near Valencia and Castelló engaged in biological control programmes against several insect pests. These insectaries produce natural enemies which are supplied to growers for augmentative biological control (i.e., the ladybug *Crytolaemus montrouzieri* against mealybugs). They also support the release of exotic natural enemies when necessary (e.g. *Citrostichus phyllocnistoides*, introduced in the late 90s against the citrus leafminer, *Phyllocnistis citrella*). Two classical biological control programmes are underway nowadays (against the mealybug *Delottococcus aberiae* and the African citrus psyllid, *Trioza erytreae,* in citrus) and these insectaries may be involved in the mass rearing of other introduced natural enemies when necessary. At present, other natural enemies reared at these facilities include the predatory beetle *Chilocorus bipustulatus*, and the parasitoids *Encarsia perniciosi* and *Psyttalia concolor*.

In the questionnaires however, farmers pointed out that the adoption of alternative control methods is contingent to the costs not increasing and the production staying the same.

5 Discussion

The information and feedback received from the stakeholders reveals that the conditions and needs in the various countries and in regions within the same country vary greatly and pest management solutions must take into consideration this diversity.

Production overview

The farming situations in the target areas of the project are extremely varied in terms of the crop spectrum, field topography, farm size, concentration of production, destination of the product, farmers organization and current IPM practices. In some cases, most of the product goes to exports, such as for citrus in the Region of Valencia, while in others production is destined to national markets. This greatly affects the value of the production and the choice of IPM practices. In regions that export to medfly-free countries, the losses can be high even in the case where damage is low. This is the case of Spanish citrus production exported to the US market. In these cases, it is important to think how the solutions proposed by the project can also be integrated with medfly control protocols for exports at field level, transport, packhouse and shipping. Another important factor when developing control solutions is that, in such cases, the required level of control is much higher than when production is either sold locally or goes to other countries where *C. capitata* is present.

Another important dimension is farmers' organization. There is a lot of heterogeneity in famers' organization in the project areas, with areas where farmers are not organised, others where they are loosely organised, and others where they are organised in strong cooperatives. This dimension will have an impact on the way the project solutions may be developed and disseminated. In addition, in regions such as Valencia, where medfly control is centrally organised and where different solutions including some biocontrol is already in use and being tested, the type and range of possible solutions will be different from the ones in areas where farmers still rely mostly on pesticides.

Medfly damage

Medfly is reported to be a key pest of fruit crops in all the areas.

There are some differences between the levels of infestation reported by stakeholders and the data from the literature. For instance, in Greece, stakeholders reported low levels of infestation in mandarins, while the literature reports high infestation. In fact, they reported on infestation levels in an isolated area in Argolida, Greece. Earlier studies demonstrated substantial and high levels of infestation in mandarins in Greece. Interestingly, on the other hand, they reported high infestation rates of medfly on grapes. They estimated that infestation rates in grapes can go as high as 25% although it may be limited to some areas of production. In the questionnaires, stakeholders also identified damage in apricots and plums and grapes, which were not often reported as main hosts in the literature. In general, the damage in pome fruit is slightly lower than in stone fruits. However, stakeholders reported the same damage for pome and stone fruits. This may probably be because they took into consideration pears, despite apples, persimmon, and quinces that are highly susceptible.

Also in Spain, the results also show some disparities with the literature. It seems that 16% damage in stone fruits is very low. This may be attributed to growers in those areas producing mostly early cultivars, which suffer much less from the medfly than full season cultivars (where 50% and even higher losses should be expected if untreated).

The reported disparity between the perception reported by the fruit producers and the literature is not unusual and may stem from various reasons. The specificity of the local topography, host-fruit composition and phenology, and also weather patterns - all together contribute to such differences. FF-IPM is fully aware of such locality-effects, and that is the main reason for our focus on the development of the locally-tuned IPM. However, in addition to the local farm topography, ambient conditions and pest biology, human psychology also plays a role. It is known that the perception of the severity of damage depends also on the value or importance attributed to the resource being damaged or lost. Differences in the market destination and value of various fruit species may modulate famer's perceptions and impart a degree of subjectivity into their assessment. Nevertheless, the practical value of such perceptions and assessments has to be recognised and their implications taken into account during project execution.

One of the first tasks of the FF-IPM project has been to verify the situation 'on the ground' with rigorous methodology and adjust our strategy of IPM development accordingly. Although the development of IPM must be based on locally verified "hard" biological information, it should not be forgotten that ultimately the adoption of IPM technology will depend on the farmer's perception and assessment of priorities.

Medfly control methods

In terms of medfly control, there are great disparities between countries and regions. In Valencia, there is an official centrally organised medfly control programme compatible with IPM, with a trapping grid to assess risk, and a control programme combining SIT, bait spaying and mass trapping. Farmers participate in the programme to the extent that they apply bait sprays and mass trapping, which is subsidised by the government. They do not use trapping to monitor the pest but rely on warnings from the Department of Agriculture. However, the analysis of the questionnaires also seems to show that, in some cases, farmers may be using pesticides that are not recommended by the advisory services. There are also differences between citrus producers, at the centre of the programme, and producers of other fruits, which for instance do not fully benefit from the releases of sterile males.

In other countries/regions, stakeholders state that farmers follow IPM. However, this seems to be largely limited to the selection of less harmful pesticides. According to the stakeholders, farmers use mainly pyrethroids and organophosphate use seems to be secondary. However, some refer to the use of substances such as malathion, which has been withdrawn or to the use of pesticides that are not authorised for that specific crop. This is the case for instance in Spain, where farmers report using acetamiprid in stone crops that is no longer permitted. According to the warning bulletin ('Butlletí d'avisos fitosanitaris') from the Valencian Dept. of Agriculture last year, the pesticides in table 14 were authorised for medfly control, so farmers could use them in terrestrial applications.

Table 14. Pesticides authorised for medfly control in Valencia. Exceptions/special cases in brackets.

Crop	Pesticide
Stone fruit	azadirachtin
	Beauveria bassiana
	deltamethrin
	beta-cyfluthrin (not for cherries)
	lambda-cyhalothrin
	deltamethrin + thiacloprid (apricots and peaches)
	phosmet (peaches)
	lufenuron (plums and peaches)
	spinosad (plums and peaches)
Persimmon	spinosad (bait treatments).
	lambda-cyhalothrin (bait treatment)
	deltamethrin (in traps)
	etofenprox (bait treatments)
	lufenuron (in traps)

Stakeholders, however, did not refer to the use of traps, bait sprays, or any alternative control method to medfly control that pesticides. Use of monitoring traps by farmers seems to be limited only to large farmers receiving advice from private advisors, which seems to be rare. Interestingly, conservation biological control, which is one of the tools to be developed within the OFF-Season FF-IPM project, was never mentioned by stakeholders.

As we have seen also, in some areas, farmers seem to spray upon warnings from extension services however other must rely on calendar applications.

This heterogeneity in the approach adoption rate of IPM is in line with what research has shown for IPM in the EU and is affected by different social, economic, environmental and institutional factors (Parsa et al. 2014; Lefebvre et al. 2015).

Challenges in the integration of improved medfly control with the overall IPM in orchards

Possible overlaps in the timing of control operations against medfly and that targeting other pests, in particular when the pesticides are used in the form of cover sprays, may constitute a serious obstacle for the development of low- or no-pesticide medfly management tools. In the current IPM practice such overlap in pest management schedules is 'not an issue, because medfly is being controlled late in the fruiting season, after the application of control measures targeting the other pests. However, this aspect will have to be carefully considered and properly addressed during the development of the OFF-season medfly management.

Public Services /Warning systems

In the case of Valencia, due to the concentration of the production and the importance of the citrus export market, public authorities are deeply involved in pest management. On the other hand, in other regions, the support farmers receive from agriculture extension services is mostly limited to the receipt of warnings, since the number of technicians and locally available advisers is limited. In other situations, like the one reported for Latium in Italy, farmers feel mostly abandoned by local authorities.

In Spain, the trapping network is managed by a public company and detailed risk maps are produced based on which spraying is conducted. In Greece, the fragilities of the trapping network were reported due to lack of resources and unsustainable partnerships with research that led to the abandonment of some of the systems that had been put in place.

Stakeholder needs

Integrated pest management. Stakeholders are interested in a range of pests while researchers usually focus their attention in one pest. It is important to take their need for information about different pests into consideration during meetings and in presenting solutions. In both Italy and Greece the stakeholders were, for instance, interested in olive fruit fly control. It seems that same growers cultivate fruits and olives in these two countries and respective areas. Therefore, IPM technologies that will be developed by FF-IPM will have to be presented and implemented taking into account the broader context of the local fruit production.

Knowledge about pest identification. Stakeholders including farmers also identify a need for more knowledge about pest identification and damage. They report a lack of knowledge in the identification of fruit flies, as the pest identification in general and a need for such information, accessible knowledge about pest biology and easier ways to identify them. FF-IPM is planning to address this gap by conducting taxonomy workshops for stakeholders training.

Trapping continues to be challenging both for public authorities and farmers. The lack of enough human resources and knowledge about fly identification are some of the limitations mentioned.

Packhouse requirements. Stakeholders also report the difficulties in implementing requirements regarding fruit fly control in the packhouses. Consider how FF IPM can help in fulfilling export requirements by improving trapping in the packhouses and fruit inspection.

Public extension services need to be reinforced as their work is critical to the adoption of new strategies. "What happens to the areas that are abandoned by public services? They don't know what to do, so they spray, and they spray a lot" (meeting of the meeting in Naoussa in the frameworks of Deliverable 5.1).

Farmers' organization is necessary. How are farmers organised and how to promote their organisation for pest control? In some regions there are cooperatives, while in some others there are not. During the meeting in northern Greece (Naoussa), stakeholders identified clear differences in two areas, one where farmers are organized and where pesticide application is coordinated and another where farmers are not organised. They stressed the value of collaboration in pest management. In Latium (Italy) there are cooperatives of fruit growers, and, in the area of Paliano some growers have joined such cooperatives. In Korinthos there are few growers' organizations. In general growers' cooperatives have gone through a major crisis over the last few decades in Greece resulting in major "depreciation" of their role. However, most of the farmers participating in the workshop were not members of a cooperative.

Willingness to adopt

In Spain, alternative solutions may be easier to adopt but these need to be designed to fit the needs of the public administration as well as the farmers. On the other hand, if the technology and the system fulfil the needs and requirements of public authorities in charge of the medfly control programme, then their uptake is much easier. In both Greece and Italy, stakeholders are looking for support as far as medfly control is regarded and hence, they are willing to adopt new developments.

There are lessons to be learned from success cases of dissemination and adoption of alternatives to pesticides. One of the successful examples of technology adoption at large scale mentioned by stakeholders was that of Mating Disruption (e.g. MD) that can provide important lessons for the development of FF-IPM strategies.

For instance, in Italy, Lucchi and Benelli (2018) analysed the importance of cooperation between extension services and farmers in the adoption of MD. These authors mention that the situation regarding cooperation between extension services and farmers in Italy is patchy and confused. However, in the Trentino South Tyrol in the north of Italy there is close cooperation between growers and research institutions, which allowed establishment of Integrated Pest Management (IPM) in the Region namely driven by the adoption of Mating Disruption. Although the conditions were not favourable for MD in the mountainous areas of Trentino the joint efforts of researchers, advisors, cooperatives, growers, pheromone distributors, and related industries, resulted in the adoption of MD. Research institutions had an important role in conducting research and provided credible assessments of various MD formulations as well as in education (Ioriatti et al. 2011, 2012). Grower cooperatives had a major role in convincing growers to accept MD technology (Lucchi and Benelli, 2018).

Gaps in knowledge and inadequacy of dissemination channels

The level of uptake of IPM alternatives in some countries is limited by several critical factors. One of them, but by far not the only one, is lack of knowledge about alternatives. These need to be taken into consideration when developing the improved IPM approaches. In situations where public services are not fulfilling extension roles, how will the information about alternatives get to the farmers?

Often the lack of knowledge is also due to a reluctance from pest management advisors to suggest alternatives because the estimation of the risk is high as there is low trust that the alternatives will give the same level of control. This stresses the need for on-farm demonstration of the developed technologies.

Lessons learned for stakeholder engagement:

- It is important to plan the meetings taking into account the type of stakeholders present and their interests and needs. The meetings should be about two-way communication, they should be about transmitting information on the project but also leaving enough space for discussion and collecting information to inform the development of the project.
- To engage stakeholders with the project it is also important to giving out information/knowledge/other resources that may be useful for stakeholders in their daily practice. This gives stakeholders a sense that the workshop was a learning experience for them.

- Presentations by the organisers should, however, be limited in time and useful for stakeholders (not just presenting the project) and enough time should be allocated in the programme for stakeholders' participation.
- The stakeholder group should be well balanced to have different perspectives from farmers, retailers and traders, industry, researchers, plant protection authorities and policy makers and plant protection advisors. But this may not be possible everywhere especially if other dynamics already exist. For instance, in Spain, it made more sense to have a meeting with farmers, because this is the way the cooperative usually communicates with its members. In this case, other stakeholders were consulted using questionnaires and one-to-one meetings.
- The questionnaires have to be short and different questionnaires should be developed for different stakeholder groups.
- Follow up: It is important to set up a system to follow up the stakeholders meeting (thank you message, evaluation form, and inclusion in the newsletter mailing list).
- Once working relations are established and a mutual interest is recognised, there will be an opportunity to continue collecting information about stakeholders' perceptions and needs through the questionnaires, beyond the meetings.
- During the execution of FF-IPM tasks and implementation of the developed technologies, a broader view of the local fruit production system must be kept in mind, which includes also the stakeholder needs. The latter frequently go well beyond the project scope, but nevertheless should not be disregarded or ignored. As much as possible, such needs and priorities have to be taken into account and accommodated. For example, in Greece, industry stakeholders suggested the need for a workshop on pest identification. Attending to such needs could be a way further in strengthening the relationship with stakeholders.

6 Conclusion

The conducted workshops and stakeholder interviews revealed a substantial dose of interesting information, modified our perspective and improved our understanding of the local conditions where FF-IPM tasks will be performed. The collected information will be further analysed and used to shape project execution. The unexpected crisis caused by the COVID-19 virus pandemic restricted the scope and interrupted our initial interactions with the stakeholders. Nevertheless, the primary objective of the SM1 workshops has been accomplished - the initial working relations between the FF-IPM project and its ultimate beneficiaries or 'target clientele' were established.

The process of organising and running the workshops provided valuable information for the development of the FF-IPM multi-actor engagement strategy as well as for the development of the project solutions. In each country, contacts have been established with several groups of stakeholders that the project will be able to build upon. The dynamics of the meetings was very different from country to country and the different partners had an opportunity to learn from each other and improve the methodologies for data collection and for meaningful stakeholder engagement along the project.

The analysis of stakeholder feedback in the various countries highlights commonalities and differences between the countries. This information is very important for the development of the control solutions that need to be designed according the specificities and needs of the different production areas. As presented in the discussion, the difference between the type of methods of control that producers use, the destination markets, the organisation of farmers, the strength and role of research and well as the role of extension services and private advisory services, all define important conditions for the development of the projects solutions.

This deliverable will be used by partners in WP6 for the development of IPM control packages but also for all those involved in the development of specific control solutions.

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8 Annex I: Questionnaires

8.1 Stakeholders meeting questionnaire

FRUIT PRODUCTION

What are the main fruits and vegetables that are medfly hosts in your area?

Can you provide estimates of the areas and yields?

Can you provide estimates of the destination market and prices?

CROP	Area (hectares total)	Total yield ('000 tonnes)	% of the total crop in each market			Average Price (€/tonne)	Total production value (€ million)
			Export fresh	Processing	Local fresh		

DAMAGE CAUSED BY MEDFLY

What is the percentage of damage caused by medfly in the different hosts? Please provide information on percentage of damage if no control measures are applied and damage that still occurs even after control.

CROP	% damage if no control measures are applied	% of damage despite control

Does medfly damage affect the quality of the fruit? Does it affect price? Does it make it more difficult to market? How else does medfly affect production?

MEDFLY CONTROL

How is medfly controlled (indicated % of farms using each method)?

	Cover	Bait Sprays	IPM
Citrus			
Pome			
Stone			

What are the decision factors when choosing between control alternatives? (for instance, high costs of pesticide, market value of the crop may lead to a decision on not spraying)

What pesticides are used for medfly control under conventional schemes? How many applications?

CROP	Cover		Bait Sprays (composition)	
	Pesticide	Number of applications	Pesticide	Number of applications

Do you think these pest management strategies are effective? Do you identify any limitations or negative impact of these methods?

How is medfly controlled under IPM?

CROP	IPM		
	Pesticide	Number of applications	Other methods

Do you think these pest management strategies are effective? Do you identify any limitations or negative impact of these methods?

OTHER KEY PESTS AND DAMAGE CAUSED

Can you identify other the key pests and provide an estimate if the damage they cause?

CROP	PEST	Damage caused (%)

CONTROL OF OTHER KEY PESTS

How are other pests controlled under conventional control?

CROP	PEST	AUTHORISED PESTICIDES	NOTES

How are these pests controlled under IPM?

CROP	PEST	AUTHORISED PESTICIDES	OTHER METHODS

Can you provide a calendar of IPM practices (indicate the stage of the production cycle in which they are applied)?

What are the critical points or thresholds for applying control methods? (e.g. a certain number of pests caught in a trap, visible fruit damage)

IPM areas and legislation

Could you estimate the area under integrated pest management (IPM) or other production protocols?

CROP	IPM (hectares or %)	Other similar protocols (hectares or %)	Organic production (hectares or %)

What was the latest change in IPM practices (year and type of change)?

What are the motivations for using IPM?

Could you estimate the main benefits achieved by using IPM?

- Reduction of costs:
  - specifiy which ones _________________________ in % ___
  - specifiy which ones _________________________ in % ___
- Yield increase (%)
- Improvement of product quality (if possible, indicate whether there has been a change from a standard to a higher one) (in %)_________________________
- Increase in market prices (%) ___
- Changes not of an economic nature but of an organisational one (specify which, e.g. organisation of work, use of machinery, ...)
- other (specify)

Willingness to change

Do you think producers would be interested in changing their control pest management practices? Why?

Under what conditions would producers be willing to change current pest management? (e.g. by decreasing the number of pesticide treatments or applying another method) Choose ONLY two options:

- If costs do not increase
- If yields are not reduced
- If quality is improved (if possible, specify the change from a standard to a higher one)
- If market prices are not reduced or are increased
- Changes not of an economic nature but of an organisational one (specify which, e.g. organisation of work, use of machinery, ...)
- Other (specify) ____

What would be the motives to change conventional pest management? (e.g. by decreasing some chemical treatments). Rank from 1 to 4:

Motivations	Ranking from 1 to 4
reduction of health risks to workers	
reduction of environmental risks	
reduction of risks to consumers	
reduction of economic risks for the company	

Did you benefit from public contributions related to phytosanitary management practices?

8.2 Follow up questionnaire

Stakeholders Questionnaire

Stakeholders' needs and recommendations regarding Medfly OFF-Season management

(Comunitat Valenciana)

Name:

Organization:

Fruit production

- What are the main fruit crops that are medfly hosts in your area?
- What are the main countries of destination of exports? What are the requirements of these markets in terms of medfly control? Do you have knowledge of any problems with exports to these countries?

Medfly damage in the Comunitat Valenciana

- On the table indicate, damage caused by medfly in the different hosts; damage that still occurs even after the application of control measures

CROP	% damage if no control measures are applied	% of damage after control

Medfly control

- What is the percentage of farmers in the Comunitat Valenciana who follow IPM? Is this percentage the same for citrus and other fruit producers?
- How is medfly controlled in your area? Have there been recent changes to the system?
- In the table below, indicate: control methods used by the official medfly control programme; methods farmers use for medfly control

Crop	Official Medfly Programme			Farmers		
	Pesticide	Number of applications	Other control methods	Pesticide	Number of applications	Other control methods

- How do farmers decide when to spray?
- Do they use traps to monitor medfly? If not, what do you think can be the reasons for that?
- Do farmers receive advice on pest control? From whom? What kind of information do they receive in the advice?
- What other sources of information do farmers have (mail, website, training course, other?

<u>IPM adoption</u>

- What are the motivations of farmers for adoption of IPM? (e.g. *Reduction of product costs, Decrease in labour needed; Easier to apply; Yield increase; Better fruit quality (reduction of pesticide residues); Better market access; Better market prices; Less environmental impact; Less risks to consumers; Less health risks to farm workers, Government policy, Others*)

- What are the difficulties related to the adoption of IPM by farmers in your area?

<u>Stakeholder needs</u>

- In general, what are the major obstacles farmers face in fruit production?

<u>Medfly control by the official medfly programme:</u>

- What are the problems that this programme faces? Can you identify any limitations? (*for instance,are there any problems with pesticide efficiency and/or pest resistance? Are they any organizational challenges (for instance in the distribution of the pesticide treatments)? Are there problems with the cost of the programme? Are they any problems with exports? Are there any concerns about environmental impacts of pesticides?*

- Do you have any suggestion on how the official medfly control programme could be improved?

<u>Official medfly trapping system</u>

- What are the limitations in this system? How can it be improved?

<u>Farmers:</u>

- What are the problems farmers face in medfly control?
- Do they have gaps in knowledge regarding medfly and pest control in general?
- Do you have any suggestion on how to improve the way farmers control medfly?

<u>Willingness to adopt alternative pest management strategies</u>

<u>Official medfly programme:</u>

- To what extent are public authorities managing the medfly control programme interested in new alternatives?

- To what extent are national authorities interested in improving their risk assessment systems?
- To what extent are national authorities interested in incorporating biological control methods into the Medfly Control Plan?
- What factors could affect the decision of public authorities to include a biocontrol method in their programme?

Farmers:

- Do you think producers would be interested in changing their pest control practices?
- What factors could affect grower's willingness to change?
- Would farmers be willing to adopt new biological control methods? Do you know of any obstacles they have had in the past regarding biological control?
- What factors would affect their willingness to adopt biological control methods?

Pest Management Advisors:

- What factors affect Advisors decisions to recommend alternative control methods?
- Would Advisors be willing to recommend new biological control methods? What factors would affect their willingness to do so?

9 Annex II: Participants List in First Stakeholder Meetings (SM1)

9.1 List of participants in the Stakeholders Meeting (SM1) in Greece

- The names of participating stakeholders cannot be revealed according to D9.1.

FF-IPM Participants

- Ana Larcher Carvalho (ISCTE)
- Dimitrios Papachristos (BPI)
- Panos Milonas (BPI)
- Slawomir Lux (in-Silico IPM)
- Nikos Papadopoulos (UTH)
- Elma Bali (UTH)

9.2 List of participants in the Stakeholders Meeting (SM1) in Italy

- The names of participating stakeholders cannot be revealed according to D9.1.

FF-IPM Participants

- Marco Colacci (UNIMOL)
- Andrea Sciarretta (UNIMOL)
- Pasquale Trematerra (UNIMOL)
- Nikolaos Papadopoulos (UTH)
- Ana Larcher Carvalho (ISCTE)

9.3 List of participants in the Stakeholders Meeting (SM1) in Spain

- The names of participating stakeholders cannot be revealed according to D9.1.

FF-IPM Participants

- Nicolas Juste Vidal (ANECOOP S. COOP.)
- Armando Perez (ANECOOP S. COOP.)
- Joaquín Cruz Miralles (UJI)

9.4 List of additional stakeholders that filled in the follow-up questionnaires (Spain)

- Production technician in Coabe (Cooperative in Bétera, with more than 9 million kg of citrus, pomegranate)
- Quality technician in Coabe.
- Production technician in La Constancia (cooperative in La Pobla de Vallbona, with 8 million kg of citrus, pomegranate, stone fruit and persimmon)
- Quality technician in La Constancia
- Production technician in Anecoop

The names of participating stakeholders cannot be revealed according to D9.1.

10 Annex III: Stakeholders Meeting programme

10.1 Programme of the meeting in Greece

8:30 – 9:00: Registration

9:00 – 9:30: Welcome and Introductions

Outline the workshop structure, and clarify the aims and expectations. Brief introductions by participants and hosts

9:30 – 10:30: Presentation of WP6

Outline the structure and content of WP6 as a framework for the subsequent discussions, including comments on pros and cons on the proposed approach (present the project goals, OFF- & ON-Season IPM concepts and strategies, in-silico approach to design and optimisation of local IPM).

10:30 – 11:00: COFFEE BREAK

11:00 – 12:45: Interactive discussion with stakeholders on current situation, problems and vision, focusing on the following points:

- The current IPM practices and pest management applied on farms
- Economic constrains and perspectives
- Critical points and modifications of current IPM practices

12:30 – 13:00: Completion of the questionnaire

13:00 – 13:15: Final remarks and conclusions

13:15 – 14:30: LUNCH

10.2 Programme of the meeting in Italy

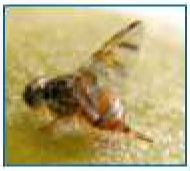
Università degli Studi del Molise

Horizon 2020 European Union Funding for Research & Innovation

FF-IPM

Incontro Tecnico-scientifico

L'impiego degli insetticidi in frutticoltura e sviluppo di una difesa ecosostenibile: il Progetto Europeo FF-IPM



Martedì 4 febbraio 2020
Ore 15.30 – 19.00

Sala ex Cinema Esperia
Piazza XVII Martiri – Comune di Paliano (Frosinone)

15.30 – Registrazione dei partecipanti

15.45 – Saluti dalle Istituzioni

16.00 – Ciclo biologico e danni della mosca mediterranea della frutta *Ceratitis capitata*
Dott. Marco Colacci, *Università degli Studi del Molise*

16.15– Buone pratiche per la difesa dei frutteti: le soluzioni per arginare i problemi causati dalla mosca mediterranea della frutta e altri insetti di recente introduzione
Dott.ssa Maria Rosaria Tabilio, *CREA – Centro di Ricerca Olivicoltura, frutticoltura e agrumicoltura (Roma)*

16.45 – Pausa con rinfresco

17.15 – Presentazione del Progetto Europeo FF-IPM e illustrazione delle attività previste
Prof. Andrea Sciarretta, *Università degli Studi del Molise*

17.45 – Compilazione di un questionario

18.15– Intervento dei produttori partecipanti al progetto e Dibattito

19.00 – Conclusioni e Chiusura dell'incontro

Durante l'evento sarà distribuito del materiale divulgativo

Evento patrocinato dal comune di Paliano (Frosinone)
Assessorato Agricoltura

Città di Paliano

10.3 Programme of the meeting in Spain

- **Welcome and Introductions**: the president of the cooperative of Bèlgida presented the workshop and the Speakers

- **Presentation of the project** (Nicolás Juste):

  - It was explained what the project was and the objectives to be achieved, the members of the project and the budget.

  - The problem of medfly in the countries involved in the project

  - The activities to be carried out in the project

- **IPM activities and management** (Joaquín Cruz):

  - Current IPM practices and pest management applied on farms

  - Which activities we are going to do in each area.

  - The traps that will be used in the project

- **Fill the questionnaire & Conclusions** (Nicolás Juste & Joaquín Cruz)