EIP-AGRI Focus Group

Sustainable ways to reduce pesticides in pome and stone fruit production

STARTING PAPER - REPORT

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Introduction

Fruits are important for human health. The health benefits of regular consumption of fruit and vegetables have been widely demonstrated. Numerous scientific studies prove it: eating fruit and vegetables every day helps to cover the body's needs in terms of numerous nutrients (water, fibre, vitamins, minerals, antioxidants) and plays a positive role in the prevention of chronic diseases (cardiovascular diseases, obesity, several cancers, etc.). But fruit production is one of the most contested by the general public for its use of chemical pesticides.

Fruit growers face many challenges. To produce a competitive yield with desired quality, many growers rely on pesticides. Compared to other crops, fruit production uses a significantly higher quantity of pesticides to control pests and diseases, weeds and to regulate growth (e.g. apples are treated with various pesticides 20-30 times a year).

Pesticides are also applied to meet consumer demand in terms of aesthetics, while maintaining nutritional value and hygiene standards. These pesticides may affect the environment (soil, water, air, biodiversity), non-target organisms, animals and human health.

To reduce the risks and impact of chemical synthetic pesticides on human health and the environment, one of the targets of the Farm to Fork strategy is to reduce the use and risk of chemical pesticides by 50% by 2030 at European Union level[1]. Developing and promoting non-chemical practices could contribute to achieving this aim.

This starting document provides the state of play and knowledge about alternatives to chemical pesticides to protect orchards against pest and diseases, their potential efficacy levels, the barriers and limits to adapt them in practice. The Focus Group will share practical experiences and research knowledge to analyse how to combine different alternative methods to reduce the negative effects of pesticides use in fruit production.

Although a great variety of different fruits are cultivated, apples are the dominant fruit crop in the EU (***Table 1***). This Focus Group will concentrate on two important fruit groups: pome (apple and pear) and stone fruits (peach, cherries, plum, apricot). These fruits are present in all climate zones, represent a significant part of the fruit area in the EU and they are under high pressure of pests and diseases, which has an impact on both quantity and quality.

	Volume 1.000 tons
Apples	10.705
Pears	2.328
Peaches & Nectarines	3.606
Apricots	553
Cherries	784
Plums	1.291
Total fruit production	42.700

Table 1: EU 27 Fruit production in 2020

(source: EU Fruit and vegetable market observatory PIP Fruit subgroup September 2021 and Stone Fruit subgroup June 2021)

[1] https://ec.europa.eu/food/horizontal-topics/farm-fork-strategy_en

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Main tasks for the Focus Group

Composed of experts in the fields of fruit production, advice, experimentation and research, the main question for Focus Group 44 is: "**How can alternative methods reduce the use of pesticides in pome and stone fruits and support the productivity of the sector in a sustainable way?"**

Their main tasks are:

- **Identify good practices to deal with pests and diseases in pome and stone fruits which may be adapted to different conditions**, including prevention practices, early detection, diagnostics and monitoring.
- **Take stock of preventive agro-ecological strategies and solutions** including current and forgotten methods as well as strategies of organic agriculture (indirect and direct measures) to further minimise the use of pesticides in pome and stone fruit production.
- **Make an inventory of IPM (Integrated Pest Management) strategies** (including biological control) to combat pests and diseases in pome and stone fruits.
- **Compare** these different management practices and strategies (agro-ecological practices and IPM), consider existing problems and opportunities, also bearing in mind practicability and costs.
- **Compile examples of 'good practice'**, i.e. a number of case studies, from farm level in particular, across different regions in Europe.
- **Identify needs from practice (farming sector) and possible gaps in knowledge** on particular issues concerning the management of pests and diseases in pome and stone fruit production which may be solved by further research.
- **Propose priorities for relevant innovative actions / projects** including practical ideas for EIP-AGRI Operational Groups.

The outcome of the Focus Group will be a report published on the EIP-AGRI website.

This starting paper serves as background document to prepare the first meeting of the EIP-AGRI Focus Group on "Sustainable ways to reduce the use of pesticides in pome and stone fruits production" which will take place in March 2022. For this purpose, the document aims to:

- establish a common understanding about the purpose and scope of the Focus Group
- identify some preliminary issues and key questions for discussion at the first Focus Group meeting
- present the available knowledge on how to reduce the use of pesticides in fruit production, which also serves as a preliminary basis for the Focus Group final report.

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Pesticides in orchards: why do we use them?

The term pesticide covers a wide range of compounds including insecticides, fungicides, herbicides, rodenticides, molluscicides, nematicides, plant growth regulators and others. The aim is to protect crops from insects, fungal and bacterial diseases that can affect fruit quality. On pome (***Table 2***) and stone fruits (***Table 3***) more than ten major problems threaten fruit trees and their yields.

Diseases & Pests	**Type of damages**
Apple scab	Black lesions on leaves and fruits *(photo 1)*
Storage diseases (*Gloeosporium*)	Fruit rot *(photo 2)*
Codling moth	The worm in the apple
Psylla (pears)	Vector of a phytoplasma (pear decline), fruits covered by black sooty mold
Aphids	Biting insect acting on the growth of trees and resulting in soiled and deformed fruit *(photo 3)*

Table 2: Major diseases and pests on pome fruits

	Diseases & Pests	**Damages**
Stone fruits	Leaf curl *(Taphrina deformans)*	Leaf puckering and distortion, fruits drop prematurely (*photo 4)*
	Monilinia spp	Flowers wilt, turn brown and fruit rots (*photo 5)*
	Drosophila suzukii	Fruit rot caused by the fly who lay its eggs in ripening and ripe fruits
	Aphids	Curved leaves and flowers or newly formed fruits abort *(photo 6)*
	Oriental fruit moth	Larvae feed first on new terminal growth and continue to attack and tunnel in the developing fruit

Table 3: Major diseases and pests on stone fruits

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Photo 1: Apple scab symptoms on fruits make the fruit unmarketable (CTIFL)

Photo 2: Serious fruit damage on apples caused by fungi during storage (CTIFL)

Photo 3: Aphids feeding activity causes deformed apples (CTIFL)

Photo 4: Peach leaf curl is one of the most common diseases (CTIFL)

Photo 5: Due to the fungus *Monilinia spp*, ripe stone fruits may completely rot (CTIFL)

Photo 6: Stunting and deformation of peach leaves due to aphids (CTFL)

The challenges of fruit growing and reducing pesticides

Pesticides may have an adverse impact on non-target organism (like animals, fish, beneficial insects) and affect the environment (soil, water, air and biodiversity) by spray drift, vaporisation, surface run-off. It is estimated that only about 10% of the pesticides used are actually effective against target-organisms, about 90% end up on non-target organisms. Furthermore, some pesticides can persist in the environment, and remain there for years.

Also humans can be exposed. Pesticides are associated with both acute and delayed health effects, ranging from simple skin and eye irritation to more severe impacts on the nervous and reproductive systems. Especially occupational exposure to pesticides is associated with the development of a wide spectrum of pathologies (Parkinson, cardiovascular diseases). Also indirect exposure via air drift, water and nutrition may affect humans living near intensively managed agricultural areas.

Integrated Pest Management (IPM)[2] was developed in response to steadily increasing pesticide use that resulted in pest control crises (outbreaks of secondary pests and pest resurgence following development of pesticide resistance) and increasing evidence and awareness of the full costs to human health and the environment of the intensive use of pesticides. IPM is an ecosystem-based strategy that focuses on long-term prevention of pests or their damage through a combination of techniques such as biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides may be used only after monitoring indicates they are needed according to established guidelines, and the goal of treatments is to only remove the target organism. Pest control treatments are selected and applied in a manner that minimises risks to human health, beneficial and non-target organisms and the environment.

The challenge for fruit growers is to continue protecting orchards against pests and diseases while "key" active substances are banned or restricted, and the conditions of application of other pesticides may be revised. This may lead to technical impasses in orchards. As a result, a repeated number of applications of more "generalist" plant protection products causes resistant strains, emerging pests and diseases, and impacts on the environment, in particular the beneficial insects.

Alternative solutions have been developed, some are already used, others are still being tested. There is often a gap between regulatory changes and technical and scientific advances, causing problems for fruit growers.

The "Farm to Fork" strategy aims to make the European food system fair, healthy and environmentally-friendly. The strategy includes two pesticide reduction targets: these are a 50% reduction in the use and risk of chemical pesticides and a 50% reduction in the use of more hazardous pesticides by 2030 at European Union level[3].

The use of pesticides has become a societal issue due to their impact on environment, consumer and growers' health. Are alternative means a solution to move towards "zero impact"?

[2] https://ec.europa.eu/food/plants/pesticides/sustainable-use-pesticides/integrated-pest-management-ipm_en
[3] https://ec.europa.eu/food/plants/pesticides/sustainable-use-pesticides/farm-fork-targets-progress_en

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Overview of alternative methods in orchards

- Biocontrol agents (BCAs): macroscopic (insects, mites, nematodes); microscopic (bacteria, viruses, fungi)
- Natural products (from plants, animals or minerals)
- Semio-chemicals, attractants and repellents
- Physical barriers (excluding nets, plastic covers)
- Physical treatments (Hot water, UV-light)
- Mechanical techniques (weed management, reduce inoculum, thinning)
- Genetics (Resistant varieties)
- Cultural practices

Biocontrol agents

Biological control is based on the use of organisms which can reduce the populations of harmful organisms that cause pests or diseases. Biocontrol agents (BCAs) can be classified as macroscopic, including insects, mites and nematodes, or microscopic including bacteria, viruses and fungi. Thus, macroscopic BCAs are useful to control only pests, while microscopic biocontrol agents have a wider range of targets, from bacteria, fungi to insects. The main advantage of microscopic BCAs is no residues in fruits and reduced risk of development of resistance among pathogen populations. Moreover, they are highly specific to a pathogen and hence considered as harmless to non-target species. Their mode of action is based on space and nutrition competition with the pathogens, on production of antimicrobial compounds or induction of plant resistance against diseases.
In the case of macroscopic biocontrol agents, the most common strategy of application is called "augmentative", based on the introduction of biocontrol agents in large populations to obtain immediate control of the pests. Recently, the trend is moving towards "conservation biological control" which consists of adapting the habitat (*Photo 7*) to attract and retain natural enemies (*Photos 8 and 9*) controlling pests in more natural ways.

The important point is to manage a living organism.

Photo 7: Hedges and flowers for Biodiversity (CTIFL)

Photo 8: Chrysopa larvae, a beneficial insect (CTIFL)

Photo 9: Syrphidae larvae eating an aphid (CTIFL)

Natural products

Natural products have a long history of use in crop protection. There are three types: minerals such sulphur, potassium bicarbonates, acid clay (*Photo 10*); plant extracts like from *Equisetum arvense*, *Urtica spp* or animals (e.g. chitosan, fibrous compound derived from the shells of crustaceans). In most cases they are available as commercial products, but plant extracts may also be prepared directly by the growers.
Botanical products generally have low toxicity, a shorter shelf life, limited field persistence (repeated applications are needed) no risk for pathogen pest resistance, and are considered safe to humans and the environment.

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Photo 10: Clay applications on leaves in autumn to limit the return of rosy aphids (CTIFL)

Photo 11: Mating disruption against codling moth (CTIFL)

Photo 12: Mass trapping against *Zeuzera* (CTIFL)

Semio-chemicals, attractants and repellents

Insect pheromones are volatile chemicals produced by insects as part of their social signalling system. For example, insects may release pheromones to attract individuals of the opposite sex for mating. The term "mating disruption" (*Photo 11*) refers to the use of sex pheromones to confuse male insects so they cannot find females, thus preventing mating and suppressing the growth and spread of infestations.
Mass trapping (*Photo 12*) consists of trapping a large number of individuals in order to limit the populations of the pest. It can be food, scent, light or sexual trapping.
The Push-Pull strategy consists of applying a repellent diverting egg-laying females from their egg-laying sites (e.g. fruit) and attracting them to a trap outside the orchard.

Physical barriers

The concept of exclusion nets (e.g. in France called Alt'Carpo) is based on a barrier effect *(Photo 13*). The fact that several apple orchards are protected with hail nets, to prevent them from meteorological damage, gives the possibility to completely close the orchard, installing anti-insect nets on sides and thus prevent entering of insects like *Lepidoptera* (codling moth, oriental fruit moth) and flies (*Drosophila suzukii*). In some orchards nets are directly put on each tree row. The use of this netting system can also help to introduce biological control of other pests such as aphids by introducing beneficial insects.

Plastic covers (*Photo 14*) installed on the top of the trees like a roof protect the orchards and fruits against rain and consequently against infection by diseases caused by fungus and bacteria.

Photo 13: Exclusion nets around orchards, a barrier against insects (CTIFL)

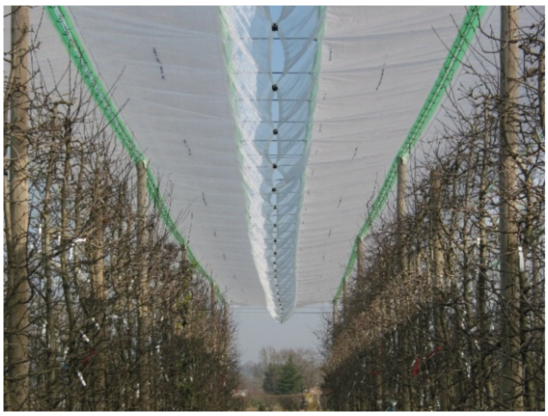

Photo 14: Rain covers against apple scab and storage diseases (CTIFL)

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Physical treatments

Alternatives to postharvest treatments on apples or peaches are hot water treatments. The fruits are drenched with hot water to prevent the development of storage rots (*Monilinia spp, Gloeosporium*) and storage apple scab.

Ultraviolet C light can control pathogens on fruit surfaces and could potentially be used on fruit packing lines to ensure food safety, research on this topic is ongoing. But UV-C light cannot penetrate solid objects, it sanitises surfaces. Furthermore, as UV-C is harmful to the naked eyes, UV-C lamps should be enclosed behind protective barriers inside a tunnel on a packing line, where fruit passes on the conveyor belt.

Mechanical techniques

Groundcover management in orchards is a critical component of successful fruit production. Fruit trees need to be free of weed competition for at least part of the year, and especially during the initial establishment years in order to maximize vegetative growth and fruit production. There are different types of mechanical equipment (*Photo 15*) to maintain only a weed-free strip on the tree rows and mow the grass on the orchard alleys, where the tractor goes, to keep the orchards accessible. In some cases, mulches (produced by mowing, sowing ground cover plants or installing plastic cover) can provide good weed control.

Schredding leaves in autumn, when they fall on the soil is a prophylactic way to reduce fungi inoculum for the next season. This technique has to be integrated in a global fungi protection programme.

For many varieties of fruit trees, annual thinning of flowers and fruitlets is a crucial step in regulating the number of fruits per tree, improving fruit quality and avoiding the phenomenon of biennial bearing. Pre-bloom mechanical thinning is done with flexible wires that are set into motion by a mechanical device. This practice allows for an apple tree's blossoms to be reduced by 30 to 50%. However, if used alone, this technique does not provide sufficient thinning of all varieties of apple trees.

Photo 15: Mechanical weed management (CTIFL)

Photo 16: Wood chip mulch (CTIFL)

Photo 17: Mechanical thinning in apple orchards (CTIFL)

Genetics

The aim is to breed varieties that are resistant or less susceptible to pests and diseases, but genetics will not be able to do everything. The difficulty is that there are many different pests and diseases and it is also important to maintain the fruit quality characteristics. In addition, pests can overcome varietal resistance.

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Cultural practices

Cultural control consists of adapting the various cultural operations (pruning, thinning, fertilisation, etc.) to limit the damage caused by certain bio-aggressors. It is usually referred to as "sanitation practices". There are different ways to reduce the inoculum or limit the sensitivity of the plant to pests: removal of infested organs, aeration of the vegetation, limitation of vigour and water management.

The following three tables (***Tables 4, 5 and 6***) give an indication on the efficacy levels each alternative method may achieve on pome and stone fruits. The colour code is as follows:

low efficacy
partial efficacy
satisfactory efficacy

Alternative methods	Insects	pome fruits	stone fruits
mating disrution	codling moth, oriental fruit moth		
mass trapping	mediterranean fruit fly, forficula		
eliminate wormy fruits	codling moth, oriental fruit moth		
removal of infested branches	Zeuzera		
laying trap strips	codling moth		
green pruning	codling moth, oriental fruit moth		
root cutting	aphids		
nitrogen managament	aphids, psylla		
insect proof nets	codling moth, *Drosophila suzukii*		
conservation biological control	mites, aphids, psylla		
granulosis virus	codling moth		
Bacilluls thurinIensis	codling moth and other Tortrix		
nematods	codling moth		
introduction of beneficial insects	mites, aphids, psylla		
clay	psylla, flys, codling moth		
glue	forficula, aphids		

Table 4: Alternative methods to limit the use of insecticides

Alternative method	Diseases	pome fruits	stone fruits
destruction of leaf litter	apple scab		
pruning of contaminated organs	powdery mildew		
removal of mummified fruits	Monilinia spp		
green pruning, leaf removal	Monilinia spp, Botrytis		
nitrogen and irrigation management	Monilinia spp		

Table 5: Alternative methods to limit the use of fungicides

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Alternative method	pome fruits	stone fruits
grassing, plant cover		
mechanical weeding		

Table 6: Alternative methods to limit the use of herbicides

A combination of approaches to reduce the use of pesticides

The principle of pest and disease management is based on preventive and curative measures. The saying goes: "*Prevention is better than cure*".
The susceptibility to pests and diseases varies: i) with the range of varieties and even rootstocks, ii) orchard management (e.g. nutrition, irrigation, sanitation measures) and its environment, iii) the climate conditions favourable to fungal, bacterial and insect infestations. At all stages of planting an orchard to adulthood, the choices made by the grower are decisive for the management of orchard protection.

None of the control methods provide satisfactory and effective protection if applied individually. Growers wishing to engage in an integrated pest management (IPM) approach must find the right combination of the different methods to compensate for the reduced use of pesticides to maintain crop health compatible with agricultural production activities.

There are three levels of disruption and transition to change practices: increase in efficacy, substitution of pesticides and re-design of orchards (***Figure 1***).

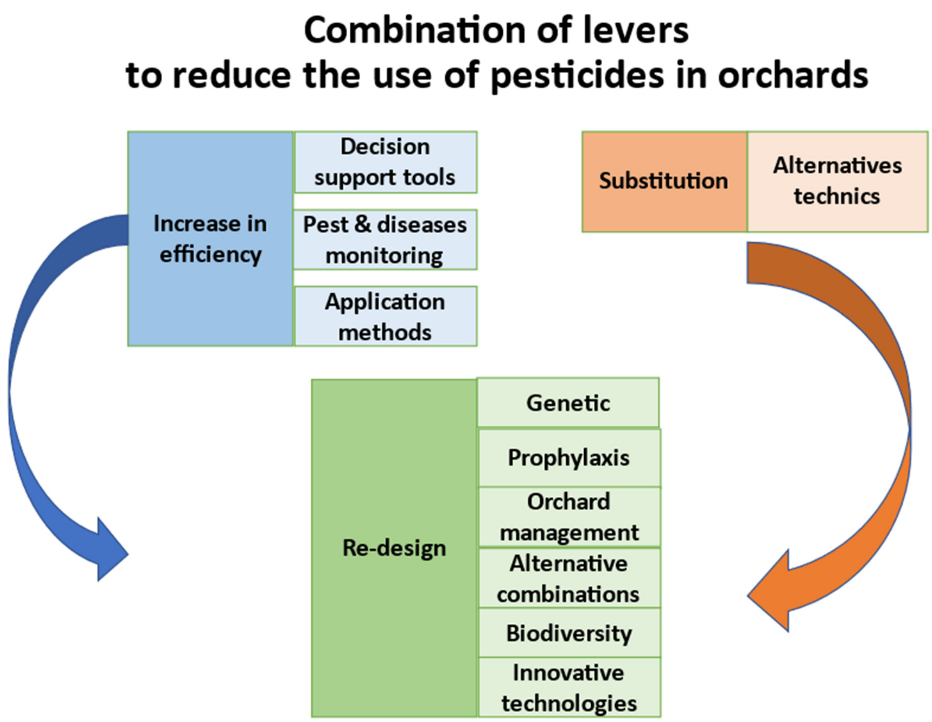

Figure 1: The systems approach based on three main levels to change practices

- **Efficiency**
  Increasing efficiency allows the use and consumption of pesticides to be reduced by better reasoning the treatment interventions (biology of the pests and diseases, stage of the plant) through the use of decision-support tools such as risk prediction models, but also pest and disease observations. Increasing

efficiency means also optimising the application methods: spray quality, adaptation of the volume of the spray mixture and the dose of active substance to the volume of the plant to be treated, optimising the effectiveness of treatments (application conditions, adjuvants, etc.).

- **Substitution**
  Substitution allows chemical inputs to be replaced by alternative practices (biological control, physical control, etc.).

- **Re-design**
  To redesign a system means profound changes in crop protection management by acting preventively to make the system less susceptible to pest and disease attacks. The aim is to enhance the ecological processes and natural regulatory capacities of agro-ecosystems by favouring the plant's natural defences and the action of beneficial insects through: choice of varieties, tree architecture, plant associations and by combining alternative techniques.

Example of a French Initiative: "Dephy FERME" and "Dephy EXPE"

The aim of the "Dephy network" is to contribute to developing agricultural practices to reduce and improve the use of phytosanitary products. Launched in 2009 following the EcoPhyto I plan, it currently brings together 3,000 volunteer farms throughout France. In 2021, the "Dephy fruit-growing network" (Dephy FERME) included 19 groups of farms with a dozen or so holdings.

Today, a third of "Dephy" fruit farming systems can be considered as economical with less phytosanitary products, but most of the reduction in phytosanitary products is linked to the conversion to organic production. ***Table 7*** represents the evolution of the chemical treatment frequency indicator (TFI) between the initial stage of the Dephy Farm network and the average of 2014-2015-2016 for fruit production. The average reduction of the chemical treatments (without biocontrol agents, natural products and semio-chemicals, attractants) achieved was 25%.

GLOBAL FRUITS	Apricot	Clemen-tine	Peach	Plum	Pears	Apple	Nut	Olive
– 25 %	– 41%	– 49%	– 10%	– 10%	– 28%	– 14%	– 17%*	– 11%*

Table 7: TFI reduction between 2014-2015-2016 for fruit production – Dephy FERME (France) source: INFOS CTIFL JUNE 2019 N°352 (* in 2017)

The innovative "Dephy EXPE systems" tested in the research centres and experimentation stations, led to significantly reduced TFI compared to the reference systems (above 50%). Although these innovative systems achieved the objective of reducing TFI, on average they did not achieve the same yield levels as the conventional systems. For the systems tested in organic production, the better price received for the fruit resulted in a turnover almost equivalent to conventional systems.

The EcoPêche 2 project (2019-2023) is one example. Its objective is to create a multi-criteria performance evaluation of peach-nectarine orchards that are low in phytopharmaceutical products, and to explore the feasibility of new agro-ecological and technological systems (called Eco +) that are even more ambitious with a reduction of TFI by -80% compared to conventional practice (Integrated pest management), with a chemical TFI of less than 4, without herbicides and no residues.

At the halfway point of the project, the environmental objectives have been achieved for most of the systems in place, however, this strong reduction in the use of synthetic plant protection products has penalised the agronomic and technical-economic performance of the management systems, despite the implementation of combinations of methods designed to mitigate losses due to diseases and pests.

The systems are evaluated on their environmental (TFI), agronomic (yield, grading, waste rate, etc.) and technical-economic (production costs, economic margins, etc.) performance in relation to the results obtained on the IPM references plots (***Table 8***). The indicators are expressed per tonne of commercial fruit.

	Enviro. Perf.	Agronomic performance						Technical-economic performance				
	TFI / com.t.	Gross yield	Gross commercial return	% fruit size A and above	% losses	Ferti N / com. t.	Irrig. Water (m³/com. t.)	Total hours /ha	Hours / com. t.	Production cost/kg fruits	Production costs excl. mechanical costs	Average Partial Margin
2019	28%	91%	86%	128%	104%	101%	92%	85%	96%	100%	89%	
2020	1%	81%	76%	134%	176%	157%	164%	84%	131%	142%	87%	71%
2021	15%	89%	73%	148%	188%	127%	124%	76%	109%	110%	76%	34%
Average	**21%**	**87%**	**78%**	**136%**	**156%**	**128%**	**127%**	**82%**	**112%**	**117%**	**84%**	**63%**

Table 8: Average performance of "ECO +" systems compared to IPM (IPM base 100)

Example of an Interreg-project "Model orchards for further development of integrated crop protection" (Switzerland, Germany and Austria)

The goals of the project are to study new ways of fruit production to minimise pesticide use, to reduce pesticides with a high environmental risk and to minimise residues on fruits, and finally to combine promising measures in model orchards.

At Agroscope, in Wädenswil (CH), the approaches investigated were the varieties (scab resistant), rain cover against apple scab and storage diseases. The insect exclusion net against codling moth and weeds were also managed with alternative techniques.

Rain cover significantly reduces scab infections, but is less effective against storage diseases. However, as leaves take longer to dry under cover, it creates a favourable microclimate for powdery mildew.

Figure 2 summarises the effect of the insect net and rain cover alone or combined on the pesticides and residues reduction, the storability of the fruit and costs of these techniques compared to a standard IPM plot. The fungicide and insecticide strategy in these plots was kept to a minimum.

After three years, physical protection showed no negative effect on fruit quality on the varieties Gala and Bonita, reduction of pesticides and detected residues was possible. But how can the additional production costs be compensated? Moreover, this new system approach requires long term observations for yield, quality and storability of the fruits, behaviour according to different disease pressures, population dynamics of pests and beneficials.

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Summary

	Anti hail net		
		Rain cover	
	Insect net (lateral)		Insect net (lateral)
Potential for pesticides reduction			
Fungicides	same as standard	less applications than standard	less applications than standard
Insecticides	less applications than standard	same as standards	less applications than standard
Peticide residuea	slightly less residues than standard	less residues than standard	considerably less residues than standard
Storability	same as standard	better than standard	better than standard
Costs of infrastucture			
Construction	slightly higher costs than standard	considerably higher costs than standard	considerably higher costs than standard
Maintenance	slightly higher costs than standard	higher costs than standard	higher costs than standard
Labor costs for plant protection	slightly less applications than standard	less applications than standard	considerably less applications than standard

strongly positive | positive | rather positive | no difference | rather negative | negative | strongly negative

Interreg Project Model Orchards | EUFRIN Meeting, Bologna, 15.09.2021
Andreas Naef

Figure 2: Incidence of insect nets and rain cover in apple orchards. Source: Interreg project Moel Orchards, Agroscope (CH)

Barriers and limits to adopting practices to reduce the use of pesticides

The range of Biocontrol agent products available to producers is still limited. In France, the use of Biocontrol agents (beneficial insects, entomopathogen nematodes, bactericidal and fungicidal yeasts), natural products (kaolin, potassium bicarbonate) and pheromones represents 12% of the plant protection market.
Efficiency levels are generally around 50%. This low effectiveness can be explained by the lack of information about the optimum methods and times of deployment that maximise the effectiveness of the products. Compatibility of BCA with chemical pesticides has to be checked. The optimal conditions of use seem to be only partially known by users.

To insure the best efficacity of Biocontrol agents, it is important to respect storage conditions (for example in a fridge) and the way to apply them (example: luminosity, temperature). The acceptance of these products by advisors and producers requires support.
Natural products such as plant extracts are attracting more attention. However, for industry, the major difficulties to reach the market is standardisation of active ingredient(s) and the regulatory requirements for approval.

The challenge with beneficial insects is to produce them in bigger volumes to carry out releases in orchards at a reasonable cost and to encourage them to establish in the long term. In case of exotic insects, an authorization to experiment and introduce them is necessary. It is important to determine the specificity of the beneficial insect otherwise there is a risk of disturbing the natural balance of the fauna. It is difficult to measure the impact of the use of beneficial insects in orchards.

To achieve good results with mating disruption, pheromones must be applied on larger plots. Depending on the initial pressure of the pests, this technique needs to be combined with insecticides to have 100% efficacy.

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Pheromone dispensers are distributed manually in the orchards and require time to install and remove. Aerosols that release pheromones at regular intervals are now also available.

The installation of nets and plastic cover is a way to limit the entry of insects and the spread of diseases by rain. Depending on the pressure of pests and diseases, their effectiveness is partial or total. However, the cost of the installation remains an obstacle as long as the growers cannot better valorise their fruit. From a technical point of view, the plastic covers are still not ready for widespread commercial use. The negative points are: a poor performance in strong winds, a short lifetime, yield reduction and reduced fruit colour, in some cases a development of other pests and diseases than the main targets, and finally also the visual aspect and the noise of the plastic covers moving in the wind.

Hot water treatments in storage facilities need to be adapted to treat larger fruit volumes, and their energy consumption is relatively high.

When using mechanical tools the soil condition must be taken into account: risk of erosion, soil compaction, not practicable after rain, too stony and too steep. Orchards may have to be adapted to be mechanised, like for example the 2D training system on apple trees, to get a more uniform and narrower canopy to prune and thin mechanically.

Take the right decision *(Figure 3)*
Producers are confronted with daring to take risks, without ever losing sight of the economic and social aspects

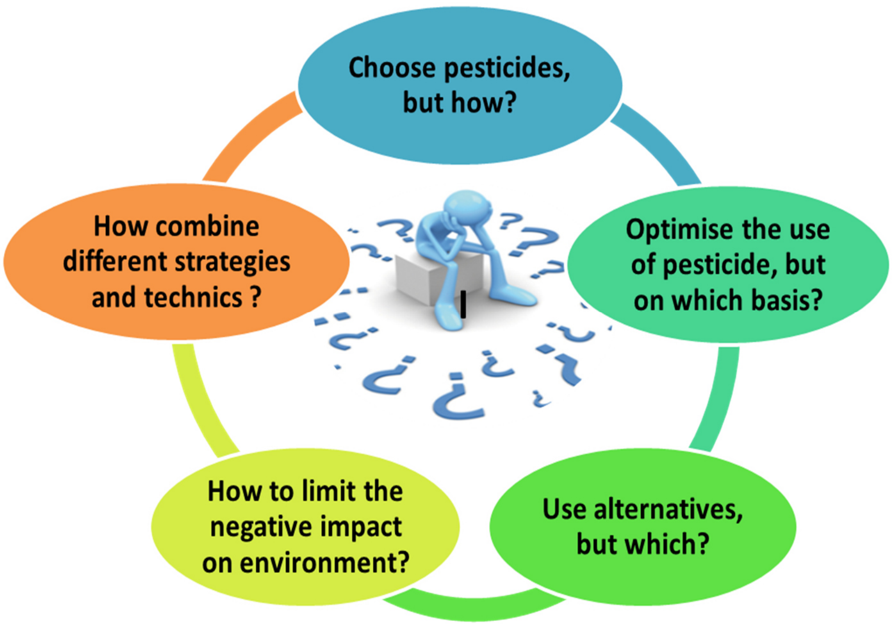

Figure 3: Orchard protection based on complex decision making

Find the right balance
The use of alternative methods requires changing practices and overcoming apprehension. Biocontrol agents, natural products, semio-chemicals are not applied in the same way as conventional pesticides. This can be a hurdle for growers.

Reviewing one's technical itinerary, redesigning of the orchards, establishing real monitoring of the crop, is a long-term commitment. The results are not immediate. These changes require a human and financial investment. It means changing habits and reviewing the thresholds for the presence of pests and diseases. There is no single solution for protection, but it is the combination of approaches and methods that should make it possible to find the right balance.

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We have to learn that as soon as we change something in our environment, we impact the balance of the plant.

Further points to reflect on:

- What are the limits, difficulties to develop alternatives practices in orchards?
- What is needed to do so? *(Guidance, pilot orchards, basic or/and applied research, communication, training, support etc.)*
- Can nutrition help to reduce the impact of pests and diseases?
- How can soil structure and soil life contribute to improving the resistance and resilience of orchards?
- To prevent pests and diseases, could we use biostimulant products (like plant extracts)?
- Can Agroecological Crop Protection be the future of crop protection?
- Changing practices, how much risk is taken by the growers? Are consumers willing to accept less perfect looking fruits?
- Fruits are safer than ever, but people often think differently. How can growers promote understanding and a positive view on their work and products?
- What kind of intermediate activities should be carried out to support the reduction of pesticide use? Different actors may be involved: extension services, agricultural and rural development, research, education.

More on this topic:

- THE EUFRUIT PROJECT: REDUCTION OF PESTICIDE RESIDUES ON FRUIT AND IN THE ENVIRONMENT. Franziska ZAVAGLI, Hors série InfoCtifl, November 2018
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