State of the art of Integrated Crop Management & organic systems in Europe, with particular reference to pest management

Apple production

Pesticide Action Network (PAN) Europe

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Apple production

According to the FAO the production of apples in the 25 European Union countries was 11.96 million tonnes in 2005 (1). Such considerable production entails a high use of pesticides in apple orchards. Fruit trees are the second crop in terms of quantity of pesticides used by hectare, only exceed by vineyards (2). The volume and the number of pesticide applications during the growing season results in the frequent presence of residues in apples, often exceeding the Maximum Residues Limit (MRL) (3), which can cause adverse human health effects. Organic production, despite having none of these drawbacks, currently accounts for a very small percentage of total apple production. Therefore, the use of pesticides in conventional production should only be considered when every other method of crop protection fails and carefully selecting the timing, the dosage, frequency of applications and the type of pesticide, respecting the Integrated Pest Management (IPM) principles.

The International Organization for Biological and Integrated Control of Noxious Animals and Plants (IOBC) defines Integrated Fruit Management as "the economical production of high quality fruit, giving priority to ecological safer methods, minimizing the undesirable side effects and use of agrochemicals, to enhance the safeguards to the environment and human health"(4). The IOBC principles have been taken on board by several regional and national governments and numerous farmers organisations all over Europe when defining Integrated Pest Management standards for apple production. Integrated Pest Management employs monitoring of pests, weather conditions, stage and condition of plants in order to decide whether or not the treatments should be undertaken. This includes physical, biological, mechanical, cultural and educational tactics to keep pest numbers at the level that does not endanger the production in economic terms. Treatments should not have adverse effects on the environment, beneficial and non-target organisms and human health. The principles of Integrated Fruit Production take the following elements into account: the identification of pests and their natural enemies, monitoring their populations and record keeping; setting the thresholds for each pest correlated with the numbers of beneficial insects; economic and aesthetic damage; stage of the plants and pests; time of the season; opting for the least hazardous control measures; and evaluating the outcome of the measures to build experience. Despite the principles, different countries apply slightly different versions of IPM. In Germany, for instance, IPM practices are characterised by a high use of pesticides and do not gather full support from stakeholders (5).

Although IPM guidelines are based on the best disease and pest management practices and have been established by several regional and national governments and adopted by many farmers and farmers' organizations, the IPM standards, unlike organic production, are not precisely defined or legally specified in a EU or international agreement. Although the restrictions on inputs such as fertilizers, pesticides and others agrochemicals are defined in various guidelines, in practice the level of implementation varies (6). European countries have no unified standards or requirements imposed on farmers, but there are many local, regional and national initiatives to create labels and sell IPM products as better for the environment, consumers and offering economical advantages to farmers (7).

Organic and integrated apple producers face many obstacles and difficulties in dealing with pests, diseases, weeds and finding suitable ways to market their products and increase their profits. While the economics of organic fruit growing is comparatively healthy due to the higher farm gate price for the product and State support, labour hours exceed those of conventional and Integrated Fruit Production due to blossom thinning by hand, manual weed control and mice control among others. The main advantages and difficulties of Integrated Fruit Production are summarised, for example, by a Dutch research showing that although integrated apple growing has much lower impact on the environment in comparison with conventional farming systems, it can be less profitable due to the necessary extra labour inputs. The practice in Holland also showed that the reduction of fungicide use proved more difficult in susceptible varieties as disease management currently depends on fungicide application (8). Despite the difficulties, there are numerous examples of successful practices in Europe. This briefing focuses on successful examples and shows that integrated and organic apple production is feasible and can be a commercial success. This review and a briefing are available at: http://www.pan-europe.info/publications/index.htm.

I. SOME INDICATIONS OF CONVENTIONAL PRODUCTION AND PESTICIDE USE

The total production of apples of 11.96 million tonnes was achieved in a planted area of 575,796 ha in the 25 European Union countries in 2005 (1).

Indicators of conventional use of pesticide in apples in Europe are difficult to find in the scientific literature. We opted to provide one case study on the national level (for the UK) that might illustrate the current situation in conventional apple production in Europe. The data originates from a survey about the overall use, extent and quantities of pesticides used in Great Britain in 2004 carried out by the Department for Environment, Food and Rural Affairs and The Scottish Executive Environment and Rural Affairs Department (9).

Table 1 - Percentage of area under Cox apple treated with pesticides in Great Britain

Chemical group	Treated area (%)
Acaricides	12.0
Biological control agents	0.1
Insecticides	94.0
Fungicides and prunning paints	97.0
Herbicides	91.8
Sulphur	12.1
Growth regulators	77.3
Tar oil / defoliants	6.2
Urea	28.4
Not treated	0.8

Over 90% of the area under apple production is sprayed with insecticides, fungicides and herbicides, where nearly 80% of orchards are treated with growth regulators. Contrarily, the biological control is used to manage pest and disease problems on only 0.1% area.

Cox dessert apple crops received, on average, seventeen spray rounds, with 99.2% of the total area grown receiving at least one pesticide treatment. Thirteen fungicide sprays, five growth regulators, five insecticide sprays, two herbicides and a urea spray comprised the average treatment regime, with 42 products used, indicating a considerable degree of tank mixing.

The five most extensively-used fungicide formulations were captan, myclobutanil, penconazole, carbendazim and dithianon. Myclobutanil and captan were used with an average of five applications of each being made during the season. The largest number of treatments were against mildew (Podosphaera leucotricha) 41%, scab (Venturia inaequalis) 38% and canker (Nectria galligena) 9% of all treatments.

Insecticide usage was dominated by chlorpyrifos, methoxyfenozide, thiacloprid, fenoxycarb and triazamate. Chlorpyrifos was applied to almost 90% of the area of Cox dessert apples grown. The largest number of treatments were against codling moth (Cydia pomonella) 21% and the rosy apple aphid (Dysaphis plantaginea).

In terms of herbicide use, glyphosate was the main herbicide used, accounting for over a third of the volume of all herbicides, followed by dicamba/MCPA/mecoprop-P, diuron, 2,4-D and glufosinate-ammonium. In terms of reasons for use, farmers indicated general weed control, especially during the winter months.

Paclobutrazol (58%) and gibberellins (42%) accounted for the majority of growth regulator usage. Paclobutrazol was used for growth regulation while gibberellins were mainly used to improve skin finish and fruit set.

Although the majority of pesticides mentioned fall into the categories of slightly (III) hazardous and unlikely to be hazardous (U), this could be misleading when observed solely, because these pesticides are applied frequently in the seasons, sometimes up to 25 sprayings per season. Furthermore, many of the approved pesticides are moderately hazardous pesticides regarding their toxicity (chlorpyrifos, thiacloprid, triazamate, 2,4-D) and proved or suspected to be carcinogenic (captan, carbendazim, thiacloprid Fenoxycarb, MCPA, mecoprop-P, diuron, 2,4-D), endocrine disruptors (Myclobutanil, carbendazim, chlorpyrifos, Fenoxycarb, dicamba, diuron and 2,4-D), developmental and reproductive toxin (myclobutanil, chlorpyrifos, fenoxycarb, dicamba, diuron, 2,4-D), cholinesterase inhibitor (chlorpyrifos) and ground water contaminators (methoxyfenozide, fenoxycarb, dicamba, mecoprop-P, diuron, 2,4-D).

Table 2 – Hazards associated with the most commonly used pesticides in apples according to several EU and International classifications

Active ingredient	WHO	Acute toxicity	Carcinogenic	Endocrine disruptor, developmental/reproductive toxin	Groundwater contaminant	Cholinesterase inhibitor
Captan	U	Unlikely	Possible	Not listed	Insufficient data	Not listed
Myclobutanil	III	Slightly	Not listed	Yes	Insufficient data	Not listed
Penconazole	U	Unlike	Not listed	Not listed	Insufficient data	Not listed
Carbendazim	U	Unlikely	Possible	Suspected	Insufficient data	No
Dithianon	III	Slightly	Not listed	Not listed	Insufficient data	Not listed
Chlorpyrifos	I	Moderately	Not listed	Yes	Insufficient data	Yes
Methoxyfenozid	U	Unlikely	Not likely	Not listed	Potential	No
Thiacloprid	II	Moderately	Liklely	Not listed	Insufficient data	Not listed
Fenoxycarb	U	Unlikely	Likely	Yes	Potential	Not listed
Triazamate	II	Moderately	Not likely	Not listed	Insufficient data	No
Glyphosate	U	Unlikely	Not likely	Not listed	Insufficient data	No
Dicamba	III	Slightly	Not listed	Yes	Potential	Not listed
MCPA	III	Slightly	Possible	Not listed	Insufficient data	Not listed
Mocoprop-P	III	Slightly	Possible	Not listed	Potential	No
Diuron	U	Unlikely	Yes	Yes	Yes	Not listed
2,4-D	II	Moderately	Possible	Suspected	Potential	No
Glufosinate-ammonium	-	Not listed	Not listed	Not listed	Insufficient data	No
Paclobutrazol	III	Slightly	Unclassifiable	Not listed	Insufficient data	No

WHO classification – The World Health Organization Recommended Classification of Pesticide by Hazard classifies all pesticide into four groups according to their acute toxicity: Class Ia Extremely Hazardous, Class Ib Highly Hazardous, Class II Moderately Hazardous and Class III Slightly Hazardous (The classification is based primarily on the acute oral and dermal toxicity to the rat indicated by LD50 value, a statistical estimate of the number of mg of toxicant per kg of bodyweight required to kill 50% of a large population of rats). Source: (5)



II. SCALE OF ORGANIC AND INTEGRATED PRODUCTION AND COMPARISON OF YIELD AND INCOME

There is a lack of comparable data on integrated production in different countries because national statistics differ and the distinction between conventional and integrated is not always clear in the statistics. Nevertheless, this briefing will supply some national examples that might illustrate the scale of integrated apple production and compare yield and income. IPM techniques are often economically competitive with conventional methods mainly due to the lower cost of pest management inputs by up to 50% depending on the crop and region. Since the extra labour time and scouting costs required under IPM offset savings such as these, total costs stay about the same as conventional costs. Other times, the total costs are higher under IPM. These costs will in large part depend on a grower's definition and use of IPM, on their crop, and on their region.

As for organic, of the 0.35 million ha of organic fruit, berries, citrus olives and vineyards, half is located in Italy and one third in Spain. Some smaller but important areas are located in Portugal, France and Greece. Currently, about 60% of the EU-15 organic apple sales originated from Italy. Market share of organic fruit is only 1 to 2 % in EU but it reaches 4 to 5 % in Switzerland (11).

A survey of integrated pome fruit production in western Europe conducted by the IOBC in 1994 showed that integrated pome fruit production and similar quality assurance schemes were operating in nearly all fruit producing countries in western Europe accounting for approximately 35% of the total area of pome fruit production (circa 322,000 ha) (12) and it has increased since then. The fact that most EU countries give incentives to the implementation of Integrated Production and or IPM for a number of crops under the Agri-Environmental measures of the Rural Development Programmes is likely to have played an important role in this increase.

The Belgian government, for example, grants a premium per hectare to IPM fruit growers. Research by the Centre for Agricultural Economics (CAE) has found that the total use of active ingredients of pesticides in the traditional production method of apples was one third higher than in the integrated production method. There was no significant in profitability difference between conventional system and integrated method. It was concluded that the introduction of integrated methods leads to the reduction of pesticide use and does not affect the income of the fruit holdings (13).

Most studies agree that IPM considerably reduces the environmental impacts while yield and income are either equal or lower to conventional. A study from the Netherlands comparing conventional, integrated and a system with minimum chemical inputs (use of biological control measures and reduction of pesticides applications to 25% of the recommended dose) in apple growing, shows considerable less environmental impacts but higher production costs due to higher labour requirements. The loss due to quality and production losses seemed to play a minor role in the overall economic results (8).

Table 3 measures the environmental yardstick (values sprayings according to their environmental impacts measured in terms of water and soil biodiversity and quality of groundwater resources). Fungicides and insecticides gave the highest environmental impacts in the environmental yardstick indicator in the conventional systems. In particular, the use of the fungicide thiram (moderate toxicity, developmental or reproductive toxin and suspected endocrine disruptor) and the insecticides propoxur (acute toxicity, carcinogen, cholinesterase inhibitor) and phosalon (moderate toxicity, cholinesterase inhibitor and potential groundwater contaminant) accounted for the bulk of the environmental hazards in the conventional system.

Table 3 – Average yearly scores on the conventional, integrated and minimum systems on the environmental yardstick for pesticides in Zeewolde (1992-1999)

	Conventional			Integrated			Minimum		
	Water life	Soil life	Groundwater	Water life	Soil life	Groundwater	Water life	Soil life	Groundwater
Fungicides	4,639	455	1,977	1,727	361	962	1,218	325	862
Insecticides	2,768	504	6,802	3,249	435	4,005	396	191	1
Herbicides	667	116	259	189	32	84	42	8	16
Total	32,463	1,076	9,038	5,165	828	5,052	1,655	524	880

Source: (8)

A review of the situation in Poland might give us a good insight into the status of IPM in new Member States. Integrated Fruit Production was established in Poland in 1991 after the collapse of the communist regime and has expanded since then. In 1999, as many as 100,000 tonnes of apples from 625 producers (13% of the total production of Polish table apples) was certified integrated production. In a survey conducted in the end of 2000, Polish IPM fruit growers stated that they practised IPM mainly due to the lower number of applications of pesticides and fertilisers and better contact with advisors. Probably the most important statement in the survey was that about 90% of the farmers accepted IPM and 93% considered IPM to be the future in fruit production. The main problems encountered were the low availability of insecticides (50% of all respondents) (14).

While in western European countries labour costs seem to be the main responsible for the higher production costs in organic farming and IPM when compared to conventional systems, a study comparing costs between conventional, integrated and organic systems in Poland concluded that organic production of apples can be cheaper than that of conventional. When organic apple production is higher than 15 tonnes per ha, the variable costs per ha and per kg were almost the same as in conventional orchards. The costs of biological control in organic apple farming were comparable with those of pesticide application in conventional. The biggest savings were made in machinery costs, with costs about 65% lower in organic orchards when compared to conventional. Although labour costs were higher in organic systems they are relatively low when compared to western European prices, which gives Polish organic apple production a great export potential to other EU countries (15).

III. HOW INSECT PESTS ARE MANAGED

Although the use of a certain number of pesticides is permitted in integrated pest management, producers use a set of techniques to discourage and reduce the population of insect pests. These include: planting resistant varieties, crop rotation, soil fertility and irrigation management, monitoring, cultural practices to avoid introduction of pathogens or eliminate habitat needed by pests, building and maintaining populations of natural enemies of insect pests (known as beneficials), and measures to block or disrupt reproduction. When pesticides are used, they should have low toxicity in order not to affect the population of beneficial insects, and a narrow spectrum of action so as to kill only the target pests.

Most important pests that cause significant damage to apples

The most common and damaging insect pests of apple in Europe are: codling moth (*Cydia pomonella*), green apple aphid (*Aphis pomi*), rosy apple aphid (*Dysaphis plantaginea*), red spider mite (*Panonychus ulmi*), rust mite (*Aculus schlechtendali*), apple leaf-curling midge (*Dasineura mali*), apple capsid (*Plesiocoris rugicollis*), common green capsid (*Lygocoris pabulinus*), apple leaf miners (*Stigmella spp, Lyonetia spp*), woolly aphids (*Eriosoma lanigerum*), owlet moth (*Noctua pronuba*), oriental fruit moth (*Grapholita molesta*), light brown apple moth (*Epipyas posvittana*), apple blossom weevil (*Anthonomus pomorum*) and European apple sawfly (*Haplocampa testudinea*).

Overall pest management considerations

To maintain a good balance between the populations of insect pests and beneficial insects, we have to consider techniques to discourage the population of insect pests on the one side, and techniques to stimulate the populations of beneficial insects.

Avoiding alternative plant hosts and creating host-free zones is a major aspect in IPM apple production. Alternative host plant or tree species attract and encourage the multiplication of pests. By creating zones free of these alternative hosts the risk of pest occurrence can be significantly reduced. On the other hand, by using habitat manipulation, beneficial parasitoids (parasitic wasps which lay their eggs in the larval or egg stage of pest insects) and predators are encouraged in habitats bordering orchards or on plants grown under or along the orchards before moving into apple trees (16). For example, bottle

Codling moth (*Cydia pomonella*) control

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refuges containing corrugated paper and cage refuges containing chopped straw attract earwigs – important predators of aphids and psyllid bugs during the summer. Flowering plants such as cornflower (*Centaurea cyanus*), corn marigold (*Chrysanthemum segetum*) or corn chamomile (*Anthemis arvensis*) attract beneficials like predatory *Anthocoris* bugs and hoverflies (*Syrphid* family). Refuges can be used to manipulate numbers of earwigs by either placing them on trees or introducing collected species into an orchard (17). Beneficials such as hoverfliess, cecidomiid flies, lacewings, earwigs and spiders can be attracted into orchards by sowing mixtures of flowering plants in alternation with grass strips.

Broad spectrum insecticides should be avoided for they negatively affect non-target organisms, particularly beneficial insects and trigger the problem of pest resistance and accordingly pest outbreaks (18). If the usage of pesticide is inevitable, they should be chosen carefully taking into consideration their toxicity, persistence and environmental interactions. Such insecticides pose lower risks to the environment and human health, for their low application rates and low-toxicity. An example is the biopesticide *Bacillus thuringiensis* (BT) is used successfully to control codling moth. Some insecticides are quite selective, for example: insect growth regulators like tebufenozide, fenoxycarb and pyripoxyfen; nicotinoid insecticides such as imidacloprid and thiamethoxam; new aphicides such as pymetrozine and pirimicarb; and the miticides pyridaben and abamectin.

Several studies have been carried out in order to test the effect on beneficial organisms. The selective insecticides (pirimicarb, difubenzuron, fenoxicarb, lufenuron, *B. thuringiensis*, sulphur+vaseline oil) applied in IPM plantations are proved not to have negative effects on populations of parasitoids of leaf miners and predatory mites (19). On the other hand, the number of beneficial insects increases significantly in an orchard when organophosphate pesticides are eliminated.

Introducing beneficial insects is also a widely used technique. There are successful examples in Europe of introducing mite predators such as *Typhlodromus pyri*, *Zetzellia mali* and *Anystis baccarum* (20). *Anystis baccarum*, in particular is compatible with several of the most commonly applied fungicides (e.g. dithianon) in local orchards (21) but such compatibility with fungicides is not always the case with other predatory mites such as *phytoseiids*. There are also important predatory bugs from the Miridae family such as *Malacocris chlorizans*, *Pilophorus perplexus* and *Blepharidopterus angulatus*; from the *Anthocoridae* family such as *Anthocoris nemoralis* and *Orius spp*.; and from the *Nabidae* family such as *Nabis spp* and *Himacerus spp*.

Several important wasps parasitize the three main species of leaf miners in orchards By avoiding insecticide spraying which harms these wasps, studies show that these parasitoids can reduce leaf miner population density down to the economic threshold level (22).

Experiments also attest the efficacy of *Aptesis negrocincta* as a successful parasite for the cocoons of the apple sawfly (23) and *Orius spp.* as a predator for the red mite (*P. ulmis*) (24). A three year experiment in IPM orchards in Hungary saw the number of predatory mites increased after introducing IPM (25).

Monitoring and control

Traps are effective tools to control and monitor pests, determining the optimum timing for insecticide spraying. Pesticide-treated traps are used, for example, to control apple maggot (*Ragolestis pomonella*) and visual traps are effective against tarnished plant bug (*Lygus lineolaris*), European apple sawfly (*Hoplocampa testudinea*), leafminers (*Pyllonorycter spp*) and apple maggot. Pheromone traps are a popular method used to monitor and control the populations of tentiform leafminer (*Phyllonorycter mispilella*), codling moth, oriental fruit moth, lesser appleworm (*Grapholita prunivora*), oblique-banded leafroller (*Choristoneura rosaceana*), red-banded leafroller (*Argyrotaenia velutinana*) and European apple sawfly. Pheromone products are also used as mating disruptors and pheromone-based "Attract and Kill" feeding stations and traps,in combination with natural biopesticides such as azadirachtin (neem) and the concentrated fermentation product spinosad, to significantly reduce the amount of pesticides applied. Mating disruption based on sex pheromones are effective against key pests such as codling moth (*Cydia pomonella*), oriental fruit moth (*Grapholita molesta*), and light brown apple moth (*Epipyas posvittana*).

Regular examination of the trees and fruit, up to three times a week depending on the season, along with a good weather forecasting and warning system is a key aspect of IPM and is sometimes referred to as “scouting”.

Zero pesticides residues

An IPM system was developed in UK to produce apples free from pesticide residues after the harvest. It is based on the use of conventional pesticides such as diflubenzuron, thiaclopyrid or fenoxycarb but excluding organophosphate insecticides up to petal fall and after harvest and using biocontrol methods such as granulosis virus and *Bacillus thuringiensis*, sulphur and cultural methods between petal fall and harvest. Pest control, although satisfactory, was more expensive due to the higher costs of selective insecticides (26). The reduction of insecticide spraying (27) and in particular broad spectrum insecticides (28), are key for success in reducing or totally eliminating pesticide residues in commercial apple orchards.

Codling moth

Codling moth (*Cydia pomonella)* is one of the major and most destructive pests in apple orchards in Europe. Its alternative hosts can be pears, quinces and walnuts. The control of the codling moth can prove to be difficult due to the overlapping of its generations and the limited time when spraying can be applied, which is the period between the hatching of the maggots and their entrance into the fruit. Once the larvae have entered the fruit, control is not possible. Fortunately, there are a number of non-chemical methods available to control codling moth: mating disruption, viruses, habitat management and other measures to stimulation the growth of predator populations.

In US commercial IPM orchards insecticide application is recommended as long as at least five moths are captured per pheromone trap per week but is restricted during the season (29). To define the accurate time when the treatments are the most effective it is necessary to observe the pest biology, especially the timing of mating, egg laying and hatching. This can be achieved by placing pheromone traps in the orchards that catch the males. By closely monitoring their numbers, the best moment for spraying can be easily calculated. After the first sustained moth captures occur (the 'biofix'), degree days are calculated on a daily basis and a running total is kept (30). The codling moth has a 50 degree F (10 degree C) threshold temperature, DD50. These degree day accumulations are compared with the target table values for codling moth. The first spray is applied at 250 DD50, after the biofix, the second 10-14 days later .

In Switzerland, the pest forecasting system SOPRA (Schadorganismen-Prognose auf Apfel) for apple relies on species specific phenology models. It is effectively used for timing, monitoring, management and control of rosy apple aphid, apple sawfly, smaller fruit tortix (*Grapholita lobarzewskii*) and codling moth, based on temperatures and relation between the pests' stage of developmental and reproduction (31).

Adult codling moth (*Cydia pomonella*)

Due to frequent sprays with insecticides that have similar modes of action, codling moth has now developed resistance to many pesticides used in European orchards. As the alternatives to synthetic pesticides, techniques such as the use of mating disruptors, granulosis virus and semiochemicals are being effectively introduced to deal with the problem of resistance.

Entrance hole caused by codling moth

For example in Switzerland, resistant strains of codling moth are successfully controlled by combining mating disruptor techniques and granulosis virus. The practice tackles the problem of the cross resistance to insecticides and shows very good results when the pest pressure is not too high and applied in lower doses in frequency of 6-7 times every 10 days. A few treatments with granulosis virus biopesticide can reduce the population of codling moth effectively. In some cases, a single treatment kept codling moth under control for two months. One or two treatments could reduce the population considerably, down to the level where pheromone mating disruption techniques alone will be adequate to maintain the population under control until the end of the season (32).

In Austria, a "branch cage technique" is used as a method to control codling moth. It is a cylindrical cage around the trunk or a main branch, in which over-wintered moth larvae are placed. When these turn into adults they are placed in a transparent egg laying box in the centre of the tree where mating and oviposition occur, so that the number of eggs can be easily recorded and their development is monitored. This site-specific view of reproductive activity gives more detailed information than using pheromone traps alone. The precise stage of egg laying of the new generation adults is the moment when growth regulators and granulovirus biopesticide should be applied as this is the phase when the larvae are the most susceptible (33).

If the use of pesticides cannot be avoided, the following recommendations should be put into practice:

- Products with the same mode of action should not be used over a long period and product types should be changed during the season to avoid resistance;

- Growth regulators should be combined with codling moth granulovirus or pesticides for the best control of codling moth and reduction of the number of sprayings;

- Early catches in pheromone traps do not require early treatments, but additional applications might be needed at the end of the season;

- For the fast growth of fruits at the beginning of the season growth regulators are recommended to be used late in the season, when their long lasting activity is more effective and can cover a period of more than three weeks of egg laying;

- Priority should be to successfully control the first generation of insects;

- Careful inspection of the orchard, pheromone traps and fruit is vital. If there are no signs of activity of codling moth the risk of the second generation is low and spraying is not necessary (34).

Aphids

The rosy apple aphid (*Dysaphis plantaginea*) is one of the main apple pests in Europe. Other important aphid species that cause damages to apple orchards are the apple-grass aphid (*Rhopalosiphum inserum*) and the green apple aphid (*Aphis pomi*). In conventional apple growing *Dysaphis spp* are usually tackled with an application of aphicide before flowering, followed by another after flowering or in early summer. This strategy is condemned to failure due to the appearance of resistance and the high impacts of the insecticides in the environment and for the health of farmers and consumers. Successful strategies with less environmental impacts such as biological control, defoliation or application of low toxicity substances are already in use in Europe.

Controlling this pest in spring is very difficult as the aphids are protected in tightly curled leaves. Artificial defoliation in autumn has proved a good control of rosy apple aphid and apple grass aphid, though it may be rather labour consuming. The winged male and female generation in autumn are more vulnerable to sprays since they are not protected within tightly rolled foliage hence autumn applications are more effective and successful. Monitoring the migration of winged adults assists in the optimal timing of autumn sprays. Pheromone and suction traps are available for orchard monitoring (35).

Neem tree oil has been applied successfully against rosy apple aphid. It is necessary to apply several sprays of pyrethrum to reliably get a reasonably high standard of aphid control, possibly because the persistence of pyrethrum is very short. As a result of this work, pyrethrum has now been approved for use on apple in the UK (available as Py Insect Killer) to target both rosy apple aphid and apple blossom weevil. As a purely contact insecticide, best results are achieved with high volume sprays designed to directly intercept the maximum proportion of the aphid population (36).

Colony of rosy apple aphid (*Dysaphis plantagenea*)

Mites

The stinging of mites such as the red spider mite (*Panonychus ulmi*) and the rust mite (*Aculus schlechtendali*) causes a bronzing of the leaves. In the case of heavy infestations, they considerably weaken the trees, causing fruits to be smaller, less coloured and diminishing taste quality, as well as causing russeting of the fruit skin and premature leaf fall. In conventional orchards, the use of large spectrum insecticides completely eliminates the natural predators, while in IPM and organic orchards the presence of natural predatory mites, especially *Typhlodromus pyri*, helps keep mites under control.

In a Belgian growers association, after 2 years of introducing IPM techniques, the red spider mite was efficiently under control. This was achieved by completely eliminating acaricides, while increasing the amount of predatory insects and predatory mites (37).

IV HOW DISEASES ARE MANAGED

The most important diseases with economic importance for apples are scab (*Venturia inaequalis*), powdery mildew (*Podoshaera leucotrycha*), fruit canker, storage moulds such as *nectria*, *fusarium*, *gloeosporium* and *botrytis*, and fireblight.

Controlling disease in conventional apple growing requires many preventive fungicide treatments. In IPM, apart from selecting the least toxic fungicides, control is made according to the risk of infection. Growers are kept informed of the risk through a network of weather stations (that define the real conditions of fungus infection) and based on biological observations. A further pesticide use reduction in IPM as well as in organic farms can only be expected if resistant or tolerant apple varieties are cultivated. On the one hand there are new varieties that have been grown to meet these criteria; on the other hand, there are many old, regional varieties that are resistant to a number of diseases under their local soil and climate conditions (5).To make better use of natural resistance in apple cultivars, a group of Belgian and French farmers is trying to reintroduce 10 old apple varieties using European funding to stimulate cross-border cooperation (INTERREG Programme). The varieties were chosen from the collection of the Regional Centre of Genetic Resources of the Nord-Pas-de-Calais region, as well as from that of the Phytopathology Station of the Agronomic Research Centre of Gembloux. Besides resistance to diseases, the following criteria were taken into account: the region they originated from, their taste and special culinary qualities and their capability to adapt to the culture of dwarf trees (37).

Scab

Apple scab (*Venturia inaequalis*) is of major economic importance in the mid-Atlantic region. If not controlled, the disease can cause extensive losses where humid, cool weather occurs during the spring months. Losses result directly from fruit infections, or indirectly from repeated defoliation which can reduce tree growth and yield. In unfavourable weather conditions, with high humidity and frequent rain, when disease incidence tends to be high, the number of treatments in conventional apple production could go up to 25-20 times per season. More favourable conditions allow 8 sprayings per season when disease management can rely mainly on sulphur and copper use (non-synthetic fungicides permitted in organic cultivation).

Nevertheless, the number of treatments can be significantly reduced by using scab forecasting methods, which are based on measuring leaf humidity and temperature. Fungicide treatments can be minimized and made most efficient by designing them around weather conditions (infection periods), inoculum availability (the presence of disease spores), cultivar susceptibility, and specific characteristics of the available fungicides. Season-long control of apple scab is difficult if primary infections are allowed to develop. Even moderate numbers of primary infection spots can produce an extremely large population of fungal spores, requiring an intensive fungicide program to protect fruit throughout the summer. Conversely, good control of primary infections allows use of fungicides to be reduced or omitted during the summer, once spores have been depleted and fruit becomes less susceptible.

The INRA (National Institute for Agronomic Research) has been conducting intensive research and experimentation with scab resistant varieties in France. In a 4 year study, the number of pesticides treatments was substantially reduced in resistant varieties, as demonstrated in Table 4.

Table 4 – Average number of treatments (1990-1993)

	Fungicides	Insecticides	Miticides	Number of pesticides
Resistant	3.25	11.25	0	14.5
Susceptible	19	11	1	31

Source (38)

Examples of apple scab resistant cultivars: Prima, Priscilla, Freedom, Liberty, Florina, Goldrush, Enterprise, Pristine, Jonafree, Macfree, Redfree, Sir Prize, William's Pride, Moira, Priam, etc.

In a UK zero pesticide residues management system scab control pre blossom was based on a pre-bud burst spray of copper oxychloride and conventional fungicide dithianon, captan, myclobutanil until petalfall (26).

In organic production there are no effective eradicative or curative fungicides for apple scab control available. Only protective, copper-based fungicides and lime-sulphur are allowed in most European countries, but the use of copper is being phased-out in Europe due to its negative environ-

Damage caused by scab (*Venturia inaequalis*)

mental impacts on soils. Alternative fungicides for apple scab control are needed and there is at the moment abundant research and experimentation going on in Europe. The most consistent results seem to be achieved with sulphur (39), clay powder and resistant inducers (40) but optimal control cannot be achieved without adopting resistant varieties. Lime sulphur, although effective, can be phytotoxic and cause russeting in apples (41).

Powdery mildew

Powdery mildew (*Podosphaera leucotrycha*) can be a persistent disease of susceptible apple cultivars throughout the mid-Atlantic region. It is the only fungal apple disease that is capable of infecting without wetting from rain or dew. The dormant season control of powdery mildew is the key component in keeping the disease under control. Powdery mildew is managed by pruning out infected shoots in winter, during dormant period and infected shoots as they appear in spring. Prunings should be burned subsequently. In conventional apple production, chemical control is usually done in conjunction with controls for scab and sprayings are applied as necessary from spring onwards to prevent build-up of mildew.

In an IPM system, mildew is controlled by post bloom multiple low dose sulphur sprays and the pre bloom control is done via removal of infected blossoms and shoots swiftly at pink bud and petal fall stage and use of DMI (sterol-inhibitor) fungicides to suppress spore formation. Removing over-wintering silvered shoots is also an important part of control (26).

When scab and mildew are controlled together, a programme of copper (Cuprokylt) and sulphur sprays might be used from bud-burst onwards according to weather conditions and levels of disease inoculum. This has to be combined with the destruction of leaf litter on the orchard floor by maceration after leaf fall and before bud burst to try to minimise the amounts of over wintering scab inoculum. Whenever possible, wood scab should be removed during winter pruning. Removal of mildewed shoots (primary mildew) should be carried out during flowering and at petal fall (36).

Resistant varieties

In the UK, a recent project identified varieties of apple of low susceptibility to diseases that have high fruit quality, a range of seasons (storage potentials) and markets (dessert, culinary, juicing and processing) and are suitable for UK production. When planting a new organic or IPM orchard, it is essential to start off with strong, robust trees on a semi-vigorous rootstock (e.g. MM106) which can compete successfully with the orchard. In these conditions, sulphur and frequent application of low rate copper were effective against powdery mildew and scab, respectively. Sulphur was also relatively effective against apple scab (36).

Recommended dessert varieties:
Ceeval (early season), Rajka, Resi, Rubinola and Rubinstep (mid season) were identified as the most promising dessert varieties for organic production after 4 years of evaluation. They were deemed the best varieties in terms of eating quality and consumer acceptance. In addition, each also has a reputed resistance or tolerance to scab, although mildew is likely to remain a problem on all varieties. The varieties Rubinola and Rubinstep also have excellent storage potential.

Recommended culinary varieties:
The varieties Edward VII, Encore, Howgate Wonder and Pikant were identified as the most promising culinary varieties for organic production. The varieties Edward VII, Encore and Pikant also have reputed resistance or tolerance to scab, although mildew can still be a problem. In contrast, Howgate Wonder has reputed resistance against mildew, but may suffer from scab.

Juicing varieties:
The French variety Judeline, a highly disease resistant and productive variety which produces fruits of high juice content with a good sugar – acid balance, was initially selected as having great potential for juicing. However, further trials revealed that the variety has an extremely limited storage life and is therefore not likely to be acceptable for large-scale commercial juice production. It is likely that varieties which express a good volume of juice (e.g. Red Falstaff) and which are less susceptible to the diseases scab and mildew will continue to fill the organic juice market.

V HOW WEEDS ARE MANAGED

In an IPM or organic system, weeds can be controlled mechanically with rototiller or disc harrow, can be hand-hoed or removed thermally by flaming. Different soil coverage methods can be applied, including mulches of plastic (film or web), chopped wood, sawdust, chopped tree bark, straw, seaweed or cut grass, as well as sown understoreys of different green manure plants. In the Swiss "sandwich" system a narrow strip of understorey vegetation along the trees is combined with tilled strips on both sides of the understorey. In commercial IPM or organic fruit production, it is important to find the least expensive method in terms of labour and machinery costs simultaneously giving the best results in terms of yield and fruit quality. In a Norwegian study, some of these alternative weed treatments were studied. The results indicated that mechanical fallowing before planting resulted in a significantly lower weed density after planting than continuous grassland. The effect was particularly notable on couch grass (*Elymus repens*) density. A significant reduction in weed density was also found as a result of using a hairy vetch ground cover as a pre-planting strategy. The results showed that the best control of weeds in the tree row was obtained when using plastic mulch, however soil cultivation by rototiller also proved an effective method (42).

A popular system of soil coverage is the "Sandwich system" where a narrow strip about 30 cm wide is sown between the trees and a soil strip is kept free of growth on both sides by a rotary hoe without feelers. The term 'sandwich' indicates how this system, when seen from above, resembles a sandwich; the dark soil strips resemble slices of bread and the strip of cover crop resembles the filling. It was developed in Switzerland by the Research Institute of Organic Agriculture (FIBL). This system combines the advantages of a tree strip that is kept clear of growth with those of a cover crop. In the Dutch climate the best results were achieved with sowing white pasture clover (*Trifolium repens*) and spontaneous weed growth (43).

VI PESTICIDE REDUCTION INFORMATION

In the latest EU coordinated residue monitoring results, over 60% of all apple samples had detectable levels of residues, while 2% of all samples had residues above the legal limit. The most frequently detected pesticides were pesticides from the benomyl group (20%), chlorpyrifos (16%) and diphenylamine (15% of all samples) (3).

The reliance on synthetic pesticides can be reduced or even totally eliminated with careful management which involves growing disease-resistant cultivars and opting for least-toxic alternatives such as biological and cultural controls. Residues on fruits at harvest can be reduced by maximizing the withholding period after application until harvesting and by minimizing post-harvest chemical treatments. No pesticide should normally be applied within 21 days of harvest. However, in seasons where there is significant rainfall and/or a high risk of pests or diseases during late summer, insecticide or fungicide sprays may exceptionally be applied nearer to harvest if required, but not if post-harvest fungicide treatment is to be applied (4).

The IOBC list of pesticides and chemicals that are approved for use in an integrated production system is called the 'green list' as the adverse effects of their implementation are the least. However, applying 'green list' pesticides is not the preferred option in the IOBC approach to IPM.. These pesticides ought only to be applied in cases where non-chemical measures prove to be insufficient in pest, disease and weed control.

IOBC guidelines for integrated apple production focus on preventative, indirect measures to keep pests under economical thresholds (the level of damage which causes economic losses). The chemicals which are not permitted are pyrethroid insecticides and acaricides, non-naturally occurring plant growth regulators, organochlorine insecticides and acaricides and toxic, water polluting or very persistent herbicides. Use of enzimidazole fungicides is restricted to storage rots and blossom wilt and, as paint for canker control.Dithiocarbamate fungicides are only permitted to up to a maximum of 3 applications per season and not consecutively to avoid killing predatory phytoseiid mites. Sulphur and residual herbicides are also restricted (4).

The pesticides approved for integrated fruit production differs from country to country. For example, in Germany there are national guidelines for integrated apple production emphasising good practices and a list of pesticides permitted for use. Tables 5, 6, and 7 show respectively the active substances authorised for use in conventional, integrated and organic pome production in Germany (5).

Table 5 - List of approved pesticide for conventional pome fruit production in Germany

	Active substance
Fungicides	Benomyl, Bitertanol, Captan, Cyprodinil, Dichlofluanid, Dithianon, Fenarimol, Fluquinconazole, Kresoxim methyl, Copper hydroxide, Copper oxichloride, Lezithin, Mancozeb, Metiram, Myclobutanol, Penconazole, Propineb, Pyremethanil, Sulphur, Tolylfluanid, Triadimenol
Insecticides and acaricides	Amitraz, Codling moth, granulosis virus, Bacillus thuringiensis, Clofentizin, Cyfluthrin, beta-Cyfluthrin, Diflubenzuron, Dimethoate, Ethiofencarb, Fenazaquin, Fenoxycarb, Fenpyroximate, Imidacloprid, Potash-soap, Mineral oils, Neem, Oxydemetonmethyl, Parathion-methyl, Phosphamidon, Piperonylbutoxide, Pirimicarb, Pyrethrins, Rapeseed oil, Scale bug granulosis virus, Sulphur, Tebufenozide, Tebufenpyrad
Herbicides	Amitrole, Diuron, Glufosinat, Glyphosate, Glyphosatetrimesium, MPCA, Mecoprop-p, Propyzamide, Simazine
Rodenticides	Chlorphacinon, Zinc phosphide, Difenacoum, Sulfuramid
Pheromones	codlemone
Growth regulators	Urea, Ammonium thio sulphate, Ethephon
Bactericides	Streptomycine

Table 6 - List of approved pesticide for integrated pome fruit production in Germany

	Active substance
Fungicides	Benomyl, Bitertanol, Captan, Cyprodinil, Dichlofluanid, Dithianon, Fenarimol, Kresoxim methyl, copper hydroxide, Copper oxichloride, Mancozeb, Metiram, Myclobutanol, Penconazole, Pyremethanil, Sulphur, Triadimenol
Insecticides and acaricides	Codling moth, granulosis virus, Bacillus thuringiensis, Clofentizin, Diflubenzuron, Fenoxycarb, Fenpyroximate, Imidacloprid, Potash-saponin, Mineral oils, Neem, Parathion-methyl, Phosphamidon, Piperonylbutoxide, Pirimicarb, Pyrethrins, Rapeseed oil, Scale bug granulosis virus, Sulphur, Tebufenozide, Tebufenpyrad
Herbicides	amitrole, diuron, glufosinate, glyphosate, MCPA, Mecoprop-P, propyzamid
Rodenticides	chlorphacinon, zinc phosphide
Pheromones	codlemone
Growth regulators	amidthin, etephon
Bactericides	Streptomycine

Integrated fruit production leaves growers with a limited choice of pesticides, especially insecticides, acaricides and herbicides. But the number of pesticides approved for organic apple production in Germany is even smaller, if compared to the pesticides approved for integrated production. Organic farmers use a variety of cultural and biological control methods to control pests and diseases with pesticides playing omly a marginal role. Herbicides, bactericides, rodenticides and synthetic growth regulators are totally forbidden.

Table 7 - List of approved pesticide for organic pome fruit production in Germany

	Active substance
Fungicides	copper hydroxide, copper oxichloride, sulphur, lime sulphur
Insecticides and acaricides	codling moth granulosis virus, *Bacillus thuringiensis*, mineral oils, neem, piperonylbutoxide, pyrethrins, rapeseed oil, scale bug granulosis virus
Pheromones	codlemone
Predators	Trichogramma parisitic wasp
Growth regulators	Algae extracts, Alginic acids, Betonit, Powdered grit, Horsetail extract, sulphuric acid clay

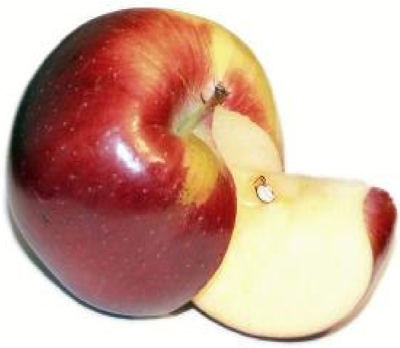
The UK also published guidelines for best practice in Integrated Pest and Diseases Management in apple production, including a list of approved pesticides and a check list for integrated pest and disease management tasks (44). The annex summarises the main actions during the year.

IOBC has published crop specific Integrated Production guidelines for pome fruits. National or regional producer organisations can apply for endorsement by the IOBC to verify that they are producing in accordance with these guidelines In addition, IOBC emphasizes that farm managers must be professionally trained in all aspects of Integrated Production by attending locally organized training courses.

Table 8. Guidelines for pome fruits production recommended by IOBC

Function	Preferred options	Strict rule or prohibition
Conserving the orchard environment	At least 5% of farm surface must be managed as ecological compensation areas (no fertilizer and pesticide input) to maintain biodiversity.	
Site, rootstocks, cultivar and planting system for new orchards	Cultivars resistant to diseases or pests are preferred. Plant material should be virus-free. Single rows are preferred.	Chemical soil sterilization is not permitted.
Soil management and tree nutrition	The total maximum nitrogen input, period and methods of application should be set to minimize leaching and after measured by soil analysis.	
Alleyways and weed-free strip	Non competitive herb/grass mixtures are recommended.	Bare soil management is not permitted.
Irrigation	Daily rainfall must be measured and soil moisture deficit estimated.	
Tree training and management	Excessive growth should be controlled by cultural measures. Pruning should aim to achieve a healthy and manageable size of trees.	
Fruit management	Hand thinning is preferred.	
Integrated plant protection	Priority must be given to natural, cultural, biological, genetic and biotechnical methods. Pesticides may only be used when justified and the most selective, least toxic and persistent product selected. Populations of pests, diseases and weeds must be monitored and recorded. Populations of key natural enemies must be preserved and where phytoseiid predators are not present they must be introduced.	Benzimidazole fungicides, dithiocarbamate fungicides, sulphur and residual herbicides are permitted with restrictions. Pyrethroid insecticides, non-naturally occurring plant growth regulators, organochlorine insecticides and toxic, water polluting or very persistent herbicides are not permitted. No pesticide should be applied within 21 days of harvest.
Application methods	Sprayers must be regularly serviced and calibrated and must comply with spray testing requirements. Statutory buffer zones must be observed.	Radial flow air assisted sprayers should be avoided and progressively replaced.
Harvesting and storage	Fruit in store should be regularly monitored and only fruit of sound quality can be certified.	
Post-harvest treatments	Fungicide treatments are only permitted where non-chemical methods are not available and cultivars are susceptible.	Use of synthetic, non-naturally occurring anti-oxidants for control of scald and other disorders are not permitted.

Source: (4)


VII INFORMATION ON QUALITY AND COSMETIC STANDARDS, MARKETING STRATEGIES

Apples categories (depending on size) allowed in the market are regulated in Europe. Besides the size, apples sold in the European market should conform to a set of cosmetic standards including a certain shape, colour and no presence of pests, diseases or signs of their damage. If the fruit is somehow damaged or overripe, farmers can still sell the fruit in the juice market providing that the fruit does not have any worms or rot. However, the juice price is usually about a quarter of the price for fresh apples, and this price will not cover the grower's production costs.

Besides expecting cosmetically perfect apples, consumers are increasingly concerned with the presence of pesticides residues in fruits. A recent Eurobarometer survey about EU citizens' general fears and fears about food shows that 63% are concerned about pesticide residues in fruit and vegetables (45). This is the main driver for the development of fruits free of pesticides residues in some European countries. In the UK, for example, supermarket chains are adopting production and marketing strategies to differentiate their products on the basis of reduction of pesticides residues and certain pesticide active substances (46). In Italy, a not-for-profit environmental organisation created a self certification scheme for products sold without pesticides residues, including apples. The production is based on IPM techniques approved in the region where the production is carried out, supplemented with further restrictions in terms of periods of spraying (47).

VIII CONCLUSIONS AND RECOMMDENATIONS

Despite the growth of integrated production of apples in Europe since the introduction of the concept in the 60's, and the growth in organic production since the 90's especially in Southern Europe, the bulk of apple production is still done using conventional methods. We have seen that conventional apple production uses pesticides with serious health and environmental hazards. In addition the number of pesticide sprayings is very high which results in high costs for farmers in terms of inputs, health risks and results in the presence of pesticide residues in apples, often exceeding the Maximum Residues Limits.

But the current IPM practice is not the full solution either. On one hand, the level of implementation of Integrated Pest Management guidelines varies in Europe, because there is not one single definition. On the other hand, highly hazardous pesticides such as chlorpyrifos are currently permitted under some IPM apple production systems in Europe. This practice must change if IPM is to be considered (and marketed) as better for the environment and human health.

We need to change conventional orchard production towards a pesticide use reduction target and encourage the growth of organic orchards. Given the diversity of IPM guidelines in Europe (not only for apples), a set of minimum criteria should be laid out in general and per crop. These criteria should include pesticide use reduction targets and prohibition of certain pesticides based on their intrinsic hazards. But according to the new Framework Directive to achieve a Sustainable Use of Pesticides COM (2006) 373, proposed by the European Commission in 2006, general IPM standards should be adopted by all farmers from January 2014 onwards while crop specific standards shall be adopted on a voluntary basis (48). This would be a major set-back to pesticide reduction goals because in this process the necessary level of crop-specific detail will be lost. Therefore, PAN Europe calls for crop-specific standards established at the national/regional level and applied on a compulsory basis, following a set of key elements.

Key elements for general IPM standards should be, at a minimum:

1 – A **soil structure** serving as an adequate buffering system for agriculture;

2 – A **crop rotation** frequency enhancing a balanced population of soil organisms, preventing outbreak of soil-bound pests;

3 – Use of the best available pest and disease **resistant crop varieties** (excluding genetically modified crops)

4 – Optimal crop distance and **crop management** to prevent growth of fungi;

5 – Availability of **refuges for natural enemies** of pests and for the prevention of pesticide-resistant pests;

6 – Economical **nutrient management** on the basis of information of nutrients already present in the soil and of the soil structure, and dosage only on the crop;

7 – In principle only **mechanical weeding** (or other non-chemical methods like the use of heat); with the only exception in case of bad weather conditions;

8 – Use of pesticides based on information of presence of pests (scouting, trap data, on-line decision support services) and only the use of **selective pesticides** (not harming beneficial organisms) which are not persistent, bio-accumulative or toxic;

9 – Priority is given to the use of **"green" pesticides** (non-synthetic) and substances which prevent the build up of pest populations;

10 – **Minimal material resources input** (49).

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ANNEX - CHECK LIST FOR INTEGRATED PEST AND DISEASE MANAGEMENT TASKS

	Dormant period
1	Assess over wintering populations of rust mite behind growing shoot buds, fruit tree red spider mite winter eggs round spurs, aphid and sucker eggs on shoots and scale insects on bark. Earmark orchards with damaging populations of any of these pests for treatment at the appropriate time.
2	Apply tar oil winter wash only if strictly necessary i.e. for high populations of scale insects on bark, while trees are fully dormant using sufficient volume to cover wood.
3	Remove badly cankered branches, wood scab and mildew infected (silvered) shoots, root stock sucker growths (which may harbour capsid eggs) during winter pruning. Protect pruning wounds with suitable canker paint.
4	Check whether any leaf litter is left in the orchard by the end of February as this may be a source of scab inoculum. Macerate thoroughly well before bud burst to aid biodegradation.
5	Service and calibrate weather station. Start temperature records from 1 January.
6	Stock check pesticide store.
	Just pre bud-swell
1	Consider a pre-bud-burst spray of a copper fungicide, especially where canker and scab were bad the previous season. This may give some control of overwintering scab and protect against Nectria canker.
	Bud-swell
1	Start weather station records of leaf wetness, humidity and rainfall. Run disease forecasting (e.g. ADEM) and pest life cycle (e.g. PESTMAN) computer models at least weekly and before spray rounds are applied.
2	Start programme of fungicide sprays for scab control promptly. Choice of fungicide and spray interval will depend on varietal susceptibility, scab levels the previous season including late season infection of leaves and the amount of leaf litter present.
	Bud-burst
1	Monitor populations of apple blossom weevil adults at edges of orchards using beating method if pest was present previous season.
2	Continue sprays for scab to maintain good protection at this sensitive stage.
	Mouse ear
1	Monitor numbers of rust mites on outer rosette leaves. If threshold (5 mites per outer leaf) is exceeded, apply acaricide, or include sulphur at reduced (25-33%) rate in next 3-4 spray rounds.
2	Continue sprays for scab to maintain good protection at this sensitive stage.
	Green cluster
1	Conduct pre-blossom pest assessment for aphids, winter and tortrix moth caterpillars, apple sucker, capsids, rust mite and other minor pests. Apply pre-blossom insecticide spray if necessary.
2	Start mildew spray programme. Choice of product, dose, volume and interval will depend on varietal susceptibility and mildew levels last year.
3	Continue sprays for scab to maintain good protection at this sensitive stage.
	Pink bud
1	Check truss leaves for scab until early June. Early detection of a potential problem is essential.
2	Assess primary mildewed flower trusses. > 2% indicates a problem, > 10% a severe problem. Use eradicant mildew fungicide.
3	Apply pre-blossom spray of fenoxycarb (Insegar) for summer fruit tortrix moth if required. Fenoxycarb has a high risk to bees and should not be used once blossoms are open as bees are likely to be foraging.
4	Put out white sticky traps for sawfly adults.
	First flower
1	Continue spray programme for scab and mildew as necessary
2	Apply first spray for blossom wilt. Repeat 7 days later. Cox, James Grieve and Lord Derby are very susceptible.

Full bloom	
1	Continue spray programme for scab and mildew as necessary, but try to avoid spraying fungicides at this critical time if possible.
Late blossom	
1	Conduct late blossom pest assessment for rosy apple aphid, sawfly, winter moth, clouded drab moth, fruit tree red spider mite, rust mite and capsid, and capped blossoms due to apple blossom weevil.
2	Continue spray programme for scab and mildew as necessary.
End of blossom	
1	Continue spray programme for scab and mildew as necessary.
2	Assess primary mildew vegetative terminal buds. > 2% indicates a problem, > 10% a severe problem. Use good eradicant mildew fungicide, decrease spray interval and increase spray volume if a problem.
3	Check for signs of wilting, dying blossoms due to blossom wilt. Cut out affected trusses now while they can be seen and before cankers form.
4	Check for early signs of collar rot in older orchards on susceptible rootstocks. Early detection means the tree can be saved.
5	Apply post blossom insecticide spray if required for capsid, sawfly, winter moth, clouded drab moth, rosy apple aphid or other pests.
6	Apply acaricide spray for rust mite or fruit tree red spider mite if necessary.
7	If required, apply second spray of fenoxycarb (Insegar) for summer fruit tortrix moth as soon as risk to bees has ceased.
8	In orchards where leaf midge has been a severe problem and where establishment of the parasitic wasp *Platygaster demades* is to be encouraged, start monitoring numbers of leaf midge eggs in growing points twice weekly in a representative orchard until harvest. Avoid spraying broad-spectrum insecticides when midge eggs are numerous to avoid harming the adult parasite, which is active when leaf midge eggs are numerous.
9	Set out pheromone traps for codling, fruit tree tortrix moth and summer fruit tortrix moth. Record the catch of moths of each species at least weekly.
Early June	
1	Check orchard thoroughly for signs of scab on leaves or fruitlets and for wood scab. Continue sprays as necessary if scab is present, or if the weather is very wet or if scab problems occurred last year.
2	Monitor secondary mildew in shoots regularly, at least fortnightly, ideally before each spray round. Continue mildew sprays until the extension growth has ceased. Adjust rate and interval according to the levels of mildew present, the favourability of the weather for mildew and the rate of growth of the trees.
3	In orchards where canker is a problem, apply a spray, e.g. captan or carbendazim, to protect leaf scars from canker during summer leaf fall. Sprays at this time may reduce Nectria rots in store.
4	Conduct early June pest assessment for rosy apple aphid, woolly aphid, rosy leaf curling aphid (look out next year), sawfly damage (earmark for treatment next year), clouded drab moth, fruit tree red spider mite, rust mite.
5	Continue frequent monitoring of leaf midge eggs where required. Avoid using broad-spectrum insecticide sprays when eggs are numerous to avoid harming *Platygaster demades*.
6	If *Blastobasis* was present last year or infestation is suspected, conduct beat samples for adults at fortnightly intervals throughout June or July. Insecticidal treatment should be considered if the pest is detected.
7	Calculate daily egg development amounts for summer fruit tortrix using maximum and minimum air temperatures and look up table provided. Apply egg hatch spray of suitable insecticide when sum reaches 90-100%. Repeat sprays to maintain protection through egg hatch period. This action should not be necessary if fenoxycarb (Insegar) was used just before and, if necessary, just after blossom.
8	Continue weekly monitoring of pheromone traps for codling and tortrix moths. If diflubenzuron (Dimilin) is to be used for control of codling or fruit tree tortrix moth, then a spray should be applied as soon as the threshold pheromone trap catch is exceeded. If chlorpyrifos (Dursban etc) is to be used, which is advisable if Blastobasis is a problem the first spray should be delayed until the start of egg hatch.

Late June	
1	Continue monitoring secondary mildew in shoots regularly, at least fortnightly, ideally before each spray round. Continue mildew sprays until the extension growth has ceased. Adjust rate and interval according to the levels of mildew present, the favourability of the weather for mildew and the rate of growth of the trees.
2	Continue sprays for scab only if necessary.
3	Look for signs of die back on extension growth caused by canker. Cut out and burn.
4	Conduct late June pest assessment for woolly aphid, green apple aphid, fruitlet mining tortrix, fruit tree red spider mite, rust mite. Apply control treatments as necessary.
5	Continue weekly monitoring of pheromone traps for codling and tortrix moths. If diflubenzuron (Dimilin) is to be used for control of codling or fruit tree tortrix moth, then a spray should be applied as soon as the threshold pheromone trap catch is exceeded. If chlorpyrifos (Dursban etc) is to be used, which is advisable if *Blastobasis* is a problem, the first spray should be delayed until the start of egg hatch.
6	Continue frequent monitoring of leaf midge eggs where required. Avoid using broad-spectrum insecticide sprays when eggs are numerous to avoid harming *Platygaster demades*.
7	Continue regular beat sampling for Blastobasis if necessary.
July-August	
1	Continue monitoring secondary mildew in shoots regularly, at least fortnightly, ideally before each spray round. Continue mildew sprays until the extension growth has ceased. Adjust rate and interval according to the levels of mildew present, the favourability of the weather for mildew and the rate of growth of the trees.
2	Continue sprays for scab only if necessary.
3	In orchards where a risk of *Gloeosporium* rot or *Phytophthora* rot has been determined, and where post harvest drenches will not be used, apply sprays of captan at 2-3 week intervals to protect fruit against infection.
4	Conduct late July-mid August pest assessment for woolly aphid, green apple aphid, fruit tree red spider mite, rust mite. Apply control treatments as necessary.
5	Continue frequent monitoring of leaf midge eggs where required. Avoid using broad-spectrum insecticide sprays when eggs are numerous to avoid harming Platygaster demades.
6	Continue regular beat sampling for Blastobasis adults throughout July if necessary. Apply chlorpyrifos (Dursban etc) sprays if pest is detected.
Pre-harvest	
1	Conduct rot risk assessment in each orchard. Determine best way of minimising losses due to rots with minimal use of post harvest fungicide treatments.
Harvest	
1	Train pickers to be vigilant for pest and disease blemishes to fruit and record the causes of significant losses in each orchard. Be vigilant for sawfly and Blastobasis damage.
2	Only drench fruit in fungicide where a significant risk of rotting has been determined.
Post-harvest	
1	In orchards with a high level of scab, apply a spray of 5% urea post picking and before appreciable leaf fall. This will help aid microbial breakdown of the leaves bearing scab perithecia and prevent the overwintering stage of scab developing.
Leaf fall	
1	To protect leaf scars from canker infection, apply a copper spray the start of leaf fall and again at 50% leaf fall.
Grading	
1	Train grading staff to be vigilant for pest and disease blemishes to fruit and fungal rots and record the causes and extent (% incidence) of losses due to each cause in each orchard.

Source: (42)

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Stock Exchange http://www.sxc.hu/
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