◆ EPPO Standards ◆

GUIDELINES ON GOOD PLANT PROTECTION PRACTICE

POME FRUITS

PP 2/18(1) English

oepp
eppo

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APPROVAL

EPPO Standards are approved by EPPO Council. The date of approval appears in each individual standard.

REVIEW

EPPO Standards are subject to periodic review and amendment. The next review date for this set of EPPO Standards is decided by the EPPO Working Party on Plant Protection Products.

AMENDMENT RECORD

Amendments will be issued as necessary, numbered and dated. The dates of amendment appear in each individual standard (as appropriate).

DISTRIBUTION

EPPO Standards are distributed by the EPPO Secretariat to all EPPO Member Governments. Copies are available to any interested person under particular conditions upon request to the EPPO Secretariat.

SCOPE

EPPO guidelines on good plant protection practice (GPP) are intended to be used by National Plant Protection Organizations, in their capacity as authorities responsible for regulation of, and advisory services related to, the use of plant protection products.

REFERENCES

All EPPO guidelines on good plant protection practice refer to the following general guideline:

OEPP/EPPO (1994) EPPO Standard PP 2/1(1) Guideline on good plant protection practice: principles of good plant protection practice. *Bulletin OEPP/EPPO Bulletin* **24**, 233-240.

OUTLINE OF REQUIREMENTS

For each major crop of the EPPO region, EPPO guidelines on good plant protection practice (GPP) cover methods for controlling pests (including pathogens and weeds). The main pests of the crop in all parts of the EPPO region are considered. For each, details are given on biology and development, appropriate control strategies are described, and, if relevant, examples of active substances which can be used for chemical control are mentioned.

EUROPEAN AND MEDITERRANEAN PLANT PROTECTION ORGANIZATION
ORGANISATION EUROPÉENNE ET MÉDITERRANÉENNE POUR LA PROTECTION DES PLANTES

PP 2/18(1) English

Guidelines on good plant protection practice

POME FRUITS

Specific scope

This standard describes good plant protection practice for pome fruits.

Specific approval and amendment

First approved in September 1999.

This guideline on good plant protection practice (GPP) for pome fruits forms part of an EPPO programme to prepare such guidelines for all major crops of the EPPO region. It should be read in conjunction with EPPO Standard PP 2/1(1) Principles of Good Plant Protection Practice. The guideline covers methods for controlling pests (including pathogens and weeds) of apples (*Malus* × *domestica*) and pears (*Pyrus communis*).

A broad range of pests affects apple and pear in Europe. In pome-fruit growing, good plant protection practice has reached its greatest maturity, and strategies for integrated pest management (IPM) have been developed. This guideline, however, is not meant to be a manual for IPM, but lists current GPP for the EPPO region. Therefore, some of the active substances recommended may not be allowed in special IPM programmes in individual EPPO countries. If IPM is implemented, then it is GPP.

The use of a suitable application technique for plant protection products is of considerable importance in pome-fruit production. It is GPP to reduce drift and unwanted dispersal of plant protection products as much as possible by using suitable nozzles and equipment that produces a good and uniform droplet spectrum. Cross-flow and axial-fan sprayers with blower attachments should be adjusted to the type of crop (tree volume and height), which then results in less drift.

The timing of spray treatments is of particular importance, and the insects causing damage to pome fruits can be grouped in categories against which the same treatments are applied:

- most aphids overwinter as eggs and produce a few generations on leaves during flowering before they migrate to other hosts or continue to multiply on apple;
- fruit moths overwinter mostly as young larvae. The first generation caterpillars hatch in early summer and move from the leaves to the fruits, where they are then accessible to insecticides. There can be up to three generations;
- leaf-rolling tortricids overwinter mostly as young larvae. They are active (and accessible to insecticides) in spring before flowering. There can be up to three generations;
- leaf miners overwinter as pupae or adults, which become active after flowering. There may be up to three generations;
- winter moths lay their eggs in late autumn, and the eggs hatch in spring. The caterpillars (only one generation) feed on leaves, flowers and young fruit.

Other pests may cause damage, but are usually of local importance.

Although this demonstrates that an impressive number of insect attacks pome fruit, these can be mostly controlled by relatively few insecticide treatments, from 2-4 in northern to 4-10 in southern Europe. It is useful to consider the moments of application and which insects are controlled at those times:

- treatments during dormancy in winter (winter washes): against aphids, winter moths, *Quadraspidiotus perniciosus*. Treatments with specific insecticides after bud burst should generally be preferred;
- treatments between bud burst and flowering (pre-flowering): against aphids, tortrix caterpillars, winter moths, bugs, *Quadraspidiotus perniciosus*, *Cacopsylla mali, C. pyri* and *Anthonomus pomorum*;
- treatments immediately after flowering (post-flowering): aphids, tortrix caterpillars, bugs, leaf miners, *Hoplocampa testudinea*, *Cacopsylla mali*, *Cacopsylla pyri* and *Quadraspidiotus perniciosus*;
- treatments during the summer (summer treatments): against leaf miners and some aphid species that have not migrated (*Aphis pomi*) (but usually these pests should have been controlled earlier), tortrix moths, fruit moths, *Eriosoma lanigerum* and *Argyresthia conjugella*.

If insecticides are sprayed, it should be taken into account that certain products may have a negative impact on natural enemies and/or a stimulating effect on spider mites. For the control of aphids, use of certain selective insecticides (e.g. pirimicarb) will favour natural enemies. Treatments against other pests, especially the major fungal diseases and the mites, follow strategies that are presented individually.

The principal pests considered in this guideline are the following:

- *Venturia inaequalis* and *Venturia pirina* (apple and pear scab);
- *Podosphaera leucotricha* (powdery mildew);
- *Nectria galligena* and other fungi (canker);
- *Monilinia laxa* (blossom wilt);
- *Phytophthora cactorum* and other *Phytophthora* spp. (crown and collar rot);
- *Gymnosporangium sabinae* (European pear rust);
- post-harvest diseases of apple and pear;
- apple proliferation phytoplasma;
- pear decline phytoplasma;
- *Erwinia amylovora* (fireblight);
- *Pseudomonas syringae* pv. *syringae* (bacterial blight);
- *Agrobacterium tumefaciens* (crown gall);
- viruses;
- aphids;
- *Eriosoma lanigerum* (woolly aphid);
- *Cacopsylla spp.* (pear suckers);
- *Lygocoris pabulinus* and *Plesiocoris rugicollis* (mirids);
- *Anthonomus pomorum* and *A. pyri* (blossom weevils);
- *Cydia pomonella* (codling moth);
- *Argyresthia conjugella* (apple fruit moth);
- leaf-rolling tortricids;
- *Yponomeuta malinellus* (small ermine moth);
- leaf miners;
- *Operophthera brumata* (winter moth);
- noctuids;
- *Hoplocampa testudinea* and *H. brevis* (sawflies);
- *Dasineura pyri* (pear leaf midge);
- scales;
- *Xyleborus dispar* (broad-leaved pinhole borer);
- *Synanthedon myopaeformis* (apple clearwing moth);
- spider mites;
- *Aculus schlechtendali* (apple rust mite);
- *Epitrimerus pyri* (pear rust mite);
- *Phytoptus pyri* (pear leaf blister mite);
- weeds;
- plant growth regulators.

Explanatory note on active substances

The EPPO Panel on Good Plant Protection Practice, in preparing this guideline, considered information on specific active substances used in plant protection products and how these relate to the basic GPP strategy. These details on active substances are included if backed by information on registered products in several EPPO countries. They thus represent current GPP at least in those countries. It is possible that, for any of numerous reasons, these active substances are not registered for that use, or are restricted, in other EPPO countries. This does not invalidate the basic strategy. EPPO recommends that, to follow the principles of GPP, only products registered in a country for a given purpose should be used.

Venturia inaequalis **and** ***Venturia pirina*** **(apple and pear scab)**

General

Venturia inaequalis and *V. pirina* overwinter in fallen leaves, in which pseudothecia develop over the winter. In early spring, the pseudothecia mature and, under wet conditions, discharge their ascospores. Under suitable conditions of temperature and humidity, the ascospores infect the leaves, causing primary lesions. Conidia formed on these primary lesions 2-3 weeks later will infect further leaves, causing successive secondary lesions and, finally, lesions on the developing fruit. According to the cultivar and the disease incidence of the previous year, overwintering mycelia on leaves still attached to the shoots or on shoots and buds may produce conidia providing an additional source of inoculum in spring. In the absence of control, trees may be completely defoliated. While some damage to leaves can be tolerated, scabby fruits cannot be sold in high-quality grades, and are less suited for storage, being liable to infection by various rotting organisms.

Basic strategy

The ideal aim is to prevent primary infection by ascospores in spring, thus minimizing the need for further treatments against secondary infections through the summer. This can be assured by spraying at regular intervals (7-14 days) from bud-break (BBCH 07) or by spraying with curative fungicides according to the infection periods ("Mills periods") detected by monitoring weather conditions and leaf wetness. In general, in most European countries, advisory services provide a scab warning service on this basis. In addition, commercial devices are available to provide a local warning. Further observations may be made on the presence of ascospore inoculum, on plant growth (susceptible leaves, fungicide cover) and on rainfall (fungicide wash-off). It is sometimes recommended to adjust the frequency of summer sprays according to the scab susceptibility of the cultivar.

If treatment timing is based on Mills periods, the type of fungicide used becomes critical. Most systemic fungicides can be applied up to 96 h after the beginning of the Mills period and can thus be used for curative treatments. Contact fungicides can also be applied for a certain time after the beginning of the Mills period but, to be effective, fungicides must be present before spores penetrate the plant surface, and then have a socalled "stop" action. Reliance on curative treatments can lead to failure of disease control if wet weather prevents timely application of the fungicide. Because the preventive action of the systemic fungicides is less than that of contact compounds, and strains resistant to some systemic compounds have appeared, they should be used sparingly and/or in mixtures.

The detailed strategy of scab control depends on the fungicides currently available, on their mode of action, their persistence and the risk of resistance. A mainly preventive approach, based on phenology and/or calendar, is currently GPP for scab control. When general climatic conditions are less favourable to scab, or on less susceptible cultivars, it may be possible to reduce the number of treatments and time them by Mills periods. It may finally be mentioned that various treatments can be applied after harvest (before leaf fall) or in winter (to fallen leaves) to prevent pseudothecium formation in the leaves (e.g. the application of urea to the fallen leaves to speed up decomposition).

Resistance

Resistance to DMI fungicides (demethylase inhibitors) and dodine has been found at some locations. There is also concern about decreased sensitivity to other fungicides. DMI fungicides are not recommended for season-long use alone. Where repeated fungicide applications are required, DMIs should be used in mixtures or alternations with a non-DMI fungicide and, even then, a maximum of four DMI applications per season is recommended. Curative applications should only be made when accurate disease-warning systems are used.

Main fungicides

Sprays: bitertanol, captan, copper oxychloride, cyproconazole, cyprodinil, dichlofluanid, difenoconazole, diniconazole, dithianon, dodine, fenarimol, fenbuconazole, flusilazole, kresoxim-methyl, mancozeb, maneb, metiram, myclobutanil, penconazole, pyrifenox, pyrimethanil, sulfur, tetraconazole, tolylfluanid, triforine, zineb.

Podosphaera leucotricha **(powdery mildew)**

General

Podosphaera leucotricha mainly attacks apple. It overwinters as mycelium in bud scales on shoots infected during the preceding season. These shoots are the source of primary inoculum in spring. The conidia from them infect young leaves as they develop, and several cycles of infection will occur on newly formed foliage through the summer. Infected leaves are severely distorted and may fall. Damage is essentially from defoliation and destruction of next year's fruit-bearing sites, but there may be an indirect effect on fruit size and quality. Fruit infection can occasionally occur and causes russeting. Although not usually affecting pear leaves, the disease can appear on the fruits of some cultivars.

Basic strategy

The basic strategy for powdery mildew control is to reduce primary inoculum by pruning away infected shoots and to apply preventive sprays to the young foliage until the end of extension growth. The influence of weather on powdery mildew is complex. Infection is favoured by warm conditions, and by high humidity, but not by actual rain. The conditions favouring spore release are not necessarily the same as those favouring infection. Thus weather-based disease forecasting is difficult in practice (although some systems are available), and spraying generally follows a programme (at 7- to 14- day intervals according to local conditions).

Cultivars vary considerably in powdery mildew susceptibility, and the number of sprays or spray concentration can be adjusted accordingly. Infected shoots, recognizable by their "silvered" appearance, should be removed during normal early spring pruning. Because of the high sporulation potential of the fungus and ready dispersal of the conidia, this pruning needs to be done very thoroughly. Ideally, infected shoots should be removed throughout the season, but this is difficult in practice.

Systemic or contact fungicides may be used in a preventive spray programme. Systemic fungicides have a curative action on existing lesions and will, in particular, prevent sporulation. In some countries, it is accordingly recommended to use systemic fungicides for the early season sprays to keep down inoculum as much as possible. Because the timing of sprays for the control of *Venturia inaequalis* is more critical, and the same fungicides can often be used, the timing of treatments against powdery mildew is often determined by the spray programme against scab, especially early in the season. Powdery mildew control can be interrupted earlier than scab control, because it needs only to be continued until the end of extension growth and does not principally concern protection of the fruit.

Main fungicides

Sprays: cyproconazole, diniconazole, dinocap, fenarimol, kresoxim-methyl, nitrothal-isopropyl, myclobutanil, penconazole, pyrazophos, pyrifenox, sulfur, tetraconazole, triadimefon, triadimenol, triflumizole, triforine.

Nectria galligena **and other fungi (canker)**

General

Nectria canker (caused by *Nectria galligena*) is one of the most destructive diseases of apple in Europe. Pear is also affected, but the disease is usually less severe than in apple. A canker starts as a sunken area which increases in size and becomes elliptical. It is usually centred around leaf scars, wounds, twig stubs or in crotches of limbs, and encircles and kills twigs or branches. Young cankers are small, circular, brown areas. Later, the central area becomes sunken and black, whereas the host produces callus tissue around the margin of canker cracks. In young trees, the fungus may girdle the trunk or scaffold branches, while in older trees, mostly small branches are killed. Fruits are also infected and develop a circular, sunken brown rot with white pustules produced by numerous conidia. The conidia are produced mostly early in the season and spread by wind and raindrops. A high relative humidity is essential for ascospore discharge, which occurs mainly in spring and autumn. Infection is mainly by natural wounds, leaf scars, or pruning wounds.

Various other fungi, causing relatively unimportant cankers of apple and pear (*Botryosphaeria obtusa, Diaporthe eres, Valsa* spp., *Diplodia mutila, Phomopsis mali, Cytospora schulzeri, Pezicula spp.*) or silver leaf disease (*Chondrosterum purpureum)*, can be treated in the same way.

Basic strategy

The basic curative treatment of cankers is to remove them by pruning down to healthy wood, and then to treat with a wound-healing compound to ensure that the cut surface is protected from infection and that wound callus forms as quickly as possible. The wound-healing compound may contain a fungicide, partly as a preventive, partly as a curative against any remaining traces of infected tissue. *N. galligena* is also liable to infect through pruning wounds and through leaf scars at leaf fall. It some cases, it can also be suggested to spray at leaf fall and/or at the time of pruning with a preventive fungicide. Mineral fungicides tend to hasten leaf fall, while organic fungicides do not.

Main fungicides

Sprays: benomyl, carbendazim, copper hydroxide, copper oxychloride, thiabendazole.

Paints: carbendazim, octhilinone thiabendazole, triadimefon.

Monilinia laxa **(blossom wilt)**

General

Monilinia laxa can affect apple and pear in some seasons, especially if the weather is wet during flowering. The fungus overwinters in infected peduncles and twig cankers on branches. Conidia are disseminated by rain and infected flower parts.

Basic strategy

A treatment with a fungicide is seldom needed, but should then be done at flowering. Fungicides for scab control that are also active against *M. laxa* should be used where the disease is a problem. If possible, wilted blossom trusses should be cut out and burnt.

Main fungicides

Sprays: carbendazim, iprodione, vinclozolin.

Phytophthora cactorum **and other** ***Phytophthora*** **spp. (crown and collar rot)**

General

Crown rot and collar rot of apple are caused by several *Phytophthora* species, of which *P. cactorum* and *P. syringae* are the most important. The pathogens may also infect pear, but rarely cause problems in this crop. Crown rot is a disease of the rootstock portion of the tree, affecting bark tissues of the root-crown region, whereas collar rot is a disease of the scion portion, affecting bark tissues of the lower trunk. Symptoms are often only visible after removing the bark layer. This tissue is necrotic and orange to red-brown. A clear margin separates healthy and necrotic areas; this is the zone of greatest pathogen activity. All *Phytophthora* species that attack apple and pear are soil-borne. Once introduced into the orchard, they persist as mycelia or oospores in organic debris or soil. Other inoculum sources are fallen fruits and leaves. Zoospore dispersal is by mass flow of soil water, irrigation or rain splash, and is thus associated with wet conditions and poorly drained soils. Infection is mostly through wounds and natural openings, such as stomata or lenticels. The diseases may be very destructive when susceptible cultivars such as Cox's Orange Pippin or rootstocks such as MM 106 are grown.

Basic strategy

An integrated disease management programme, employing cultural practices, host resistance and chemical treatment, is recommended. This first includes preventive methods, such as the use of resistant rootstocks, interstocks and cultivars, and the avoidance of poorly drained sites. Chemical treatment is primarily based on copper products to prevent bark infections and protect pruning wounds. Systemic fungicides, such as metalaxyl and fosetyl-Al, also give efficient chemical control.

Main fungicides

Sprays: copper oxychloride, fosetyl-Al, metalaxyl.

Paints: copper oxychloride, fosetyl-Al.

Soil treatment: metalaxyl.

Gymnosporangium sabinae (pear rust)

General

Gymnosporangium sabinae (syn. *G. fuscum*) infects leaves and fruit of pear, and sometimes also twigs and branches. First symptoms are bright orange leaf spots in which black pycnia develop in spring and summer at the upper leaf surface. Later, not before August, acorn-shaped aecia, which are ruptured along the sides, appear on the lower leaf surface. Aeciospores infect *Juniperus* species (e.g. *J. sabina*), the alternate hosts, on which teliospores are formed the following year and can infect pear again. The disease is only important when alternate hosts are present at a distance of not more than 300 m from the orchard.

Basic strategy

Pear rust can be prevented by removing alternate hosts in the vicinity of orchards. If this is not possible, the disease, which is favoured by wet weather, can be controlled by applying cover sprays at intervals of 7-12 days from flowering through mid-June.

Main fungicides

Sprays: bitertanol, cyproconazole, difenoconazole, mancozeb, maneb, triforine.

Post-harvest diseases of apple and pear

General

Many fungi infect fruits of apple and pear, causing rotting on the tree and/or, more importantly, in store after harvest - *Phytophthora syringae*, *Botryotinia fuckeliana* (anamorph *Botrytis cinerea*), *Penicillium expansum*, *Monilinia fructigena*, *Glomerella cingulata*, *Pezicula alba*, *P. malicorticis* and *Nectria galligena*. *P. syringae* is a major cause of fruit loss in store since the introduction of herbicide-treated strips under the trees. In wet weather close to harvest, contaminated soil can be splashed up onto low-hanging fruit. *B. cinerea* (grey mould) and *P. expansum* (blue mould) infect fruits mainly after harvest through wounds, and cause fruit rot in store. Brown rot (*M. fructigena*) occurs on fruits still on the tree. Gloeosporium rot (*Glomerella cingulata*, *Pezicula alba*, *P. malicorticis*) and nectria eye-rot of apple (*Nectria galligena*) result from infections that occur in the field but are quiescent or otherwise escape notice at harvest. *B. cinerea* can infect at flowering and remain latent in fruits until late in the storage period.

Basic strategy

Post-harvest rots which result from incipient or quiescent infections caused by fungi that infect fruit in the field can be reduced by protection of fruits from pre-harvest infections by fungicide sprays. Control measures against wound pathogens (*Penicillium*, *Botrytis*) include general sanitation to reduce the exposure of the fruit to spores and harvesting and handling methods that maintain the integrity of the harvested fruit. Rapid cooling of fruit, which should not be over-mature, also reduces the incidence of decays in storage. Sprays against *P. syringae* may be applied shortly before harvest. Infections occurring after harvest may be controlled with post-harvest dips or drenches with various fungicides, but countries differ in whether they authorize post-harvest treatment of fruits.

Post-harvest rots caused by fungi that infect fruits in the field are usually more important than wound pathogens that cause infection after picking. Post-harvest treatments with systemic products control these rots to some extent, but treatments made over the summer months, and especially immediately pre-harvest, are also effective. In countries in which post-harvest treatments are authorized, it is recommended to use both. Contact and systemic fungicides are used. When a post-harvest dip in a benzimidazole fungicide is included, it is generally recommended to treat twice with a benzimidazole, 4 and 2 weeks before harvest. Where no post-harvest treatment is possible, two sprays before harvest may be sufficient, but treatment may have to start earlier and comes to overlap with scab treatments. Fungicides are recommended at 8-14 day intervals, starting in mid-July or early August. Since the benzimidazoles are more effective, it is still recommended to use them 4 and 2 weeks before harvest. However, it is not advised to use them earlier, because of the considerable risk of development of resistance. In general, the levels of infestation with fungi causing post-harvest decays may vary from orchard to orchard. Also, cultivars vary in susceptibility. Whether it is necessary to treat will depend on the past prevalence of the fruit-rotting fungi in the orchard.

Resistance

Benzimidazole-resistant strains of *B. cinerea*, *P. expansum* and of the fungi causing gloeosporium rot are very common in pome fruit, and disease control is adversely effected. In pears, dicarboximide-resistant strains of *B. cinerea* occur occasionally, but control is still adequate. Strains of *P. syringae* less sensitive to metalaxyl have been found, but there is no evidence that these have affected the efficiency of post-harvest treatment with this product.

Main fungicides

Pre-harvest sprays: benomyl, captan, carbendazim, dichlofluanid, folpet, metalaxyl, pyrimethanil, thiophanate-methyl, tolylfluanid, ziram.

Pre-harvest sprays and post-harvest dips: captan, carbendazim, thiophanate-methyl.

Post-harvest dips: carbendazim, metalaxyl.

Apple proliferation phytoplasma

General

Apple proliferation phytoplasma occurs in the southern part of Europe and is of great economic importance locally.

Basic strategy

Healthy planting material should be used. Diseased trees should be removed, at least in orchards less than 5 years old. In general, phytoplasmas are transmitted by leafhoppers, and vector control offers one method of preventing disease spread. However, no specific vectors have been demonstrated for apple proliferation. Control of other homopteran pests may incidentally have some effect on transmission of apple proliferation.

Pear decline phytoplasma

General

Pear decline phytoplasma occurs in the EPPO region wherever pears are grown. The disease is vectored by psyllids and is particularly severe on trees grown on certain rootstocks, such as *Pyrus ussuriensis* and *P. pyrifolia*. Trees on *P. communis* seedling rootstocks are usually moderately affected, while those on quince (*Cydonia oblonga*) most often show only light transient symptoms.

Basic strategy

Healthy planting material grafted on decline-resistant or decline-tolerant rootstocks such as quince should be used. Diseased trees should be removed, at least in orchards less than 5 years old. Because severe epidemics usually occur after heavy infestations of *Cacopsylla* spp., these pests should be adequately controlled.

Erwinia amylovora (fireblight)

General

Erwinia amylovora affects both apple and pear. However, pears are usually more susceptible, and most apple cultivars are relatively less so. The pathogen may infect all the above-ground parts of the host. The first symptoms usually appear on the flowers, which become water-soaked, shrivel rapidly and turn brownish or black in colour. Terminal twigs wilt from the tip downwards and turn hooked with brownish leaves. The symptoms may progress down to the branch or trunk, where girdling and/or canker formation may occur. Under humid conditions, droplets of typical white exudate appear on the surface of infected parts. The pathogen overwinters in "hold-over" cankers, which are the most important sources of inoculum for flower infections in spring. The bacteria enter the plant through flowers, natural openings (stomata, lenticels, hydathodes) or wounding caused, for example, by insects, wind or rain. Besides apple and pear, wild Rosaceous plants (especially *Crataegus* spp.), ornamental shrubs and trees (*Chaenomeles*, *Cotoneaster*, *Pyracantha*, *Stranvaesia*, *Sorbus*), and other fruit trees (*Cydonia*, *Eriobotrya*, *Mespilus*) are also affected and may be important sources of primary inoculum.

Basic strategy

The pathogen is a quarantine pest and its introduction is prohibited by almost all countries. Even countries where the disease exists have restrictions for the introduction of susceptible host plants. Several countries have been successful in maintaining major fruit-producing areas free from *E. amylovora* (as "protected zones"). It is recommended to maintain strict phytosanitary measures on movement of host-plant material to prevent further spread of *E. amylovora*. For control of the disease, an integrated programme of chemical control combined with sanitation, pruning, eradication and use of resistant or tolerant cultivars is recommended. Warning systems based mainly on climatic data are used to optimize the efficiency of control.

Main bactericides

Copper, fosetyl-Al.

Pseudomonas syringae pv. *syringae* (bacterial blight)

General

Bacterial blight of apple and pear is caused by *Pseudomonas syringae* pv. *syringae*. In apple, infection mainly induces bark necrosis. The affected parts turn brownish to reddish in colour and burst. Such necrotic areas may occur in different sizes on twigs, shoots and the trunk. Lesions extending along branches and the main trunk develop early in summer. Terminal dieback of branches can occur. In most cases, the necrosis starts from infected buds and leaf scars.

In pear, the most typical symptom is blossom blight, but the pathogen may also infect shoots, leaves, buds and branches. The affected parts turn black in colour and die back. The pathogen has a wide host range and survives epiphytically. It commonly overwinters in buds and leaf scars of fruit trees. In both apple and pear, the disease is favoured by temperatures fluctuating around freezing point, high soil moisture, and high N-fertilization.

Basic strategy

Pruning away diseased plant parts is the only possibility for controlling the disease in apple. For controlling blossom blight in pear, a delayed dormant spray with copper-containing chemicals has been recommended, but is frequently not effective. Pruning of affected blossoms and shoots may help to reduce spread of the disease. Growing of pear cultivars with a lower susceptibility is recommended.

Agrobacterium tumefaciens (crown gall)

General

Agrobacterium tumefaciens, causing crown gall, has a very wide host range and occurs worldwide in nurseries and orchards. Usually, the disease is more important in apple than in pear. The pathogen infects the plants through wounds and stimulates the parenchyma cells to abnormal growth, which results in the formation of galls, particularly near the soil surface (crown). The bacterium may survive saprophytically for long periods in the soil and can be transmitted with contaminated tools and grafting material. Affected plants are stunted and are not marketable when galls are present. The disease is influenced by the susceptibility of the cultivar and the planting site. Among the apple rootstocks, M 7 is reported to be most susceptible followed by M 9 and M 26. Crown gall is often severe on apple trees planted in fields where previously rosaceous nursery crops were heavily infected.

Basic strategy

The most important methods of control are based on cultural and sanitary practices. Wounding of the trunk and roots during cultivation should be avoided, and planting and grafting material should be obtained from disease-free stock plants. Tools, containers and equipment should be sterilized. The antagonistic agent *A. radiobacter* (strain K 84), which is very effective on other host plants, has been largely ineffective on apple.

Viruses

Basic strategy

Apple and pear are affected by many viruses and virus-like organisms. As vector transmission is not known in the EPPO region for any of them in these hosts, chemical control of insects or nematodes only for this purpose is not important. The viruses are transmitted by grafting and, in apple and pear, are controlled by the use of healthy planting material. Elimination of the viruses from infected apple and pear cultivars and rootstocks for nuclear stock plants is done by selection or by heat treatment. Successful virus elimination is verified by applying laboratory test methods and indicator tests in the field or glasshouse. Virus-tested plants are then propagated under controlled conditions. In several EPPO countries, this is officially supported by national certification schemes for the production of healthy fruit trees and rootstocks. OEPP/EPPO (1999) presents EPPO's recommendations for the certification of pome fruits.

Aphids

General

Several aphid species live on apple. The green apple aphid, *Aphis pomi*, which is also an important pest in pear orchards, sucks sap from leaves and young shoots during spring and summer. It does not migrate to another host. Spring infestation is usually unimportant on mature trees, but summer attack often causes considerable leaf curling and stunted shoot tips on nursery stock and on young trees.

In many apple-growing regions, the rosy apple aphid, *Dysaphis plantaginea*, is of greatest economic importance. Feeding of *D. plantaginea* before, during and after flowering causes leaf chlorosis and curling. A toxin injected during feeding leads to deformed and stunted fruit clusters and to misshapen unmarketable fruits at harvest. In June/July, aphids migrate to their summer hosts (such as *Plantago* spp.).

The apple-grass aphid, *Rhopalosiphum insertum*, is abundant on apple, pear and quince but rarely a serious pest. Overwintered eggs hatch in early spring. In mid-May, winged aphids of *R. insertum* migrate to grasses. The first colonies of *R. insertum* serve as a food source for predators (syrphids and coccinellids), which later feed on colonies of *D. plantaginea* and A. *pomi.*

The rosy leaf curl aphids constitute an aphid complex of at least of five species (*Dysaphis devecta*, *D. chaerophylli*, *D. anthrisci*, *D. radicola* and *D. brancoi*). At the green bud stage (BBCH 56), first colonies start feeding on rosette leaves; infested leaves are down-curled and of a characteristic bright red colour. Infestation is often restricted to single trees.

The pear-bedstraw aphid, *Dysaphis pyri*, is the most important aphid on pear, on which it is widespread and often common. Overwintered eggs hatch by the white bud stage (BBCH 57) and colonize the rosette leaves. Later, young shoots are also invaded. From June onwards, winged aphids disperse to *Galium* spp. Infested leaves are severely distorted. Heavy attack may lead to leaf fall and reduced plant growth. Honeydew production by the aphids may downgrade fruit, which become covered with sooty mould.

Basic strategy

In early spring, field observations should be regularly carried out, especially regarding *D. plantaginea*. These will determine whether spraying is required. Selective aphicides such as pirimicarb, not harmful to aphid predators, should be preferred. Examples of economic thresholds are: *A. pomi*, 10% of the shoots with leaf curling; *D. plantaginea*, 1-2% of the spurs with attack; *R. insertum*, 80% of the spurs with attack.

Main insecticides

Sprays: acephate, alpha-cypermethrin, azinphos-methyl, beta-cyfluthrin, bifenthrin, chlorpyrifos, cypermethrin, deltamethrin, diazinon, dimethoate, esfenvalerate, ethiofencarb, fenitrothion, fenthion, heptenophos, imidacloprid, lambda-cyhalothrin, malathion, methamidophos, mevinphos, omethoate, oxydemeton-methyl, phosalone, pirimicarb, pirimiphos-methyl, propoxur, tau-fluvalinate, triazamate, vamidothion.

Eriosoma lanigerum **(woolly aphid)**

General

Eriosoma lanigerum is an important apple pest that feeds on the trunk, branches and shoots of apple, rather than on leaves, and so is considered here separately from the other aphids. It was introduced from North America and is now common and widespread in most European apple-growing areas. The aphid hibernates as wax less nymphs in bark splits. In cold winters, only aphids living on the trunk basis or on roots survive. *E. lanigerum* has several generations a year and is conspicuous because of its secretion of a mass of wool-like wax. The feeding results in the formation of knots or swellings termed galls, which are more obvious on water sprouts than on callus of wound tissues. Often such calli are infected by *Nectria galligena.* Feeding by *E. lanigerum* promotes apple canker and vice versa. Honeydew excretion causes sooty mould, which may downgrade the quality of the fruit. On young trees and nursery stock, heavy infestation may retard plant growth or disfigure plants.

Basic strategy

Orchard management has a great impact on population development of *E. lanigerum* and its natural enemies. The most important and well-known predator is *Aphelinus mali*. Methods such as removal of suckers and water sprouts, and painting of wounds and larger pruning cuts, eliminate preferred feeding sites and prevent new colonies from establishing. If locally recognized thresholds are met on visual observation, one insecticide spray may be necessary. Selective insecticides should be preferred, which are non-hazardous to natural enemies. Summer pruning often eliminates the need for an insecticide spray.

Main insecticides

Sprays: chlorpyrifos, diazinon, fenitrothion, heptenophos, malathion, phosalone, pirimicarb, pirimiphos-methyl, propoxur, triazamate, vamidothion.

Cacopsylla **spp. (pear suckers)**

General

Pear suckers *(Cacopsylla pyricola, C. pyri, C. pyrisuga)* are important insect pests of pear. All three species overwinter as adults. *C. pyrisuga* has only one generation per year, the other two species have three or four. The nymphs feed by sucking sap from buds, leaves and shoots, causing distortions, wilting and scorching and premature leaf drop. Honeydew produced by the nymphs leads to formation of sooty mould, which russets the skin of fruits, causing them to be downgraded, or reduces the photosynthetic capacity of the leaves. Heavy populations threaten the tree, reduce terminal growth and may influence the following season's crop by reducing fruit-bud set. Moreover, *Cacopsylla* spp. are vectors for an important phytoplasma disease, pear decline. *Psylla mali* is a similar but much less important species on apple.

Basic strategy

Orchard practices can influence the activity of *Cacopsylla* spp. and the extent of infestation. Good orchard management includes good balanced fertilization in order to control tree growth, the removal of water sprouts and suckers in the centre of the tree, planting at proper density (not too densely, according to the cultivar) and good spray coverage. *Cacopsylla* populations should be monitored year round to forecast and prevent outbreaks. Predators are important in reducing populations, anthocorids being the main species involved.

If chemical control is necessary, an insecticide can be sprayed. A mixture of diflubenzuron and oil after flowering gives good control. With heavy infestations, this treatment should be repeated about 3 weeks later. If possible, selective products should be used to preserve natural enemies. In orchards where fenoxycarb is used to control leaf-rolling tortricids, early infestations by *Cacopsylla* spp. are much reduced, so that the first treatment against them can be omitted. Monitoring of freshly laid eggs is then necessary.

Main insecticides

Sprays: abamectin, amitraz, azinphos-methyl, deltamethrin, diflubenzuron, dimethoate, fenoxycarb, fenvalerate, flufenoxuron, hexaflumuron, lambda-cyhalothrin, teflubenzuron, triflumuron.

Lygocoris pabulinus **and** ***Plesiocoris rugicollis*** **(mirids)**

General

Lygocoris pabulinus (common green capsid) is widespread and often abundant. The pest is of local importance as a pest of fruit crops in many northern parts of Europe. Apple cultivars differ in sensitivity to the damage. On pear, *L. pabulinus* and a few other mirids often cause severe brown markings and deformation of the fruit. After hatching in spring, the nymphs feed on buds, leaves, shoots and fruitlets. Punctured leaves and fruits develop small, reddish or brown markings. Also corky scars are formed on damaged shoots and fruits become deformed. Later instars of the bug migrate to herbaceous hosts. Adults of the second generation return to the woody winter hosts to lay eggs.

P. rugicollis (apple capsid) has regained importance during recent years in some regions. It causes damage similar to *L. pabulinus*, but mostly more severe, as it stays on its woody host throughout the year. Repeatedly attacked shoots die, and lateral shoots sprout prematurely.

Basic strategy

Visual controls should be carried out to decide whether a treatment is necessary. Suggested damage thresholds include: before or during flowering, two nymphs per 100 shoots (beating sample, *L. pabulinus* and/or *P. rugicollis*); after flowering, two or three adults per 100 shoots (beating samples). Best control can be achieved by a single spray treatment shortly before flowering. Examples of economic thresholds are: in apple three to five nymphs or adults per beating sample of 33 branches, or 1% of the shoots with damaged tip before June 1; in pear one or two nymphs or adults per beating sample of 33 branches.

Main insecticides

Sprays: carbaryl, chlorpyrifos, beta-cyfluthrin, cypermethrin, deltamethrin, dimethoate, ethiofencarb, fenitrothion, imidacloprid, lambda-cyhalothrin, pirimiphos-methyl, propoxur.

Anthonomus pomorum **and** ***A. pyri*** **(blossom weevils)**

General

The characteristic damage by *Anthonomus pomorum* is the appearance of brown-capped flowers formed after the larvae have fed inside the flower at the bases of the petals. In years of abundant flowering, light infestations may have a beneficial thinning effect. However, heavy infestation leads to destruction of most of the flowers on the clusters. Larvae pupate within the shelter of the capped flowers. Adult weevils hibernate in neighbouring hedges or woodland. They return to apple orchards in the next spring at the bud-break stage (BBCH 53). This pest has increased dramatically over the last 5 years with the adoption of IPM.

A. pyri is a common and occasionally important pest of pear in some European countries. Damage is similar to that by *A. pomorum*. Infested buds are hollowed out, fail to open and remain as dead husks.

Basic strategy

Beating samples and visual observations should be taken at BBCH stages 53-55 (bud-burst to flower buds visible) onwards and sprays against weevils, if required, should be applied before eggs are laid during green bud (BBCH 56). *Scambus pomorum* can be an important predator.

Main insecticides

Sprays: bensultap, carbaryl, chlorpyrifos, fenitrothion, phosalone, phosmet.

Cydia pomonella **(codling moth)**

General

Cydia pomonella is the most important and widespread pest of pome fruits. Chemical control of this species is one of the best documented topics in the applied entomological literature. The damage is caused by larvae, which burrow into the fruits. Infested fruit are unmarketable. In years with heavy infestations in untreated orchards, yield loss by *C. pomonella* damage reaches 80%. Overwintering occurs as mature larvae diapausing in cocoon in bark splits or in the ground. The number of annual generations varies from one to four according to local climatic conditions, depending on latitude, altitude and host plant.

Basic strategy

Chemical spray reatment is widely used for the control of *C. pomonella*. The key element is accurate timing of the first treatment. This can be refined by pheromone trapping of the first flight of adults. Mating requires two consecutive evenings at a temperature over 15°C. Eggs are laid over 5-6 days and have to incubate over 8-18 days. A simple temperature sum curve can be used to estimate when the eggs will hatch. The first treatment can then be timed just before egg hatch (except diflubenzuron to be applied during oviposition). Computer-based prognosis models are available, generally used by the official forecasting services. In northern Europe, the second generation can also be timed but, in southern Europe, the generations rapidly come to overlap. In summer, thresholds can also be used to decide whether to treat (% infested fruits, numbers of adults caught in pheromone traps).

The difficulty of controlling *C. pomonella* differs from area to area and from year to year and increases with the number of generations. Depending on population pressure, in many locations two to six cover sprays with broad-spectrum insecticides are applied to prevent fruit injury. Three stages of *C. pomonella* are exposed to control measures: the eggs, the neonate larvae and the adult moths. In integrated fruit production (IFP) systems, insect growth regulators (IGRs) are preferred. These should be timed critically using pheromone traps.

Several non-chemical control methods have reached commercial application. Microbial insecticides based on cydia pomonella granulovirus (CpGV) exist and are implemented in IFP in several European countries. CpGV is inactivated by UV light and has to be sprayed more often than chemicals, from first egg-laying nearly until harvest if necessary. The virus is highly specific to *C. pomonella* and non-toxic to mammals. Mating disruption with codlemone has also been successfully introduced into practice in some European fruit-growing areas.

Main insecticides

Sprays: azinphos-methyl, *Bacillus thuringiensis*, beta-cyfluthrin, carbaryl, chlorpyrifos, cydia pomonella granulovirus, cypermethrin, deltamethrin, diazinon, diflubenzuron, dimethoate, fenoxycarb, hexaflumuron, lambda-cyhalothrin, malathion, methidathion, methomyl, phosalone, phosmet, propoxur, teflubenzuron, triflumuron.

Argyresthia conjugella **(apple fruit moth)**

General

Argyresthia conjugella is regarded as a key apple pest in the Nordic countries. Its natural and preferred host is the commonly distributed and wild-growing *Sorbus aucuparia*. However, in those years when berry production on *S. aucuparia* is too small to support all the egg-laying females, a number of them migrate to apple for oviposition. The injury to the apple crop may then be severe, even resulting in total destruction of the crop.

Adults occur from late May to late August. The moth deposits approximately 80% of its eggs in July, with a clear peak in the first half of the month. Most of the eggs are laid on the fruitlets, and they hatch in about 10-14 days. The young larvae immediately burrow into the flesh to feed, and several larvae often occur in an infested fruit. These become riddled with tunnels and the skin is marked with small discoloured, sunken blotches. Later the fruit skin is pierced by numerous 1- to 2-mm-wide holes, and the damaged fruit is not marketable. When fully grown, the larvae drop to the ground and pupate in the soil. This insect develops only one generation a year.

Basic strategy

A special warning system has been developed in some countries, which provides reliable information about infestation on apple, whether infestation should be expected or not and also the length of the oviposition period. In years with moderate infestation, edge-spraying normally gives complete control of *A. conjugella*. This treatment, in which only the outer one to three rows and the ends of the rows are sprayed, protects the inner untreated part of the orchard from infestation. The edge spray should be applied before the moths start their migration, and an insecticide persistent enough to last for the critical period of time should be used. At more severe infestation, or in an outbreak situation, one or two all-over coverage sprays are recommended.

With severe infestation on apple, two or three treatments of diflubenzuron give some, but not satisfactory, control of *A. conjugella*. Azinphos-methyl, at various dosages, is therefore the most commonly used insecticide against this pest.

Main insecticides

Sprays: azinphos-methyl, diflubenzuron.

Leaf-rolling tortricids

General

An increase in damage caused by leaf-rolling tortricids (*Adoxophyes orana, Pandemis heparana, Archips podanus, Spilonota ocellana*) has been observed in the past few decades in most of the fruit-growing regions of Europe. The summer fruit tortrix, *A. orana*, is the most important. It is a polyphagous species, feeding on all types of pome and stone fruit and on numerous deciduous trees in hedgerows and woods. This species has developed into a key pest in apple orchards in many fruit-growing regions. It is a bivoltine species and produces a third generation under favourable climatic conditions. Overwintering occurs in the second or third larval stage. At bud-break (BBCH 07), larvae begin to feed on young leaves, later on shoots and fruit. First-generation females start to emerge in early summer. The summer larvae cause the greatest economic loss to fruit production, making large irregular feeding patches on fruits. The second-generation moth appears in later summer. Autumn larvae cause minor surface damage to fruits before entering diapause.

The larvae of *P. heparana* are polyphagous on many trees and shrubs. The attack on foliage, flowers and fruit is less important than feeding of *A. orana*. The species is bivoltine. The fruit tree tortrix moth, *A. podanus*, is univoltine and widely distributed. The species is common and polyphagous to many fruit trees and shrubs. Main damage is done by young larvae biting irregular pits in the skin of maturing apples. The bud moth, *S. ocellana*, is generally common and polyphagous to wild hosts and many fruit crops. Sometimes, it is a serious pest. In contrast to the three tortricid species described above, young larvae of *S. ocellana* cause little or no harm during summer and no damage to fruits of apples and pears. Significant attack occurs in spring. Infested buds and flowers are destroyed. Several other similar species are found on apple: *Pandemis cerasana* (central Europe), *Hedia variegana*, *Ptycholoma lecheanum*, *Archips rosanus* and *A. xylosteanus* (northern Europe).

Basic strategy

Chemical spray treatment is widely used for the control of tortricids. Numerous methods have been reported on the optimal timing of control treatments. The timing depends on methods and products used. Insect growth regulators such as fenoxycarb are very effective. Pheromone traps for monitoring leafroller species are widely used in practice. Mating disruption can be used against *A. orana*.

Main insecticides

Sprays: as for *Cydia pomonella*.

Yponomeuta malinellus **(small ermine moth)**

General

Yponomeuta malinellus is polyphagous and generally distributed, causing considerable defoliation in unsprayed fruit trees and other deciduous hosts. Adults occur in July/August, the eggs hatch in autumn, and small larvae hibernate. In early spring, first-instar larvae mine in young leaves. Older stages live gregariously under webs and their feeding may lead to complete defoliation. The species is of minor importance in commercial orchards, but may cause severe damage in organic fruit growing, unsprayed gardens and hedgerows.

Basic strategy

Y. malinellus is controlled effectively by insecticide sprays against major pests. If specific control is needed, *Bacillus thuringiensis* in early spring or insect growth regulators may be used.

Main insecticides

Sprays: *Bacillus thuringiensis*, diflubenzuron, triflumuron.

Leaf miners

General

The three leaf miner species *Leucoptera malifoliella* (pear leaf blister moth), *Phyllonorycter blancardella* (spotted tentiform leaf miner), *Lyonetia clerkella* (apple leaf miner) are common and widely distributed. They are polyphagous and feed on a number of rosaceous hosts as well as on species of other families, e.g. *Betulaceae*. Apple and pear are, however, the preferred hosts. *L. malifoliella* has two generations per year. The larvae form round mines which are visible on the upper side of the leaf. Full-grown larvae vacate their mines and pupate in a white boat-shaped cocoon. *P. blancardella* has three generations per year allowing a tremendous potential for populations to build up. The larvae form mines which at first are only visible from the underside of the leaves. Later, the mines have a characteristic mosaic pattern visible on the upper side of the leaves. Pupation occurs within the mine. *L. clerkella* usually has three generations per year. The larvae form characteristic, very long, winding narrow mines, widening gradually throughout their length. Pupation is outside the mine in hammock-like cocoons which are suspended by strands of silk attached to leaves or to rough bark. Outbreaks of leaf miners are observed regionally and are often closely related to favourable weather conditions as well as to the plant protection measures, i.e. the use of insecticides that harm the natural enemies of leaf miner populations. Heavy infestations cause premature dropping of leaves and fruits.

Several other species attack apple in a similar way: *Stigmella malella, Nepticula pomella, Phyllonorycter corylifoliella.*

Basic strategy

Use of selective plant protection products is recommended against main pests (e.g. cydia pomonella granulovirus against *Cydia pomonella*), in order to preserve the parasitoids which play an essential role in the regulation of leaf miner populations. If insect growth regulators are used to control leaf tortricids and *C. pomonella*, these mostly give sufficient control of the leaf miners. If specific control of leaf miners is needed, chitin synthesis inhibitors should be used at the beginning of egg-laying. For timing of the insecticide spray, the flight of the moths should be monitored (e.g. with pheromone traps or by coating leaves with insect glue). The chitin-synthesis inhibitors should not be used too often because of possible build up of resistance. Examples of damage thresholds are 0.5-1 mine per leaf after blossom in the case of *L. malifoliella,* 1-2 mines per leaf after blossom in the case of *P. blancardella* and *L. clerkella.*

Main insecticides

Sprays: imidacloprid and as for *Cydia pomonella*.

Operophthera brumata **(winter moth)**

General

Operophthera brumata is a very common and often important pest of apple and pear, which also attacks other woody hosts (cherry, plum, gooseberry, nut and forest trees). The species has a marked sexual dimorphism. Whereas the male moths have well-developed wings, the wings of the female moths are reduced to stubs. Depending on temperature, adults occur from October to January. After emergence from the pupae, the female crawls up the trunk of the tree and, after mating, lays its eggs singly in crevices. The larvae hatch in spring, and the young larvae feed on the developing leaves and on flower trusses. Later instars also attack fruitlets. When fully grown, the larvae drop to the ground and pupate in the soil. Damage to the flowers is often considerable and, if infestations are severe, all flowers and greenery on the food plant may be eaten. Larvae often bite holes into the fruitlets, causing them either to drop prematurely or to develop into malformed fruit with corky scars or depressions, or sometimes a deep hole that extends down to the core. Other species such as *O. fagata, Erannis defoliaria, Alsophila aescularia* and *Agriopis aurantiaria*, also behave as winter moths, and may occur in severe outbreaks in association with *O. brumata*.

Basic strategy

Glue bands should be attached around the tree trunks during the emergence of the moths to catch the females as they climb up to the tree crown. The use of these glue bands can result in a 70-80% reduction in damage but, as a rather labour-intensive method, it seems to be suitable mainly for single trees and small orchards. Otherwise, an insecticide spray can be used against the larvae. As selective insecticides, *Bacillus thuringiensis* or insect growth regulators may be used, but it is important to apply them against young instars which are most susceptible. Most insecticides give satisfactory control only when temperatures are above 15°C, so that the larvae are active and ingest enough of the active substances. Specific thresholds should be respected, if these exist for the region concerned. The thresholds can be given as larvae per shoots in beating sample or assessed by visual control, or as infested trusses per tree.

Main insecticides

Sprays: azinphos-methyl, *Bacillus thuringiensis*, beta-cyfluthrin, carbaryl, chlorpyrifos, diflubenzuron, dimethoate, fenitrothion, phosalone, triflumuron.

Noctuids

General

Some noctuids (*Eupsilia transversa*, *Lithophane socia, Orthosia* spp., *Cosmia trapezina*) are common and widely distributed pests on fruit trees. They are all polyphagous. *E. transversa* and *L. socia* hibernate as adults, while the adults of the *Orthosia* spp. emerge from the pupae in early spring. The eggs, which are laid singly or in large batches on the bark, hatch in spring, and the larvae feed on the developing leaves and on flower trusses. *E. transversa* may destroy a great number of trusses. Later instars also attack the fruitlets by chewing holes into the fruit flesh. The attacked fruits either drop prematurely or develop into deformed fruits with corky scars or depressions.

C. trapezina, which may occur in dense populations on fruit trees, hibernates in the egg stage. The larvae hatch very early, and the larvae are normally fully grown before the fruitlets start to grow. Therefore, they seldom cause fruit damage. When fully grown, the larvae drop to the ground and pupate in the soil.

Basic strategy

All noctuid pests in orchards can be controlled efficiently by applying suitable insecticide sprays. Because of the different injuries the various species cause to fruits, the economic thresholds are different. Examples are: *C. trapezina*, 25-30 larvae per beating sample of 33 branches or 17-20 larvae per 100 spurs; *E. transversa* and allied species on apple, 8-10 larvae per beating sample of 33 branches or 5-7 larvae per 100 spurs; *E. transversa* and allied species on pear, 3-5 larvae per beating sample of 33 branches or 3-5 larvae per 100 spurs.

Main insecticides

Sprays: azinphos-methyl, diflubenzuron.

Hoplocampa testudinea **and** ***H. brevis*** **(sawflies)**

General

The apple sawfly, *Hoplocampa testudinea*, is univoltine. Single eggs are laid directly into the receptacle at the base of the sepal. First-instar larvae tunnel under the fruit skin and cause typical ribbon-like scars. Sometimes the larvae persist until harvest. Secondarily infested fruitlets drop. Light infestation may have a beneficial thinning effect but, in years with high population density, fruit losses can be extremely severe both in commercial orchards and in untreated gardens. Several cultivars are very susceptible.

The pear sawfly, *H. brevis,* is common and widespread in continental Europe. It overwinters as a full-grown larva in a cocoon in the soil. After pupation in spring, adults occur in April. Eggs are laid singly in young fruitlets. Larvae grow rapidly in the flesh of the fruitlet, and one larva may attack and destroy several fruits. The species is single-brooded. The pest is of minor importance in Central Europe.

Ametastegia glabrata is another sawfly which attacks apple in Scandinavia and in some other north-eastern countries.

Basic strategy

Prognosis can be based on monitoring data from the previous year. White-coloured sticky traps are widely used in practice for monitoring adult flight. An example for a threshold is 5-10 egg-laying slits found in visual observations in 100 flower clusters. When this threshold is reached, a spray treatment with an insecticide becomes necessary.

Main insecticides

Sprays: chlorpyrifos, cypermethrin, deltamethrin, demeton-S-methyl, dimethoate, fenitrothion, oxydemeton-methyl, phosalone, phosmet, pirimiphos-methyl, propoxur.

Dasineura pyri (pear leaf midge)

General

Up to 35 eggs are laid within the rolled margins of young pear leaves. Larvae of *Dasineura pyri* feed gregariously on the upper epidermis. In a severe attack, distorted leaves turn red, finally blacken and die. Heavy infestation may cause considerable crop loss. Full-grown larvae drop to the ground and pupate in cocoons. In central Europe, the midge usually has three generations per year. *D. mali* is a similar but less important species on apple.

Basic strategy

If chemical control is necessary, one spray at the beginning of flowering is recommended. Phosalone is recommended as also being effective against *Hoplocampa brevis* and *Anthonomus pyri*, but has minor side-effects on natural enemies.

Main insecticides

Sprays: fenitrothion, phosalone, vamidothion.

Scales

General

Three members of the genus *Quadraspidiotus* occur in central Europe as pests of pome fruit trees: *Quadraspidiotus perniciosus*, *Q. ostreaeformis* and *Q. pyri*. *Lepidosaphes ulmi* is also an important pest.

Q. perniciosus (San José scale) is polyphagous, with a host range of over 700 plant species. It was introduced into central Europe about 55 years ago. It hibernates as a first-instar nymph in the "blackcap" stage. *Q. perniciosus* has several generations per year depending on local climatic conditions, e.g. two in southern Germany and five in southern Italy. One female gives birth to about 400 "crawlers". In most apple-growing areas, crawlers infest fruit from mid-August until October and cause direct economic losses. Scale infestation leads to purple discoloration around the calyx end of apple and pear. Heavy infestation on the bark may weaken the trees and reduce crop. Flight of the males can be monitored by white sticky traps and pheromone traps.

Q. ostreaeformis (European fruit scale or oyster scale) distributed almost worldwide and polyphagous on numerous deciduous trees, including pome and stone fruit, but of lower economic importance than *Q. perniciosus*. Overwintering occurs in the second-instar nymph stage. This species is univoltine. Up to 200 eggs are laid by one female. *Q. pyri* (pear scale) also overwinters as the second-nymph stage and develops into adult by end of May. One female lays 50-150 eggs; there is one generation per year. Heavy attack on trunk and branches may weaken the vigour of the tree by sap feeding and may lead to yield loss.

L. ulmi (oystershell scale or mussel scale) hibernates as eggs, which hatch in late May. Nymph crawlers settle down on the bark and start sap feeding. They are mobile for about 3 weeks. The later stages are protected by a mussel-shaped shield. The adult stage of this univoltine species is reached in July/August. Heavy infestation, which reduces vigour, is usually found on unsprayed trees. This scale is of increasing importance in commercial orchards.

Basic strategy

Q. perniciosus can easily be controlled with winter sprays of organophosphorus insecticides plus oil, and has generally become a sporadic minor pest. From 1990, however, these products are no longer used in the IFP systems of some countries, and this secondary pest is again causing economic losses. Biological control by mass release of *Encarsia* (*Prospaltella*) *perniciosi* should be used. Sprays can be used at bud burst (BBCH 53) and, at the latest, at pink bud (BBCH 57).

Main insecticides

Sprays: chlorfenvinphos, chlorpyrifos-methyl, methidathion, omethoate.

Xyleborus dispar (broad-leaved pinhole borer)

General

Xyleborus dispar is widely distributed over the fruit-growing areas of Europe. Adult females fly in April/May if temperatures exceed 18°C and bore into the bark of host trees, producing cylindrical breeding galleries directed both upwards and downwards. One female lays up to 50 eggs. Larvae feed on ambrosia fungi. Adults emerge during the summer. After hibernation and mating in the following spring, males die and females swarm and search for new hosts. The beetles colonize trunks and branches, often in orchards located near woodlands. In heavy attacks, branches or even whole trees may become extensively riddled with galleries, and serious infestation may kill the tree.

Basic strategy

X. dispar normally only attacks trees in poor condition and is not therefore a pest of well-managed commercial orchards. To prevent invasion by this beetle, trees should be properly fertilized and irrigated. Heavily infested branches and trees should be removed and burned. Mass trapping with bio-colour traps (attractants: red colour and ethanol), 8-10 traps per ha, has proved to be very effective.

Synanthedon myopaeformis (apple clearwing moth)

General

Synanthedon myopaeformis hibernates in seven larval stages. The larvae live underneath the bark forming irregular winding galleries. They prefer wound callus and burr knots, especially on rootstock M9. An interaction exists between *S. myopaeformis* and apple canker caused by *Nectria galligena*. Larval feeding in commercial apple orchards shortens the life of trees and may lead to considerable yield loss. *S. myopaeformis* is univoltine, with adults appearing from May to September. In unfavourable conditions, development may last two years.

Zeuzera pyrina and *Cossus cossus* are other lepidoptera whose larvae burrow in the wood of pome fruit trees, especially in southern Europe.

Basic strategy

Prevention of wounds on the tree and treatment with wound-protecting products are the main preventive measures. Mating disruption techniques may be used. Pheromone traps for monitoring adult flight are available. If necessary, the trunks should be treated in order to prevent adults from laying eggs. These sprays are, however, only effective if applied to run-off, at high concentrations, to the rootstock and grafting point.

Main insecticides

Sprays: deltamethrin, flucythrinate, lambda-cyhalothrin, methidathion, phosalone.

Spider mites

General

The fruit-tree red spider mite, *Panonychus ulmi*, is a widespread and important pest of apple and other fruit trees. Mite feeding causes leaves to lighten in colour, becoming mottled and stippled. Heavy infestations cause leaf bronzing, drying of leaves and premature leaf fall. Tree growth is reduced, which impairs fruit ripening as well as the yield of the following year by reducing fruit-bud set. Populations of *P. ulmi* can grow rapidly, hot and dry climates being favourable. Four to six generations can develop per year. *Tetranychus urticae* also sometimes attacks apple and can be treated in exactly the same way.

Basic strategy

Trees should be grown at moderate vigour and nitrogen fertilization should be minimal. When planting a new orchard, the cultivar most suited for the site should be chosen. Regular control of the *P. ulmi* population level is of basic importance. Chemical spray treatments every spring are only recommended if the overwintering population exceeds 1000-2000 eggs per 2 m fruit spur. During spring and summer, sprays are necessary only if 60% of the leaves are infested. If predatory mites are present, a higher percentage can be tolerated.

Phytoseiid mites are the most important predators of *P. ulmi*. Where these natural enemies are absent, they should be introduced if possible. In order to preserve the phytoseiid populations, plant protection products which are harmful to them should be avoided.

Main acaricides

Harmless for predatory mites: clofentezine, fenbutatin-oxide, flucycloxuron, flufenoxuron, hexythiazox, propargite, tetradifon.

Moderately harmful for predatory mites: chinomethionat, fenazaquin, fenpyroximate, pyridaben, pyridaphenthion tebufenpyrad.

Harmful for predatory mites: abamectin, acrinathrin, amitraz, azocyclotin, bifenthrin, bromopropylate, dicofol.

Aculus schlechtendali (apple rust mite)

General

The free-living eriophyid mite *Aculus schlechtendali* is widely distributed and common on apple, where it can cause severe leaf damage. Mites emerge from bud-burst onward (BBCH 53) and invade the opening fruit buds to feed on leaf tissue and on the developing flowers. Population growth is rapid because of short generation times and high fecundity. High populations turn leaves silver to brown. Depending on the apple cultivar, ripening and coloration of the fruit is impaired (e.g. cvs Jonagold, Elstar). Other susceptible cultivars are Summerred and Ingrid Marie. Russeting of the fruits occurs only rarely, in the case of very early heavy infestations. Apple rust mites provide an alternative food source for predatory mites.

Basic strategy

Predatory mites being the most efficient antagonists of *A. schlechtendali*, these should be preserved by choosing compatible plant protection products during the whole season. In orchards in which heavy infestations have been observed in the previous year, three or four spray treatments before and after blossom can be carried out. Visual controls are recommended during the growing season in order to recognize a population increase in time. Chinomethionat and clofentezine used against spider mites, e.g. *P. ulmi*, are also normally effective against rust mites. The insecticides azinphos-methyl and dimethoate also have a significant side-effect on *A. schlechtendali*.

Main acaricides

Harmless for predatory mites: fenbutatin-oxide, flufenoxuron, tetradifon.

Moderately harmful for predatory mites: fenpyroximate, sulfur.

Harmful for predatory mites: abamectin, amitraz, azocyclotin, bifenthrin, bromopropylate, dicofol.

Epitrimerus pyri (pear rust mite)

General

Epitrimerus pyri is widely distributed on pear and is becoming more common. This is probably a result of the reduced use of lime sulphur for scab control and the introduction of non-acaricidal fungicides. Over-wintering females emerge in spring and begin to feed and to lay eggs around the base of the bursting buds. They also invade the flowers and the foliage and occur on the fruits. Heavy infestation causes bronzing of the tissue and may stunt the growth of trees. Ripening fruits may become russeted.

Basic strategy

A suitable acaricide should be applied at petal fall in orchards in which severe infestations have been observed the previous year (cf. *Aculus schlechtendali*).

Main acaricides

Harmless for predatory mites: fenbutatin-oxide, flufenoxuron, tetradifon.

Moderately harmful for predatory mites: fenpyroximate, sulfur.

Harmful for predatory mites: abamectin, amitraz, azocyclotin, bifenthrin, bromopropylate, dicofol.

Phytoptus pyri (pear leaf blister mite)

General

Phytoptus pyri is a widespread and common pest on pear, occasionally found on apples. After overwintering beneath the outer bud scales, mites of both sexes become active in early spring and penetrate deeper into the buds where they feed and deposit eggs. Whereas mites first occur mainly on the underside of the developing leaves, causing blistering of the tissue, they later gain access to the inside of the leaf, and distinctive pocket-like galls are formed. Breeding continues in the galls. Young mites disperse to young shoots, where they initiate new blisters and galls. Badly infested leaves die and drop. Infestations may spread to the fruitlets and fruit stalks, which then become marked with reddish or brownish to black pustules. Damaged fruits are often distorted and drop prematurely.

Basic strategy

Spray treatment may be needed where severe infestations have been observed the previous year. A single application is made in early spring or summer.

Main acaricides

As for *Aculus schlechtendali.*

Weeds

General

Weed control is necessary in apple and pear. Both crops are now mostly grown in a one-row system, although multiple-row systems still exist. In a multiple-row system, it is difficult to apply plant protection products homogeneously. In addition, with single rows, there is less area of weed-free strips per given area than for multirow beds and, therefore, a lower total amount of applied herbicides is necessary. Therefore, it is GPP to prefer a one-row system if possible.

The trees should be grown in soil free from all vegetation (barren), in order to prevent weed competition and to reduce the risk of night frost damage. However, especially in wetter climates or under irrigation, grass is generally sown between the rows to increase the machine-carrying apacity of the soil and as a cover crop for the control of weeds. This leaves barren soil only in a strip along the row, which should be as narrow as possible to reduce the use of herbicides. The barren strip can be reduced after some growing seasons, e. g. from 150 cm to 100 cm after the first three growing seasons The grass should tiller rapidly in order to cover the soil and prevent the germination and growth of weeds. Growth of weeds in the barren strip should be controlled at least in spring and summer. In autumn and winter, a closely mown weed cover may be tolerated to improve fruit quality, to reduce leaching of nutrients and for soil protection. Apple is more sensitive to weed competition than pear.

Chemical control of weeds is the common practice. Mechanical weed control, e.g. with scufflers, is also possible and GPP. Mulching with, for example, straw along the rows is another possibility.

The following weed species are considered to be difficult to control in orchards with the available herbicides: *Cirsium arvense*, *Convolvulus arvensis, Conyza canadensis, Cynodon dactylon, Cyperus esculentus, C. rotundus, Epilobium* spp., *Equisetum ramosissimum, E. telmateia, Galium aparine, Heracleum sphondylium, Lactuca serriola, Paspalum paspalodes, Polygonum aviculare, Polygonum persicaria, Potentilla* spp., *Ranunculus repens, Rorippa sylvestris, Rubia peregrina, Rubus saxatilis, Rumex obtusifolius, Senecio vulgaris* (simazine-resistant strains), *Tussilago farfara, Urtica dioica*.

Basic strategy

For good weed control, about three treatments a year are necessary. The choice of herbicides depends on the weed species and the occurrence of resistance. There are many examples of resistance of *Senecio vulgaris* and *Poa annua* to simazine and of *Conyza canadensis* to glufosinate-ammonium. Overall spray treatment is usual, but spot treatments are also possible.

Main herbicides

For the control of annual dicot weeds: diuron, dichlobenil, glufosinate-ammonium, glyphosate, isoxaben, linuron, napropamide, metazachlor, metobromuron, metolachlor, monolinuron, oxadiazon, pendimethalin, prometryn, propyzamide, terbumeton, terbuthylazine, simazine (some of the herbicides can only be applied if trees have reached a certain age).

For the control of established perennial dicot weeds: amitrole, glufosinate-ammonium, 2,4-D, dicamba, fluroxypyr, glyphosate, MCPA, mecoprop-P (some of the herbicides can only be applied if trees have reached a certain age).

For control of monocotyledonous weeds: fluazifop-P-butyl, glufosinate-ammonium, glyphosate (some of the herbicides can only be applied if trees have reached a certain age).

For control of rootstock suckers: 2-(1-napthyl)acetic acid, glufosinate-ammonium, glyphosate (some of the herbicides can only be applied if trees have reached a certain age).

Plant growth regulators

General

Several plant growth regulators are commonly used in pome fruit production with the main aim of improving and stabilizing yields and fruit quality and a secondary aim of reducing labour costs. Plant growth is controlled in a number of ways. In addition to physical means of control, including pruning, shoot training, shoot snapping, bark ringing and sometimes root pruning, chemical means of extension growth control are widely used. There are two elements of chemical growth control: the reduction in growth of extension shoots; and the desiccation of living tissue, such as unwanted shoots in the centre of the tree (water shoots) and root suckers arising from the root system. A plant growth regulator is also used to encourage fruit set and to ensure that there is a crop. A related chemical is used to improve fruit skin finish, and other plant growth regulators can be used to thin fruit.

The general aim is to avoid alternate bearing and to achieve optimum yield and quality. This is achieved by ensuring good fruit set during blossom, thinning fruit where necessary soon after petal fall and controlling shoot extension growth during the growing season in order to reduce the competition between fruit and shoots for nutrients. Water shoots and root suckers compete with fruits for resources and may cause shading of fruits and potential fruit buds, and so are generally controlled either by summer pruning or by plant growth regulators.

Basic strategy

The range of approved products now available to top-fruit growers is very limited.

- growth control: paclobutrazol
- control of water shoots: 2-(1-napthyl) acetic acid
- increasing fruit set: chlormequat chloride, gibberellic acid (pears only)
- improving skin finish: gibberellin A4 + gibberellin A7, borate
- flower and fruit thinning: carbaryl, 2-(1-naphthyl) acetic acid and 2-(1-naphthyl) acetamide for flower and fruit thinning, ethephon for flower thinning
- post-harvest treatment: diphenylamine
- for preventing premature flower and fruit drop: 2-(1-naphthyl) acetic acid

References

OEPP/EPPO (1999) EPPO Standards PM 4/27(1) Certification Schemes. Pathogen-tested material of *Malus, Pyrus* and C*ydonia. Bulletin OEPP/EPPO Bulletin* **29**, 239-252.