Organisation Européenne et Méditerranéenne pour la Protection des Plantes
European and Mediterranean Plant Protection Organization

Normes OEPP
EPPO Standards

Good plant protection practice
Bonne pratique phytosanitaire

PP 2/27(1)

Organisation Européenne et Méditerranéenne pour la Protection des Plantes
1, rue Le Nôtre, 75016 Paris, France

Approval

EPPO Standards are approved by EPPO Council. The date of approval appears in each individual standard. In the terms of Article II of the IPPC, EPPO Standards are Regional Standards for the members of EPPO.

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 Standards 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.

Outline of requirements

For each major crop of the EPPO region, EPPO Standards 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.

Existing EPPO standards in this series

Twenty-six EPPO standards on good plant protection practice have already been approved and published. Each standard is numbered in the style PP 2/4(1), meaning an EPPO Standard on Plant Protection Products (PP), in series no. 2 (guidelines on GPP), in this case standard no. 4, first version. The existing standards are:

PP 2/1(2) Principles of good plant protection practice. *Bulletin OEPP/EPPO Bulletin* **33**, 87–98
PP 2/2(2) Potato. *Bulletin OEPP/EPPO Bulletin* **31**, 183–200
PP 2/3(2) Lettuce under protected cultivation. *Bulletin OEPP/EPPO Bulletin* **31**, 201–210
PP 2/4(2) *Allium* crops. *Bulletin OEPP/EPPO Bulletin* **31**, 211–230
PP 2/5(1) Rodent control for crop protection and on farms. *Bulletin OEPP/EPPO Bulletin* **25**, 709–736
PP 2/6(1)* Hop. *Bulletin OEPP/EPPO Bulletin* **26**, 295–309
PP 2/7(1)* Vegetable brassicas. *Bulletin OEPP/EPPO Bulletin* **26**, 311–347
PP 2/8(1) Rape. *Bulletin OEPP/EPPO Bulletin* **26**, 349–367
PP 2/9(1) Strawberry. *Bulletin OEPP/EPPO Bulletin* **26**, 369–390
PP 2/10(1) Wheat. *Bulletin OEPP/EPPO Bulletin* **27**, 311–338
PP 2/11(1) Barley. *Bulletin OEPP/EPPO Bulletin* **27**, 339–362
PP 2/12(1) Beet. *Bulletin OEPP/EPPO Bulletin* **27**, 363–384
PP 2/13(1) Ornamental plants under protected cultivation. *Bulletin OEPP/EPPO Bulletin* **28**, 363–386
PP 2/14(1) Pea. *Bulletin OEPP/EPPO Bulletin* **28**, 387–410
PP 2/15(1) Tobacco. *Bulletin OEPP/EPPO Bulletin* **28**, 411–424
PP 2/16(1) Farm grassland. *Bulletin OEPP/EPPO Bulletin* **29**, 353–366
PP 2/17(1) Maize. *Bulletin OEPP/EPPO Bulletin* **29**, 367–378
PP 2/18(1) Pome fruits. *Bulletin OEPP/EPPO Bulletin* **29**, 379–406
PP 2/19(1) Rye. *Bulletin OEPP/EPPO Bulletin* **29**, 407–422
PP 2/20(1) Mushrooms. *Bulletin OEPP/EPPO Bulletin* **31**, 231–242
PP 2/21 (1) Sunflower. *Bulletin OEPP/EPPO Bulletin* **31**, 243–256
PP 2/22 (1) Umbelliferous crops. *Bulletin OEPP/EPPO Bulletin* **31**, 257–288
PP 2/23 (1) Grapevine. *Bulletin OEPP/EPPO Bulletin* **32,** 371–392
PP 2/24 (1) Oat. *Bulletin OEPP/EPPO Bulletin* **32**, 393–406
PP 2/25 (1) Leguminous forage crops. *Bulletin OEPP/EPPO Bulletin* **32**, 407–422
PP 2/26 (1) *Ribes* and *Rubus* crops. *Bulletin OEPP/EPPO Bulletin* **32**, 423–442

*Note that these two guidelines for hop and vegetable brassicas appeared in *Bulletin OEPP/EPPO Bulletin* as, respectively, numbers 5 and 6, whereas they are in fact numbers 6 and 7 respectively. This numbering error is now corrected.

These EPPO Standards have also been published together in a new publication, *Good Plant Protection Practice*, available from the EPPO Secretariat, 1 rue Le Nôtre, 75016 Paris (FR).

Good plant protection practice
Bonne pratique phytosanitaire

Citrus

Specific scope

This standard describes good plant protection practice for citrus.

Specific approval and amendment

First approved in 2003-09.

This Standard on GPP for citrus 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(2) Principles of good plant protection practice. It covers methods for controlling pests (including pathogens and weeds) of citrus crops (*Citrus* spp.) cultivated in Mediterranean countries, particularly *Citrus sinensis* (orange), *Citrus reticulata* (mandarin, clementine), *Citrus limon* (lemon), *Citrus paradisi* (grapefruit) and their rootstocks.

Citrus is produced for the fresh fruit market or for processed citrus products. In fruits grown for processing, external quality is not important and the level of damage which is tolerable is much greater than for fresh fruits. Therefore, there is less need to manage pests which cause only external blemishes, and biological control is more easily implemented.

Citrus is grown successfully under a wide range of climatic conditions, in soils ranging from very poor sands to heavy clays, with or without irrigation, and with varying degrees of mechanization. Soil conditions, particularly fertility and drainage, have a major influence on the health of citrus trees, and on the yield and quality of fruits. Soils should supply adequate nutrients. Adequate soil drainage is important. Citrus trees can grow adequately at pH 5.5–7.5, depending on the rootstock and other conditions.

Citrus is exotic to the Mediterranean region and the diversity of arthropods and pathogens in the citrus biocenosis of the Mediterranean basin is a consequence of pest invasions and natural enemy introductions. Although application of plant protection products is still the most commonly applied pest control method, considerable attempts to develop integrated pest management (IPM) methods have been made in the region during the last 30 years. Because citrus has the potential to be productive for many decades, it is imperative that growers develop effective long-term pest management strategies. Careful selection of healthy, high-quality certified nursery plants is most important. Preventive measures, phytosanitary and certification programmes should address the exclusion of graft-transmissible diseases caused by viruses, viroids, some bacteria, and phytoplasmas. Use of resistant or tolerant cultivars is recommended. Cultural practices, including the establishment of cover crops, tree spacing, and water and nutrient management, can influence weed invasion. Varietal differences and cultural practices such as fertilization, irrigation and pruning can influence the densities and control of insect populations (in particular Homoptera) by affecting the physiology and phenology of the citrus tree. Sampling methods such as food, visual and sexual attractants are used to monitor the main citrus pests. The use of behaviour-modifying chemicals such as food attractants and sex pheromones is being developed, and also application of the sterile insect technique. Control tactics include the lure-and-kill method, mass trapping and mating disruption. Thresholds have been developed for the main insect pests of citrus. Most citrus cultivars require pollination for fruit production and honeybees are the best pollinators. So special care should be taken if insecticides are to be applied.

In citrus, the need to address year-round problems involving a large complex of arthropod pests and diseases provides additional opportunity for the development of resistance to plant protection products. Resistance should be a consideration in the choice of plant protection product for a single treatment, and also for season-long application strategies as part of the GPP for citrus.

Post-harvest pests can cause serious losses, and their incidence may be affected by various cultural practices: proper irrigation, soil drainage management and planting on well-drained soil; improving ventilation under the tree canopy by pruning low-hanging branches and mowing or removing vegetation; removal of deadwood by pruning; keeping the orchard floor free from fallen fruits. The probability of infection and decay is directly related to the number of injuries that occur in harvesting and transporting (see section on Post-harvest diseases).

The principal citrus pests considered are the following

Phytophthora spp.
Phoma tracheiphila
Post-harvest diseases (*Penicillium*, *Aspergillus*, *Galactomyces citri-aurantii*, *Alternaria citri*, *Glomerella cingulata*, *Botryotinia fuckeliana*, *Botryosphaeria rhodina*)
Spiroplasma citri
Citrus tristeza closterovirus
Mites
Armoured scales
Aonidiella aurantii
Unaspis yanonensis
Saissetia oleae
Pseudococcus citri
Icerya purchasi
Aphids
Whiteflies
Thrips
Ceratitis capitata
Cacoecimorpha pronubana
Prays citri
Phyllocnistis citrella
Ectomyelois ceratoniae
Cryptoblabes gnidiella
Calocoris trivialis
Snails and slugs
Tylenchulus semipenetrans
Weeds
Plant growth regulators

Explanatory note on active substances

The EPPO Panel on Good Plant Protection Practice, in preparing this standard, 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. It may be noted that many active substances currently used in registered products in EPPO countries will no longer be authorized in the EU after 2003-07.

Phytophthora spp.

General

Phytophthora spp. cause the main diseases of citrus. The most important are *Phytophthora nicotiana* var. *parasitica* and *Phytophthora citrophthora*.

Foot rot and gummosis

The pathogens can survive saprophytically in the soil, as mycelium or chlamydospores on plant remains and decomposing matter, from several months to 1–2 years. Sexual reproductive organs are formed which, without being directly important for infection, favour survival and persistence in the soil. Growing plants are attacked on the main roots, root collar, base of the stem, and fruits. Complete development requires water for the production and maturation of sporangia and zoospores. Irrigation, or rain water arriving in the soil, initiates production of sporangia in a few hours. The zoospores move in the liquid to the surface of the plant organs. Infection takes place if the host tissues are appropriately receptive. It causes dehydration and necrosis of the cortical zone of the stem or root collar, leading very quickly to the appearance of symptoms of gummosis or collar rot. Irrigation by flooding (or rainfall above 40–50 L m^2) at intervals superior to 20–25 days creates an alternation between dry periods of several weeks (2–3) and high humidity levels in the soil for 3–4 days. This is dangerous in September and October when temperatures are very mild during the day and at night (14–22 °C), and favour the increase in the inoculum, provided that the soil is humid. If there are wounds or cracks at the base of the stems and trunks, zoospores settle in them and infection can readily occur. The disease should not be confused with 'dry root rot' of trifoliate orange (*Poncirus trifoliata*) and citrange (*Citroncirus webberi*). This disease presents symptoms of dry gummosis and does not seem to have a parasitic origin.

Brown rot

The most important disease caused by *P. citrophthora* and *P. nicotianae* var. *parasitica* is brown rot of citrus fruits. Damage is extremely serious, especially in rainy autumns. Under conditions favouring sporulation in the soil (see above), small quantities of soil and water containing sporangia and zoospores are carried by the wind, or splashed onto fruits. The pathogen can then establish on the fruit surface and infection begins. The incubation period ranges from 5–7 days at 12–14 °C to 3–5 days at 18–20 °C. The symptoms begin with a grey discoloration. Conditions favouring development of the disease are: temperature 20–28 °C, precipitation above 40 mm (100 mm during 2–3 days), fruits at the most susceptible stage (change of colour, in October–November). Fruits touching the soil are less affected by the disease because they are only in contact with the soil water and these conditions are not sufficiently aerobic for infection to develop.

Basic strategy

Foot rot and gummosis

Control is based on the following indirect measures: providing the best growing conditions for the plant; avoiding contact between plant and inoculum, especially contact of water; ensuring good vigour of the trees throughout the growing season; not using too much fertilizer (especially nitrate), in order to avoid salt accumulation in the soil; avoiding long dry periods followed by abundant irrigation; avoiding all type of traumatic or phytotoxic effects. In general, in young plantations, it is advisable to use tolerant rootstocks, to graft the cultivar at less than 30 cm height and avoid contact with water, to eliminate flooding by good drainage and avoid accumulation of water around the collar, roots and the base of the trunk, and to avoid wounds in the zone of the collar and the base of the trunk. In mature plantations, contact of water with the trunk should be avoided and roots should not be uncovered (e.g. by wheels). The soil should not be compacted and a ploughing 'sole' should not be allowed to form, so that good water drainage is assured.

All rootstocks are more or less susceptible. *Poncirus trifoliata*, Troyer citrange, Carrizo (a grapefruit–tangerine hybrid) and *Citrus aurantium* are relatively resistant; *Citrus sinensis*, *Citrus deliciosa*, *Citrus reshni* and *Citrus limon* are particularly susceptible. Vigour is the determining factor for the susceptibility or resistance of the plant. If vigour decreases or if the turgescence of the tissues increases, *Phytophthora* infection increases, especially if rain or irrigation causes temporary flooding. In this case, even resistant species may be affected.

Possibilities for biological control of *Phytophthora* spp. in the soil have been investigated, but have hardly been applied in practice. Mulching the soil with wood chips increases the populations of *Trichoderma* spp. and decreases that of *P. citrophthora* and *P. nicotianae* var. *parasitica*. The fungus *Myrothecium roridum*, a cosmopolitan fungus with a high cellulolytic activity, has also been proposed as an agent for control of *Phytophthora* spp.

Control of foot rot and gummosis is mainly by application of fungicides by specific well-defined techniques. Treatments aim at preventing the fixation and germination of zoospores in the basal part of the trunk and in a limited zone of the main roots, or at stopping the development of mycelium in the bark. There are two main application techniques. The first is direct application by spraying or painting the base of the trunk with a concentrated product (or hydrophobic tarred paint or mastic applied to the affected area). Satisfactory results are obtained with two or three applications per year. The second, more expensive method is the Fawcett technique: surgery to eliminate all infected bark, followed by treatment with tarred mastic. Dead and encrusted bark is scraped off and the wood gently scraped to eliminate possible gum infiltration. Adjacent healthy bark should also be removed over 1–2 cm to eliminate any spreading mycelium. The surface should then be disinfected with potassium permanganate and fungicide, and mastic should be applied once the surface is dry. A callus zone is produced shortly afterwards on the adjacent healthy zone.

Sprays or soil application of systemic fungicide can also be used. Fosetyl-Al gives the most rapid results for control of cankers. The number of treatments depends on the level of attack in field, but not more than three treatments should be applied when the tree is developing (coinciding with spring, summer and autumn growths). This treatment should not be applied on weakened trees because of their low foliar and root activity.

Brown rot

Preventive measures should be used in addition to fungicide treatments. They aim to prevent inoculum from reaching the fruits, e.g. leaving the soil covered with vegetation (such as *Oxalis* spp.) and lifting low branches as much as possible using supports. Fungicides may be applied preventively by spraying before the rainy period (October–November), ensuring the foliage up to 1.5 m above the soil is thoroughly wetted. Fruits of all citrus species are attacked by *Phytophthora* spp., with a higher incidence on orange than on mandarin. Special attention should be paid to trees with low branches. There are no possibilities for biocontrol at the moment.

Main fungicides

Foot rot and gummosis

Sprays: copper oxychloride, maneb, mancozeb, fosetyl-Al, metalaxyl-M.
Soil application: fosetyl-Al.

Brown rot

Sprays: copper oxychloride, mancozeb (preventive applications).
Fosetyl-Al (curative treatment not later than 48 h after the beginning of precipitation).

Phoma tracheiphila

General

Phoma tracheiphila is an A2 quarantine pest, absent from certain citrus-growing areas in the EPPO region (particularly the Iberian peninsula). It causes a vascular disease known as 'mal secco', meaning dry disease. It first manifests itself as a sudden wilting and drying of leaves and, later, a rapid dieback of twigs and branches. This often takes place first on one side or one section of the tree. Symptoms appear in spring. Growth of sprouts from the base of affected branches or stems, and development of suckers from the rootstock, are common responses of the host to infection. An internal symptom is a pink-salmon or orange-reddish discoloration of affected wood, seen on slanting cuts of recently infected twigs. If not controlled, the disease progressively kills the whole tree. The disease is highly destructive for lemon and other susceptible *Citrus* species. Some species and cultivars show different degrees of resistance.

Inoculum is usually provided by conidia extruded from pycnidia on withered twigs and suckers. They are spread by rain and wind, or accidentally by insects and birds. All injury to the plant facilitates infection. Temperatures above 30 °C stop mycelial growth but do not kill the fungus within infected host tissues.

Basic strategy

Careful pruning of withered shoots bearing pycnidia, timely removal of suckers, and burning pruned branches is recommended in order to reduce the amount of inoculum. Soil cultivation in late autumn or winter and prolonged non-tillage enhance the risk of root infection. The protection of orchards from wind and hail effectively reduces infections. Fungicides are not widely used, except in nurseries. Spraying of trees is recommended immediately after hail or frost damage. Systemic fungicides should be applied as either soil drenches or foliage treatments.

Main fungicides

Sprays: carbendazim, thiophanate-methyl.

Post-harvest diseases

The main post-harvest diseases affecting citrus fruits are those caused by *Penicillium* and *Aspergillus* spp., *Galactomyces citri-aurantii*, *Alternaria citri*, *Glomerella cingulata*, *Botryotinia fuckeliana* and *Botryosphaeria rhodina*. Brown rot caused by *Phytophthora* spp. is also very important, but is covered under *Phytophthora* spp. (see above).

Penicillium rot

General
Penicillium italicum (blue mould) and *Penicillium digitatum* (green mould) are the commonest agents of citrus fruit rot. All kind of citrus are affected. Symptoms appear as soft discoloured areas on affected fruits, on which a powdery mycelium develops on the rind surface, producing at the end a mass of blue (*P. italicum*) or olive-green (*P. digitatum*) spores. The sporulating rind surface is surrounded by a soft area. Tissues become initially soft, water-soaked, and finally rot. At high relative humidity, the rotted fruit becomes a dry mummy. In packed containers, fruits infected by *P. italicum* may contaminate healthy ones, producing nests of rotting fruits. Optimum growth temperature for both fungi is about 24 °C, but *P. italicum* also develops at temperatures below 10 °C. Both fungi overwinter in the orchard as conidia and contaminate fruits during the season. Airborne conidia cause infections through fruit injuries.

Basic strategy
Prevention is essential. Wounding of fruits should be avoided during handling and harvesting, infected fruits should be promptly eliminated and the surfaces of equipment should be disinfested. Cooling immediately after packing also helps to delay the onset of fruit rot. Fungicides should be applied after harvest during fruit washing (misted on top of the fruits, alone or in a water-based wax). *Penicillium* spp. can develop resistance to some fungicides.

Main fungicides
Post-harvest treatment: carbendazim, imazalil, thiabendazole, thiophanate-methyl.

Aspergillus rot

General
The disease is caused by several species of *Aspergillus*, of which the commonest is *Aspergillus niger.* Infections are caused by wind-borne spores that initially colonize the surface of the fruit and then penetrate through wounds at harvest. During storage, a single infected fruit may contaminate adjacent fruits. Fruits of any *Citrus* sp. may be affected if stored at high temperature. Light-coloured soft areas appear on the fruits and the fruit tissues then rot producing a powdery mass of spores. The fungus survives saprophytically.

Basic strategy
Fruits should be stored at temperatures below 15 °C. Fungicides may be applied after harvest during fruit washing (misted on top of the fruits alone, or in a water-based wax).

Main fungicides
Post-harvest treatment: carbendazim, imazalil, thiabendazole.

Galactomyces citri-aurantii

General
Sour rot is caused by *Galactomyces citri-aurantii* (anamorph *Geotrichum citri-aurantii*). Infections are caused by conidia spread by wind or raindrops from the soil onto the fruits. Fruits are infected through wounds. The rot affects all kinds of citrus and is frequently associated with *Penicillium* rot. Lesions first appear as light to dark yellow water-soaked areas As the rot progresses, rind and juice vesicles degrade, causing the fruit to disintegrate into a watery mass. Watery fruits may contaminate adjacent healthy ones, causing a nest of decay. Ripe fruits are more susceptible.

Basic strategy
Wounding of fruits should be avoided during handling and harvesting, fruits should not be allowed to touch the soil, infected fruits should be eliminated promptly, and containers, equipment surfaces and rooms should be disinfected with quaternary ammonium compounds, formaldehyde, alcohol or hot water. Cooling immediately after packing (at 10 °C) delays disease development. Fungicides should be applied after harvest. Guazatine is applied as a drench, whereas sodium *o*-phenylphenate is applied during fruit washing.

Main fungicides
Post-harvest treatment: guazatine, sodium *o*-phenylphenate.

Alternaria citri

General
Alternaria rot is caused by *Alternaria citri*. The pathogen lives saprophytically in the orchard and produces airborne conidia that cause latent infections in the button or stylar end of the fruit. In the orchard, infected fruits colour prematurely and develop a light brown to blackish discoloration of the rind at or near the stylar end. *A. citri* causes a stem-end rot on fruit stored for a long time. The disease is also a problem for the processing industry because of the bitter taste of infected fruits.

Basic strategy
Stylar-end infection cannot be controlled by spraying fungicide in the orchard. For fruits for processing, it is recommended to delay harvest until affected fruits drop to the ground. Harvesting at optimum maturity prevents stem-end rot. Some control may be obtained by the use of imazalil on harvested fruit.

Main fungicides
Post-harvest treatment: imazalil.

Glomerella cingulata

General
Glomerella cingulata (anamorph *Colletotrichum gloeosporioides*) appears only on over-ripe fruits, on fruits injured by other pests or by phytotoxic products, or on sunburned fruits. On wounded fruits, symptoms appear as brown to black spots initially firm and dry, becoming softer as the disease progresses. Under humid climatic conditions, pink to salmon spore masses develop on lesions. *Glomerella cingulata* persists on twigs and most infections are caused by conidia that develop on dead twigs and are spread by rain or overhead irrigation. Germinating conidia cause latent infections that develop when other environmental factors weaken the fruit tissues. Usually, ethylene-treated fruits are more susceptible to the disease.

Basic strategy
Prevention is essential. Dead wood should be removed from the orchard to reduce inoculum potential. Wounding of fruits should be avoided during handling and prolonged storage. Washing the fruits helps to remove latent inoculum on the rind surface. It is advisable to delay harvest until fruits are naturally coloured. Post-harvest treatments and storage at temperatures below 10 °C help to contain the disease.

Main fungicides
Post-harvest: thiabendazole.

Botryotinia fuckeliana

General
Botryotinia fuckeliana (anamorph *Botrytis cinerea*) causes a rot of lemon fruits in particular. Symptoms appear as firm brown areas on which, in humid conditions, grey to olive spore masses form (grey mould). In packed containers, infected fruits may contaminate the adjacent healthy ones leading to nests of rotting fruits. During the growing season, conidial inoculum forms on organic debris in the orchard and is spread by wind and raindrops to the flowers during flowering, leading to latent infection of the stem end of the fruit. The infection then manifests itself after harvest. Alternatively, the fungus may penetrate through wounds during handling and harvest.

Basic strategy
Fruits should not be stored in humid conditions. Post-harvest fungicide sprays against *Penicillium* spp. may also control grey mould. Fungicides applied during flowering are not effective.

Main fungicides
As for *Penicillium.*

Botryosphaeria rhodina

General
Botryosphaeria rhodina [anamorph *Lasiodiplodia theobromae* (syn. *Diplodia natalensis*)] causes diplodia stem-end rot. It affects all kind of citrus fruits growing in warm and humid areas. *B. rhodina* overwinters as perithecia and pycnidia on dead twigs in the orchard. The ascospores become airborne and may spread disease over long distances. Conidia are dispersed by rain splash and, on the button of young fruits, germinate to form latent infections in necrotic tissue on the button. The fungus does not normally invade the fruits until after harvest, when the button abscisses and provides a temporary natural opening for penetration. Symptoms appear after harvest, when the fungus becomes active at the stem end of the fruits and penetrates the rind and core. Decayed tissue is initially firm and later becomes wet and mushy.

Basic strategy
The occurrence of diplodia rot is affected by the age of the orchard, and by ethylene application for fruit degreening, especially at high temperature (over 21 °C) and relative humidity (> 90%). Cultural practices minimizing the presence of dead wood in the orchard and care during harvest help to reduce the rot. It is also advisable to delay harvest until fruits are naturally coloured, and to cool below 10 °C immediately after packing. Post-harvest applications of fungicides provide good control. Treatments may be applied before degreening by drenching pallets of harvested fruits.

Main fungicides
Post-harvest treatment: carbendazim, guazatine, imazalil, sodium *o*-phenylphenate, thiabendazole, thiophanate-methyl.

Spiroplasma citri

General

The bacterium *Spiroplasma citri* causes the serious disease of citrus known as 'stubborn', which can much reduce the quality and quantity of yield under hot dry conditions. Affected trees are more or less stunted. Leaves are shorter and broader, cupped, abnormally upright, sometimes mottled and chlorotic. Under very hot conditions, leaves on some shoots may have misshapen, blunted or heart-shaped yellow tips. Shoots may be abnormally bunched. Fruits may be stunted, lopsided or acorn-shaped. In Mediterranean countries, *S. citri* is mainly vectored by two cicadellids, *Circulifer tenellus* and *Neoaliturus haematoceps*.

Basic strategy

Production of healthy budwood is the only practical means of control, so production should be covered by a pathogen-free certification scheme. The fact that the pathogen is vector-transmitted makes the disease more difficult to control. Trees showing symptoms should be rogued and replaced. Insecticide treatments against the vectors are not effective, because *S. citri* can be transmitted very rapidly after arrival of infective vectors.

Citrus tristeza closterovirus (CTV)

General

CTV is the most destructive virus disease of citrus and has been recorded in many of the citrus-growing countries of the EPPO region. It causes the death of infected trees of most citrus cultivars grafted on the highly susceptible sour-orange rootstock (*C. aurantium*). CTV may also induce stem pitting, stunting, low yields and poor fruit quality in susceptible cultivars (mainly sweet orange in the EPPO region). The cultivars affected and the intensity of the symptoms depend on the virus strain. CTV is even transmitted from the scion cultivar grafted on a tolerant rootstock. The vectors are several aphid species, which transmit in a semi-persistent manner (*Toxoptera aurantii*, *Aphis gossypii*, *A. citricola*). The most effective vector *Toxoptera citricida* is not present in the EPPO region.

Many other viruses, viroids and virus-like diseases also affect citrus, but are mostly not vector-transmissible. Use of certified virus-free material for CTV control will also protect against the other pathogens.

Basic strategy

In areas where CTV is widespread, its effects can only be controlled by the use of tristeza-tolerant rootstocks. This has been widely used in some Mediterranean countries and depends on the presence of mild strains only. Severe strains from other parts of the world can produce symptoms even when citrus is grafted on tolerant rootstocks. Exclusion of these severe strains is thus a key element of tristeza control for the Mediterranean region. In principle, virus-free planting material should be used, but the operation should be managed on a sufficient scale to limit the possibilities of natural reinfection. In areas where CTV is only found sporadically, only certified virus-free planting material should be used. Regular monitoring and testing for CTV should be maintained, and any new outbreaks eradicated.

Mites

General

Several species of mites occur in citrus orchards in EPPO region. *Tetranychus urticae*, red spider mite, is a polyphagous species attacking a wide range of crops and causing serious damage on citrus, especially on clementines and lemons, by severe and sudden defoliation. In cold-winter regions, the pest overwinters on wild hosts or in the bark of the lower part of the trees. Where winters are mild, the pest remains active on the trees and forms new colonies. The life cycle is very short. One generation is completed in 10 days under optimal conditions (30 °C). Another tetranychid mite, *Tetranychus cinnabarinus* (carmine spider mite), mainly affects mandarin trees.

Panonychus citri, citrus red mite, is easily distinguished by a purplish-red body with long reddish bristles on numerous prominent tubercles. It feeds primarily on foliage, and only occasionally on fruits. Injury from leaf feeding can result in leaf loss under dry conditions, and terminal dieback occurs in heavy infestations. Fruits which are damaged before change of colour show a pink discoloration. If the attack occurs before the fruit has completed its development, it may lead to early fall or to smaller-sized fruits. If a serious attack coincides with warm dry winds, i.e. low humidity content of the plants, serious defoliation may occur. In many countries, two major peaks of population of the mite occur, in spring and in autumn.

Aceria sheldoni, citrus bud mite, is one of the main pests of lemon, which is its preferred host. It feeds and reproduces on citrus foliage and moves to buds and young fruit as they become available. The mite population builds up throughout the period of fruit development. The mites puncture rind cells and extract the cell contents. Cells damaged by repeated puncturing discolour, and the result is a russeting of the fruit surface. Severe attack can contribute to water loss from the fruit, reduction in fruit size and premature fruit drop. One generation is completed in 15 days in summer and 30 days in winter. The optimal conditions for development are relative humidity close to 100%.

Basic strategy

A control programme should be based on early mite detection through regular orchard inspection. For example, clementines and lemons are susceptible all year round and sampling should be done twice a month, whereas oranges are most susceptible at the time of change of colour (BBCH 81–89; August to October) and that is when sampling should be intensified. Sampling methods are developed for individual species and may differ by region. In general, the aim is to determine the average number of eggs and/or motile stages (adult female mites) per leaf or shoot or bud. The need to control mites is based on temperature and humidity conditions, population levels, tree vigour and time of the year. When populations reach a locally established control threshold, an acaricide spray should be applied, especially if the trees are stressed. However, infestations comprised predominantly of adults, particularly males, are in decline and do not require control. When mostly eggs are present (at the time of highest population level), products with ovicidal activity should preferably be used, or else the acaricide used should have sufficient residual activity to kill subsequently emerging larvae.

Mites are often suppressed to low densities by various species of predacious mites, insects and entomopathogens occurring naturally in healthy orchards under a GPP programme. For example, larvae and adults of the coccinellid *Stethorus punctillum* have been observed on colonies of *Tetranychus urticae*. *Euseius stipulatus* is a particularly efficient and widespread native predacious mite and, if acaricides are to be used, products with little activity against *E. stipulatus* should be preferred.

To minimize the risk of resistance, specific acaricides should not be applied more than once per season.

Main acaricides

Sprays: abamectin, amitraz, bromopropylate, clofentezine, dicofol, fenbutatin oxide, hexythiazox, petroleum oil, propargite, pyridaben, tetradifon.

Armoured scales

General

Due to their great reproductive capacity, survival ability, and the difficulty of insecticide control, armoured scale insects (*Diaspididae*) are highly destructive pests of citrus. Apart from the newly hatched larvae and the adults which are mobile, all other stages are sessile, feeding on shoots, leaves or fruits. Sap sucking results in direct damage in the form of defoliation. Indirect damage includes depreciation of fruits, due to reduced size, green spots on the mature fruit at places where the scales were fixed, remains of scales.

Lepidosaphes beckii (citrus purple scale) is a cosmopolitan armoured scale. The female cover is 2.5–3 mm long, convex, purple-brown or yellow-brown in colour. There are two to four overlapping generations a year, depending on the climatic conditions. *Parlatoria pergandii* (chaff scale) is widespread in the Mediterranean region. The female cover is translucent, brown to grey, flat, circular to oval. The scales form dense colonies, composed of several strata, on the bark of citrus trees. On leaves, scales are found on the surface, mainly along the main vein. On fruits, they are mainly situated around the calyx and in the zone of the style. This attack is generally important; a greenish blotch remains at the feeding point when the fruit matures. There are three generations per year, although the last is much less important than the others. The life cycle coincides closely with the life cycle of *L. beckii*. Another species, *Parlatoria zizyphi*, is also widespread in the Mediterranean region, mostly affecting mandarins. The female has a black cover about 1.5 mm long. It has three to four generation per year.

Aspidiotus nerii (oleander scale) is highly polyphagous and widespread throughout the world. The female cover is translucent, white, circular, convex. On lemon, the larvae which develop into females tend to move towards the inside of the calyx, and enter the scales of the bud, i.e. an area which is not accessible to insecticides. Future males remain on the surface of branches, leaves or fruits. The pest has three well-spaced generations per year. The first occurs from mid- to end of April, the second at the end of June/beginning of July, and the third at the end of September/beginning of October. In areas with mild winters, one more generation can occur in January/February. The pest causes an indirect effect on fruit quality (greenish blotches appearing at the change of colour or the presence of scales). Other *Aspidiotus* species also attack citrus fruits (*A. destructor*, *A. hederae*).

Basic strategy

All citrus species are susceptible to attack by *P. pergandii* and *L. beckii*. Indigenous predators and parasites have little or no effect. There are only a few polyphagous coccinellid predators (*Chilocorus bipustulatus* and *Exochomus quadripustulatus*), the ectoparasite *Aphytis hispanicus* and an endoparasite *Encarsia* (*Prospaltella*) *inquirenda*, which gives only partial control of *P. pergandii*. A parasitic wasp, *Aphytis lepidosaphes*, has been successfully introduced to control *L. beckii*. If treatments are necessary in orchards with introduced or naturally occurring populations of natural enemies, they should either be spot treatments, or else applied to every fourth or sixth row at a 4- to 6-week intervals during August and September. Insecticide sprays mainly target populations on the trunk and branches, which carry the initial foci of infestation and can infest or reinfest leaves and fruits. If the pests occurs in localized isolated patches, the affected wood can be painted with lime wash.

In the absence of natural enemies, insecticide sprays are often needed. To determine the time of application, samples are taken weekly throughout the year. Four 10- to 15-cm-long branches orientated at each compass point are selected on each tree, with the wood of the last two growth flushes carrying two leaves for each type of wood. The different forms should be noted, and a distinction should be made between dead and alive, and parasitized and non-parasitized. No tolerance threshold is fixed. However, if attacked fruits were observed during the last harvest, the presence of two sampling units carrying living forms is considered sufficient for action. Two treatments may be applied in accordance with the life cycle of the pest: the first at the end of May/beginning of June; a second at the beginning of September (60% developed females with larvae). Spraying at high pressure is needed to obtain good coverage. Another way to determine the period of application is to use the thermal integrals, expressed in degrees-days (°D): from the 1 January for *L. beckii*, the thermal integral is 1083 degree-days, with a zero of development at 7.6 °C. For *P. pergandii*, the thermal integral is 720 degree-days, with a development zero at 11 °C.

Lemon is the only species attacked by *A. nerii*. *Aphytis melinus* and *Aphytis chilensis* provide good control. In spring, insecticide sprays should be applied before the females go inside the calyx, shortly after fruit formation. This treatment coincides with the last treatment done against *Prays citri* at flowering, and the two pests can be controlled together. This treatment should be enough to ensure that fruits of the year are free from *A. nerii*. Treatment of the second generation should be avoided. If, however, scales are observed on fruits at the beginning of autumn, another treatment can be done before the females shelter in the buds.

Main insecticides

Sprays: azinphos-methyl, chlorpyrifos (also effective against *Prays citri*), malathion, methidathion, pirimiphos-methyl, quinalphos.

Aonidiella aurantii

General

Aonidiella aurantii (California red scale) is probably the most important pest of citrus throughout the world. The female cover is translucent, usually red-brown, circular (about 2 mm). Although it is not as widespread as *L. beckii*, *A. aurantii* causes more damage and is more difficult to control. It prefers sun-exposed parts of the tree. It is thus found mainly in young plantations or on the outside rows of adult plantations. It can be observed on all parts of the plant but prefers green areas and fruits. The population density is very asymmetrical, which should be taken into account when sampling. There are three or four generations per year. *A. aurantii* causes direct damage by injection of a toxic substance contained in the saliva into the leaf tissues, leading to yellow discoloration. This causes defoliation and drying of the leaf tips, and in severe cases branches die back, fruits fall prematurely and yield is reduced for one or several years. Fruits are particularly susceptible to attack. The insect causes distortion of the rind on young fruits. There is no distortion on mature fruits but the scale adheres strongly to the fruit which must be destroyed.

Basic strategy

All citrus species are susceptible. Parasitoids attacking *A. aurantii* include *Aphytis melinus*, *A. chrysomphali*, *A. lingnanensis* and *A. coheni*. *A. melinus* has the best potential for spread and mass-rearing is already practised in several countries. *A. chrysomphali* is more tolerant to cold and less to warmth than *A. melinus*. The two species are complementary. Although they are less efficient than the above parasitoids, the following predators can be mentioned: *Conwentzia prociformis*, *Chilocorus lipustrilatus*, *Pediculoides ventricosus* (a mite of minor importance). To determine the time of application, samples should be taken from 10 randomly selected trees per ha every 3 weeks. Twenty fruits are sampled per tree (five for each compass point) and four 20-cm-long, 2-year old shoots with leaves. One living female per 100 leaves in July/August causes 10% loss. If two or more are present, the harvest will not be economic. Treatments should be applied when the maximum number of susceptible forms are present (80% of females with larvae), during both first and second peaks. These coincide with treatments against *L. beckii* and *P. pergandei*.

Main insecticides

Sprays: chlorpyrifos, methidathion, pirimiphos-methyl, mineral oil only at the second peak.

Unaspis yanonensis

General

The female cover of *Unaspis yanonensis* (Japanese citrus fruit scale) is brown-black, margin lighter, oystershell shaped, slightly convex. It feeds on bark, leaves and fruit of citrus. On leaves, it produces chlorotic areas at feeding points and can cause premature leaf drop. In the Mediterranean region, it has two generations a year.

Basic strategy

For treatment against overwintering *U. yanonensis*, mineral oils can be used. Two treatments may be applied in summer, after population monitoring (because density can vary greatly within a region). Biological control is still under study. One coccinellid, *Chilocorus kuwanae*, and two hymenopteran parasitoids, *Aphytis yanonensis* and *Coccobius fulvus*, have been introduced without great success so far.

Main insecticides

Sprays: methidathion, mineral oils

Saissetia oleae

General

Among soft scales (*Coccidae*), the black scale *Saissetia oleae* is the most damaging, while the citrus brown soft scale *Coccus hesperidum* only causes occasional problems. Direct damage is caused by feeding which restricts the flow of assimilates to the fruits. The scales also secrete honeydew, on which sooty mould develops, reducing the vigour of the tree, causing defoliation, and suppressing flowering and fruiting on affected trees. *S. oleae* overwinters as larvae. Under Mediterranean conditions, there are two generations per year but this varies with climatic conditions.

Basic strategy

Saissetia oleae can be successfully controlled over February and March, when the most susceptible stage, the overwintering larva, is dominant. Adult females are more resistant and eggs, which are protected by the body and abundant wax secretion covering the whole cuticle of the female, are nearly inaccessible. An early insecticide treatment presents the following advantages: minor incidence on natural enemies, no residue problems, use of IGRs, no proliferation of mites. At other periods, treatments are less efficient due to the simultaneous presence of all development stages (susceptible and resistant). To determine the time of application, samples of leaves and portions of branches between two internodes are taken. For adult stages, sampling is done on the last three growth flushes. For larval stages, this is done on the last growth flush. Three shoots are chosen, orientated at each compass point and the larvae fixed on the wood and leaves between randomly chosen internodes of the last completely formed growth are counted. Sampling is done weekly throughout the year for females and in February/March and mid-July/August for larvae. If the locally established thresholds (e.g. one female or three larvae per sampling unit) are exceeded, insecticides sprays are applied.

The most important parasitoids of *S. oleae* are: *Metaphycus lounsburyi*, *M. flavus*, *Coccophagus scutellaria*, *Diversinervus elegancei* and *Scutellista cyania*. *M. lounsburyi* is the most effective.

Main insecticides

Sprays: azinphos-methyl, fenoxycarb, methidathion, phosmet.

Pseudococcus citri

General

Pseudococcus citri, citrus mealybug, is a cosmopolitan polyphagous species which damages fresh fruits by blemishing the rind. It also causes direct feeding damage, leading to fall of flower buds and recently formed fruits. It produces abundant honeydew, leading to production of cotton-like masses in which microlepidoptera (*Apomyelois ceratoniae*, *Cryptoblabes gnidiella*) lay their eggs. The number of generations can reach five per year, but this varies according to climatic conditions. The overwintering stages emerge from their shelters at the beginning of April. The larvae establish on soft tissues, and can enter below the calyx of the fruit. Others gather at the point of contact of two fruits, or fruit and leaves, where they form cotton-like masses of honeydew and sooty mould.

Basic strategy

It is particularly important to localize foci early in cracks and cavities in the bark of the trunk and main branches, as well as in fruits which remained on the tree after harvest. Oranges of the Navel and Valencia-Late group are the most susceptible. The control strategy is biological, using appropriate entomophagous species. Biocontrol is implemented early, when the first foci appear at the end of April/beginning of May, using *Leptomastix dactylopii* (a parasitoid of older larvae and young females) and *Cryptolaemus montrouzieri* (predators whose larvae feed on the eggs of *P. citri* while the adults feed on females). If third-stage larvae and young females are abundant, 10–20 adults of *L. dactylopii* are released per tree. If females with egg masses are abundant, 3–10 adults are released per tree. If control is done later, the numbers of the natural enemies should be increased.

Insecticide sprays should be used if biocontrol fails. To determine the time of application, 20% of trees in the orchard should be sampled, with 10 fruits randomly taken from the perimeter of the tree. This should be done weekly from BBCH 73 (nut-sized fruits) until harvest. The threshold is 5–10% of fruits attacked at the stage of change of colour (BBCH 81) and 15% after that stage. Sprays should be applied manually at high pressure to break up the cotton-like masses so that the product can reach the insects.

Main insecticides

Sprays: buprofezin, chlorpyrifos, chlorpyrifos-methyl, diazinon.

Icerya purchasi

General

Icerya purchasi (cottony cushion scale) can reproduce without mating and males are rare. Females are quite large (*c*. 3.5 mm) and easily distinguished by the white, fluted cottony egg sac that they secrete. There are three generations per year: the first from February to June, the second from June to August and the third from August to October/November. *Icerya purchasi* extracts plant sap from leaves, twigs, and branches, thus reducing tree vigour. If infestations are heavy, leaf and fruit drop can occur along with twig dieback. The scale secretes honeydew, which promotes the growth of sooty mould.

Basic strategy

Control by the coccinellid *Rodolia cardinalis* is sufficient except in extreme cases. If the natural balance breaks down, the natural enemy should be released again. All insecticide treatments against this pest should be avoided, since they aggravate the problem and delay the solution.

Aphids

General

The main species of aphids present in citrus orchards are: *Aphis spiraecola*, *Toxoptera aurantii*, *Myzus persicae*, *Aphis gossypii*. Less important are: *Aphis craccivora*, *Aphis fabae*, *Aulacorthum solani*, *Brachycaudus helichrysi*, *Macrosiphum euphorbiae*. *Aphis citricola* has lost importance as the occurrence of *A. gossypii* has increased. Repeated failures in the insecticide control of *A. gossypii* and its role as a vector of CTV have increased the importance of controlling this pest. *T. aurantii* is frequently observed on lemon and is mainly abundant in spring and autumn. *Myzus persicae* is less frequent, but is very important on clementine. *Toxoptera citricida* (the most important vector of CTV) has not been reported on European citrus. Aphids cause direct feeding damage. The plants are weakened, and leaves and shoots are distorted and curled (this can be very important on young trees and rootstocks). They also produce honeydew on which sooty moulds develop, and transmit viruses and viroids.

Basic strategy

All species are susceptible, but mainly clementines, Navel oranges, young trees and rootstocks. Natural biological control has not been successful. Sampling to determine the timing of insecticide sprays should be done every 2 weeks (except in critical periods when it should be done weekly) during the spring and autumn flushes, from phenological stage BBCH 51 (inflorescence buds swelling) to BBCH 67 (petal fall), and from the beginning to the end of the autumn flush. In all cases, the dominant species should be determined. There are three sampling methods:

- counting all young buds in a 28-cm-diameter circle and recording attacked and non-attacked buds;
- selecting 10% of the trees in the plot and examining a 0.25 m^2 on each tree, recording attacked and non-attacked buds;
- marking two branches (orientated towards the south and west) and counting all shoots existing at that moment, then counting at each further assessment the number of shoots attacked.

Typical thresholds are as follows: 10% for *M. persicae*, *A. gossypii* and *T. aurantii* on clementine, or on young trees and rootstocks of any citrus (5% for *A. citricola*); 20% for *A. gossypii* and *T. aurantii* on any other citrus at the adult stage (10% for *A. citricola* and *M. persicae*). Treatments should be applied when the tolerance threshold is reached, by spraying or misting with the quantity of liquid appropriate to the volume of the plant cover, taking into account whether the product is systemic or not.

Main insecticides

Sprays: carbosulfan, dimethoate, lambda-cyhalothrin, oxydemeton-methyl, pirimicarb, tau-fluvalinate.

Whiteflies

General

The following species of whiteflies are present on citrus in the Mediterranean region: *Bemisia citricola*, *Dialeurodes citri*, *Aleurothixus floccosus*, *Parabemisia myricae*, *Paraleyrodes minea* and *Aleurodicus dispersus*. The last three are only reported from time to time. Others, such as *B. citricola*, may be occasionally damaging. *Parabemisia myricae* is a polyphagous species recently introduced into the Mediterranean region. It still has a limited distribution and it is on the quarantine lists of certain countries. Adults are dusty-grey or lavender in colour, around 1.2 mm long (smaller than *A. floccosus* or *D. citri*).

Larvae and, to a lesser extent, adults cause direct feeding damage. They also block stomata with the large quantities of honeydew produced by the larvae. Sooty moulds develop on the honeydew, which impairs photosynthesis. This may lead to defoliation, weakening of the trees or interruption of growth, decreased number and size of fruits, spots on fruits and depreciation of their commercial quality. Other consequences are: diminution of the efficacy of plant protection products, proliferation of other pests living protected under the cover of deposits or of secretion (*Lepidosaphes beckii*, *Aonidiella aurantii*, *Pseudococcus citri*, mites), difficulties at harvest.

Basic strategy

All types of citrus are susceptible. Yellow sticky traps are useful to monitor population levels and to indicate the need for control measures. Biological control is possible with *Eretmocerus* sp. nr *californicus*, an introduced hymenopteran species. The hymenopteran parasitoid *Cales noacki* gives the best control of *A. floccosus*. Biological control can also be achieved with *Encarsia lahorensis*. The coccinellid egg predator *Clitostethus arcuatus* has been found eating *D. citri* eggs and, if egg numbers are moderate, provides some population suppression. Use of the coccinellid *Serangium parcesetosum* is also known.

If biological control is not used, sampling methods are recommended, to determine when to apply insecticide sprays: 10% of the trees in an orchard should be sampled by taking 5–10 randomly selected leaves from the last flush. Larvae of second instar and older are counted weekly. The suggested treatment application threshold is 5–10 second instar or older larvae per leaf on clementine, or 20–30 second instar or older larvae per leaf on lemon. Special attention should be paid to the quality of insecticide treatment. Insects are well protected with wax and on the underside of leaves. Trees can be sprayed with mineral oils in February or March against larvae. Later in the spring, other insecticides can be used. The infestation can be also suppressed during August when spraying against leafminers (*Phyllocnistis citrella*). Generally, fertilization and irrigation favour these pests, while pruning discourages them. Another technique which might supplement insecticide control is elimination of infested lateral shoots.

Main insecticides

Sprays: buprofezin: effective against eggs and first larval stages (up to L2), imidacloprid, lufenuron, mineral oils, tau-fluvalinate.

Thrips

General

In the Mediterranean region, the most frequently found thrips is *Heliothrips haemorrhoidalis*. Other thrips species present are: *Thrips tabaci*, *Thrips major*, *Thrips urticae*, *Thrips alni* and *Taeniothrips meridionalis*. They all feed on citrus flowers, leaves and fruits, leaving little silvery puncture marks. They are, however, only of secondary importance among the arthropod pests of citrus, as infestations are rather rare. They can sometimes be heavy enough to cause damage to fruit production and to require specific control measures.

Basic strategy

Treatments against scales in winter and/or summer normally control thrips. During spring and autumn, sampling is recommended to determine whether to apply insecticide sprays (four shoots per tree and 20 fruits per tree on 10% of the orchard). For example, the presence of 2–3% of infested fruits and 5–10% of leaves is considered to be the economic threshold. If sprays are used they should be overall, and directed also at the underside of the leaves. To monitor populations, yellow or blue sticky traps can be used.

Main insecticides

Sprays: dimethoate, malathion.

Ceratitis capitata

General

*Ceratitis capitata (*Mediterranean fruit fly) is the only tephritid attacking citrus in Europe. The fruit fly oviposits in developing fruits, and hatching larvae burrow within the fruits to feed. The larvae in fruits cause direct damage resulting in local decay and premature fruit drop. Fungi and bacteria may enter the fruits through the injuries. Even greater concern is the presence of larvae in harvested fruits, because of the threat of introduction into countries for which it is a quarantine pest. This makes phytosanitary treatments compulsory, with an increase of 40–100% in production costs. The number of generations varies (normally three or four generations, up to seven or eight in regions where winter temperatures remain above 0 °C).

Basic strategy

All species are susceptible except lemon. No consistent biological control exists. The pest population should be evaluated by building the curve of adult flight using traps of different types: McPhail – glass trap with attractive food; Nadel or Steiner – plastic trap with sexual pheromones, usually from males; Jackson – cardboard trap with male sexual pheromones or angelic oil (males and females); colour trap – yellow plates with or without sexual pheromones. A 4% solution of ammonium phosphate is preferred to other food attractants such as 5% pear juice or 1/3 diluted white wine vinegar. The trapping stations can consist of two glass traps and one plastic trap (or 3 + 2), hanging on the branches of trees at approximately 1.5 m high, and orientated so as to be protected from the sun. Two trapping stations should be placed per ha. Observations should be performed at least weekly, from the 1 March until harvest for late cultivars, and from mid-August until December for others. Treatments should be applied when the tolerance threshold is reached, that is one fly per trap per day, 21 flies per trapping station per week, when fruits have reached their definitive size at about the change of colour (BBCH 81).

Treatment should be applied with large droplets, using ground or aerial application. On small isolated areas, ground treatment is appropriate. Targeted sprays should be applied to the southern side of trees, on areas of about 1 m^2, at 1 m height, using products with a hydrolysed protein bait (volume about 0.5 L per tree). Bait sprays applied at low level in this way have less negative impact on the environment than aerial applications. On large areas, aerial treatment is appropriate. Applications are made with large droplets, in bands normally separated by 50 m, with a volume of 20–25 L/ha.

An alternative sampling methodology has been proposed by an EU expert group. White traps coated with glue mixed with trimedlure are placed 10 per ha, with a weekly count of captured adults. Thresholds are: 10 adults per trap-week in spring on late-ripening cultivars; 40–50 adults per trap-week in autumn on oranges (preripe and ripe); 20 adults per trap-week in autumn on clementines approaching ripeness.

A mass-trapping method may also be used: traps baited with behaviour-modifying chemicals are used, e.g. trimedlure-baited Nadel or sticky traps (attractive only to males), McPhail traps baited with biammonium phosphate, transparent Plexiglas sticky traps baited with trimedlure dispensers and protein hydrolysate, wood traps soaked in deltamethrin and baited with trimedlure dispensers and protein hydrolysate.

The sterile-male technique used in other continents (release of males sterilized by irradiation) is eradicative in purpose. It has been tried in Mediterranean countries, but has failed because populations of *C. capitata* survive on wild hosts. The method is not cost-effective for simple suppressive control.

Main insecticides

Sprays: deltamethrin, fenthion, malathion.

Cacoecimorpha pronubana

General

Cacoecimorpha pronubana (Mediterranean carnation leafroller), indigenous to the Mediterranean region, is a polyphagous lepidopteran pest which also attacks citrus. Terminal and axial leaves and buds are enclosed in silk and eaten, becoming typically crooked. Young stems may be mined. On fruits, there are two types of damage. In April to July, the larvae penetrate the young developing fruits, feeding superficially on the skin at the peduncle base. The larvae then move up the fruit and continue to consume the skin while protected by leaves which they have spun together with silk. The damaged fruit surface quickly suberizes, but the fruit loses its marketability. The second type of damage is on the ripe fruit, attacked in October to November; the calyx end is not usually affected, and damaged areas do not suberize, so favouring the development of rots. *Cacoecimorpha pronubana* has three or four generations per year. Humidity is an important factor. Larvae can develop at very low humidity but, above 90% relative humidity, larval and pupal mortality is increased.

Basic strategy

The use of sex pheromone traps is recommended to determine flight periods. Insecticide sprays may be applied 10–11 days after maximum flight.

Main insecticides

Sprays: azinphos-methyl, *Bacillus thuringiensis*, chlorpyrifos, deltamethrin, phosmet.

Prays citri (citrus flower moth)

General

Prays citri is a major pest of lemon. Under certain conditions, it may also cause damage on clementine De Nules, possibly because of the characteristics of its flowering (irregular and extended over a long period). It usually appears at the same period as *Aspidiotus nerii*. There are three or four generations a year. Damage arises from drying out of recently formed flowers and fruits, gum exudation on fruits (loss of quality), galleries in green shoots which eventually dry.

Basic strategy

Lemon and clementine are susceptible if the flight of adults coincides with flowering. The incidence of natural enemies is low and there is no possibility of biological control. The occurrence and development of the pest can be followed using pheromone traps. To determine the time of insecticide sprays, 10% of trees in the orchard are sampled with three buds at each compass point (12 per tree) or 50 random flowers per tree, at weekly intervals. The threshold is, for example, 7% of buds damaged or 15% of flowers infested.

Main insecticides

Sprays: azinphos-methyl, chlorpyrifos, deltamethrin, diazinon, esfenvalerate, lambda-cyhalothrin.

Phyllocnistis citrella

General

Phyllocnistis citrella, the most important citrus leafminer in many areas of the world, has recently been introduced into most Mediterranean citrus-growing countries. The adults are tiny moths (wing span 6 mm). The larvae are only 3 mm long and feed on the epidermal tissue of leaves. They tend to occur in synchrony with periods of increasing temperature and active flushing. Most damage is done to young plants and to the second flush of shoots. In combination with water stress, citrus leafminer injury can result in severe defoliation. *Phyllocnistis citrella* has three generations a year.

Basic strategy

As *P. citrella* is a fairly new pest of Mediterranean citrus orchards, programmes for its management are still under investigation. At the moment, insect growth regulators are recommended against larvae. Treatments should be applied at the beginning of the attack (end of July, throughout August), when new shoots are less than 10 cm long and new flush leaves are less than 1 cm. Other insecticides can be used against larvae and adults and they should be applied at dusk when flight activity is at its peak. There may be possibilities for control by natural enemies.

Main insecticides

Sprays: abamectin, acetamiprid, azadirachtin, diazinon, esfenvalerate, imidacloprid, lufenuron, tebufenozide, teflubenzuron.

Ectomyelois ceratoniae and *Cryptoblabes gnidiella*

General

These moths cause severe damage in orange cvs Navel and Navelina, causing premature fall of fruits which seem to have matured too early. The fruits which remain on the tree colour on the lowest part but remain green elsewhere. There are two or three generations. The first occurs at the end of July. Each cycle lasts more than one month. These pests are associated with the occurrence of *Pseudococcus citri*. *Cryptoblabes gnidiella* is known to be attracted to the honeydew of coccids.

Basic strategy

Control is mainly indirect, through the control of *Pseudococcus citri*, before July. Sampling to determine the timing of insecticide sprays is done weekly from BBCH growth stage 73 (nut-sized fruits) until harvest, by examining four branches on each tree and five fruits per branch. The application threshold is e.g. 5–10% of fruits attacked at BBCH 81 and 15% afterwards. If the threshold is exceeded, a treatment around the first week of August is normally sufficient to obtain satisfactory control. Application is done by overall spraying at high pressure (wetting the trees until dripping).

Main insecticides

Sprays: diazinon, phosmet, trichlorfon.

Calocoris trivialis

General

This mirid bug is an occasional pest which mainly attacks orange cv. Navel and the clementine group, near non-cultivated areas or mountain slopes. It shows a preference for the stage green flower buds (BBCH 55) and white flower bud (BBCH 56). It sucks the shoots which show a droplet of blackening liquid, and cuts the flower buds. Symptoms are similar to those of frost damage.

Basic strategy

This pest may require control on all types of citrus. There are no natural enemies. Sampling prior to insecticide sprays is done weekly from BBCH 53 (first growth of flower buds) to 60 (first flower). Five buds are selected at each compass point on each tree, and the number of buds showing symptoms is recorded. Young trees should be treated when the first buds are attacked; no tolerance threshold is needed for adult trees. The treatment should be applied at BBCH 55.

Main insecticide

Sprays: malathion.

Snails and slugs

General

Attacks by snails (*Theba pisana*, *Helix aspersa*) and slugs (*Agriolimax agrestis*, *Arion hortensis*) are occasional. They mainly attack citrus at night and early morning when it is damp. All are highly polyphagous. They feed on leaves, fruits and near flower buds. Lesions on leaves are characteristic: more or less circular holes in the centre or at the border of the blade. Fruits with sweet rinds are preferred to others, as well as those which are on the soil. Attacks begin after rainy periods.

Basic strategy

These pests can cause severe problems in citrus orchards where no-till weed control and sprinkler and drip irrigation create an ideal environment for snail development. Barrier trunk treatments can be made with a band of copper foil wrapped around the trunk, which repel snails for several years; with an annual application of a Bordeaux slurry that is painted around the trunk; or with an application of a sticky material that contains tribasic copper sulphate. Baits should be put out after rainfall, from spring to autumn.

Main molluscicides

Baits: metaldehyde, methiocarb.

Tylenchulus semipenetrans

General

Tylenchulus semipenetrans (citrus nematode) is a semi-endoparasite that creates feeding cells (nurse cells) in the cortex of fibrous roots. Damage caused by a *T. semipenetrans* infestation depends on the age and vigour of the tree, density of the nematode population, and susceptibility of the rootstock. Mature trees can tolerate a considerable number of these nematodes before showing lack of vigour and decline symptoms. In heavily infested sites, young trees may be stunted or fruit production may be reduced on bearing trees that have susceptible rootstocks. Below-ground symptoms of *T. semipenetrans* infestation include poor growth of feeder roots and soil adhering to roots giving them a dirty appearance. The damage is greater when trees are predisposed by other factors such as *Phytophthora* root rot and water stress. *Tylenchulus semipenetrans* is disseminated primarily on infected planting material and secondarily by water and tillage.

Basic strategy

Tylenchulus semipenetrans has a tendency to remain localized, providing an opportunity to minimize the extent of its infestations through good sanitation practices. Certified nematode-free material for planting should be used. Using a resistant rootstock is recommended whether or not nematodes are present. Trifoliate orange is known to be tolerant to *T. semipenetrans*. Rotation with annual crops for 1–3 years before replanting citrus helps to reduce *T. semipenetrans* populations.

Weeds

General

Weeds affecting citrus can be separated into two groups: winter growing and summer growing, each being subdivided into annual and perennial plants. The degree of competition from weeds in citrus orchards depends on the weeds concerned and the period of the year. During winter, in the Mediterranean area, the prevalent weeds do not significantly compete with the citrus trees and can bring benefits to the plantation (*Oxalis*, *Poa*). In spring and summer, however, the suffocating effect of weeds is well known and ploughing or herbicides should be used. The main need for herbicide use in citrus arises from summer-growing monocotyledonous perennial weeds, such as *Cynodon dactylon*, *Cyperus rotundus*, *Sorghum halepense*, *Imperata cylindrica*, *Paspalum* spp. and *Piptatherum multiflorum*. The first four are considered at a global level among the 10 worst weeds. The last two are carried by irrigation canals or streams into orchards where persistent herbicides have been used (mainly triazines). They develop if no supplementary treatments are applied. Among dicotyledonous weeds, the most frequent which is not eliminated by ploughing is *Convolvulus arvensis*, which has a deep root system up to 1 m. Its tolerance to the persistent herbicides generally used in citrus is well known. However, it can be successfully controlled by the use of complementary treatments.

Basic strategy

Weed management programmes vary with location and individual orchard sites, depending on the climatic conditions, soil type, weed species, tree age, rooting depth, and planting system. Mowing, cultivation, and application of herbicides in tree rows are common methods used in citrus orchards. Cultivation kills annual weeds efficiently, but rarely achieves control of most perennials. On the contrary, it spreads and invigorates them, and can also damage citrus surface roots. Herbicide treatment, including use of low application rates, post-emergence herbicide spray applications, and herbicide wiping, is used in combination with mechanical mowing. Supplementary weed control is possible. It includes the injection of herbicides into low-volume irrigation systems (herbigation) and localized spot spray treatments (applied by battery-powered sprayers on all terrain vehicles) for weeds escaping the regular treatment.

In general, in the first years after planting, one or two applications are made against annual weeds of summer and winter, with localized specific treatments against summer perennial weeds. Once the system is established, application is limited to localized treatments with systemic or contact herbicides.

Main herbicides

On the whole area: first years without cultivation
Two treatments a year (spring and autumn) or one larger dose: diuron (preferably in autumn), simazine (preferably in spring). These products should not be used on watered or irrigated soils on young plants (less than 4 years old). They should be incorporated with irrigation at most 7 days after treatment. The herbicide should be applied on the soil. A wetting agent should be added in the case of emerging weeds, and a contact product mixed if adult weeds are present.
One annual treatment: terbuthylazine. Atrazine may be added in winter. To allow for resistant grass weeds, treatments should be applied at maturity or with watering 10 days after application. These herbicides should not be used in watered soil or soils with less than 1% organic matter, twice in the same year, nor on plants less than 4 years old. The herbicide should be applied on the soil. Alternatively, diuron may be used, with watering as soon as treated.
Variable number of treatments per year: paraquat may be applied between the rows in 4-year-old citrus, or on all the soil before 4 years old. A wetting agent should be added. Several treatments per year are necessary (at least five). ULV equipment should not be used. Alternatively, glyphosate is suitable for ULV-CDA equipment. The weeds should be well developed and without water deficit. Treatments should not be applied if rainfall is expected shortly. Glyphosate can be mixed with simazine around the rainy season, when vegetation is short and weeds cover the whole ground.

After several years without cultivation
The annual weeds are first controlled, then directional application of glyphosate is used on perennial weeds, as follows:
Convolvulus arvensis: oxadiazon, 2,4-D, MCPA, glyphosate, glufosinate;
Cyperus rotundus: MCPA, glyphosate, glufosinate;
Cynodon dactylon: amitrole, glyphosate;
Sorghum halepense: glyphosate, glufosinate;
Imperata cylindrica: glyphosate, glufosinate;
Paspalum dilatatum: glyphosate, glufosinate;
Allium spp.: amitrole, glyphosate, glufosinate.

Plant growth regulators

A few plant growth regulators are available for use on citrus and are used to a limited extent. Main potential uses include: for fruit set, gibberellic acid (applied during full flowering); for fruit quality, ethephon; for peel firmness and colour, gibberellic acid (applied prior to harvest).

Erratum

Bulletin OEPP/EPPO Bulletin **34** (2004), 43-56.

At its last meeting in May 2006, the Working Party on Plant Protection Products decided that in EPPO Standard PP 2/27 (1) *Citrus*, the last paragraph of the section Basic Strategy for the citrus pest *Ceratitis capitata* needs to be aligned with current developments regarding the use of the sterile insect technique in citrus.

The corrected text is printed below.

Reference

OEPP/EPPO (2004) PP 2/27 (1) Citrus. *Bulletin OEPP/EPPO Bulletin* **34**, 43-56.

The sterile-male technique (release of males sterilized by irradiation) is used on other continents for both eradication and suppression. In the Mediterranean region economic and ecological factors favour suppression. The method can be cost-effective for suppression in areas of concentrated citrus production. The sterile-male technique is currently used extensively on citrus in Spain and Israel.