◆ EPPO Standards ◆

GUIDELINES ON GOOD PLANT PROTECTION PRACTICE

ORNAMENTAL PLANTS UNDER PROTECTED CULTIVATION

PP 2/13(1) English

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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 2/13(1) English

Guidelines on good plant protection practice

ORNAMENTAL PLANTS UNDER PROTECTED CULTIVATION

Specific scope

This standard describes good plant protection practice for ornamental plants under protected cultivation.

Specific approval and amendment

First approved in September 1998.

This guideline on GPP for ornamental plants under protected cultivation 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 cut-flower and potted-plant crops under protected conditions, such as rose, chrysanthemum, bouvardia, freesia, cyclamen, begonia, etc.

In general, the crop should be grown under good cultural conditions. This is of particular importance since most of these protected crops are capital and labour-intensive. With the given intensive cultivation methods, crop rotation is not possible or is of limited value for disease control. Healthy planting material, use of seed treatments where possible and cultivation in disease-free soil or growing medium are extremely important. The same applies to disease-free water, particularly when using recirculating water in combination with an artificial growing medium. Rock wool and other matting should be re-used only after steam sterilization, and tools and machinery should be cleaned after use. Damage to plants should be avoided.

Netting of windows and ventilation openings is useful in preventing the entry of insects such as aphids, moths, adult leaf miners and whiteflies, but screen apertures need to be very small for thrips and other minute insects.

Cultivars resistant or less sensitive to diseases such as mildews and rusts should be used whenever possible. It is GPP to use seed treatments and dipping of seedlings against pests of young plants, especially if such treatments result in fewer spray applications.

Pests should be monitored at regular intervals. A spray programme of plant protection products can be established and is GPP if the pests to be chemically controlled are indeed present or to be expected. Dosages should satisfy the requirements on the label, taking account of the individual effects and possible interactions. Combining plant protection products or alternating them can help to avoid the development of resistance. In the case of ornamental plants grown for export, many importing countries do not allow any symptoms of diseases or insect attack. Chemical control, including prophylactic treatments, is therefore often inevitable, despite all precautions taken.

Avoiding the possible phytotoxicity of plant protection products is particularly important for ornamental plants. Although phytotoxicity is considered during registration, cultivars may vary considerably in sensitivity and, because of the high number of cultivars, only a few representative cultivars will have been checked. For other cultivars, it is GPP to check if there is any uncertainty concerning this point. It is also recommended to choose plant protection products that do not leave spray deposits on the plants.

It is GPP to use well maintained equipment. Application is done mainly as a spray, e.g. with power sprayers, or as a space treatment, e.g. with Low-Volume Mist (LVM), swing fogs, or pulse fogs. Application through trickle irrigation is also GPP. Applying plant protection products by means of overhead sprinklers or by dusting may cause unreliable effectiveness because of uneven deposition. Soil sterilization can, if necessary, be used to control weeds or other pests before planting. However, it is not considered GPP to use soil sterilants systematically to eliminate soil pests; such treatments should be limited to what is strictly necessary.

In glasshouses it is particularly important to respect safety regulations for workers applying plant protection products, re-entering after spraying, and handling sprayed plants. When applying chemicals, especially for space treatments, windows and doors should be thoroughly closed to avoid emission into the environment.

Biological control as part of an IPM (Integrated Pest Management) programme is becoming common practice in the production of ornamental plants. If biological agents are used and the use of plant protection products is necessary, the side-effects of plant protection products on the biological agents should be taken into account for the choice and the moment of application of the plant protection product (see for example, the tables published by Plantenziektenkundige Dienst in 1998 (*Bulletin OEPP/EPPO Bulletin* **28**, 423-429). If plant protection

products with harmful effects on natural enemies have nevertheless to be used, spraying only part of a crop can be an option to avoid a total failure of the biological control system.

The principal pests of ornamental plants under protected cultivation considered are the following:

- seedling diseases;
- *Botrytis cinerea* (grey mould);
- powdery mildews;
- *Sclerotinia sclerotiorum*;
- downy mildews;
- rusts;
- wilting;
- bacterial diseases;
- viruses;
- aphids;
- *Tortricidae* (leafrollers);
- caterpillars;
- *Otiorhynchus* spp.;
- *Spodoptera exigua;*
- leaf miners;
- scale insects and mealybugs;
- *Sciaridae*;
- thrips;
- whiteflies;
- mites;
- slugs;
- leaf nematodes;
- *Meloidogyne* spp.;
- weeds.

In addition, information is given on GPP in the use of 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.

Seedling diseases

General

Seedlings, cuttings or transplanted material of ornamental plants rot near the soil surface and die. Such damping off or collar rot is caused by a variety of soil fungi, especially *Pythium* spp., *Phytophthora* spp., *Thanatephorus cucumeris* (anamorph *Rhizoctonia solani*), *Fusarium* spp., *Botryotinia fuckeliana* (anamorph *Botrytis cinerea*).

Basic strategy

Hygiene is of utmost importance. Since the fungi concerned are soil-borne, it is important to use disease-free soil, substrates, pots, etc. This is preferably done by using new or steam-sterilized material, but cleaning and sterilization of pots, glass, etc., is also possible with chemical disinfectants, such as copper sulphate, quaternary ammonium compounds, formaldehyde and sodium hypochlorite. Moist conditions often favour these fungi and should be avoided. In systems where recirculating water is used, the diseases can spread rapidly. For these systems, the water should therefore be disinfected. This can be done by heating, with sand filters or by UV radiation. Fungicides can be used, by application to soil in pots or by spray. They are generally used preventively, in cases where the risk is considered to be high. Seed treatment against these fungi is also GPP. Cultivars have different degrees of resistance towards these diseases.

Main fungicides

Against all the fungi concerned: etridiazole, furalaxyl, propamocarb (by pot soil treatment); etridiazole, fosetyl-Al, furalaxyl, propamocarb (by spray).

Against *Pythium* spp. and *Phytophthora* spp.: furalaxyl, metalaxyl, oxadixyl.

Against *Rhizoctonia solani*: iprodione, pencycuron, tolclofos-methyl.

Against *Botrytis cinerea*: iprodione, prochloraz, procymidone, vinclozolin.

Botrytis cinerea (grey mould)

General

Botryotinia fuckeliana (anamorph *Botrytis cinerea*) attacks many species of ornamental plants. Infected plant parts (leaves, stems, flowers) die and are gradually covered by a grey mycelium which releases clouds of spores into the air when touched. On flowers, *B. cinerea* may also cause small spots or sunken areas, rendering the product of no value. The fungus survives as sclerotia or mycelium in dead or living plant tissue or as sclerotia in the soil.

Basic strategy

Hygiene is very important. Detritus and infected leaves, stems and flowers should be removed. Soil or growing medium should be well drained and a dense stand should be avoided. The relative humidity should be generally low, without too much water sprinkled over the plants. Plants should not be allowed to become wet (e.g. by condensation) or, if they do, should be dried as soon as practicable. Fungicides should be applied as sprays, as soon as symptoms are seen.

There are reports on the development of resistance of *B. cinerea* to both systemic and non-systemic fungicides. In particular, the possibilities for using the benzimidazole group of fungicides are now very limited. Alternation of fungicides is suggested to prevent resistance problems.

Main fungicides

Sprays: carbendazim, chlorothalonil, dichlofluanid, iprodione, procymidone, thiram, tolylfluanid, vinclozolin.

Space treatments: chlorothalonil, dicloran, iprodione, vinclozolin.

Powdery mildews

General

Erysiphaceae cause white "mildew" spots on the upper side of leaves, which are easily removed by gentle rubbing. On severely infected plants, spots also occur on the lower side of leaves and stems. They later turn brown with black dots (fruiting bodies). Roses are particularly susceptible (*Sphaerotheca pannosa*). Other examples are *Microsphaera begoniae* on begonia, *Oidium chrysanthemi* on chrysanthemum, *Oidium dianthi* on carnation.

These fungi survive on plant debris. The spores can also enter the glasshouses through open windows. The spread of powdery mildews is favoured by dry conditions (typically during daytime). Infection is favoured by high relative humidity, but not by free water (typically during night).

Basic strategy

Dense stand of the plants, high nitrogen concentrations and temperature fluctuations should be avoided. The plants should be watered at a proper time (allowing the soil to dry before night) and frequently ventilated. Affected plants or their parts (leaves, stems, and flowers) should be removed. Contrary to most fungal diseases, the release of conidia of these fungi is stimulated by low relative humidity. If under these conditions an attack develops, the application of a fungicide spray becomes necessary. The use of resistant cultivars can, however, reduce fungicide treatments.

Main fungicides

Benomyl, bitertanol, bupirimate, carbendazim, dichlofluanid, dinocap, dodemorph, fenarimol, imazalil, penconazole, propiconazole, thiophanate-methyl, triadimenol, triforine.

Sclerotinia sclerotiorum

General

Sclerotinia sclerotiorum forms a thick, white felt-like mycelium at the base of the affected plant. In this mycelium and the diseased parts of the plant, large white, later blackish sclerotia develop. Plant parts above the affected areas wilt and rot.

Basic strategy

The spaces between plants should be wide, moist conditions should be avoided and affected plants should be removed. If infestation is to be expected, the soil should be steam-sterilized or the soil surface should be covered with mulch. Fungicides should be applied as sprays, as soon as symptoms are seen.

Main fungicides

Iprodione, procymidone, thiophanate-methyl, thiram, vinclozolin.

Downy mildews

General

Downy mildew fungi (*Peronosporaceae*) form yellow spots on leaves, with grey-white sporangiophores appearing on the lower side of the spots. Leaves shrivel up and die. They persist as resting oospores in soil and debris, and the sporangia are readily dispersed in the air. Examples are *Pseudoperonospora sparsa* on rose, *Peronospora grisea* on hebe.

Basic strategy

These fungi like moist conditions, wet leaves and a high relative humidity. Wet crops should therefore be dried as quickly as possible by heating or ventilation and temperature fluctuations should also be avoided. In many crops, a prophylactic treatment with fungicides is necessary. In case of an infestation, a treatment with a curative fungicide should be done, followed by a series of prophylactic sprayings.

Main fungicides

Prophylactic: chlorothalonil, fosetyl-Al, mancozeb, propamocarb.

Curative: furalaxyl, metalaxyl.

Rusts

General

The rust fungi (Uredinales) form orange or brown spots containing spores on stems or leaves. The spores are widely dispersed in the air. Examples are *Coleosporium tussilaginis* on cineraria, *Puccinia horiana* on chrysanthemum, *Puccinia pelargonii-zonalis* on pelargonium, *Pucciniastrum epilobii* on fuchsia, *Uromyces dianthi* on carnation.

Basic strategy

Healthy plant material and resistant cultivars should be used. If plants are infected or seem to be infected, they should be removed. Overhead irrigation should be avoided because high humidity stimulates the disease. Fungicides should be applied as sprays, as soon as symptoms are seen.

Main fungicides

Bitertanol, oxycarboxin, tolylfluanid, triforine.

Wilting

General

A variety of fungi cause wilting and eventually dying of ornamental plants. These fungi may be true vascular wilt parasites, invading the vascular system of the plant, such as *Verticillium albo-atrum*, *V. dahliae* and the various formae speciales of *Fusarium oxysporum.* Alternatively, wilting may also be caused by infection of the foot of the plants by fungi like *Phytophthora* spp., *Thanatephorus cucumeris* (anamorph *Rhizoctonia solani*) and *Botrytis cinerea*, hampering upward water transport. Root-knot symptoms may be caused by *Pythium* spp., *Nectria radicicola* and *Chalara elegans*, but also by high salt concentrations, high water content or nematodes.

Basic strategy

Hygiene solves many problems and all possible precautions and actions associated with proper sanitation and management should be taken. If there have been previous problems with wilting, the soil should be steam-sterilized before planting or use as pot soil, and again after harvest. Infected plants should be removed. After harvest, the pallets, water hoses, glass walls, etc., should be cleaned thoroughly. The water table should be checked and should be kept sufficiently low. High sodium and nitrogen concentrations should be avoided and only healthy planting material should be used. Fungicides can use prophylactically (by soil treatment before planting, or added to water for pouring after planting), or curatively (by spraying or pouring from a watering can). The sensitivity of the different pathogens to individual fungicides varies considerably. Therefore, in case of doubt, the problem should be thoroughly investigated, the pathogen identified and expert advice obtained on suitable fungicides.

Main fungicides

Prophylactic: furalaxyl, metalaxyl, prochloraz, propamocarb, tolclofos-methyl, zineb.

Curative: carbendazim, furalaxyl, iprodione, metalaxyl, prochloraz, tolclofos-methyl.

Bacterial diseases

General

Infection by bacteria may cause various symptoms such as leaf spots (e.g. *Xanthomonas hortorum* pv. *pelargonii* on pelargonium, *X. axonopodis* pv. *begoniae* on begonia), discoloration of the vascular bundles (*Erwinia* spp. in *Kalanchoe*, *Pseudomonas cichorii* in chrysanthemum) or root galls (*Agrobacterium tumefaciens* on rose and chrysanthemum). In case of doubt, it is advisable to identify the pathogen correctly through expert advice, and at least verify whether the disease is caused by bacteria, or by other pathogens which may cause similar symptoms (fungi or nematodes). In particular, crown gall caused by *A. tumefaciens* is often mistaken for a *Meloidogyne* attack.

Basic strategy

It is very important to start with uninfected planting material and to ensure good, continuous growth. General hygiene is equally important and means the removal of affected plants and debris, sterilization of working tools such as knives, etc. High temperatures and high relative humidity should be avoided. The plants should be kept dry. If problems with these diseases have occurred, the soil should be steam-sterilized (as deep as possible) after harvest. If a system of recirculating water is used, the water should be disinfected, e.g. by heating, with sand filters or by UV-radiation. No plant protection products are available against bacterial diseases of ornamental plants.

Viruses

General

Ornamentals are affected by a great number of viruses, of which some examples are given below (with their means of transmission in brackets):

on rose - *Prunus necrotic ringspot ilarvirus* (PNRSV) (vegetatively propagated rootstocks);

on chrysanthemum - *Tomato aspermy cucumovirus* (TAV) (aphids);

on pelargonium - *Pelargonium leaf curl tombusvirus* (PLCV) (mechanically transmitted) and others;

on carnation - *Carnation vein mottle potyvirus* (CVMV) (aphids), *Carnation ringspot dianthovirus* (CRSV) (mechanically transmitted), *Carnation latent carlavirus* (CLV) (aphids), *Carnation etched ring caulimovirus* (CERV) (aphids), *Carnation mottle carmovirus* (CarMV) (mechanically transmitted);

on tulip and other liliaceous bulbs - *Tulip breaking potyvirus* (TBV) (aphids), *Tobacco necrosis necrovirus* (TNV) (*Olpidium* spp.);

on achimenes, alstroemeria, eremurus, gerbera, ornithogalum, phlox - *Tobacco rattle tobravirus* (TRV) (free-living nematodes);

on alstroemeria, anthurium, begonia, chrysanthemum, impatiens, kalanchoë, pelargonium, phalaenopsis - *Tomato spotted wilt tospovirus* (TSWV) (thrips).

Virus diseases cause major losses in quality of ornamental plants. Infection by viruses may cause various symptoms such as yellowing, leafroll, leaf curl, chlorotic spots and rings, necrosis, leaf and flower malformation.

Basic strategy

It is essential to start with virus-tested, vector-free planting material and to ensure continuous growth. General hygiene is equally important and means the removal of affected plants and debris, sterilizing working tools, the use of sterilized soil and resistant cultivars. The vectors should be controlled.

Aphids

General

Aphids affect ornamental plants by sucking from the phloem of the vascular bundles of young shoots and leaves. Plant parts affected by aphids will wilt, discolour or deform. Aphids also secrete sticky honeydew often resulting in sooty mould. Some aphids transmit viruses. Common species on ornamentals include the polyphagous *Aulacorthum circumflexum*, *Macrosiphum euphorbiae*, *Myzus ornatus*, *M. persicae*, *Aphis gossypii*, *Macrosiphoniella sanborni* on chrysanthemum, *Aulacorthum solani* on pelargonium, *Macrosiphum rosae* on rose, *Dysaphis tulipae* on bulbs.

Basic strategy

Starting with plant material free from aphids at least delays the development of the population. So does netting of openings of the glasshouse. Yellow traps and regular inspection of the crop provide information concerning presence, population increase and the need for treatment.

Chemical treatment, by spray or trickle irrigation, is widely used against aphids. Repeated treatments may be needed to keep populations at low levels. Treatment should be started as soon as aphids are detected. There is considerable resistance of aphid populations (especially *Aphis gossypii* and *Myzus persicae*) to pirimicarb and organophosphorus compounds. In these cases, active substances with a different mode of action, such as imidacloprid or nicotine, can be used.

Biological control agents like *Aphidoletes aphidimyza*, *Aphidius matricariae*, *A. colemani* and *Verticillium lecanii* are available. They are generally used preventively but *Verticillium lecanii* can also be used curatively.

Main insecticides

Acephate, bifenthrin, cypermethrin, deltamethrin, diazinon, dichlorvos, dimethoate, formothion, heptenophos, imidacloprid, malathion, methomyl, mevinphos, oxamyl, permethrin, phosalone, pirimicarb, propoxur, resmethrin, thiometon.

Space treatments: diazinon, dichlorvos, nicotine, pirimicarb, propoxur or sulfotep.

Tortricidae (leafrollers)

General

The mainly brown or green caterpillars of tortricid leafrollers, like *Adoxophyes orana*, *Cacoecimorpha pronubana*, *Clepsis spectrana*, *Epichoristodes acerbella* live between leaves spun together. They feed on leaves and buds.

Basic strategy

Tortricids normally enter the glasshouse through openings in spring and summer during cultivation or are imported with planting material. Where pheromone traps are available, monitoring of adult moths by trapping can provide information on the appropriate timing of application, when the sensitive stages of the pests are exposed (i.e. larvae before leaf rolling, or flying adults). Chemical control can be necessary, by spraying against larvae or by use of space treatment against adults. *Trichogramma evanescens* can be used as a biological control agent.

Main insecticides

Against larvae: acephate, bifenthrin, cypermethrin, cyfluthrin, deltamethrin, diflubenzuron, fenpropathrin, lufenuron, methomyl, permethrin, , teflubenzuron, trichlorfon.

Against adult moths: space treatment with dichlorvos or pyrethroids (see above).

Caterpillars

General

The caterpillars of various lepidoptera (e.g. *Pieris* spp., *Plusia* spp., *Autographa* spp. and *Mamestra* spp.) feed on the leaves and flowers of ornamental plants. They

normally enter the glasshouse through openings in spring and summer during cultivation or are imported with planting material.

Basic strategy

As soon as larvae are detected, chemical control can be necessary, by spraying against larvae or by use of space treatment against adults. The biological insecticide *Bacillus thuringiensis* can be used, but there is variation in sensitivity of the different caterpillar species. Biological control with *Trichogramma evanescens* is possible.

Main insecticides

Acephate, *Bacillus thuringiensis*, bifenthrin, cyfluthrin, cypermethrin, deltamethrin, diflubenzuron, fenpropathrin, methomyl, permethrin, teflubenzuron, trichlorfon.

Against adult moths: space treatment with dichlorvos or pyrethroids (see above).

***Otiorhynchus* spp.**

General

These are grey to black-coloured weevils of about 1 cm that feed on leaves and stems. More important are the whitish larvae that live in the soil and feed on roots.

Basic strategy

Sanitation and general hygiene are important. Larvae are spread with soil, e.g. potted plants. Detritus should be removed and hiding places should be kept free from adult weevils. The soil should be sterilized/treated before planting or potting or should be drenched after potting. If in spite of these precautions infestation occurs, a chemical or biological treatment may be necessary. Larvae can successfully be controlled by the entomopathogenic nematodes *Steinernema carpocapsae* and *Heterorhabditis* spp. The nematodes are most effective at soil temperatures higher than 13°C.

Main insecticides

Against larvae: carbofuran, chlorpyrifos-ethyl, fonofos.

Against weevils: acephate, cypermethrin, deltamethrin, diflubenzuron, methamidophos, methomyl, pirimiphos-methyl.

Spodoptera exigua

General

The caterpillars are light to dark green, up to 3 cm in length and feed on young leaves, shoots and flowers. Young larvae may skeletonize leaves near the soil. Moths are brownish grey and hide during the day.

Basic strategy

Infestation may develop very rapidly because of the short generation time. Frequent inspection of the crop is thus necessary. The glasshouses should be kept closed at night to prevent the moths from entering. Application of insecticides may be necessary, but only young larvae are susceptible. *Spodoptera exigua* nucleopolyhedrovirus can be used as a biological insecticide, but also in that case only larvae are susceptible. After ingesting the insecticide, they will die within 3-6 days.

Main insecticides

Against young larvae: *Spodoptera exigua* nucleopolyhedrovirus, diflubenzuron, lufenuron, methomyl, teflubenzuron.

Against adult moths: space treatment with dichlorvos or pyrethroids (see section on *Tortricidae*).

Leaf miners

General

The adults of *Liriomyza trifolii* and *L. huidobrensis* cause small white feeding spots on leaves, normally of little significance. The larvae mine in the leaves. The larvae of *L. huidobrensis* are whitish to yellow; the pupae are brown. The larvae of *L. trifolii* are yellow; the pupae are greyish black. The larvae of both *L. huidobrensis* and *L. trifolii* leave the mines to pupate in the soil, however, the pupae of *L. trifolii* can sometimes also be found on the leaves. These organisms are quarantine pests. Therefore, plants for export have to be free from these insects.

Basic strategy

Infestation in the glasshouse is caused by infested planting material and by the entering of flies through doors and windows. The use of different traps (yellow, sticky, water) or frequent inspection of the plants can indicate the presence of the pest. The use of healthy seedlings is important. Insect nets are effective in keeping the flies out and the crop clean.

Chemical treatment, by spraying against the larvae or space treatment against the adults, is widely used against leaf miners. Treatment should start as soon as damage due to adults (little white dots) is detected. Repeated treatments may be needed to keep populations at low levels. However, chemical control of *L. huidobrensis* larvae in a crop is not very effective. The same applies to killing the pupae in the soil. *L. trifolii* is easier to handle. The parasitic wasps *Dacnusa sibirica*, *Diglyphus isae* and *Opius pallipa* are being developed as biological control agents in

ornamental crops in glasshouses. Where possible and when available, these parasites should be used.

Main insecticides

Abamectin, cyromazine, methamidophos, methomyl, oxamyl, pyrazophos, thiocyclam hydrogen oxalate, triazophos.

Against *L. huidobrensis* larvae: abamectin, cyromazine, oxamyl, thiocyclam hydrogen oxalate.

For the control of adult flies: space treatment with dichlorvos or pyrethroids (see section on *Tortridicae*) is effective.

Scale insects and mealy bugs

General

A large number of species belong to this group. Larvae and adults feed on stems and leaves by puncturing the vascular bundles of woody or annual plants. Many of them produce a waxy secretion or/and honeydew, thus reducing the ornamental value of the plants. Examples include the polyphagous mealybugs *Planococcus citri*, *Pseudococcus affinis* and *P. longispinus*, the polyphagous scale *Coccus hesperidum*, *Diaspis boisduvalii* on orchids.

Basic strategy

It is important to use healthy planting material and to avoid growing plant batches of different growth stages, and direct contact between them. Multiplication of these insects is rather slow. Direct movement of the larvae is limited and slow, and adults are (almost) sedentary. Their way of life is often hidden, and a thorough and regular, but not necessarily frequent, inspection is necessary to be sure to detect them. If scale insects or mealy bugs are detected, a chemical treatment is required. Biological control is possible, e.g. with *Cryptolaemus montrouzieri* against mealy bugs. The parasitic wasps *Leptomastix dactylopii* and *Metaphycus helvolus* can be used against *Planococcus* spp.

Main insecticides

Acephate, buprofezin, bifenthrin, chlorpyrifos-ethyl, deltamethrin, etrimfos, methidathion, mevinphos, mineral oil, oxamyl, pirimiphos-methyl, propoxur.

Sciaridae

General

The larvae live in the soil and feed on young plants. The larvae are 3 to 4 mm, are transparent and have a dark-coloured head.

Basic strategy

Larvae can successfully be controlled by entomopathogenic nematodes of the genus *Steinernema* spp. The nematodes are most effective at soil temperatures higher than 13°C. The predatory mite *Hypoaspis* can also be used for biological control. Chemical control is also possible, by spraying against the larvae as soon as detected or space treatment against the adults.

Main insecticides

Permethrin, teflubenzuron.

Thrips

General

Larvae and adult thrips feed on the epidermal cells of leaves, buds and flowers, giving them a silvery appearance (on leaves) or causing malformation and discoloration (on buds and flowers). The thrips species present in Europe (e.g. *Thrips tabaci*) cause only very minor problems on ornamentals. However, the introduced American species *Frankliniella occidentalis* is now one of the most serious pests of ornamentals in Europe. It is also an important vector of *Tomato spotted wilt tospovirus.*

Basic strategy

It is important to start with thrips-free planting material. Yellow or blue (especially for *F. occidentalis*) sticky traps can indicate the presence of thrips. The yellow traps also indicate the presence of other pests (e.g. whiteflies, aphids and leaf miners).

The predatory mites *Neoseiulus cucumeris, Amblyseius degenerans* and the predatory bugs *Orius* spp. should be used for preventive biological control where possible. The fungus *Verticillium lecanii* has a side-effect on thrips. If population densities increase, single or repeated spray with an insecticide is necessary. If only chemical control is used, the first spray is applied as soon as thrips are detected. In the case of *F. occidentalis*, this is not easy because of resistance to many products. Because of the hidden way of life of many thrips, including *F. occidentalis*, space treatment may be necessary, particularly if the thrips have infested the flower buds. Although pyrethroids are effective, they can destroy all biological control efforts for weeks (e.g. *N. cucumeris*).

Main insecticides

Abamectin, acephate, acrinathrin, chlorpyrifos-ethyl, cypermethrin, deltamethrin, fenpropathrin, malathion, methamidophos, methomyl, mevinphos, oxamyl, pirimiphos-methyl, pyrazophos, thiocyclam hydrogen oxalate.

Space treatments: dichlorvos or sulfotep.

For thrips other than *F. occidentalis:* imidacloprid and several organophosphates and pyrethroids (see above) may be used.

Whiteflies

General

Trialeurodes vaporariorum is very common worldwide in glasshouses, and *Bemisia tabaci* has become so in recent years. Adults are small white insects of about 1.5 mm. The larvae are almost immobile and feed on the lower side of the leaves. They excrete honeydew making the plants sticky (sooty mould).

Basic strategy

Cultural methods or resistant cultivars are of no importance for the control of these pests in ornamental plants. The use of traps (yellow, sticky or water) or frequent inspection of the plants can indicate their presence. Control is essential as soon as populations are detected, and can be assured by single or repeated sprays or space treatments with insecticides, or biologically. *Encarsia formosa*, a parasitic hymenopteran well known for its effective control of whiteflies in vegetables, is now also used successfully in protected ornamentals. *E. formosa* should be used when available and effective and, in that case, any insecticides used should be known to be harmless to this natural enemy. The fungus *Verticillium lecanii* or the predatory ladybird *Delphasius pusillus* can also be used for the biological control of whiteflies. *V. lecanii* has a side-effect on thrips.

Main insecticides

Sprays: abamectin, bifenthrin, buprofezin, cyfluthrin, cypermethrin, deltamethrin, diazinon, dichlorvos, fenazaquin, fenpropathrin, imidacloprid, malathion, methomyl, mevinphos, nicotine, oxamyl, permethrin, pirimiphos-methyl, propoxur.

Space treatments: buprofezin, diazinon, dichlorvos, pyrethrins, teflubenzuron.

Mites

General

Tetranychus urticae, and other tetranychid species, feed mainly on the lower side of leaves by puncturing the epidermal cells with their stylets. The leaves lose their normal colour and often drop prematurely. If infestation becomes high, the lower surface of the leaf is covered with fine webs. They are among the most serious pests of glasshouse ornamentals.

Other mites also attack these crops. *Polyphagotarsonemus latus* is a polyphagous pest, with adults about 0.1 mm in size. A generation develops within 4-5 days. The symptoms on ornamentals are deformed flowers or inflorescences, brown colouring of the bottom side of the leaves, deformed upper leaves, brown shoots. *Steneotarsonemus pallidus* can be found in the growing point and cause growth inhibition. The older leaves curl and become glossy with a bronze colour. Younger leaves and flowers deform. *Brevipalpus* spp. are small orange-red mites with glossy orange-red eggs. They can be found on the underside of leaves. The symptoms are a bronze colouring of the older leaves.

Basic strategy

Spider mites thrive at high temperature and low relative humidity. Increasing the relative humidity or moistening the foliage is an effective control method, but may stimulate fungal diseases. Control is essential as soon as populations are detected, and can be assured by spray treatment with acaricides. Biological control is also possible with the predatory mites *Phytoseilus persimilis* or *Neoseiulus californicus*, or else the predatory midge *Feltiella acarisuga*. The other mites can be controlled by similar treatments.

Main acaricides

Abamectin, amitraz, bifenthrin, benzoximate, bromopropylate, clofentezine, dicofol, dienochlor, fenbutatin oxide, fenpropathrin, flucycloxuron, hexythiazox, oxamyl, tetradifon,.

Slugs

General

Slugs (e.g. *Arion* spp., *Deroceras* spp. and *Lehmannia* spp.) may inflict considerable damage to young plants and occasionally the leaves of older plants by feeding and by forming slimy tracks.

Basic strategy

General hygiene is important. All plant debris, left-over plastic and growing medium, etc., that may serve as hiding places or oviposition sites should be removed. The soil should be free from weeds, also under the tables and along the walls. Moist conditions favour the development of a slug population. Biological control is possible with *Phasmarhabditis hermaphrodita*. If the population increases beyond a tolerable level, a molluscicide may be applied.

Main molluscicides

Mercaptodimethur pellets, metaldehyde pellets.

Leaf nematodes

General

Aphelenchoides ritzemabosi and *A. fragariae* are polyphagous nematodes, which live and feed in leaves and buds, causing malformation of leaves, shoots and flowers. Typical leaf symptoms are discoloration between the veins. *Ditylenchus dipsaci* (affecting certain bulb crops) can be treated in a similar way.

Basic strategy

General hygiene, healthy plant material and clean soil are normally sufficient to keep the crop free from these nematodes. Soil sterilization is also effective. If these measures are respected, the use of plant protection products is not necessary and therefore not GPP. Because of the importance of healthy plant material, chemical application may be justified in the production of breeding or planting material.

Main nematicides

Aldicarb granules.

***Meloidogyne* spp.**

General

Meloidogyne spp. (root-knot nematodes) are polyphagous nematodes causing knots, swellings and other malformations on the roots, tubers and buds of almost any ornamental crop. This results in poor growth, occasionally wilting and thus poor yields. Under protected conditions, the stems, buds and even leaves may also be affected. *Pratylenchus penetrans*, *P. vulnus*, *P. bolivianus* and *Radopholus similis* can be treated in a similar way.

Basic strategy

Nematode-free planting material and non-infested soil are normally sufficient to keep the crop free from these nematodes. Hot-water treatment of planting material and steam sterilization of the soil are effective curative treatments and chemicals are normally not necessary. Weeds should be thoroughly controlled, also in cases when (and where) no commercial crop is grown. Except for the production of breeding or planting material, the use of chemicals is not considered GPP.

Main nematicides

Ethoprophos, oxamyl granules.

Weeds

General

Weeds can be a problem in ornamentals under protected conditions grown in soil. In general, there will be no problems with weeds if the crop is grown on an artificial substrate. In glasshouses, algae or mosses can be a problem.

Basic strategy

Good general hygiene is important. The soil may be sterilized (e.g. by steaming) to ensure a weed-free start. In most cases, this will be sufficient. If weed control is needed, mechanical or hand weeding may solve some of the problems, otherwise a herbicide treatment may be necessary. Under certain conditions, monocultures of weeds, such as ferns, may develop in glasshouses, and chemical control is then the only solution. If herbicides are spilt on heating pipes, it is recommended to clean these before the heating is put on. After application of herbicides, doors and windows should be closed for a few days to avoid damage of crops in the neighbouring compartments.

Main herbicides

Pre-sowing/pre-planting

Dazomet: soil temperature has to be at least 10°C, the soil should be covered with plastic after application.

Pre-emergence or pre-sowing

Chlorpropham (for some crops), diquat, glufosinate-ammonium, paraquat.

Post-emergence

Chlorpropham (for some crops), glyphosate (only spots), linuron, metamitron, oxadiazon, simazine.

Against algae or mosses

In empty glasshouses to clean windows: alkyl dimethyl benzyl ammonium chloride, benzalkonium chloride, didecyldimethyl ammonium chloride.

On crops that are at least 1 year old: dichlorophen, linuron.

Plant growth regulators

General

Control of plant growth is usually achieved by environmental manipulation: controlling the growing temperatures, the amount of irrigation water applied, the amount of fertilizer supplied and the space allowed for individual plants. However, in certain situations, it

is not possible to attain adequate growth control by manipulating such environmental parameters and growth regulators need to be used to achieve the desired result. In certain ornamentals (e.g. poinsettia, chrysanthemum), growth regulators are used regularly.

Basic strategy

Depending upon the crop in question, growth regulators can be applied either proactively, according to a plan, or reactively, according to crop development and/or changes in the weather. The choice of growth regulator will depend on the crop to be treated (the growth regulator may possess label recommendations for a specific crop), the effect required and the prevailing temperature.

Main plant growth regulators

Inducement of flowering: ethephon (in bromeliads), gibberellic acid.

Stem shortening, internode reduction: ancymidol (chrysanthemums, clerodendrons, lilies, poinsettias), chlormequat (camellias, dahlias, lilies, bedding plants, pot plants), chlorphonium (chrysanthemums, pelargoniums, petunias), daminozide (azaleas, bedding plants, chrysanthemums, hydrangeas, poinsettias, pot plants), ethephon (forced daffodils), flurprimidol (ornamental cover species, chrysanthemums, pelargoniums, paclobutrazol (begonias, chrysanthemums, freesias, lilies, poinsettias, roses, tulips).

Some of the growth regulators that primarily reduce growth may also increase the number of buds and flowers, and increase lateral shoots.

Increased number of buds and flowers: chlorphonium (azaleas, pelargoniums, rhododendrons), dikegulac (azaleas, fuchsias, and other ornamental plants), ethephon (basal-bud stimulation in roses).

Increased branching: chlormequat (azaleas, fuchsias, begonias, poinsettias, pelargoniums), chlorphonium (petunias, pelargoniums), dikegulac (azaleas, begonias, fuchsias, dahlias, pot plants), ethephon (pot plants, azaleas, pelargoniums, roses), paclobutrazol (increases flowering in bedding plants).

Colour improvement: flurprimidol (increases green colour in leaves), paclobutrazol (pot plants).

Flower-life prolongation: sodium silver thiosulfate (pot plants, cut flowers).

Rooting of cuttings: gibberellic acid, 2-(1-naphthyl) acetic acid; indol-3-ylacetic acid, 4-indol-3-ylbutyric acid.