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 2/30(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).

European and Mediterranean Plant Protection Organization
Organisation Européenne et Méditerranéenne pour la Protection des Plantes PP 2/30(1)

Good plant protection practice
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Outdoor solanaceous crops

Specific scope

This standard describes good plant protection practice for solanaceous vegetable crops grown in the open.

Specific approval and amendment

First approved in 2003-09.

This Standard on GPP for outdoor solanaceous crops 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 Principles of good plant protection practice. It covers methods for controlling pests (including pathogens and weeds) of vegetables of the family *Solanaceae* grown in the open field, such as tomato *Lycopersicon esculentum*, capsicum or sweet pepper *Capsicum annuum* and aubergine *Solanum melongena*.

Solanaceous vegetables are typical warm-season crops, grown in the open field mainly in regions with a temperate climate. Tunnels or row covers are often used in cooler climates to create a warmer environment, which gives young seedlings an early start (for Solanaceous crops under protected cultivation, see EPPO Standard PP 2/29). Tomato, for example, is one of the most common fresh market vegetables grown outdoors in the southern countries of the EPPO region. Processing tomato is grown almost exclusively outdoors. Climatic conditions, in particular temperature, are of vital importance for development. For germination, aubergine and capsicum require a minimum temperature of 16–18 °C, whereas tomato growth and development virtually stop at temperatures below 10 °C. All crops are also negatively influenced by hot weather. Temperatures of 30–35 °C cause abnormal fruit coloration, and early fall of flowers and fruits. Soil characteristics are equally important for growth. Optimal cultural practices, including field and bed preparation, drainage, irrigation, pH control and fertilization, have been developed to provide a satisfactory production level and high degree of fruit quality. Solanaceous crops prefer well-drained, light soils with a high amount of organic matter. The pH should be kept near 6.5 in order to avoid certain diseases, such as verticillium and fusarium wilt and grey mould. Soil should be ploughed under 30–40 cm deep, usually following a subsoiling. Forming soil into raised beds allows good development of the root system and avoids water-logging, thus reducing potential problems with soil-borne pathogens. In the open field, soil sterilization cannot be applied because of its high cost, and solarization is not as effective as when it is applied under protected cultivation.

Crop rotation is a major component of sustainable solanaceous crop production in the southern EPPO region, affecting both soil conditions and pest cycles. Rotation to non-solanaceous crops (e.g. leguminous crops or wheat) for 3 years is usually recommended to avoid pest problems common to this group of vegetables. Rational fertilization, following a chemical analysis of the soil, leads to well-balanced plant growth and increases yield. Available nutrients in the soil may prevent certain physiological diseases. Solanaceous crops benefit from organic manures, which play a fundamental role, both as a nutritional factor and as a soil amendment improving the physical and biological features of the soil. Manuring, one of the most ancient means of improving fertility and stimulating greater biological complexity, can limit the action of some soil-borne pathogens. In fact, roots are colonized by micro-organisms that provide significant biological control of soil-borne pathogens, both through the physical occupation of the rhizosphere and by release of antifungal substances. Chemical fertilizers can be applied in bands, broadcast or by micro-irrigation. The latter method allows plants to be provided with water and nutrients in a more balanced way, reduces leaching and minimizes disease problems.

In open-field cultivation, solanaceous crops usually start as bare-rooted seedlings or containerized transplants produced in nurseries. However, direct seeding is often used to grow processing tomatoes. Healthy seeds and disease-free certified seedlings should always be used. Seedlings are transplanted to the open field from March to June depending on the geographical region, as soon as temperatures are high enough to avoid cold damage. Transplantation into mulched soil is recommended in order to reduce herbicide applications and

Table 1 Principal pests of solanaceous vegetables grown in the open

Pests	Crops on which economic damage occurs
Stem and root rots	Tomato, capsicum, aubergine
Phytophthora root rot	Tomato, capsicum
Fusarium and verticillium wilts	Tomato, capsicum, aubergine
Anthracnose	Tomato, aubergine
Alternaria solani	Tomato
Phytophthora infestans	Tomato
Septoria lycopersici	Tomato, aubergine
Fulvia fulva	Tomato, capsicum, aubergine
Powdery mildews	Tomato, capsicum, aubergine
Botryotinia fuckeliana	Tomato, capsicum, aubergine
Bacteria	Tomato
Viruses	
Aphids	Tomato, capsicum, aubergine
Thrips	Tomato, capsicum, aubergine
Whiteflies	Tomato, capsicum, aubergine
Wireworms	Tomato, capsicum, aubergine
Noctuids	Tomato, capsicum, aubergine
Ostrinia nubilalis	Capsicum
Leptinotarsa decemlineata	Tomato, aubergine
Mites	Tomato, capsicum, aubergine
Meloidogyne spp.	Tomato, capsicum, aubergine
Weeds	Tomato, capsicum, aubergine

evaporation of water, and to prevent direct contact between fruits and soil, and subsequent fruit rots.

Solanaceous crops are affected by many pests that in some cases limit their cultivation. In order to restrict their impact, the control strategy should integrate different cultural practices and use of plant protection products. Growing crops should be examined for attacks by pests, and field treatments applied if infestation levels justify them or when climatic conditions are favourable for the development of some diseases. Use of threshold values or warning systems will ensure appropriate timing of the application of plant protection products and help to avoid unnecessary treatments. Whenever possible, resistant or less susceptible cultivars should be used.

Although biological control methods are widely used in protected solanaceous crops, in an outdoor setting, where favourable temperature and light conditions cannot be maintained, the use of biological control agents is limited. However, for some pests it is possible, as long as environmental conditions are suitable and as long as it is practical to monitor effectively.

Seed treatments are normally applied to protect young plants against diseases. Such treatment may also result in a reduced application of plant protection products early in the season, and so is favoured in GPP. A spray programme of different products is also GPP, if certain pests, which can only 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 products, or alternating them, can reduce the development of resistance.

It is GPP to use well-maintained equipment, such as tractor-mounted sprayers. Because vegetables are directly consumed by humans, the preharvest interval sets an additional constraint to the use of plant protection products.

The main pests of solanaceous vegetable crops covered by this guideline are given in Table 1.

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.

Stem and root rots

General

Several different fungi are associated with stem and root rot of solanaceous vegetables. Although they differ in their biology, the basic strategy for their control is common. *Sclerotinia sclerotiorum* and *Corticium rolfsii* (anamorph *Sclerotium rolfsii*) are an occasional problem on solanaceous crops, whenever cool and moist weather conditions prevail during crop development. The inoculum comes from sclerotia in the soil. The pathogens may survive as sclerotia in the soil for many years. It is usually first noted on the stem base of plants, where it forms white cottony mycelium. 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.

Thanatephorus cucumeris (anamorph *Rhizoctonia solani*) is a ubiquitous soil-borne fungus, which causes damping-off, root rot, basal stem root (foot rot), and fruit rot of solanaceous plants. It survives in soil, compost and infected debris as mycelium and undifferentiated sclerotia. The pathogen produces reddish-brown or dark brown lesions on germinating seedlings, which may be destroyed before or soon after emergence. The young stem is constricted and the plant dies. Root rot appears especially on plants whose roots are already damaged, for example by *Meloidogyne* spp. Above-ground stem canker develops occasionally at pruning wounds. In warm wet areas, a brown rot with alternating light- and dark-coloured rings may develop on fruit of tomato.

Thielaviopsis basicola (black root rot) occurs mainly on young seedlings, but even mature plants can be infected. Infected plants externally show discoloration and wilting. The pathogen attacks the root on which it forms blackish areas. Roots then narrow and rot. The pathogen usually survives in the soil as mycelium and chlamydospores. Optimum conditions for infection are a temperature of 18–20 °C, a slightly basic soil pH and high moisture content in the soil. *Didymella lycopersici* is frequent on tomato, capsicum and aubergine. First symptoms are dark brown stem lesions at soil level which may girdle the stem and the whole plant wilts. Numerous black pycnidia form on the stem lesions, and the plant may die. Lower leaves turn yellow and leaf lesions are brown with concentric rings. The centre of the lesion generally becomes lighter in colour, and a few pycnidia may develop. On fruits, blackish areas form and enlarge becoming necrotic while internal tissue rots. The pathogen survives in the soil on plant debris. Infection occurs at an optimum temperature of 15–17 °C, and spreads through wounds, particularly during routine trimming. *Pyrenochaeta lycopersici* is responsible for brown root rot and corky root rot. As the latter name suggests, the outer layers of the roots become swollen and corky and gradually break off. No discoloration is present in the xylem tissues. Plant vigour is reduced and wilting may occur as the root system is progressively destroyed. The fungus persists in the soil as microsclerotia and, once germinated, produces a mycelium which invades the host.

Basic strategy

Although treatment of the soil with a fumigant before transplanting or sowing is known to be effective against most of these soil-borne pathogens, routine use of this practice is not considered to be GPP. Such treatments should be limited to what is strictly necessary. Although fungicides can also be applied during the season, as soon as symptoms occur, their effectiveness is usually only partial. Accordingly, the main emphasis for control of stem and root rots of outdoor solanaceous vegetables is on preventive measures.

Disease-free transplants should be used, from treated or tested seeds. If possible, transplanting should be delayed until the soil is warm. Frequent irrigation will allow plants to form secondary roots and tolerate light infections. Adequate drainage is useful. Heavy nitrogen fertilization should be avoided. Any condition that contributes to poor air circulation and the retention of moisture is likely to aggravate the spread of these diseases. Affected plants should be removed and destroyed. Dense stands should be avoided.

Long crop rotations with tolerant crops are in general advisable, depending on the pathogen to control. Usually alternation of solanaceous crops with maize or small grains, less susceptible to *S. sclerotiorum*, helps to reduce the inoculum potential in the soil. For *T. cucumeris*, however, epidemics are not reduced by crop rotation but rather by good soil preparation avoiding water-logging. Even *T. basicola* is not particularly affected by crop rotation. Its presence is usually associated with fumigated soils. Therefore, soil conditioning and green manuring are recommended. To prevent *D. lycopersici* epidemics, crop rotation of at least 3–4 years, use of healthy seeds and avoidance of prolonged leaf wetness periods are needed.

Resistant rootstocks and cultivars exist in relation to some of these diseases.

Main fungicides

Sprays: azoxystrobin, dazomet, carbendazim, copper, dicloran, iprodione, procymidone, tolclofos-methyl, thiram.
Seed treatments: thiram.

Phytophthora root rot

General

Phytophthora capsici causes blight of capsicum. Attack occurs on the root or at the collar and spreads into the base of the stem and xylem may also turn brown. Symptoms appear as water-soaked areas that dry and turn brownish. Infected plants grow very slowly and in hot climates they rapidly wilt and die. Early infection leads to damping-off of seedlings, while later infection usually reduces plant vigour and exposes fruit to sunscald and black mould. *Phytophthora parasitica* mainly affects fruits of tomato on which it causes water-soaked concentric spots that progressively enlarge beginning from the fruit apex. Soon after, infected fruits rot. The pathogens survive in the soil as chlamydospores and oospores for more than 5–6 years. Infection takes place at high relative humidity and at temperatures of 17–28 °C, while temperatures above 35–36 °C stop the disease. Incubation is very short (3–4 days) at optimum temperature.

Basic strategy

Phytophthora root and fruit rots are not easy to eradicate. *P. capsici* is a limiting factor of cultivation of irrigated capsicum. Watering enhances the dispersal of zoospores. However, losses can be reduced with cultural practices that improve soil drainage. Infected plants should be destroyed. Rotation with a non-solanaceous crop such as cereals helps to reduce the risk of epidemics. Field infections, particularly on fruits, can be controlled by fungicides.

Main fungicides

Sprays: benalaxyl, fosetyl-Al, metalaxyl-M, oxadixyl, propamocarb.

Fusarium and verticillium wilts

General

Various *formae speciales* of the soil-borne fungi *Fusarium oxysporum*, *Verticillium albo-atrum* and *V. dahliae* cause wilting and sometimes death of plants. These fungi parasitize the vascular system.

Verticillium wilt is a cool-weather disease. The two *Verticillium* spp. survive in soil, as dark resting mycelium or microsclerotia, respectively, in debris from infected plants. Infected plants show mild to moderate wilting during the warmest part of the day but recover at night. As the disease advances, some marginal and interveinal chlorosis develops on lower leaflets. Fusarium wilt is a warm-weather disease, most prevalent on acid, sandy soils. *F. oxysporum* can persist in the soil for several years.

The characteristic symptom for both wilts is brown or black discoloration seen in the vascular tissue in cross-sections of the lower stem. Accompanying effects may include drooping of the petioles (epinasty) in young plants, and wilting, yellowing and later shrivelling of the lower leaves. Invasion of these wilt pathogens occurs through wounds on roots, such as those produced by cultivation or as result of nematode feeding. Aubergines are particularly susceptible to *Verticillium* spp. and seedlings are easily destroyed; clearly separated yellow spots are a characteristic symptom on leaves.

Basic strategy

Only healthy planting material should be used. Resistant cultivars or resistant rootstocks may prevent early infection, but cannot prevent infection completely. Movement of infected plants and infested soil (with machinery, tools, transplants), and of *Fusarium*-infected seeds, should be prevented. Hygiene solves most problems, and all possible precautions and actions associated with proper sanitation and management should be taken. Diseased plants and plant debris should be removed and destroyed. High nitrogen concentrations should be avoided. Mulching around the stem base to encourage secondary rooting can prolong plant life. Crop rotation can reduce losses, but not eliminate the pathogens because of the wide host range of *Verticillium* spp. Fungicide applications are not effective.

Anthracnose

General

Anthracnose fungi cause black dot of tomato roots and anthracnose of fruits, and a brown root rot of tomato, aubergine and capsicum. *Colletotrichum coccodes* is the main species involved, especially on tomato, but *Glomerella cingulata* (anamorph *Colletotrichum gloeosporioides*) and *Colletotrichum dematium* also occur. *Colletotrichum coccodes* is soil-borne, overwintering as microsclerotia often in association with plant debris. Under optimal climatic conditions (20–24 °C, persistent rain and high relative humidity), microsclerotia germinate by producing conidia in acervuli. Conidia can reach the host by rain and wind or may be splashed onto foliage and fruits. Once in contact with the fruits, conidia germinate and spread the infection. Symptoms occur on roots, fruit and leaves, as brown circular sunken areas. Tissues are water-soaked and frequently rot due to secondary infections. On stems, symptoms appear as elongated necrotic areas. Maturing fruits are more susceptible.

Basic strategy

Control measures include rotation at least every other year, soil sterilization, removal of plant debris, use of healthy seeds and, when available, use of tolerant tomato cultivars. Fungicides may be applied during fruit ripening, as soon as symptoms are noticed and at 7–8 day intervals, if conducive climatic conditions persist.

Main fungicides

Sprays: chlorothalonil, copper, famoxadone, thiram.

Alternaria solani

General

Alternaria solani, causing early blight, may attack tomato at any growth stage. Stems, leaves and fruits can be affected. Symptoms occur as irregular, concentric, necrotic spots. On older leaves, lesions may coalesce and kill the leaf. Brown spots appear on ripe and green fruits, and are subsequently covered by brown mycelium and conidial fructifications. The epidemic increases when cool and humid weather persists and decreases during hot and dry conditions. The fungus survives in the soil on crop debris.

Basic strategy

It is important to start with healthy plants, and thus to use healthy or disinfected seeds. Damp soil should be avoided and irrigation reduced. Debris and infected fruits, leaves and stems should be removed. Long rotations are advisable. Use of tomato cultivars tolerant to the disease is recommended. Usually, fungicide sprays against *P. infestans* are also effective against *A. solani*. However, with severe epidemics and in humid areas, specific fungicide sprays should be applied when first symptoms occur and with 8–10 day intervals depending on the type of fungicide. FRAC anti-resistance strategies should be followed in order to avoid problems with DMI fungicides (http://www.frac.info/).

Main fungicides

Sprays: azoxystrobin, chlorothalonil, copper, difenoconazole, famoxadone, iprodione, procymidone, tolylfluanid.

Phytophthora infestans

General

Phytophthora infestans, the agent of potato late blight, also causes leaf, stem and fruit rot of tomato. Its sporangia are easily dispersed under wet conditions. It can cause a substantial loss of fruits of tomato in a few days, when these are exposed to heavy rain, fog or prolonged dew. Epidemic development stops with hot and dry weather. Root and foot infection results in internal brown discoloration and wilting. Brown, water-soaked lesions appear on root and stem. Leaves are discoloured blue-green and shrink. Brown spots appear on ripe or green fruits and develop a concentric ring pattern of brown bands. Severely affected roots show necrosis and decay. The disease is most common in tomato when it is also present in local potato crops.

Basic strategy

Healthy planting material should be used, and its growth should be stimulated after transplanting. Damage to the plants should be avoided and pruning done only in the morning to allow wounds to dry. Infected plants should be removed, and not replaced in the same holes. Short rotation and heavy nitrogen fertilization should be avoided. When conditions favour the disease, sprinkler irrigation should not be used. Crop monitoring and forecasting models, if available, provide a useful basis for deciding on the fungicide application. Fungicides can be sprayed preventively or curatively depending on the active substance, growth stage of the crop and disease cycle. Copper compounds are primarily used in the early stage of the crop. FRAC anti-resistance strategies should be followed.

Main fungicides

Sprays: azoxystrobin, benalaxyl, copper, cymoxanil, dimethomorph, dodine, famoxadone, fosetyl-Al, metalaxyl, oxadixyl, propamocarb.

Septoria lycopersici

General

Septoria lycopersici, causing leaf spot of tomato, can occur at any stage of plant development. First symptoms usually appear on older leaves as small (2–3 mm), water-soaked rounded spots, grey in the centre with black margins. Sometimes in the centre of the spot, black pycnidia with white conidial mass protruding may be visible. Heavily infected leaves turn yellow, dry up, and drop off. Fruits are rarely and only superficially affected. Optimal conditions for fungal development are a temperature of 25 °C and high relative humidity. Conidia are dispersed by wind, droplets and animal vectors. The fungus penetrates into the plant host through stomata. The pathogen survives on plant debris and on seeds, and can also overwinter on solanaceous weeds.

Basic strategy

Eliminating initial sources of inoculum greatly reduces the disease potential. The production area should be free from susceptible weeds and the previous season's tomato debris. Use of healthy or disinfected seeds, seed treatment and disinfection of seed-bed are essential. Moist conditions should be avoided. Crop rotation of at least 2 years is recommended. Fungicide sprays should be applied when first symptoms occur.

Main fungicides

Sprays: carbendazim, chlorothalonil, copper, difenoconazole, mancozeb.

Fulvia fulva

General

In the open field, *Fulvia fulva* (synonym *Cladosporium fulvum*) only occasionally affects the leaves of tomato, causing large yellowish spots with undefined margins. On the lower side of infected leaves, a black-olive velvet mould develops (leaf mould). Infected leaves shrink and die. Similar symptoms may also appear on stems, petioles and flowers. Fruits, on which the disease cause blackish necrotic spots, are rarely affected. Plants heavily affected by the disease have a reduced yield and fruits ripen slowly. Infections take place with more than 90% relative humidity and temperature between 10 °C and 27 °C (optimum 22 °C). The pathogen survives as free conidia on infected plants and on the wood structures of the glasshouse. Infection also seems to be transmitted through the seed.

Basic strategy

Cultural techniques help to avoid infections, e.g. avoiding dense stands and unnecessary sprinkler irrigation, use of resistant cultivars and healthy or treated seed. Fungicides may be applied when first symptoms are seen, and repeated two or three times with a 7–8 day interval. Resistant cultivars have significantly reduced the incidence of this disease in many countries.

Main fungicides

Sprays: azoxystrobin, carbendazim, chlorothalonil, cyproconazole, tolylfluanid.

Powdery mildews

General

Powdery mildew is a relatively new disease of tomatoes. An *Oidium* sp. (*Erysiphe* anamorph) has recently become widespread. This was initially known everywhere as *Oidium lycopersici*, but it now seems that there are two species involved: *Oidium neolycopersici*, which forms conidia singly, and is widespread throughout the world except Australia, and *O. lycopersici*, which always form conidia in chains, and is confined to Australia. *Oidium neolycopersici* can affect all aerial parts of the plant except the fruits. Severely infected leaves turn brown and shrivel, resulting in premature defoliation. Severe infections lead to a marked reduction in fruit size and quality. The spread of powdery mildew is favoured by dry conditions (typically during daytime), moderate temperature, and reduced light intensity. Infection is favoured by high relative humidity, but not by free water. The fungus survives on plant debris.

The pathogen on aubergine is *Oidium longipes*, which is not pathogenic for tomato. It causes chlorotic leaf spots on the upper side of the leaves which become necrotic after a while. The leaves are eventually overgrown by an expanding mycelial mat.

Capsicum, in particular, is attacked by the polyphagous *Leveillula taurica*, which mainly occurs in warmer countries. The host organ most affected is the leaf blade. Petioles, stalks and flowers are rarely affected and fruits are occasionally infected. Unlike other powdery mildews that produce only superficial mycelium, *L. taurica* develops within the host tissue. Diffuse yellow spots develop on the upper leaf surface, while the white powdery mass of the pathogen appears on the underside of leaves. Spots may become necrotic and plants defoliated, especially capsicums. This pathogen is favoured by high temperatures and dry weather and is most frequently found in Mediterranean countries.

Basic strategy

If an attack develops, the use of a fungicide spray becomes necessary. Recommended fungicides can cause phytotoxicity on young plants. Breeding programmes for disease resistance are under study, as well as the use of biological control for *O. neolycopersici.*

Main fungicides

Sprays: azoxystrobin, cyproconazole, difenoconazole, dinocap, fenarimol, hexaconazole, myclobutanil, nuarimol, penconazole, sulphur, tetraconazole.

Botryotinia fuckeliana

General

Botryotinia fuckeliana (anamorph *Botrytis cinerea*) attacks many plants and plant parts, mainly through wounds. All solanaceous vegetable crops are affected. The fungus causes brown spots on every part of the plant. Infected plant parts die and are gradually covered by the grey mycelium (grey mould), or affected areas may dry out. Lesions release millions of spores into the air. The fungus survives as sclerotia or mycelium in dead or living plant tissue or as sclerotia in the soil. A symptom known as 'ghost spotting' occurs as a reaction to a spore landing on the surface of immature tomato fruits. Affected flowers do not set and consequently some fruit yield is lost. *Botryotinia fuckeliana* is one of the main causes of post-harvest rot of fresh market tomatoes but only occasionally affects processing tomato during persistent rain, prolonged dew periods or fog.

Basic strategy

Soil should be well drained and a dense stand avoided. Sprinkler irrigation should be reduced whenever possible, particularly before harvest. As far as possible, wounding should be avoided and pruning wounds kept small and regular. Debris and infected plants should be removed. Disease attack can be minimized by applying preventive fungicides as soon as the crop is exposed to optimal weather conditions for the development of the pathogen.

Problems with resistance

Strains of *B. fuckeliana* resistant to a number of commonly used fungicides can occur. These include benzimidazoles (e.g. carbendazim) and dicarboximides (e.g. iprodione, procymidone). If a fungicide programme is required, different types of product should be alternated to minimize the loss of efficacy due to resistance. FRAC guidelines should be followed.

Main fungicides

Sprays: azoxystrobin, carbendazim, chlorothalonil, cyprodinil, fenhexamid, fludioxonil, iprodione, mepanipyrim, procymidone, pyrimethanil, tolylfluanid.

Bacteria

General

Bacteria may cause various symptoms such as leafspots, galls and discoloration of the vascular bundles. The most important bacteria on solanaceous vegetable crops are seed-borne: *Pseudomonas syringae* pv. *tomato* (bacterial speck), *Clavibacter michiganensis* subsp. *michiganensis* (bacterial canker), *Xanthomonas vesicatoria* (bacterial scab and leaf spot of tomato), *Xanthomonas axonopodis* pv. *vesicatoria* (bacterial leaf spot of capsicum). The last three of these are quarantine pests for some countries in the EPPO region, so that young plants are required to be free from them. The same applies to *Ralstonia solanacearum* (bacterial wilt), which is an important pathogen of solanaceous vegetables in warmer countries, but does not occur (other than very sporadically) in the EPPO region.

Basic strategy

It is very important to start with uninfected planting material and to ensure good continuous growth. General hygiene is equally important: infected plants and debris should be removed, tools such as knives should be disinfected, etc. Long crop rotation (3–5 years) is recommended. Nitrogen over-fertilization is the main predisposing factor and should be avoided. If, in spite of these preventive measures, bacterial diseases are found on the crop, spraying with copper may limit spread.

Main bactericides

Copper.

Table 2 Viruses attacking solanaceous crops and their modes of transmission

Virus	Transmission	Crop affected
Alfalfa mosaic alfamovirus	Aphids in a non-persistent manner	Tomato, capsicum
Capsicum mild mottle tobamovirus	Contact, seeds	Capsicum
Cucumber mosaic cucumovirus	Aphids in a non-persistent manner, contact, seeds	Tomato, capsicum
Pepper mild mottle tobamovirus	Contact, seeds	Capsicum
Pepino mosaic potexvirus	Contact	Tomato
Potato Y potyvirus	Aphids in a non-persistent manner	Tomato, capsicum
Tobacco mosaic tobamovirus	Contact, seeds	Tomato, capsicum (aubergine)
Tomato chlorosis crinivirus		Glasshouse tomato
Tomato mosaic tobamovirus	Contact, seeds	Tomato, capsicum
Tomato spotted wilt tospovirus	Thrips, especially *Frankliniella occidentalis*, in a persistent manner	Tomato, capsicum, aubergine
Tomato yellow leaf curl begomovirus	Whiteflies, e.g. *Bemisia tabaci*, especially biotype B, in a persistent manner	Tomato

Viruses

General

The following viruses are regularly found in solanaceous vegetables grown in the field: *Alfalfa mosaic alfamovirus*, *Cucumber mosaic cucumovirus*, *Capsicum mild mottle tobamovirus*, *Pepper mild mottle tobamovirus*, *Potato Y potyvirus*, *Tobacco mosaic tobamovirus*, *Tomato mosaic tobamovirus*. Symptoms may consist of mosaic, leaf yellowing, leaf deformation, growth reduction, chlorotic and necrotic spots, rings and patterns on leaves and fruits. Necrosis on tomato fruits can be confused with the symptoms of infection by *Phytophthora* spp. Symptoms and their severity vary with the virus isolate causing the infection, the plant species and the cultivar that is being infected, the plant stage and environmental conditions in which infection takes place. Symptoms are often not sufficiently characteristic for a reliable diagnosis to be made. Additional diagnostic methods may be needed (e.g. mechanical inoculation to test plants, ELISA test).

Certain other tomato viruses have become important in European tomato crops only recently, and are still of very limited distribution (*Tomato spotted wilt tospovirus*, *Tomato yellow leaf curl begomovirus*, *Tomato chlorosis crinivirus*, *Pepino mosaic potexvirus*). In some cases, their increased importance has been associated with the spread of newly introduced vectors (*Bemisia tabaci*, *Frankliniella occidentalis*). These viruses are regulated in many European countries, or under consideration for regulation. It is normally required that young tomato plants should be free from them, and additionally in some cases that their place of production should be free.

To minimize the effects of viruses, it is important to know which virus causes the disease and how it is transmitted. Each virus has its own mode of transmission (Table 2). In addition, all are spread by grafting (e.g. tomato cultivars on cv. Beaufort rootstocks) and by transport of infected plants.

Basic strategy

Virus diseases are difficult to control and can result in substantial crop losses. As there are no cures for virus-infected plants in the field, all measures should be directed at preventing infection. This includes removal or avoidance of sources of infection, prevention or limitation of virus spread by vectors, and improvement of crop resistance to viruses. It is important to eradicate all infected plants of both crops and weeds as these plants may act as source of infection for further spread if vectors are present. Eradication of weed hosts is often an impossible task, because of the extensive host range of some viruses.

The use of certified propagation material (seeds and transplants) greatly helps to avoid early infections in the crop. Certification also relies on inspection and testing for viruses, and on spatial isolation and planting in periods with low vector populations.

Control of vectors is of great importance for viruses which are mainly transmitted by insects. This may include insecticides and biological control, although biological control is currently used mainly under protection. Insecticide sprays are ineffective against viruses transmitted in a non-persistent manner, introduced into the crop by winged aphids coming from the surrounding crops. Treatments with mineral oils seem to show a certain efficacy against non-persistent viruses. Monitoring the presence of vectors, using yellow (*Bemisia tabaci*) or blue sticky traps (*Frankliniella occidentalis*), is advisable to apply insecticide correctly early in the season. Alternative preventive measures are e.g. using insect gauze, mulching with reflecting plastic films that reject vectors (principally aphids), adapting time of the transplantations in order to avoid exposing plants to inoculation during the periods of greater presence of the vector. For viruses which are mainly transmitted by contact, hygienic measures are important. Disinfection of tools helps to reduce spread. During crop-handling, virus spread can also be reduced by always working in the same direction in rows and beginning operations always at the same starting-point. Use of resistant cultivars is also important. Especially for tobamoviruses, many resistant tomato and capsicum cultivars are available. Cross protection by inoculating young plants with a attenuated virus strain in principle reduces severity of symptoms when the plants are later infected by a virulent strain. This “classic” method was used in the past especially for ToMV, but is now only occasionally applied because of its disadvantages, i.e. poor availability of attenuated strains, effects of such strains on other crops or cultivars, aggravated symptoms after natural infections by viruses other than the targeted virus.

Aphids

General

Aphids are sucking insects that can affect the health of solanaceous crops directly by feeding damage and also indirectly by transmitting viruses. The main species infesting solanaceous crops are *Aulacorthum solani*, *Aphis gossypii*, *Myzus persicae* and *Macrosiphum euphorbiae*. Primary damage to plants results from the effects of colonies feeding on young tissues, which weakens and distorts new growth. Aphids cause chlorotic spotting, chlorosis and distortion of leaves, and stunting and wilting of plants. Secondary damage arises from sooty mould growing on heavy honeydew secretions, which are deposited on leaves and fruit, resulting in reduced photosynthesis and fruit quality.

Basic strategy

Starting with aphid-free seedlings is important. Monitoring (yellow sticky traps, water traps, suction traps and regular inspection of both traps and plants) is important to provide information concerning the presence of aphids. It should begin just after the formation of the first true leaf. Some weed species can act as hosts for aphids and as reservoirs for viruses and should be controlled. Spray treatment may be necessary when it becomes obvious that cultural and natural control measures are not keeping aphids under control. Before spraying, the crop should be checked for the presence of beneficial insects, mainly coccinellids and syrphids. If they are found, selective insecticides should be preferred.

Problems with resistance

Several aphid species (especially *Aphis gossypii* and *Myzus persicae*) have populations with considerable resistance to certain groups of insecticides (e.g. pirimicarb, organophosphorus compounds), so product choice and rotation of products is very important. Products with a purely physical action, such as starch-based preparations or fatty acids, may be useful as spot applications and can control resistant aphids. The Insecticide Resistance Action Committee (http://plantprotection.org/IRAC/) provides a co-ordinated crop protection industry response to the development of resistance in insect and mite pests.

Main insecticide

Sprays: acetamiprid, alpha-cypermethrin, azinphos-methyl, beta-cyfluthrin, bifenthrin, chlorpyrifos-methyl, cyfluthrin, cypermethrin, deltamethrin, dimethoate, imidacloprid, lambda-cyhalothrin, methomyl, mevinphos, pirimicarb, pymetrozine, rotenone, tau-fluvalinate, zeta-cypermethrin.

Thrips

General

Solanaceous crops may be attacked by several thrips species, such as *Frankliniella occidentalis* and *Thrips tabaci*. In the open field, before the introduction into Europe of *F. occidentalis*, thrips species were not a serious problem. *F. occidentalis* is very damaging and difficult to control. Larvae and adults feed on the epidermal cells of leaves, buds and flowers. In general, symptoms of direct damage caused by thrips are light mottling and silvering of leaves and fruit and malformation and discoloration of buds and flowers. On capsicum and aubergine, they mainly attack the fruits which show deformations. Indirect damage is caused by transmission of virus diseases, e.g. *F. occidentalis* is a notorious vector of *Tomato spotted wilt tospovirus* (TSWV). *Thrips tabaci* is found primarily on foliage, seldom invading flowers. Its sap feeding causes white flecking of leaves.

Basic strategy

Starting with thrips-free seedlings and maximizing the distance from potential sources of thrips infestations is important. Yellow or blue (especially for *F. occidentalis*) sticky traps should be used to monitor the presence of thrips. If population densities of thrips increase, an insecticide spray may be necessary which, in the case of *F. occidentalis*, is not easy due to its resistance to many plant protection products. Another difficulty is the hidden way of life of many thrips, including *F. occidentalis*, particularly if the thrips have infested the flower buds.

Biological control offers good possibilities to maintain a thrips infestation under control; the predatory bug *Orius laevigatus* or the entomopathogenic fungus *Verticillium lecanii* may be used.

Main insecticides

Sprays: abamectin, acrinathrin, chlorpyrifos-methyl, deltamethrin, fenitrothion, formetanate, lufenuron, malathion, methiocarb, pirimiphos-methyl, spinosad.

Whiteflies

General

Whiteflies such as *Trialeurodes vaporariorum* and, in recent years, *Bemisia tabaci* can cause serious damage to solanaceous crops in the field. Adults are small white insects about 1.5 mm long, easily disturbed into short flights. Whiteflies lay eggs on young foliage. On hatching, young larvae crawl to a feeding location on the lower leaf surface and become sessile. Adults and nymphs attack the underside of the leaves by sucking plant juices. The damage includes chlorotic spotting and chlorosis of leaves, spotting of fruits, and stunting and wilting of plants. Whiteflies excrete honeydew on which sooty mould fungi grow, turning the foliage and fruit black in colour and thus reducing the photosynthetic potential and fruit quality. Tomatoes are often severely infested. *Bemisia tabaci* B biotype can cause uneven ripening of tomato fruits.

Bemisia tabaci is regulated as a quarantine pest in many countries, the risk being primarily to the glasshouse industry in northern countries and spread of different biotypes, as pests of field crops, in the south of the EPPO region. Young plants should be free from the pest and come from a place of production which is free. *Bemisia tabaci* B biotype transmits *Tomato yellow leaf curl begomovirus* (TYLCV), which is also regulated as a quarantine pest (see under Viruses), and *Tomato chlorosis crinivirus*, which appears on the EPPO Alert List as a potential new problem in Mediterranean countries.

Basic strategy

Crops should be examined regularly and yellow sticky traps used to trap adult whiteflies moving into a field. Monitoring should begin at the time of seedling emergence. Intermediate-aged and old leaves should be sampled for nymphs. Locally established thresholds should be used to determine the use of insecticide. Use of insecticide sprays should be kept to a minimum, and limited to emergency situations, with preference for those that are harmless to natural enemies. After harvest, crop debris should be removed.

Problems with resistance

Trialeurodes vaporariorum has been resistant to many insecticides for some years. Over-reliance on conventional insecticides has resulted in highly resistant *B. tabaci* biotypes, especially to imidacloprid.

Main insecticides

Sprays: acetamiprid, azadirachtin, buprofezin, imidacloprid, methomyl, pirimiphos-methyl, pymetrozine.

Wireworms

General

The larvae of certain Elateridae (*Agriotes* spp., e.g. *A. litigiosus*, *A. ustulatus*, *A. sordidus*, *A. lineatus*, *A. obscurus*, *A. sputator*) damage the stem bases and the roots of solanaceous crops. Development of wireworms takes 3–5 years, and larvae of different ages co-exist each year.

Basic strategy

Grassland or uncultivated land as a preceding crop should be avoided. Long rotation is advisable. Rotation with lucerne is not recommended for at least 2 years. Knowledge of the level of the population of wireworms in the soil is a basic need to make a decision on treatment. At least 14 days before transplanting, the larval population should be monitored with bait traps. These can be made with draining plastic pots (11 cm diameter) filled with vermiculite, 30 mL of maize grain and 30 mL of wheat grain. Seeds should be wet and the pot buried 5 cm deep in the soil. Larvae are attracted into the pot by the carbon dioxide produced by the wetted germinating seeds on which they feed. Traps should be checked approximately every 14 days. If a high population is detected, soil insecticides should be applied before transplanting. When infestation is detected in the presence of a growing crop, soil cultivation can be used to encourage larval migration deeper in the soil.

Main insecticides

Sprays: ethoprophos, fipronil.
Granules: benfuracarb, carbosulfan, furathiocarb, phorate.

Noctuids

General

Many polyphagous noctuid larvae may typically attack solanaceous seedlings and young plants in the field. Larvae of *Agrotis* spp. live in the ground and feeding occurs mostly at night. Young seedlings are cut at or just below ground level. Larvae of *Autographa gamma* and *Chrysodeixis chalciteses* attack leaves.

Larvae of *Heliothis armigera* feed on leaves, flowers and fruits of tomato and bore internal galleries on capsicum. Initially, larvae are yellow with a black head, then they become green-yellowish with two typical side stripes. In the central and southern European regions, they may complete two to four generations.

Spodoptera exigua is a subtropical and tropical noctuid, present in the south of the EPPO region, which can also invade glasshouses in the north. Its light- to dark-green caterpillars up to 3 cm in length feed on young leaves, shoots and flowers. Young larvae feed on the under surface of leaves and skeletonize them. Larger larvae make irregular holes in leaves. Buds and growing points may be eaten and fruits pierced. The moths are grey-brownish and hide during the day.

Spodoptera littoralis is an A2 quarantine pest. It is a totally polyphagous noctuid pest that can be found outdoors in the south and in glasshouses in the north. Females lay eggs in egg masses on the lower leaf surface. Damage arises from feeding by larvae, leading to complete defoliation. In tomatoes, larvae also bore into the fruit. The number of generations depends on climatic conditions. Weeds act as a reservoir for females and should be controlled.

Basic strategy

In general, integrated pest management (IPM) techniques, favouring natural enemies, should be used. To monitor the infestation with *S. exigua* and *S. littoralis* adult moths, the use of pheromone traps is advised. Control of *S. exigua* requires frequent inspection of the crop, since the pest has a short biological cycle and develops very rapidly. A product based on *Spodoptera exigua* nuclear polyhedrosis virus is available, which kills larvae in 3–6 days. Natural enemies which are suitable for biological control include the egg parasite *Trichogramma evanescens* and the predatory bug *Podisus maculiventris*. Insecticide sprays may be applied if necessary, including *Bacillus thuringiensis* (against the first- or second-stage larvae). Not all strains are effective (*S. littoralis* is resistant to many strains).

Main insecticides

Sprays: azadirachtin, *Bacillus thuringiensis*, deltamethrine, hexaflumuron, indoxacarb, lufenuron, methomyl, spinosad, tau-fluvalinate, teflubenzuron.
Baits: methiocarb.

Ostrinia nubilalis

General

Ostrinia nubilalis (European corn borer) can be a serious pest of capsicum, especially in southern EPPO countries where *O. nubilalis* may have a second generation. Larvae penetrate into the fruit and tunnel stems which start to rot. Larval infestation occurs mainly early in May or June and continues until the beginning of autumn.

Basic strategy

It may be necessary to spray insecticide, particularly in areas where maize (the preferred host) is grown. Likelihood of damage is reduced if nearby maize is suitable for egg-laying. Insect populations should be monitored early (April–May depending on locations) with pheromone traps or phenyl-acetaldehyde traps or light traps. When capsicum plants are fruiting and if, for example, light traps are capturing more than 5–10 moths per night, the crop should be treated at about 5-day intervals. Products based on *Bacillus thuringiensis* can be used effectively if applied at the right moment and with a weekly interval during egg-laying. Biological control can be achieved using the egg parasite *Trichogramma maydis*.

Main insecticides

Sprays: *Bacillus thuringiensis*, bifenthrin, cyfluthrin, deltamethrin, hexaflumuron, indoxacarb, lambda-cyhalothrin, lufenuron, malathion, teflubenzuron, tau-fluvalinate, zeta-cypermethrin.

Leptinotarsa decemlineata

General

Leptinotarsa decemlineata (Colorado beetle), a major pest of potato, also attacks aubergine and tomato. It is an A2 quarantine pest, rare in or still absent from some EPPO countries. Both adults and larvae feed on the leaves, and a heavy infestation results in complete defoliation. Eggs are orange-yellow, laid in batches, usually on the lower leaf surface. Larvae from the same batch of eggs remain grouped together until the first moult. The mature larvae fall to the ground and bury themselves in the soil for pupation. Adults overwinter in the soil.

Basic strategy

Because of their size and distinctive coloration, adults and larvae are not difficult to observe by visual inspection. In warmer or more continental countries, where there may be two or even three generations per year, insecticide sprays may be needed. Insecticide sprays should be applied as soon as young larvae are seen (the older larvae and adults are less sensitive). Products based on *Bacillus thuringiensis* subsp. *tenebrionis* have shown good larvicidal efficacy. *Leptinotarsa decemlineata* populations readily become resistant to insecticides, but this problem has proved relatively easy to solve by alternation of products between years.

Main insecticides

Sprays: acetamiprid, alpha-cypermethrin, azinphos-methyl, *Bacillus thuringiensis* subsp. *tenebrionis*, beta-cyfluthrin, bifenthrin, carbaryl, chlorpyrifos-methyl, deltamethrin, lambda-cyhalothrin, lufenuron, rotenone, tau-fluvalinate, teflubenzuron.

Mites

General

The spider mites *Tetranychus urticae* and *Tetranychus cinnabarinus*, and also the tarsonemid mite *Polyphago-tarsonemus latus*, cause damage to solanaceous crops. They are extremely polyphagous. Young and adult mites suck mainly on the lower side of leaves by puncturing the epidermal cells with their stylets. Leaves are discoloured and often drop prematurely. Colonies develop on all aerial parts of plants and usually contain all stages, from eggs to adults. If infestation becomes high, plants may be covered by seething masses of mites and their webs become visible. Plants can be killed quite rapidly. *Tetranychus cinnabarinus* (carmine spider mite or 'hypertoxic' mite) can cause severe plant damage at low populations. *Polyphagotarsonemus latus* also causes crinkling, cracking, discoloration and malformation. Severe attack on aubergine may stop growth. Tomato russet mite *Aculops* *lycopersici* is a particular pest of tomato. Heavy infestations may also cause injury to capsicum while aubergine supports heavy populations. Infestation usually starts at the base of the plant and spreads upwards. Mite feeding on tomato produces bronzed or russeted aspects to the stem and leaves. Hot, dry weather favours development of mites and, if populations are not checked, plants may be killed in only a few days.

Basic strategy

Weed control around the field in autumn and spring can reduce the overwintering population. Destruction of weeds around the edges of fields during the growing season is not advisable because it forces mites to migrate into the field. Monitoring should begin early in the growing season. Local thresholds should be followed, if available. If necessary, acaricides provide effective chemical control. Care should be taken to preserve beneficial mites and other arthropod predators that aid in the control of mites. Acaricides that are harmful to them should be avoided. Biological control using predatory mites (e.g. *Phytoseiulus persimilis*) used as soon as the first mobile forms are detected provides good results. The entomopathogen *Beauveria bassiana* is another alternative to chemicals.

Some mite populations have developed resistance to acaricides and, in some cases, cross-resistance. Minimizing the use of acaricides should also delay such problems with resistance.

Main acaricides

Sprays: abamectin, acrinathrin, bifenthrin, bromopropylate, clofentezine, fenazaquin, fenbutatin oxide, fenpropathrin, fenpyroximate, hexythiazox, tebufenpyrad, rotenone, tetradifon. *A. lycopersici*: dicofol, sulphur.

Meloidogyne spp.

General

Meloidogyne spp. are endoparasitic root-knot nematodes which cause knots, swellings and other malformations on the roots of solanaceous crops grown in soil. This results in poor growth, stunting and occasionally wilting, and thus in poor yields. *Meloidogyne incognita* is the commonest species. It can be found in sandy soils causing high yield losses. *Meloidogyne javanica* prevails in warm climates. *Meloidogyne arenaria* can be found mainly in loamy soils, often associated with *M. incognita*. *Meloidogyne hapla* is commonest in continental climates or on winter crops in the Mediterranean region.

Basic strategy

Healthy, nematode-free seedlings, clean soil, good general hygiene, use of resistant cultivars (where available) are essential to prevent nematode infestation. Cultural practices such as deep ploughing, fallowing and destruction of susceptible weed hosts should be an integral part of crop management. Temperature, moisture, soil type, age of the plant at infection, and inoculum density have profound influence on the damage caused by nematodes. Proper irrigation and nutrition reduce stress and may minimize nematode damage. Because of their wide host range, root-knot nematodes are difficult to control by crop rotation, except where non-hosts or resistant cultivars can be grown. If numbers are very high, the field should be avoided. Except for breeding or planting material, the use of nematicides is not considered GPP. Such treatments should be limited to what is strictly necessary. In some Mediterranean countries, good results are obtained by combining solarization with nematicides at reduced dose.

Main nematicides

1,3-dichloropropene, ethoprophos, fenamiphos, phorate.

Weeds

General

Weed management options are influenced by the growth characteristics of each crop. In general, weeds can cause yield reductions, especially when crops are not grown during their preferred season. Weeds interfere with harvest by making fruits difficult to find.

Basic strategy

The vigorous growth of solanaceous crops makes integrated weed management feasible and reduces the need for herbicides. An integrated approach is needed because of the limited availability of registered, effective, selective herbicides. Monitoring the fields and keeping records of the weed species that occur in each field is advisable. Crop rotation allows different control measures to be used in the various cropping systems, thus avoiding the increase in specific weed populations. Cultivation kills most emerged weeds but can also bring more weed seeds to the soil surface, which may cause problems later in the season. Presowing and preplanting cultural practices, such as superficial tillage, hoeing and early soil preparation to induce early weed occurrence with the use of herbicides, are recommended. Solanaceous crops can be mulch-planted to eliminate the need for herbicides.

Main herbicides

Tomato
Presowing and pretransplanting: glyphosate, glyphosate-trimesium, glufosinate-ammonium.
Pretransplanting: oxadiazon, pendimethalin, metribuzin, flufenacet, aclonifen, napropamide, trifluralin, dinitramine.

Pre-emergence: glufosinate-ammonium, metribuzin, aclonifen.
Post-emergence and post-transplanting: for dicots, metribuzin; for grass weeds or dicots, rimsulfuron, dinitramine; for grass weeds, cycloxydim, cletodim, fenoxaprop-P-ethyl, fluazifop-P-butyl, propaquizafop, sethoxydim, quizalofop-ethyl.

Aubergine
Pretransplanting: glyphosate, glufosinate-ammonium, oxadiazon, pendimethalin, napropamide, dinitramine.
Post-transplanting: for grass weeds or dicots, dinitramine; for grass weeds, cycloxydim, fenoxaprop-P-ethyl, fluazifop-P-butyl, sethoxydim.

Capsicum
Pretransplanting: glyphosate, glufosinate-ammonium, oxadiazon, pendimethalin, trifluralin, dinitramine.
Post-transplanting: for grass weeds or dicots, dinitramine; for grass weeds, cycloxydim, fenoxaprop-P-ethyl, fluazifop-P-butyl, sethoxydim.