◆ EPPO Standards ◆

GUIDELINES ON GOOD PLANT PROTECTION PRACTICE

PEA

PP 2/14(1) English

European and Mediterranean Plant Protection Organization
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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 2/14(1) English

Guidelines on good plant protection practice

PEA

Specific scope

This standard describes good plant protection practice for pea.

Specific approval and amendment

First approved in September 1998.

This guideline on GPP for pea (*Pisum sativum*) 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(1) Principles of good plant protection practice. The guideline covers methods for controlling pests (including pathogens and weeds) of *Pisum sativum*.

Peas are an annual crop grown in northern Europe from seeds sown in March or April (in southern Europe in January or February). Peas are grown for 3 main purposes:

(1) vining peas, i.e. green-harvested, fresh peas used for human consumption, mainly as frozen peas.

(2) combining peas, i.e. dry-harvested peas, canned or consumed as dry peas by humans or animals.

(3) whole crop used for animal feed, either alone or in mixture with a grass or cereal crop.

The guideline can also be adapted for use on seed crops of pea.

Many pests are capable of reducing pea yields, spoiling quality, jeopardizing the reliability of production on the farm and disrupting throughput at the factory. In a high proportion of cases with vining peas and combining peas for human consumption, crop treatment may not be justifiable for yield increases alone, but product quality and contamination are primary reasons for control measures to be carried out.

GPP in peas is based on several important elements. The cultivation methods used should help to reduce the incidence and severity of the most important pests. Most important is a crop rotation including peas only every 5-6 years, and also the use of disease-free seeds. There are subtle and often unnoticed losses, which may result from a gradual build-up of soil-borne pests, presenting little positive evidence to the casual observer, but in fact gradually reducing vitality and profitability. Use of threshold values and warning systems to establish the need for and timing of the application of plant protection products is recommended together with selection of the most suitable product for the plant protection problem concerned.

GPP for peas should include the growing of pea cultivars resistant to pests but, so far, the availability of such cultivars leaves a lot to be desired. Similarly, biological control is not available at the moment for pea growing, and therefore forms no part of GPP in pea.

Control strategies are dependent on the combination of pests present in the field environment and include different combinations of other crops in the rotation, the use of tolerant to resistant cultivars, herbicide treatments, seed treatments with fungicide in conjunction with appropriate cultural practices, improvement of soil drainage and aeration, green-manure application, spring seedbed preparation, and the regulation of pH. All these factors can be integrated into a GPP control strategy.

It is also GPP to use appropriate application techniques, and to reduce drift and unwanted dispersal. To avoid resistance, repeated use of plant protection products with the same mode of action should be avoided.

The principal pea pests considered are the following:

- *Aphanomyces euteiches* (aphanomyces root rot);
- *Pythium* spp. (root rot);
- *Peronospora viciae* (downy mildew);
- leaf and pod spot (*Ascochyta pisi*, *Mycosphaerella pinodes*, *Phoma medicaginis* var. *pinodella*);
- *Fusarium solani* (fusarium root rot);
- *Chalara elegans* (black root rot);
- *Fusarium oxysporum* f.sp. *pisi* (fusarium wilt);
- *Rhizoctonia solani* (rhizoctonia seedling rot);
- *Sclerotinia sclerotiorum (*sclerotinia rot);
- *Erysiphe pisi* (powdery mildew);
- *Botrytis cinerea* (grey mould);
- *Uromyces pisi* (rust);
- *Pseudomonas syringae* pv. *pisi* (bacterial blight);
- viruses;
- *Tipula* spp. (leatherjackets);
- wireworms;
- cutworms;
- leaf-feeding noctuids;
- thrips;

- weevils;
- *Acyrthosiphon pisum* (pea aphid);
- *Contarinia pisi* (pea midge);
- *Cydia nigricana* (pea moth);
- white grubs;
- *Bruchus pisorum* (pea seed beetle);
- *Heterodera goettingiana* (pea cyst nematode);
- millipedes;
- slugs and snails;
- weeds.

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.

Aphanomyces euteiches (aphanomyces root rot)

General

Aphanomyces root rot is one of the most important fungal diseases in certain pea-growing areas. The fungus can survive in plant debris for up to 15 years. In soils conducive for the disease, straw-coloured lesions start to spread as early as 10 days after planting, through the cortex. The cortical tissue becomes soft and decays without affecting the vascular tissue. Infected tissue often reveals typical oospores.

Basic strategy

The only reasonable way to control *A. euteiches* is by growing pea in long rotations (6 years between peas) and to avoid growing pea in infested fields. Any drainage or compaction problems should be corrected before sowing. In some countries, a soil test is available and is recommended for fields frequently cropped with peas. Some moderate-level resistance has been identified but is not yet available in commercially grown cultivars. No efficient chemical control is possible.

Pythium spp. (root rot)

General

Pythium root rot caused by *Pythium* spp. causes a watery soft rot resulting in root pruning in the early stages of emergence and onwards. The disease is promoted by a cold, wet seedbed, especially in early sowings of pea where seed is of low vigour.

Basic strategy

Fungicidal seed treatment is highly effective (phenylamides and dithiocarbamates). Some resistance has been shown to be linked with anthocyanin-pigmented seed coats. Sowing in cold, wet soil giving a low germination rate should be avoided. Any drainage or compaction problems should be corrected before sowing.

Main fungicides

Seed treatments: metalaxyl, oxadixyl, thiram.

Peronospora viciae (downy mildew)

General

Two types of infection characterize downy mildew (systemic and local). Systemically infected plants are severely stunted with heavy sporulation on the leaves. The plant usually dies before flowering. Systemic infection originates from soil and plant debris. Local infections often begin on the lower leaves and are spread upward in the crop and from plant to plant by wind-borne sporangia. In the case of both systemic and local infections, mouse-grey sporangiophores form on the under side of the leaves, corresponding to yellow-green lesions on the upper surface. Sporangium production in the field requires 12 h of at least 90% relative humidity.

Basic strategy

Seed treatment can reduce the number of systemically infected plants and thus reduce the severity of local infections. Frequent pea growing and sowing of untreated seeds in fields with heavy infections in the past should be avoided. European cultivars vary widely in their resistance to the disease. Selection of the more tolerant types should be possible in areas prone to downy mildew.

In some areas, *Peronospora viciae* has developed resistance to phenylamide fungicides (metalaxyl and oxadixyl). Where resistance has been confirmed, products containing alternative fungicides should be used.

Main fungicides

Seed treatments: cymoxanil, fosetyl-aluminium, metalaxyl, oxadixyl.

Leaf and pod spot (*Ascochyta pisi*, *Mycosphaerella pinodes*, *Phoma medicaginis* var. *pinodella*)

General

The so-called "ascochyta complex" causes leaf and pod spot on the above-ground plant parts and discoloration of the cotyledons, hypocotyls, epicotyls and root systems. The behaviour of the three members of the compex can be distinguished as follows:

- *Ascochyta pisi* causes true leaf, stem and pod spot. The symptoms include tan-coloured, circular, sunken lesions sharply delimited from healthy tissue. *A. pisi* is seldom found on plant parts below the soil surface;
- *Mycosphaerella pinodes* causes numerous small, dark-brown or purple spots on the above-ground plant parts. These spots can develop into small water-soaked patches which may enlarge, fuse, and totally destroy the affected plant parts within a few days. The disease develops rapidly under warm wet conditions. *M. pinodes* can also cause foot rot which is a black rot mainly located around the cotyledon area;
- *Phoma medicaginis* var. *pinodella* causes lesions very similar to those of *M. pinodes*, but the spots do not develop into water-soaked patches. Where *M. pinodes* is the dominating pathogen above ground, *P. m. pinodella* is the dominating root-rot pathogen.

Basic strategy

The three pathogens are seed-borne. Use of healthy seed produced in dry areas is the best way to avoid the pathogen. There are cultivars available with resistance to *A. pisi*, but the fungus exhibits different races in geographic areas. The resistant cultivar should be chosen according to the most prevalent race. No genetic resistance to *M. pinodes* is available in commercial cultivars, despite sources of resistance which have been identified. Different degrees of tolerance have been seen. Avoidance of infected seeds is the best way to avoid root rot caused by *M. pinodes* and *P. m. pinodella*. Crop rotation should be practised because high levels of soil-borne inoculum cannot be controlled effectively by seed treatment. A seed test before sowing is recommended to avoid seed lots with high proportion of infected seeds. Seed treatment with fungicides can reduce the number of infected plants, whereas sprays can reduce foliar infection.

Main fungicides

Seed treatments: thiram, thiabendazole.

Sprays: carbendazim, chlorothalonil, iprodione.

Fusarium solani (fusarium root rot)

General

Fusarium root rot is primarily caused by *Fusarium solani* f.sp. *pisi*, but several other *Fusarium* spp. (*F. oxysporum*, *F. culmorum*, *F. avenaceum*, *F. redolens*) are able to cause cortical rot. They usually attack the cotyledonary area, epicotyl and hypocotyl. The external root colour becomes dark brown. The symptoms never progress above the soil line. Fusarium root rot caused by *F. solani* f.sp. *pisi* gives a deep red discoloration in the vascular tissue which can be seen especially near the cotyledon area.

Basic strategy

There is no commercial cultivar which is resistant to the whole complex of *Fusarium* spp. However, there are large differences in tolerance which can be used with advantage when combined with good tillage practice and a rotation of at least 5 years between legume crops. Use of fungicidal seed protectants minimizes seed contamination and can to a minor extent reduce infection by soil-borne inoculum. A soil test of fields frequently cropped with peas is recommended.

Main fungicides

Seed treatments: fludioxonil, maneb, mancozeb, thiabendazole, thiram.

Chalara elegans (black root rot)

General

Chalara elegans (syn. *Thielaviopsis basicola*) causes black root rot on the whole root system below the soil line. It does not affect the cotyledons (unlike other root pathogens in pea). The fungus survives for several years by means of thick-walled chlamydospores.

Basic strategy

Black root rot only appears in fields frequently cropped with peas. There are no control measures other than avoidance of naturally infested fields. A soil test of fields frequently cropped with peas can be recommended.

Fusarium oxysporum f.sp. *pisi* (fusarium wilt)

General

Fusarium wilt or Saint John's disease is one of the best known diseases in peas. Several races have been described, of which only races 1 and 2 are present and important in the EPPO region. The symptoms include downward curling of leaves and stipules which then turn grey. Wilting progresses from the lower leaves to

the top of the plant. The roots seem to be unaffected, but a longitudinal cut of the stem exposes an orange to red discoloration which progresses in the vascular tissue from the root into the stem. Race 2 can cause symptoms of cortical rot.

Basic strategy

The only effective control measure is genetic resistance. Most commercially grown cultivars have resistance to race 1 and an even greater number to race 2. Because cool soil temperature is unfavourable for the pathogen, early sowing may reduce disease severity.

***Rhizoctonia solani* (rhizoctonia seedling rot)**

General

Rhizoctonia seedling rot (due to *Thanatephorus cucumeris*, anamorph *Rhizoctonia solani*) is considered to be of minor importance on pea. Symptoms appear on seedling hypocotyl and epicotyl as reddish to brown lesions. The apex of the germinating seedling may be affected and a second shoot may arise from the first node.

Basic strategy

No genetic resistance is available and fungicide treatment only reduces the seed rot and not the epicotyl rot.

Main fungicides

Seed treatments: flutolanil, pencycuron, thiram, tolclofos-methyl.

***Sclerotinia sclerotiorum* (sclerotinia rot)**

General

The disease is very common in warm wet weather conditions. Air-borne ascospores infect plants during the flowering stage. The infection progresses from moribund flowers which adhere to the stem and results in a wet rot and collapse of the tissue. The fungus produces dense white mycelium within which dark brown-black sclerotia, resembling rodent droppings, are formed. The disease progresses rapidly from plant to plant resulting in pod decay and subsequent death of the plants.

Basic strategy

The fungus has a wide host range and rotation is of limited value to prevent infection. Avoidance of frequent cropping with susceptible hosts and the choice of cultivars with more open foliage, such as afila types, will help to reduce the risk. Deep ploughing can help to reduce the number of sclerotia in the upper soil layers, thereby reducing the potential for production of apothecia and ascospores. Foliar sprays during flowering will also protect the crop.

Main fungicides

Sprays: carbendazim, iprodione, thiophanate-methyl, vinclozolin.

***Erysiphe pisi* (powdery mildew)**

General

Powdery mildew is commonly seen in the latest sown cultivars of vining pea. It can occasionally be very destructive, in a period with a combination of warm days and cool nights with dew formation. The foliage becomes blue-white with small black cleistothecia in mature lesions.

Basic strategy

New resistant cultivars are available and are recommended in geographical areas with high risk of *Erysiphe pisi*. Early sowing reduces the risk of powdery mildew. Chemical control is rarely applied specifically against this fungus. If necessary, a single fungicide spray may be used.

Main fungicides

Sprays: cyproconazole, difenoconazole, propiconazole, sulphur.

***Botrytis cinerea* (grey mould)**

General

Grey mould (due to *Botryotinia fuckeliana*, anamorph *Botrytis cinerea*) is a very common disease which adds to losses through other causes in excessively wet harvests. The fungus is most likely to appear first on moribund tissue, and then to develop as a destructive parasite. In peas, therefore, the commonest site of initial infection is the withering flower petal. Damage is greatly encouraged by wet weather during flowering, when damp petals stick to the young pods, or in the leaf axils, instead of blowing harmlessly away. These provide ideal sites for disease development; in addition the humid microclimate leads to rapid development of the mould.

Basic strategy

Once *B. cinerea* is established in a crop, it cannot be controlled effectively. Because flower petals are the primary site of infection, protection of pods is best affected by treating the crop with fungicides before infection takes place. This is of particular value during

wet weather conditions. In vining peas and edible-podded peas, a single application should be made at the first pod-set stage, when the maximum number of flowers is exposed. In combining peas, two applications have been shown to be effective in reducing the number of infected pods and the amount of stained produce, as well as providing an increase in yield. A spray should be applied at the first pod-set stage and repeated 10-14 days later, if weather conditions remain favourable for disease development.

Growers in areas where wet weather is likely to occur during the flowering and pod-setting period may be able to choose some of the more determinate, shorter-strawed cultivars with a semi-leafless habit. These types produce a more open crop with a drier microclimate.

Main fungicides

Sprays: benomyl, carbendazim, chlorothalonil, fludioxonil, iprodione, thiophanate-methyl, vinclozolin.

***Uromyces pisi* (rust)**

General

Rusty brown uredosori (containing the urediniospores or summer spores) appear on the leaves of pea, or more rarely on the stems and pods. The first uredosori may be observed on the lowest leaves at a plant height of 10-20 cm. The blackish-brown teliosori (in which the teliospores or winter spores are formed**)** generally appear at the end of the growing season (after flowering). Heavily infected leaves (or the whole plants) may dry prematurely.

The pathogen is holocyclic, and its spermogonia and aecidia develop on the alternate host *Euphorbia cyparissias***.** The uredomycelia of the fungus may overwinter on infected plant debris and cause epidemics in spring.

Pea rust has become an important pathogen of dry pea from the mid-1980s in some countries. In years of epidemics, the yield loss caused by the disease may be higher than 30%. The pathogen develops in warm, humid weather and may cause significant damages in poorly developed crops.

Basic strategy

The production and use of resistant cultivars is very important. *E. cyparissias* should regularly be eradicated from pea fields and their vicinities. Plant residues should be ploughed into the soil. Spraying of fungicides is possible.

Main fungicides

Sprays: chlorothalonil, cyproconazole, hexaconazole.

***Pseudomonas syringae* pv. *pisi* (bacterial blight)**

General

The disease is seed-borne, and even 0.01% of infected seeds can lead to severe attack. *Pseudomonas syringae pv. pisi* can survive up to 3 years on seeds. Often the disease is only noticed in wet growing seasons or after a late frost. It is spread in the field by rain splash and wind, or by debris carried by machines used in the field.

Basic strategy

Healthy seeds should be used. Resistant cultivars are known, but cultivars resistant to all races are not available. It is important to clean machines when going from one field to the next in order to prevent spread. No chemical treatments are known.

Viruses

General

Numerous viruses are known to infect pea. Dissemination occurs mainly via three transmission mechanisms, i.e. from plant to plant by aphid vectors, or free-living nematodes (*Trichodorus* spp.), or from generation to generation through seeds. For some viruses, symptoms are easy to recognize in the field but for others the symptoms are very insignificant and correct diagnosis demands much experience. The viruses are usually identified by serological tests combined with transmission electron microscopy.

Basic strategy

Viruses transmitted by aphid vectors

PEMV (*Pea enation mosaic enamovirus*)

BLRV (*Bean leaf-roll luteovirus*)

PSV (*Pea streak carlavirus*)

BYMV (*Bean yellow mosaic potyvirus*).

Efficient control of aphids is important to avoid rapid spread of the diseases, because even a very low number of aphids can introduce viruses into the field. PEMV and BLRV can be controlled to some extent through the use of tolerant pea cultivars. PSV persists primarily in lucerne. Immigrant aphids from nearby lucerne fields should be controlled (see Aphids below).

Viruses transmitted by nematodes

PEBV (*Pea early browning tobravirus*).

A pre-sowing treatment with a nematicide may be applied if large populations of *Trichodorus* spp. have been detected.

Viruses transmitted through seeds

PEBV (*Pea early browning tobravirus*)

PSbMV (*Pea seed-borne mosaic potyvirus*).

Healthy seeds should be used, derived from certified stock. All new breeding lines from germplasm collections should be tested before inclusion in field nurseries.

Tipula spp. (leatherjackets)

General

The presence of leatherjackets usually becomes apparent soon after crop emergence, especially where peas are sown after grass. Pairs of shoots emerge together, and lifting entire seedlings reveals that these are replacing the primary shoot, which has been severed. The pests themselves are frequently found in the soil nearby.

Basic strategy

Wherever peas are to be sown following grass, the ploughed turf should be carefully examined and if many leatherjackets are found, treatment should be carried out before drilling, so that the material may be thoroughly incorporated. Post-emergence treatment can also be carried out but, in dry conditions, control may not be fully effective.

Main insecticides

Chlorpyrifos, lindane.

Wireworms

General

Wireworms are the larvae of click beetles. They are golden yellow in colour, elongate, smooth and rigid, with three pairs of short legs at the head end of the segmented body, which varies in length from 13 to 37 mm. Peas are seldom seriously damaged by this pest, but where attacks do occur they are most likely to take place in March, April or May, in crops drilled on ploughed-up grassland. Some plants will die, and others will be weakened; yield may be reduced if severe loss of plants occurs.

Basic strategy

Preceding crops which favour these pests (e.g. long-term grassland or uncultivated land) should be avoided. If peas do follow grass, it is advisable to plough the preceding grassland early, and to examine the ploughed turf for the presence of these pests. Damage is often more serious the second year after ploughing. Treatment is as for leatherjackets.

Main insecticides

Chlorpyrifos, lindane.

Cutworms

General

Cutworms are the caterpillars of many species of medium-sized moths of the family *Noctuidae*, such as *Agrotis segetum*, *A. exclamationis* and *Noctua pronuba*. They are large, stout-bodied caterpillars, 30-40 mm long, smooth and drab in colour. They feed at night. The plant population may be markedly reduced where there is a high level of infestation. Seedlings and young plants are rarely susceptible to attack, except for late-sown peas in dry conditions on light soils. A typical sign of cutworm attack is when individual plants, or a few adjoining plants in a row, are found lying over to one side, wilting, with stems partly or wholly severed at the soil surface. Some degree of defoliation may also occur.

Basic strategy

Control can be based on forecasting systems. Pheromone traps should be used to monitor the incidence of first or second-instar larvae to enable appropriate timing of insecticide sprays. It is extremely difficult to control later instars.

Main insecticides

Sprays: acephate, beta-cyfluthrin, chlorpyrifos, cypermethrin, deltamethrin, esfenvalerate, lambda-cyhalothrin.

Leaf-feeding noctuids

General

Caterpillars of noctuids such as *Autographa gamma*, *Heliothis* spp., *Lacanobia* spp. and *Mamestra* spp. feed on young foliage, flowers and fruits of peas. High relative humidity (95-100%) is needed for eggs and first-instar larvae to develop. Females lay eggs on flowers, on the tips of young growth, and on newly set young fruits. Some species are migrant and it is therefore difficult to predict their attack.

Basic strategy

Control of noctuids should be linked to forecasting systems. Pheromone traps are available for some species. Crops should be checked regularly for eggs and young caterpillars. High-volume foliar sprays are used when most of the larvae are in the first and second larval instars. One treatment is sufficient, unless females lay eggs and they hatch over an extended period.

Main insecticides

Sprays: alpha-cypermethrin, beta-cyfluthrin, cyfluthrin, cypermethrin, deltamethrin, lambda-cyhalothrin.

Thrips

General

Thrips are tiny insects (1–1.7 mm long). Adults are generally black or brown in colour, while nymphs are often red, orange or yellow. Many species are polyphagous. *Thrips angusticeps* damages newly emerged seedlings of pea. The attack is concentrated primarily on the youngest, folded leaflets and may not be fully apparent until they open. Affected leaflets become characteristically tough and leathery, sometimes deformed, and they take on a yellowish, mottled colour, which is often the first sign noticed by the grower. If such leaflets are held up against the light, translucent spots (feeding marks) can be seen. Although pea crops may appear to be retarded by those pests, most outgrow an attack. In very cold weather, where growth is slow, damage may appear quite severe, and patches of dwarfed plants persist throughout the season. *Kakothrips pisivorus* feeds on pea in June and July causing silvery mottling on leaves and pods, blind flowers and distorted pods.

Basic strategy

Thrips have quite a wide host range and can, therefore, survive in a field for a number of seasons. Where peas follow brassica crops, *T. angusticeps* may be a problem. If insecticide spraying is warranted, it should be applied as soon as damage is obvious to newly emerged seedlings. In many cases, the crop will outgrow the effects of leaf damage without apparent loss of yield or delay in maturity. *K. pisivorus* may be a serious pest where there is no crop rotation. While treatment is not generally justified, it may be necessary to spray vining peas where damage is occurring, especially in cool weather before harvest. Use of insecticides for certain other pests, e.g. pea moth and aphids, may give control of thrips.

Main insecticides

Sprays: deltamethrin, dimethoate, fenitrothion.

Weevils

General

Sitona lineatus (and other *Sitona* spp. such as *S. humeralis*, *S. macularius* and *S. sulcifrons*) are "broad-nosed" weevils, usually with pale and dark longitudinal banding, 3-6 mm in length. The larvae are found on the roots where they feed on nodules for several weeks. Seedlings and young plants may have a considerable proportion of their leaf tissue destroyed and the effects may continue to be found on the lower leaves of quite mature plants. The adults eat U-shaped notches around the margins. The plants do not appear to be permanently damaged by these effects, except perhaps when a heavy attack develops very early. Damage to the root nodules may have a more significant yield effect, as it reduces the supply of nitrogen. Severely affected crops may exhibit symptoms of nitrogen deficiency, particularly when pest damage occurs in conjunction with other factors causing plant growth stress. Damage is generally most marked on the headlands.

Basic strategy

S. lineatus is probably the commonest pea pest throughout the main pea-growing areas of northern Europe. Peas grown near fields of vicia beans are especially at risk, but attacks may develop almost anywhere. It is particularly important to examine very carefully those crops which are slow to emerge, and those where there is a cloddy seedbed offering ample hiding places for the pests and encouraging uneven emergence of seedlings. In these circumstances pea weevils can continually eat away the emerging seedlings as they appear, retarding a crop severely. Although sprays applied as soon as serious levels of damage are seen will check further weevil activity, reductions of larvae are seldom achieved by such treatment.

Main insecticides

Sprays: bifenthrin, cyfluthrin, deltamethrin, dimethoate, fenitrothion, lambda-cyhalothrin, tralomethrin, triazophos.

Seed treatments: furathiocarb.

Acyrthosiphon pisum (pea aphid)

General

Aphids reduce yield by spoiling flowers, by causing the failure of pods to fill, and by generally reducing plant efficiency. They transmit virus diseases, such as pea enation mosaic and pea seed-borne mosaic. The aphids may cause direct feeding damage to peas. The aphid survives the winter as eggs on other legumes (clover, etc.). At 20°C, a new generation develops every 10 days. Under warm and dry conditions, rapidly growing top shoots may be deformed due to aphid damage.

Basic strategy

Direct damage from aphids varies from year to year. Aphids only multiply when conditions become favourable (warm and dry). Very warm conditions may, however, result in population crashes. Numbers of aphids in the field may be assessed by, for example, shaking or beating pea plants over a white tray, on which the aphids can be counted. Foliar sprays should

be applied when a suitable threshold is reached. Repeated applications may be necessary.

Timing of application can affect the degree of virus infection as well as yield loss. In the case of pea seed-borne mosaic and pea enation mosaic, aphids should be controlled as soon as colonies are found, especially if this occurs before flowering. Where aphid infestation occurs later in the growing season, yield of peas increases from insecticide application up to the time of the development of the fourth pod-bearing node, but aphids which invade crops after that stage do not cause appreciable yield loss. Use of certain selective insecticides (e.g. pirimicarb) will favour natural enemies.

Main insecticides

Sprays: acephate, alpha-cypermethrin, beta-cyfluthrin, beta-cypermethrin, cypermethrin, deltamethrin, dichlorvos, dimethoate, esfenvalerate, heptenophos, formothion, methomyl, pirimicarb, triazamate.

Contarinia pisi (pea midge)

General

Crops in which the developing flower buds are still protected by leaflets are at risk from this pest. The most obvious sign of attack is a bunching of the buds, an effect which is caused by a foreshortening of the flower stalks. Closer examination of these sites of infestation, and careful peeling back of leaflets and petals, will reveal the presence of a number of the small white larvae of *Contarinia pisi*.

Growth and development are retarded; the feeding habits of the larvae render buds sterile and encourage the development of fungal infections, especially by *Botrytis cinerea.* Yield may be much reduced. Occasionally larvae are to be found in the pods, and there is a very slight possibility that some contamination of the produce may occur.

Basic strategy

While it appears that combining pea cultivars are less severely damaged by *C. pisi*, there is little evidence of differences in susceptibility between cultivars of vining peas. The prime sources of *C. pisi* are fields which carried heavily infested crops in the two previous seasons. Sowing peas in areas adjoining such infested fields should be avoided where possible. Crops which are not attacked until the end of flowering will not suffer significant loss but, if attacked, may contribute to an increase in the general level of midge population in the area. Large-scale rotational practice involving neighbouring farms could be considered. In areas of high incidences of attack, routine spraying of vining peas is recommended as soon as the first midges are seen in the crop.

Main insecticides

Sprays: fenitrothion, pyrethroids as for aphids, triazophos.

Cydia nigricana (pea moth)

General

Pea plants which are producing their first flowers in mid-season, and later crops, are susceptible to attack, particularly in areas where peas have been grown for several years. There are no external symptoms of attack, and it is not until vining or combining that damage becomes apparent.

The caterpillar of *C. nigricana* feeds on peas within the pod. In the case of vining peas, there is a risk of contamination of the end product with caterpillars, frass and damaged peas. It is likely that crop rejection may result.

Basic strategy

Moth attacks are most frequent and most damaging in intensive combining pea-growing areas, where populations have reached very high proportions. Spray applications should be related to the development of the insect rather than to the stage of growth of the crop. Therefore, sprays should be applied while the larvae are exposed, i.e. from the time of hatching to the time of entering the pods. The timing of applications is critical if maximum control is to be achieved. The forecasting system is based on reaching a threshold catch in pheromone traps. For combining peas, a typical threshold catch to determine the date on which spraying should be carried out is 10 or more moths caught in either of the two traps on two consecutive occasions. If a threshold catch is not achieved, experimental evidence suggests that spraying of combining peas is not necessary as the amount of damage would be negligible. Pheromone traps should only be used as a guide to moth activity in vining peas, since thresholds for this crop have not been established.

Main insecticides

Sprays: heptenophos, pyrethroids as for aphids, triazophos.

White grubs

General

White grubs (larvae of beetles such as *Melolontha melolontha, M. hippocastani, Phyllopertha horticola and Amphimallon solstitiale*) feed on roots of pea plants. The plants may be destroyed. The adult insect lays eggs in batches into the soil to a depth between 3 and 10 cm, according to the different species. The eggs hatch in summer and the white-bodied plump larvae do

not move very much in the soil. The development of the larvae takes between 2 and 4 years and adults emerge after pupation in soil. Damage increases as the larvae develop and is often highest in the second year.

Basic strategy

Control of the pests should be directed towards the larvae. Cultural treatments such as ploughing expose the larvae to birds as important predators, but also to adverse weather conditions. Roto-tilling may physically destroy some of the larvae. The crop rotation should be adjusted and susceptible crops should not be grown in newly ploughed grassland, where populations can be very high.

Chemical control is possible by soil treatment, but should only be done if infestations are severe. In case of doubt, the soil should be assessed for the number of larvae per m^2 and local thresholds should be respected. Chemical control should be done in spring following the flight period (that usually takes place about every 3 years). If chlorpyrifos is used, it should be applied pre-sowing or pre-planting, the other insecticides can be applied in the seed furrows.

Main insecticides

Soil treatments: carbofuran, chlorpyrifos, fonofos.

***Bruchus pisorum* (pea seed beetle)**

General

Bruchus pisorum lays eggs on the developing pods. After hatching, the larvae bore into the pods (the entry hole closing later) and into the seed, where development takes 2-3 months and the seeds are damaged. The adults can emerge before or after the dried seeds have been put into storage. However, *B. pisorum* is not a pest of stored peas, as it cannot multiply in stored seeds. Hibernation of adults may take place inside the seeds in crop remnants left in the field or in litter. The pest causes damage to vining peas and also reduces emergence in peas for seed.

Basic strategy

Destruction of plant remnants after harvest can help to minimize the infestation. Only non-infested seeds should be sown. Insecticide sprays may be used against the adults as soon as infestation is found in the field, but before filling of the earliest pods.

Main insecticides

Sprays: deltamethrin, lambda-cyhalothrin.

***Heterodera goettingiana* (pea cyst nematode)**

General

Heterodera goettingiana is a soil-borne pest, and peas grown in infested soil usually begin to show signs of failure in late June. The symptoms often occur in clearly defined patches, in which the plants are short, upright, and small-leaved; the few flowers they produce tend to be early and the foliage becomes increasingly yellow. The root system is poorly developed, there are very few root nodules present, and many tiny lemon-shaped cysts can be found embedded in the outer tissues of the roots. Crop failure in such areas is likely to be complete. Although symptoms are generally first noticed in small patches, the patches will increase in size year after year if host crops are repeatedly grown until the entire field is affected. It is important not to be misled by the fact that many plants attacked by *H. goettingiana* so become infected with fungi, notably *Fusarium* spp., and many show clear symptoms of such diseases.

Positive laboratory identification is strongly advised. The initial damage is likely to be some loss of yield, coupled with the inconvenience of uneven maturity. If the problem is unchecked, the extent of the area in which yield is lost will increase until the field concerned will produce no crop of peas at all.

Basic strategy

In the absence of a host crop, the population of cyst nematodes is likely to fall quite rapidly, although not necessarily at a constant rate. However, even a low population will quickly increase to the original level if a host crop is grown. Broad beans, field beans and vetches are hosts of this nematode and, although the effect of the pest on these crops is negligible compared with its effect on peas, these other plants do sustain the nematode population. Since the cysts are present in the soil, every effort should be made to clean as much soil as possible from machinery leaving sites known to be infested. If treatment is necessary, granular nematicides can be incorporated into the soil of infested fields immediately before sowing. There is no chemical treatment for crops which are already infested. Soil treatment is relatively expensive, but the only alternative is not to grow peas again on the field concerned.

Main nematicides

Dazomet, oxamyl.

Millipedes

General

There are two important species which may severely damage peas, the spotted millipede, *Blaniulus guttulatus*, and the flat millipede, *Polydesmus angustus*. The adults have many segments with a pair

of small legs on each. *B. guttulatus* is yellowish grey in colour, round and smooth, with a row of distinct crimson or purple spots along each side of the body, which is 7-18 mm in length. *P. angustus* is rather larger, flattened in shape (as its name implies), and each of its 20 segments is covered with a bumpy shield. Flat millipedes are usually about 25 mm in length. Plants are particularly susceptible to attack during the early stages of establishment. Seeds are rasped and tunnelled and underground tissue may be partially destroyed.

Basic strategy

These millipedes can be controlled by the same treatments as other soil arthropod pests. Infestations are rarely high enough to warrant specific measures.

Slugs and snails

General

Pea plants are always liable to be attacked by molluscs, such as the slugs and snails *Deroceras reticulatum*, *Arion hortensis*, *Milax* spp., *Arion ater and Helix aspersa*, especially in damp conditions. Young plants may be completely defoliated; gaps appear in the rows, often in quite large patches. These particular pests are also liable to occur as contaminants in vining peas, especially in wet harvesting conditions and, in consequence, crops with heavy infestations are likely to be rejected. Slugs and snails prefer a damp environment and are most active at night. Some species of snails are particularly numerous on chalky soils. Eggs are laid in batches in the soil and usually take a month to hatch. Young slugs may take a year to complete their development.

There is loss of leaf area, loss of vigour in damaged plants, encouragement of diseases through tissue damage and danger of rejection through contamination of produce, particularly with snails.

Basic strategy

Good field drainage is essential, since wet places provide ideal sites for slugs and snails. Monitoring developing infestations is possible by using slug-pellet traps at strategic places in the crop. Previous cropping and history of slug incidence and damage can also be good guides to the need for treatment. If an infestation develops, granular molluscicide baits should be applied. Some snail species migrate to the crop from headlands.

Main molluscicides

Metaldehyde granules, methiocarb granules.

Weeds

General

It is important to prepare a good seedbed in order to get an optimal germination of the pea crop. Early sowing of an even population under good growing conditions will lead to the establishment of a crop that will compete more successfully with weeds. Soil cultivation depends on soil type but should be minimal to avoid soil compaction and to maintain soil moisture. Debris from the previous crop should be destroyed. For certain problem weeds, it may be useful to plough in autumn, allow weeds to emerge, then apply a non-selective herbicide followed by cultivation. Alternatively, a tank mixture of a non-selective herbicide with a soil herbicide used pre-sowing can be applied. Established annual weeds can also be removed pre-sowing by mechanical methods, e.g. harrowing. Desiccation of combining peas can be required in weedy and unevenly ripened crops.

Basic strategy

Peas offer poor competition with weeds, so it is very important to grow them in fields with low weed populations, and to optimize timing of weed control measures. Some cultivars of peas are sensitive to certain herbicides. In vining peas, it is essential to remove species which cause contaminant problems, for example *Matricaria* spp., *Cirsium arvense*, *Linum usitatissimum*, *Papaver rhoeas*, particularly those with poisonous berries, *Solanum nigrum* and volunteer potato. It may be easier to control such weeds in other crops in the rotation.

The choice of herbicides should depend on the predominant weed species. Sowing to a suitable depth is important for crop safety in the case of certain soil-applied herbicides. Optimum timing of foliage-applied herbicides is important. Application of contact-acting herbicides to peas with poor leaf wax may cause damage and it is advisable that this is checked with a crystal-violet leaf-wax test. Additives/adjuvants should not be used unless recommended on the product label and tank mixing with other chemicals may reduce crop safety. High temperature together with high air humidity can be the reason for increased susceptibility of peas to some foliage-applied herbicides.

Main herbicides

Pre-emergence herbicides

Aclonifen, chlorbromuron, chlorpropham, cyanazine, diflufenican, isoxaben, imazapyr, fenuron, fomesafen, linuron, metribuzin, metolachlor, monolinuron, orbencarb, prometryn, terbutryn, terbuthylazine, triallate, trietazine, trifluralin (can cause damage in cold wet conditions), simazine.

Post-emergence herbicides

Bentazone, carbetamide (not vining peas), cyanazine, dimefuron (not vining peas), imazapyr, MCPB, pendimethalin (not vining peas), pyridate.

Grassweed herbicides, annual

Cletodim, cycloxydim, diclofop-methyl, fenoxaprop-P-ethyl, fluazifop-P-butyl, haloxyfop-methyl, propaquizafop (not vining peas), quizalofop, sethoxydim.

Grassweed herbicides, perennial

Cycloxydim, diclofop-methyl, fluazifop-P-butyl, propaquizafop (not vining peas).

Desiccation

Diquat, glufosinate-ammonium, glyphosate.