◆ EPPO Standards ◆

GUIDELINES ON GOOD PLANT PROTECTION PRACTICE

BEET

PP 2/13(1) English

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APPROVAL

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

REVIEW

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

AMENDMENT RECORD

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

DISTRIBUTION

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

SCOPE

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

REFERENCES

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

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

OUTLINE OF REQUIREMENTS

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

EUROPEAN AND MEDITERRANEAN PLANT PROTECTION ORGANIZATION
ORGANISATION EUROPEENNE ET MEDITERRANEENNE POUR LA PROTECTION DES PLANTES

PP 2/12(1) English

Guidelines on good plant protection practice

BEET

Specific scope

This standard describes good plant protection practice for beet.

Specific approval and amendment

First approved in September 1997.

This guideline on GPP for beet 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 (*Bulletin OEPP/EPPO Bulletin* **24**, 233-240, 1994). The guideline covers methods for controlling pests (including pathogens and weeds) of *Beta vulgaris*.

Three cultural types of *Beta vulgaris* are commonly grown in Europe for their roots: 1) *sugarbeet* grown as a field crop, for the high sucrose content of its roots. After sugar extraction, the by-products (molasses and pulp) may be used for raw or processed animal feed, or as fertilizer. Foliage may be used as fodder; 2) *fodder beet* grown as a field crop for its roots and foliage for animal consumption; 3) *table beet* grown as a vegetable crop outdoors or under protected conditions for its edible roots for human consumption. This guideline is mainly intended for sugarbeet. However, the pests of other types of beet are similar, and this guideline can readily be adapted for the other types of beet crops. Crops grown for the production of seeds for planting are not covered by this guideline.

Beet is a biennial crop mainly grown in northern and central Europe from pelleted seeds sown in March or April. In southern Europe, sugarbeet is grown as a winter crop, sown in September or October, often irrigated, and harvested in the following June or July. Protection of beet against pests aims at ensuring a good qualitative and quantitative yield of roots. The crop should be grown under good cultural conditions and within an optimal crop rotation (ideally 3-4 years between beet crops). This usually includes potatoes and/or cereals, etc. Beet plants are attacked by many pests, especially in the first few weeks after sowing. It is therefore GPP to create optimal growing conditions during that time, and to select plant protection products, and time and frequency of application, in such a way that an optimal result is achieved. GPP for sugarbeet should include the growing of beet cultivars resistant to pests, but so far the availability of such cultivars leaves a lot to be desired. Biological control is not available at the moment for beet growing, and therefore forms no part of GPP in beet.

Treatments of seeds and seedlings are particularly important and form a normal part of GPP for beet. In the past, beet seeds were sown in the clusters in which they form (polygerm seed) and later thinned. Seedlings remained to replace any that were destroyed by soil pests. Since pelleted monogerm seed is now used, these possibilities no longer exist and a destroyed seedling leads to a missing plant, with consequent yield loss. Early protection of individual seedlings from soil pests thus has particular importance in modern beet production, and soil treatments form part of GPP. If, however, a seed treatment may result in a reduced use of plant protection product early in the season, it is preferable to treat the seed. Later treatments may be needed in the crop at any stage. Combined spraying of different plant protection products is GPP if the pests to be controlled are indeed present or are to be expected. The farmer has to be familiar with the main pests, monitor his fields regularly and make full use of existing early warning systems and economic threshold values. Dosages should relate to the pest spectrum observed, taking account of the individual effects and possible interactions. The volume of spray liquid is normally between 100 and 400 L ha^{-1}. It is GPP, especially early in the season, to reduce drift and unwanted dispersal of plant protection products as much as possible by using drift-preventing covers on the nozzles or equipment that produces a good and uniform droplet spectrum across all nozzles on the spray boom. Granular applications should also meet the requirements concerning optimal distribution. Row applicators for granules and for herbicides in combination with mechanical weeding have been developed for beet fields, and should be used.

Resistance is developing to several plant protection products used in beet fields. It is GPP to avoid the use of such products, and it is also GPP to avoid spraying a plant protection product later in the season if that active substance has already been applied as a seed or soil treatment. Preferably an active substance with a different mode of action should be used. Toxicity to honeybees, and carry-over effects are generally of little significance in beet growing. Attention should be paid, however, to the effects on natural enemies, since these

play an important role later in the season and the next season.

This paper presents guidelines for GPP in relation to the following beet pests:

- *Cercospora beticola* (cercospora leaf spot);
- *Ramularia betae* (ramularia leaf spot);
- *Erysiphe betae* (powdery mildew);
- *Uromyces betae* (rust);
- *Peronospora schachtii* (downy mildew);
- *Pleospora bjoerlingii* and soil fungi;
- *Beet necrotic yellow vein furovirus* (rhizomania);
- *Beet yellows closterovirus* and *Beet mild yellowing luteovirus*;
- aphids;
- *Tipula* spp. (leatherjackets);
- wireworms and white grubs;
- *Blaniulus guttulatus* (snake millipede), *Scutigerella immaculata* (garden centipede) and *Onychiurus armatus* (springtail);
- weevils;
- cutworms and leaf-feeding noctuids;
- *Scrobipalpa ocellatella* (beet moth);
- *Pegomyia betae* (beet fly, mangold fly, beet leafminer);
- *Atomaria linearis* (pygmy mangold beetle);
- *Chaetocnema concinna* (mangold flea beetle);
- *Cassida* spp. (tortoise beetles);
- *Heterodera schachtii* (beet cyst nematode);
- other nematodes;
- 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.

Cercospora beticola (cercospora leaf spot)

General

Cercospora beticola causes round, grey spots with a red or brownish border and with smaller black spots in the centre. The leaf eventually dies, and a new leaf is formed. The disease is favoured by high humidity (above 80%) and temperatures around 25-28°C. It is also favoured by irrigation. A heavy infestation affects the yield, especially sugar production (in case of heavy attacks, losses may reach 20% of yield and 1-2% of sugar content).

Basic strategy

Infected beet debris should be ploughed in. A wide crop rotation decreases the risk of infection. Beet cultivars vary in their susceptibility to the fungus and this should be exploited in countries where the disease is very important (Mediterranean countries, where beet is grown with irrigation). Some cultivars, such as rhizomania-resistant cultivars, are highly susceptible to *C. beticola*. If infection becomes too serious, fungicide sprays may be required. Though preventive use of fungicides gives better control of the disease, the infection phases of *C. beticola* are not well known and it is thus difficult to determine the timing of fungicide applications. It may be noted that 2% leaf area necrosis caused by the disease has been shown to have little or no effect on yield, so the first application should be made only after appearance of the first symptoms in the field. Fields should therefore be regularly monitored for the presence of cercospora or ramularia leaf spot. In areas with low attacks, a single spray is normally sufficient. However, in more exposed areas, 2, 3 or even 4 applications may be needed.

Problems with resistance

Resistance to carbendazim has been reported in *C. beticola.*

Main fungicides

Sprays: benomyl, bitertanol, carbendazim, cyproconazole, difenoconazole, epoxiconazole, fentin acetate, fentin hydroxide, fluquinconazole, flusilazole, flutriafol, mancozeb, maneb, prochloraz, propiconazole, tetraconazole.

Ramularia betae (ramularia leaf spot)

General

Ramularia betae makes larger spots that *C. beticola*, without a red or brownish border zone. Smaller greyish-white spots appear in the centre of the larger spots. *R. betae* can induce 10-15% yield losses and 1% reduction of sugar content.

Basic strategy

Infected beet debris should be ploughed in. A wide crop rotation decreases the risk of infection. If infection becomes too serious, fungicide sprays may be required. The first application should be made only after

appearance of the first symptoms in the field. A single spray is normally sufficient.

Problems with resistance

Resistance to carbendazim has been reported in *R. betae.*

Main fungicides

Sprays: benomyl, bitertanol, carbendazim, cyproconazole, difenoconazole, epoxiconazole, fentin acetate, fentin hydroxide, fluquinconazole, flusilazole, flutriafol, mancozeb, maneb, propiconazole, tetraconazole.

***Erysiphe betae* (powdery mildew)**

General

Greyish-white mycelium appears on the upper side of the leaves. Powdery mildew, which occurs in most beet-producing areas, may cause severe yield losses (20% of root weight and 2% of sugar content) if it is badly or not controlled. The disease needs high humidity for its development and is favoured by irrigation.

Basic strategy

Fungicide sprays should be applied as soon as symptoms are seen. One or two applications may be needed. It is common practice to treat against *Erysiphe betae* and *Cercospora beticola* together, if both diseases are present. In this case, only the triazole fungicides are active against both fungi. If only *E. betae* is present, it is preferable to use a fungicide with specific action against powdery mildew.

Main fungicides

Sprays: fenpropimorph, fenpropidin, sulphur, triadimefon, triadimenol (specific action against powdery mildew), bitertanol, cyproconazole, difenoconazole, epoxiconazole, fluquinconazole, flusilazole, flutriafol, propiconazole, tetraconazole (triazoles).

***Uromyces betae* (rust)**

General

Uromyces betae is a rust which affects only beet, causing brown-orange spotting of the leaves with rusty pustules of urediniospores at the centre of the spots. The rust persists on overwintered seed crops or as teliospores contaminating seed lots. It exists at low non-damaging levels in most beet crops. It is favoured by temperatures around 18°C and may build up to damaging levels late in the season. Severe attacks can cause yield losses (15% of root weight and 1% of sugar content).

Basic strategy

Fungicide sprays should be applied when first symptoms are seen. In general, a single spray is sufficient but more may be needed in southern Europe. If suitable products are available, it may be convenient to combine this spray with treatments against *Cercospora beticola, Erysiphe betae* and/or *Ramularia betae.*

Main fungicides

Sprays: bitertanol, cyproconazole, difenoconazole, fenpropimorph, fluquinconazole, flusilazole, flutriafol, propiconazole.

***Peronospora schachtii* (downy mildew)**

General

Peronospora schachtii persists as oospores in the soil or in beet seed crops. Young rosette leaves of infected plants become light green or yellowish, thickened and distorted. Abundant greyish sporulation appears on the lower-leaf surface under moist conditions. This disease is generally of rather minor importance except in seed crops, but some serious attacks were seen on sugarbeet in the late 1980s.

Basic strategy

The rotation should be adapted to *P. schachtii* to reduce spread of the disease. When single plants are infected by *P. schachtii*, they should be removed. Sugarbeet can tolerate and recover from a certain level of downy mildew and it is rarely necessary to apply fungicides.

Main fungicides

Sprays: copper oxychloride, mancozeb, maneb, metalaxyl.

***Pleospora bjoerlingii* and soil fungi**

General

Various fungi may cause a brown to blackish discoloration of the roots of sugarbeet seedlings, which is often accompanied by a narrowing of the root collar. Such attacks are only important when the plants are young and are also known as damping-off or root-burn, wiping out entire section of a farmer's field. *Pleospora bjoerlingii* (anamorph *Phoma betae*) is seed-borne, occurring early and infecting the entire root, especially in acid soils. It may also cause leaf spot. *Pythium ultimum* (or other *Pythium* spp.) is a soil fungus,

infecting the root of the seedling a little later than *P. bjoerlingii*, especially during cold and wet weather and also in acid soils. *Aphanomyces cochlioides* (or other *Aphanomyces* spp.) is also a soil fungus, normally attacking the root collar and the base of the cotyledons. This fungus prefers higher temperatures, occurs at late sowing or a repeated sowing. It also prefers a low pH. *Thanatephorus cucumeris* (anamorph *Rhizoctonia solani*) can also cause damping-off of sugarbeet.

Basic strategy

Appropriate crop rotation prevents the build-up of soil-borne pathogens. For example, maize should be avoided as a preceding crop as it is a host for *R. solani*. Low pH of the soil and waterlogged conditions should be avoided. A good seedbed is essential. Early sowing on heavy soils, and shallow sowing in heated soils, should be avoided. The formation of crust should be avoided during the pre- and post-emergence phases of plant development. Beet seed is normally pelleted with one or several fungicides, with the intention of treating against all the locally important fungi, including both the seed-borne *P. bjoerlingii* and the soil fungi.

Main fungicides

Seed treatments may include one or several fungicides targeting individual fungi as follows:

Aphanomyces spp.: hymexazol, thiram;

Pythium spp.: hymexazol, mancozeb, maneb, metalaxyl, oxine copper, thiram;

P. bjoerlingii: iprodione, mancozeb, maneb, thiram;

Rhizoctonia solani: flutolanil, pencycuron, tolclofos-methyl, thiram.

***Beet necrotic yellow vein furovirus* (rhizomania)**

General

Beet necrotic yellow vein furovirus (BNYVV) causes yellowing of the leaves and sometimes a white-yellow discoloration alongside the veins. Its most characteristic symptom is the formation of an abnormally high number of side-roots on the main root (rhizomania). The vascular bundles turn brown. Yield and sugar content are reduced. The virus is transmitted by the soil fungus *Polymyxa betae*.

Basic strategy

Since there are no curative control measures, control aims at preventing a field from becoming infested. If a field is infested, control measures aim to keep the level of infestation as low as practicable. Introduction of the pathogen can be prevented by phytosanitary measures such as not using water from possibly contaminated drains, not using contaminated manure or soil, ensuring that agricultural equipment is clean. Harvested beets should be transported with as little soil as possible, which can be ensured by harvesting under dry conditions. The field should be well drained and a good soil structure should be maintained. Early sowing is recommended. If the soil is known to be infested, it is advisable to grow tolerant cultivars. Some partially resistant cultivars are also available. Since tolerant or partially resistant cultivars yield well even in areas without rhizomania, it is GPP to use them in any case. The above-mentioned measures are not necessary in countries were rhizomania is not present.

Soil disinfection for the purpose of controlling rhizomania only is not considered GPP.

Beet yellows closterovirus* and *Beet mild yellowing luteovirus

General

"Virus yellows" of sugarbeet is caused by two viruses, *Beet yellows closterovirus* (BYV) and *Beet mild yellowing luteovirus* (BMYV). Viruses may be introduced into fields by several species of green aphids. The most important are *Myzus persicae* and *M. ascalonicus*, but also *Acyrthosiphon pisum*, *Macrosiphum euphorbiae*, *Aulacorthum solani*. Viruses are then spread by the black aphid *Aphis fabae*. Symptoms (yellowing and thickening of the leaf blade) may be limited to more or less circular patches, or may occur on the whole plot. The disease may cause losses up to 20-30% of yield and 2% of sugar content.

The initial infestation is caused by aphids that have left their winter hosts and have fed either on weeds carrying the viruses (such as *Senecio vulgaris* or *Capsella bursa-pastoris*) or on beets with foliage left in spoil-heaps or as animal fodder. *Sugarbeet mosaic potyvirus* is also transmitted by the same aphids, but it is important only on seed crops.

Basic strategy

It is essential to prevent entry of the viruses into the crop, by precautionary measures and by direct control of the aphid vectors. Though little can be done about the virus pool in weeds, infected beet sources should be removed. Insecticides are generally applied as seed treatments or in the row at planting and it is GPP to apply such preventive treatments against aphids. However, they may not be sufficient and spray treatments may have to be applied later, on the basis of careful monitoring for the first appearance of green aphids, following warning systems if available. Considerable reductions in virus infection are possible. More specifically, the recommendations can be summarized as follows:

- avoid growing crops near beets for seed production;
- destroy virus sources as far as possible. Fodder beets should be used before foliage emerges in spring;

- apply insecticide as a seed treatment or as granules in the row, according to the need to control other insects at the seedling stage;
- ensure that a "closed" crop is obtained as early as possible, since flying aphids are attracted to fields with open spaces or fields that are irregular in stage or colour;
- apply corrective insecticide sprays if necessary, according to the recommendations of warning systems.

Problems with resistance

Variants of *M. persicae* resistant to some groups of insecticides (e.g. organophosphorus compounds) do occur, and product choice is very important in this case.

Main insecticides

Seed treatment: imidacloprid. Row treatments with granules: aldicarb, carbofuran, carbosulfan, disulfoton, oxamyl, phorate, terbufos. Foliar sprays: beta-cyfluthrin, chlorpyrifos-methyl, deltamethrin, dimethoate, esfenvalerate, ethiofencarb, heptenophos, lambda-cyhalothrin, methidathion, oxydemeton-methyl, phosphamidon, pirimicarb, tau-fluvalinate, thiofanox, thiometon, triazamate, trichlorfon, vamidothion.

Aphids

General

The aphids *Aphis fabae* and *Myzus persicae* may cause direct feeding damage to sugarbeet. They, and other aphids, are more important as vectors of beet viruses (see *Beet yellows closterovirus* and *Beet mild yellowing luteovirus*). The root aphid *Pemphigius fuscicornis* has caused occasional damage in central Europe in recent years, but no special control measures have been applied.

Basic strategy

Direct damage by *A. fabae* and *M. persicae* varies from year to year. Early-season treatments against aphids as virus vectors constitute the first step in control of aphids as pests. Later in the season, a generally accepted threshold for damage is when colonies of more than 30 aphids are present on 50% of the plants. A foliar spray should then be applied. Such treatments will generally not be useful if made after the foliage closes. In the case of heavy infestation, it is advisable to use a mixed formulation of contact and systemic insecticides.

Problems with resistance

Where organophosphorus-resistant strains of *M. persicae* exist, pirimicarb is preferred and will have the least effect on natural enemies.

Main insecticides

Foliar sprays: beta-cyfluthrin, chlorpyrifos-methyl, deltamethrin, dimethoate, esfenvalerate, ethiofencarb, heptenophos, lambda-cyhalothrin, methidathion, oxydemeton-methyl, phosphamidon, pirimicarb, tau-fluvalinate, thiofanox, thiometon, triazamate, trichlorfon, vamidothion.

Tipula spp. (leatherjackets)

General

Leatherjackets are the larvae of craneflies (*Tipula* spp.). They live in the soil and largest populations occur in grassland.

Basic strategy

Beet crops may be damaged when following grassland or land left uncultivated. The presence of larvae can be checked before ploughing the grassland by either taking soil cores and extracting larvae in the laboratory or by pouring a salt solution onto the ground, which forces the larvae to the surface. Beet is likely to be at risk when 50 larvae per m^2 or more are present. In general, the risk is practically always high after grassland, and damage from leatherjackets is unacceptable. Accordingly, it is GPP to apply a soil treatment, by overall spray, soon after grassland or land left uncultivated is ploughed in preparation for a beet crop.

Main insecticides

Overall soil spray: chlorpyrifos, lindane.

Wireworms and white grubs

General

The larvae of certain *Elateridae* (*Agriotes* spp., wireworms) and *Melolonthidae* (*Melolontha* spp., white grubs) damage the roots of beet plants. Wireworms cut the roots of young plants and damage older roots at collar level. White grubs damage roots, particularly in spring. Development of wireworms takes several years, and adults and larvae of different ages coexist each year. Development of white grubs takes 3-4 years and is generally synchronized. Damage normally only occurs from the 3rd larval stage onwards, starting in the year after adult flight.

Basic strategy

Preceding crops which favour these pests should be avoided (e.g. long-term grassland). Knowledge of the level of population of wireworms and white grubs in the soil is needed to make a decision on treatment. If the number of larvae is higher than 2 per m^2, a soil treatment, with granules in the row, is advised at sowing. Overall treatments used against *Tipula* larvae (see above) will also be effective against wireworms and white grubs. In the case of low infestations, it may be sufficient to use a seed treatment (imidacloprid used mainly against virus-vector aphids has some action).

Main insecticides

Overall soil spray: chlormephos, chlorpyrifos, lindane. Granules in the row: aldicarb, bendiocarb, benfuracarb, carbofuran, carbosulfan, isofenphos, phorate, phoxim, tefluthrin, terbufos. Seed treatments: imidacloprid, tefluthrin.

***Blaniulus guttulatus* (snake millipede), *Scutigerella immaculata* (garden centipede) and *Onychiurus armatus* (springtail)**

General

Centipedes, millipedes and springtails normally occur together as part of the soil-pest complex. They feed on the roots of seedlings and on very young seedlings, causing irregular feeding spots. Damage is by dying of seedlings or reduced growth and malformation, especially on moist and heavy soils after green manure or grass stubble. Springtails normally live on fungi and require moist conditions with sufficient organic matter.

Basic strategy

Wet spots in the field should be prevented and all measures taken to promote good germination and rapid seedling growth. Beet should preferably not be grown after green manure or grass seed. Infestation is also reduced by sowing in a shallow seedbed and mechanical weed control after emergence of the seedlings. If damage is expected, the normal insecticide treatment against soil pests should give adequate control.

Main insecticides

Seed treatments: imidacloprid, tefluthrin. Granules in the row: aldicarb, bendiocarb, benfuracarb, carbofuran, carbosulfan, chlorpyrifos, isofenphos, lindane, oxamyl, phorate, phoxim, tefluthrin, terbufos.

Weevils

General

Bothynoderes (Cleonus) punctiventris, Tanymecus palliatus, T. dilaticollis, Psalidium maxillosum, Otiorhynchus ligustici and *Lixus junci* may attack beet. The crop is most vulnerable to the weevils during germination and while it is still young. The main pest is the adult, except for *B. punctiventris* and *L. junci* which are also dangerous as larvae.

The weevils usually attack frontally. Plants are affected along the rows, less often patches. The symptoms are the following: regular or irregular feeding on the leaf or petiole, sometimes destruction of seedlings before or after emergence. Exceptionally, a whole planting may be destroyed.

The eggs of *L. junci* are laid in petioles and stems in notches made by the adult females with their rostrum. The larvae tunnel narrow galleries in the collar, then move up into the petioles which dry out. The adults also feed directly on the leaves.

The highest damage occurs in central and eastern Europe, caused by *B. punctiventris*, which is favoured by successive dry, warm springs. *P. maxillosum* does most damage in cool springs. The weevils develop in 1 or 2 years. Most species spread only on the soil surface and do not fly. They mostly feed during the evening and the night.

Basic strategy

Since weevil activity is not consistent, it is important to determine the insect population in autumn before overwintering, then in the spring during the vegetation on the old and new fields. It is also advised to determine populations of adults and larvae of *Carabidae*, which act as predators of the weevils and their larvae.

Various cultural methods will reduce weevil damage: proper crop rotation, timely sowing, conditions favouring regular and rapid seedling development, good weed control. Insecticides are generally applied as sprays along the rows, at the time of sowing. It may also be necessary to spray the edges of fields against immigrating weevils. The best time for spraying is late afternoon, when the weevils are feeding on plants above the soil.

Main insecticides

Seed treatments: carbofuran, imidacloprid, furathiocarb. Soil treatments: aldicarb, bendiocarb, carbofuran, carbosulfan, chlorpyrifos, diazinon, imidacloprid, phorate, tefluthrin, terbufos. Sprays: bensultap, cypermethrin, cartap, chlorpyrifos, deltamethrin, lambda-cyhalothrin, parathion-methyl, monocrotophos.

Cutworms and leaf-feeding noctuids

General

Cutworms (larvae of noctuids such as *Agrotis* spp., *Euxoa nigricans* and *Noctua pronuba*) live in the soil and feed on the roots of beet, mainly at collar level. Larvae of other noctuids shelter in the soil during the day and emerge at night to feed on the foliage (*Autographa gamma*, *Mamestra oleracea*).

Basic strategy

Though cutworms can be controlled with the soil-applied insecticides used for other soil pests (wireworms, white grubs, etc.), they can also be controlled by foliar sprays. A single spray application is generally sufficient, against young larvae, as soon as damage is seen. Leaf-feeding noctuids are controlled by foliar sprays as soon as damage is seen.

Main insecticides

Soil-applied (cutworms): chlorpyrifos, tefluthrin. Sprays: acephate, alpha-cypermethrin, beta-cyfluthrin, carbaryl, chlorpyrifos, cypermethrin, deltamethrin, esfenvalerate, lambda-cyhalothrin, triazophos.

Scrobipalpa ocellatella **(beet moth)**

General

Scrobipalpa ocellatella (syn. *Phthorimaea ocellatella*) is a microlepidopteran which emerges in April and lays its eggs in the collar of beet plants. The pink caterpillars, which reach 12 mm in length, move to the young leaves in the heart of the plant. There may be additional generations. Outbreaks are relatively infrequent (every 10 years or so).

Basic strategy

If an attack is expected, an insecticide spray should be applied before the larvae reach the young leaves.

Main insecticides

Sprays: lambda-cyhalothrin, trichlorfon.

Pegomyia betae **(beet fly, mangold fly, beet leafminer)**

General

Eggs are deposited on the lower side of the leaves. The larvae mine between the upper and lower epidermis, making transparent irregular mines that turn brownish when they dry up. There are normally several generations per year, but only the first inflicts damage.

Basic strategy

Economic damage occurs only when plants are small and chemical control is not needed after the 6-leaf stage. If systemic insecticides are used against the soil insect complex or aphids (as granules or seed treatment), these will control the first generation of *Pegomyia betae*. Otherwise foliar sprays may be used, on the basis of regular inspection of the crop, when the number of eggs or larvae per plant exceeds 4 at the 2-leaf stage, or 6 at the 4-leaf stage. One application is sufficient.

Main insecticides

Seed or soil treatments: aldicarb, carbofuran, carbosulfan, imidacloprid, oxamyl, phorate. Foliar sprays: acephate, alpha-cypermethrin, azinphos-methyl, beta-cyfluthrin, cypermethrin, deltamethrin, diazinon, dimethoate, disulfoton, esfenvalerate, fenthion, formothion, lambda-cyhalothrin, parathion-methyl, phosalone, phosphamidon, trichlorfon.

Atomaria linearis **(pygmy mangold beetle)**

General

Atomaria linearis is a brownish-black beetle which feeds just below the soil surface, making small round holes in stem and main root, killing some seedlings before emergence. *A. linearis* may also attack the leaves under humid conditions. If the crop is still in the 1-2-leaf stage, damage may be considerable.

Basic strategy

Adult beetles hibernate in left-over foliage of spinach and beet. They are reactivated by higher spring temperatures and move over short distances to nearby fields, normally by walking. If temperatures rise above 15°C, the beetles may fly. Damage can be prevented or reduced by not growing beet next to spinach or next to a field where beet or spinach were grown the year before. Seed treatment is the preferred method of control, because it prevents pre-emergence damage and removes the need for later sprays in the case of a systemic insecticide. Soil treatment against the soil pest complex will normally control *A. linearis*, but it would not be GPP to control *A. linearis* alone by such treatment. If necessary, spray applications may also be made after emergence.

Main insecticides

Seed treatments: benfuracarb, carbofuran, imidacloprid, tefluthrin. Soil treatments: aldicarb, bendiocarb, benfuracarb, carbofuran, carbosulfan, isofenphos, oxamyl, phorate, phoxim, tefluthrin, terbufos. Sprays: acephate, alpha-cypermethrin, beta-cyfluthrin, carbaryl, chlorpyrifos, cypermethrin, deltamethrin, esfenvalerate, lambda-cyhalothrin, phoxim, triazophos.

Chaetocnema concinna (mangold flea beetle)

General

Chaetocnema concinna is a minute, metallic, brown-blackish beetle which makes small, irregular holes in leaves, often leaving only a leaf skeleton. It sometimes occurs in enormous numbers on lighter, sandy soils shortly after sowing and on young plants.

Basic strategy

The entire crop may be destroyed, especially at seedling stage, unless insecticides are applied. If systemic insecticides are used against the soil insect complex or aphids (as granules or seed treatment), these will control *C. concinna*. Otherwise foliar sprays may be used, on the basis of regular inspection of the crop. Normally a single application is sufficient.

Main insecticides

Seed treatments: imidacloprid. Soil treatments: aldicarb, bendiocarb, carbofuran, carbosulfan, oxamyl, phorate. Foliar sprays: acephate, alpha-cypermethrin, beta-cyfluthrin, carbaryl, chlorpyrifos, cypermethrin, deltamethrin, diazinon, esfenvalerate, lambda-cyhalothrin.

Cassida spp. (tortoise beetles)

General

There are two species of some significance : *Cassida nobilis* and *C. nebulosa*. Both adults and larvae feed on the leaves of young beet plants. They are specially important in Mediterranean countries where sugarbeet is grown as a winter crop.

Basic strategy

Foliar sprays of insecticides should be applied when the first larvae are seen. A single application is generally sufficient.

Main insecticides

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

Heterodera schachtii (beet cyst nematode)

General

Heterodera schachtii feeds on the roots of beet plants, stunting their growth and reducing yields. In the field, spots with retarded beet plants show up and at higher temperatures the leaves wilt. *H. schachtii* has host plants other than beet, mostly cruciferous such as rape and Brussels sprouts. In addition, some other *Heterodera* spp. (e.g. *H. trifolii*) are sometimes found on beet. The cysts are persistent and can survive several years without host plants.

Basic strategy

Control aims at keeping the nematode population below the economic threshold. Growing beet or other host plants not more than once every 5 years will achieve this, but this is not common practice. The crop rotation is usually more intensive than once in 5 years, and regular soil surveys are necessary (counts of viable cysts). Beet cultivars with a good level of resistance are not yet available, though it would be GPP to grow such cultivars. The growing of resistant cruciferous crops as green manure in summer also reduces cyst populations considerably. Early sowing of the beet crop allows the formation of a good root system before the larvae leave the cysts (14°C), and reduces the susceptibility to drought later in the season. Row treatments with certain insecticides against soil insects will incidentally suppress nematode populations to a certain extent. It is not GPP to treat soil systematically with nematicides. Such treatments should be limited to what is strictly necessary, and may be subjected to official limitations. However, soil fumigation will be effective against *H. schachtii* if applied at another point in the rotation (e.g. before a potato crop).

Main nematicides

Allowing for the above considerations (that nematicide use should be restricted rather than recommended), accepted uses for fumigation are as follows: cis-1,3-dichloropropene, metam-sodium.

Other nematodes

General

Meloidogyne naasi and *M. hapla* are both able to attack beet plants. Symptoms are more or less the same: additional root growth and beard formation, knots on the root system. Beet may also be attacked by free-living nematodes. *Longidorus* spp. (needle nematodes) mainly cause swelling at the rot tips. *Trichodorus* spp. and *Paratrichodorus* spp. (stubby root nematodes) mainly cause blackened stubby-ended lateral roots and may damage the tap root. Infestation by all these nematodes cause patches of reduced growth in the field.

Basic strategy

The presence of high numbers of nematodes is normally the result of a limited crop rotation. Hence, the most natural way to reduce nematode numbers is to extend the rotation to more crops. However, each nematode species may attack several crops, and it may be necessary to sample fields to identify which species are present and choose suitable crops to break the cycle

of nematode multiplication. It should be noted that *Trichodorus* spp., *Paratrichodorus* spp. and *Longidorus* spp. have a wide host range and that crop rotation is not likely to be effective. Row treatments with certain insecticides against soil insects will incidentally suppress nematode populations to a certain extent. It is not GPP to treat soil systematically with nematicides. Such treatments should be limited to what is strictly necessary, and may be subjected to official limitations. However, soil fumigation will be effective against those nematodes if applied at another point in the rotation (e.g. before a potato crop).

Main nematicides

Allowing for the above considerations (that nematicide use should be restricted rather than recommended), accepted uses for fumigation are as follows: cis-1,3-dichloropropene, metam-sodium.

Weeds

General

The control of weeds, annual and perennial, is of paramount importance in beet growing. However, herbicide inputs to sugarbeet are continuously being questioned on the grounds of cost and possible damage to the crop. Integration of chemical and mechanical methods of weed control is commonly practised.

Basic strategy

It is important to reduce the weed population as much as possible, for instance by thorough weed control in the preceding crop or, in the case of a preceding cereal crop, by pre- or post-harvest glyphosate application. The recommended good practice is to plough the soil, then apply other methods of soil preparation, depending on the soil type and time of the year, aiming to remove remnants of the preceding crop, destroy the weed population present and prepare a seedbed in optimal condition. Beet is normally grown in rows, which allow mechanical weeding well after emergence of the beet plants. However, despite all these prophylactic measures, it is still generally necessary, and GPP, to make several herbicide applications to a beet crop. Low or split dosage systems are developing rapidly and should be used when they become available.

The mode of application may be:

- overall low-volume spray (80-120 L ha^{-1});
- spraying within the row with self-steered band sprayers;
- selective application techniques (brush or mould-board with cloth, sponges etc.).

Herbicides are applied before sowing, before and after emergence of the beet seedlings and thereafter when the need arises. In general, pre-sowing applications are becoming rare, in view of the need to prepare a clean seedbed anyway (see above). Most reliance is placed on pre- and post-emergence applications. For spot treatments of perennials or of weed beet, brush-treatments are recommended. Post-emergence treatments are generally preferred to pre-emergence treatments but correct timing of the spray is essential. In general, the smaller the weed, the better the control. This allows low rates of less expensive herbicides to be used with good crop safety.

Winter crops of sugarbeet (as grown in Mediterranean countries) face different weed control problems because they follow the preceding crop immediately. In particular, volunteer cereals may have to be controlled.

Main herbicides

Pre-sowing

Effective on grasses: triallate (c[1]). Effective on dicots: chloridazon (r). Effective on annual dicots and grasses: glufosinate-ammonium (c), glyphosate (c), lenacil (r), metamitron (r and c).

Pre-emergence

Effective on dicots: chloridazon (r), chlorpropham (r), quinmerac (r et c). Effective on annual dicots and grasses: ethofumesate (r and c), lenacil (r), metamitron (r and c), metolachlor (r and c).

Post-emergence

Effective on grasses: alloxydim-sodium (c), cletodim (c), cycloxydim (c), diclofop-methyl (c), fluazifop-P-butyl (c), haloxyfop-R-methyl (c and r) , propaquizafop (c and r), quizalofop-ethyl (c), sethoxydim (c). Effective on dicots: chloridazon (r), clopyralid (c), desmedipham (c), phenmedipham (c), quinmerac (r and c), triflusulfuron-methyl (c). Effective on annual dicots and grasses: ethofumesate (r and c), lenacil (r), metamitron (r and c).

All herbicides are not effective against all weeds. The following elements are needed for good weed control in beet:

- early action on young weeds;
- programme adapted to the weed flora (species, density, stages);
- in most cases, a pre-emergence treatment with reduced doses;
- regular intervals between applications (6-10 days);
- use of a triple or quadruple mix;
- alternate mixes at each treatment according to the weed flora;
- applications at the end of the day or early in the morning, when humidity is high.

[1] r: root uptake; c: contact product.