

◆ **EPPO Standards** ◆

GUIDELINES ON GOOD PLANT PROTECTION PRACTICE

MAIZE

PP 2/17(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.

Guidelines on good plant protection practice

MAIZE

Specific scope

This standard describes good plant protection practice for maize.

This guideline on good plant protection practice (GPP) for maize 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. It covers methods for controlling pests (including pathogens and weeds) of maize (*Zea mays*).

Maize is grown throughout the EPPO region for several purposes. It is mainly used as a forage crop and for grain, but a part of the production is used for seed production or for sweet-corn production. Crops grown for the production of seeds for planting are not covered by this guideline. It should be noted that requirements for residue limits and pre-harvest application are stricter for sweet-corn production. Moreover, quality of grain is also more important for sweet-corn production.

GPP in the control of pests of maize can be considered to be composed of several elements. By using these, it should be possible to achieve effective pest control and, at the same time, to optimize the use of plant protection products:

- 1 Seeds should, as far as possible, be disease-free on planting.
- 2 The cultivars used should be suitable for the soil type and climatic conditions and preferably resistant or tolerant to the main pests.
- 3 Sanitation and cultural practices are important in maize. Although the trend is towards continuous maize cropping, crop rotation is an effective way of keeping down some pest populations. Crop residues should also be adequately incorporated or ploughed under. Cultural practices should ensure a good seedbed and the maintenance of a proper nutrient balance. The sowing date should be such that seedbed temperatures are adequate for quick germination and growth.
- 4 Threshold values based on pest incidence or climatic conditions should be used, if they exist, to decide whether control measures are necessary and, if so, to select the most appropriate timing for application of plant protection products.
- 5 The plant protection products used should be the most suitable for the pest to be controlled, at the

Specific approval and amendment

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particular time of application. It is GPP to use appropriate application techniques and to reduce drift and unwanted dispersal. The product should, as far as possible, be specific to the pest and not of a type likely to lead to the development of resistance in the pest.

The principal maize pests considered are the following:

- *Setosphaeria turcica* (northern leaf blight);
- *Sphacelotheca reiliana* (head smut);
- *Ustilago maydis* (common smut);
- *Pythium* spp. and *Fusarium* spp. (root browning);
- *Fusarium* spp. (cob and stem rot);
- *Colletotrichum graminicola* (anthracnose);
- *Sclerophthora macrospora* (downy mildew);
- soil insects;
- *Oscinella frit* and *Geomyza tripunctata* (frit fly and cereal fly);
- *Tanymecus dilaticollis* (corn weevil);
- noctuid larvae (cutworms);
- *Helicoverpa armigera* (cotton bollworm);
- aphids (*Sitobion avenae*, *Metopolophium dirhodum*, *Rhopalosiphum padi*);
- *Ostrinia nubilalis* (European corn borer);
- *Sesamia nonagrioides*;
- mites (*Tetranychus urticae*, *T. cinnabarinus*, *T. turkestanii*);
- weeds.

Diabrotica virgifera virgifera (western corn rootworm) is a quarantine pest which currently has a very limited distribution in the EPPO region. If it spreads further, good strategies for its control should be developed.

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.

***Setosphaeria turcica* (northern leaf blight)**

General

Symptoms appear on leaves, as long brown necrotic lesions developing along the veins (blight). In humid conditions, large numbers of the greyish-black conidia (anamorph *Drechslera turcica*) are produced on the lesions. Another disease (southern leaf blight) due to a related fungus, *Cochliobolus heterostrophus* (anamorph *Drechslera maydis*), causes smaller and more abundant lesions. Severe infection causes premature drying and death of the whole foliar system. The ears are not infected, although lesions may form on the outer husks. The fungus overwinters on plant debris as conidia containing infectious chlamydospores which are the primary source of infection. Mycelium present in maize debris does not form new conidia at the beginning of summer and cannot maintain its pathogenicity through the winter. Secondary spread is ensured by conidia produced in great quantities on leaf lesions, which can be carried for long distances by the wind. The teleomorph is of no significance in practice.

Basic strategy

After harvest of the preceding maize crop, it is essential to apply any method which favours decomposition of plant debris. As the disease often starts at the edges of the plot or along rows where irrigation material passes, it is important to detect the occurrence of first lesions on these sites as soon as the crop has 6-8 leaves. Fungicide sprays can also be applied. On maize for consumption, if the disease appears before growth stage "10 leaves" (BBCH 19), two applications are needed; otherwise, a single fungicide treatment may be applied between flowering and the end of milky stage.

Main fungicides

Sprays: carbendazim, chlorothalonil, difenoconazole, flusilazole, flutriafol, propiconazole.

***Sphacelotheca reiliana* (head smut)**

General

Typical symptoms of the disease are visible after flowering. *Sphacelotheca reiliana* causes sori (galls) on

ear and tassel (and rarely on the upper leaf) which contain dry masses of dark teliospores. One of the main differences with common smut (*Ustilago maydis*) is that head smut does not attack leaves (or only very exceptionally) and stems. In many cases, the contaminated inflorescence is completely destroyed by the fungus and replaced by galls. *S. reiliana* may also induce phyllody symptoms on floral parts. In general, infected plants do not produce kernels, and the size of the plant is reduced. *S. reiliana* is essentially soil-borne. Teliospores from smutted heads overwinter in soil, where they can retain their viability for more than 5 years. The fungus penetrates into the roots of maize seedlings and, when mycelium invades undifferentiated floral tissues, they will produce smutted sori. The sori are covered with a thin tissue that breaks and liberates the masses of spores. Although teliospores may be seed-borne, this is not an important source of inoculum. It has been shown that infection leads to the development of galls only if it takes place between sowing and growth stage "7 leaves" (BBCH 17). Soil temperatures of 28 °C and moderate to low soil moisture will favour seedling infection.

Basic strategy

The control strategy is mainly based on the use of resistant or tolerant cultivars and on seed treatments or row treatments immediately after sowing. Cultural methods (rotations, mode of tillage etc.) cannot limit the incidence of the disease in the long term as spores remain viable for a long period.

Main fungicides

Seed treatment: carboxin, flutriafol, triticonazole.

***Ustilago maydis* (common smut)**

General

Ustilago maydis mainly attacks parts of the plants with intensive cell division. Symptoms are grey sori appearing on stems, cobs, leaves or inflorescence. After a while, the sori burst open, and brownish black spores are liberated. These can survive in the soil for at least 4 years. Plants are infected by soil-borne or air-borne spores. The disease affects the quantity and the nutritional value of the yield. It appears mainly in dry, warm years, on maize plants suffering from drought. It is generally sporadic and of minor importance.

Basic strategy

There is no chemical control. Crop rotation (e.g. 4-year) has some effect in reducing soil-borne inoculum. The level of resistance varies among cultivars, and resistant cultivars should be used when possible. Attacks by *U. maydis* may be prevented by ensuring a good soil structure and sprinkling the crop in periods of drought.

***Pythium* spp. and *Fusarium* spp. (root browning)**

General

Pythium spp. and *Fusarium* spp. cause a brown discoloration of the roots. The consequence is irregular emergence and low growth rate. The disease occurs mostly in years with a cold, rainy spring, and symptoms are more severe on soils with high moisture content.

Basic strategy

Preventive measures include crop rotation (limited value for *Pythium*) and ensuring a good soil structure. Soil fungi attack especially when germination is slow, mainly as a result of low temperatures. The time of sowing should therefore not be too early in the spring. Resistant cultivars should be used, or the seeds should be treated.

Main fungicides

Seed treatments: fludioxonil, metalaxyl, thiram.

***Fusarium* spp. (cob and stem rots)**

General

Two species of *Gibberella* with *Fusarium* anamorphs (*Gibberella moniliformis*, anamorph *F. moniliforme*, and *Gibberella zeae*, anamorph *F. graminearum*) are common on maize, the latter occurring more in warmer regions. They can be seed-borne but, in general, survival is on plant debris. Air-borne spores are the main source of inoculum. Symptoms appear at ripening. The pathogens attack the stem from the soil through the roots or lower stem internodes. After a severe attack, the foot of the stem rots completely and the stem dies. Partly severed ears may hang down after being attacked, which can obstruct the harvesting of the maize plants and cause severe yield reduction. The ear rot due to *G. zeae* can also progress from the ear-tip downwards.

Another *Fusarium*, *F. culmorum*, is primarily a part of the foot-rot complex, but can also cause disastrous cob rots. After infection, cobs and sheathing leaves may appear rose- or pink-coloured due to mycelium and sporodochia.

Basic strategy

As no chemical control in the field is possible, prevention relies on cultural practices which are unfavourable to the disease and the use of less susceptible cultivars. Maize plants can be predisposed to infection by high levels of nitrogen and low levels of potassium or by dry conditions followed by periods of wet weather after silking (BBCH 65). Increasing the firmness of the stems by sowing at the right time with a

sufficient space between rows (an optimal plant density is 7-12 plants per m) also prevents attacks by these fungi. If the fungus has already attacked the plants, harvesting as soon as possible is the best solution. Seed treatment may be suggested as a hygiene measure.

Main fungicides

Seed treatments: carbendazim, thiram.

***Colletotrichum graminicola* (anthracnose)**

General

Colletotrichum graminicola causes lodging. Symptoms are brown spots, first appearing on the lower side of the leaves at the stem base, then on all leaves of the whole plant. At the end of the growing season, the fungus penetrates into the stem, where it destroys the pith and the sieve tubes. This causes lodging of the crop. For its development, the fungus needs high temperatures combined with high humidity.

Basic strategy

Infested straw should be ploughed in after harvest. There is no chemical control.

***Sclerophthora macrospora* (crazy top, downy mildew)**

General

Sclerophthora macrospora causes systemic infection. Symptoms vary greatly with the time of infection and the degree of colonization. Plants show excessive tillering and narrow chlorotic leaves, but the most characteristic symptom, usually known as crazy top, consists of partial or complete proliferation of the tassel, which is finally transformed into a mass of leafy structures. Phyllody may also occur in the ears. Infections start from the resting oospores which are frequently formed on perennial grasses. Seed-borne mycelium can also be a source of infection. The disease usually occurs only in restricted, low-lying, inadequately drained areas or after severe floods.

Basic strategy

The disease is not economically important, except in isolated cases of water-logged crops. Control measures other than water management are not justified. Seed treatment against *Pythium* spp. and *Fusarium* spp. may also control *S. macrospora*.

Soil insects (wireworms, white grubs and leatherjackets)

General

The larvae of certain *Elateridae* (*Agriotes* spp., wireworms), *Melolonthidae* (*Melolontha* spp., white grubs) and *Tipulidae* (*Tipula* spp. leatherjackets) feed on roots of maize and even on the stem base. Development of wireworms takes several years; consequently, larvae of different sizes may be present in the soil when maize is planted. Development of white grubs takes 3-4 years and is generally synchronized. Damage normally only occurs from the third larval stage onwards, starting in the year after adult flight.

Basic strategy

Grassland or uncultivated land as a preceding crop should be avoided. However, if a maize crop is grown in such a high-risk rotation, an overall soil spray treatment as well as seed treatment may be justified. For wireworms and white grubs, easy detection methods are available and these should form the basis for control. The main strategy is aimed at reducing the amount of plant protection products applied to soil, so localized treatments in the row are preferred whenever possible to general soil treatments. The type of treatment will depend on the level of infestation and the date of sowing. For *Tipula* spp., if the probability of infestation is low, it is preferable to treat after the emergence of the crop, at the beginning of infestation. Treatment may also be applied at or before drilling when the risk of infestation is high, with consolidation after drilling to aid control. Egg-laying can be reduced by ensuring that the soil remains bare in July/August after the previous crop.

Main insecticides

Seed treatments: bendiocarb, fonofos, furathiocarb, imidacloprid, phoxim.

Soil treatments: bendiocarb, carbofuran, carbosulfan, chlorpyrifos, fonofos, furathiocarb.

Localized treatment with microgranules: bendiocarb, carbofuran, carbosulfan, fipronil, fonofos, terbufos.

Sprays: chlorpyrifos, diazinon, fonofos, furathiocarb, tefluthrin, terbufos.

Oscinella frit and *Geomyza tripunctata* (frit fly and cereal fly)

General

Small larvae (up to 5 mm) bore into the young shoots, and their feeding destroys the growing point. Leaves may be ragged and torn. The stem at soil level may be swollen, and leaves do not emerge or emerge badly twisted. Heavily attacked plants can tiller excessively (and develop three or four stems). Larvae of *Geomyza*

tripunctata can also destroy seedlings by mining the plants or cutting them at their base (as for *Tipula* spp.).

Basic strategy

For both *O. frit* and *G. tripunctata*, early sowing of maize can avoid the attack. Resistant hybrids can be used. Seed treatment with systemic insecticides protects the seedlings. It is also possible to apply a localized treatment in the row using a systemic insecticide (e.g. microgranules) on the zones where there is a risk of infestation.

Main insecticides

Soil treatment: bendiocarb, benfuracarb, carbofuran, chlorpyrifos, imidacloprid, isofenphos, phorate, terbufos.

Seed treatment: bendiocarb, imidacloprid, methiocarb (acts as a bird repellent at the same time).

Tanymecus dilaticollis (southern grey weevil, corn weevil)

General

Adults attack young seedlings (rarely germinating seeds) and destroy them. They feed on young leaves from the leaf margin, and most damage occurs before the 4-leaf stage (BBCH 14). Higher temperatures enhance feeding. *Tanymecus dilaticollis* has one generation per year and overwinters as pupae in the soil.

Basic strategy

Various cultural methods can reduce weevil population and damage: crop rotation, time of sowing, conditions favouring rapid seedling development and plant density. It is important to assess the insect population in autumn before overwintering and then in spring when the plants start to grow. Insecticide spray application is the main control method; nevertheless, preventive systemic seed-dressing formulations may be used as well.

Main insecticides

Sprays: bensultap, cypermethrin.

Seed treatments: imidacloprid.

Noctuid larvae (cutworms)

General

The most important species attacking maize are *Agrotis ipsilon* and *A. segetum*. These species are polyphagous. Eggs are laid on the underside of the lower leaves or at the collar. Feeding occurs mostly at night, and the plants are cut at or just below ground level. During the

day, larvae remain buried near the plant not far below the soil surface. Damage resembles that caused by *Elateridae*. Damaged plants wilt and turn yellow before dying. There are one or two generations a year depending on the species. Larvae are thick, greenish or grey-brown and with darker marks, and are usually curled up in the soil when found. Depending on the species, they can be 25-50 mm long. They overwinter in the soil.

Basic strategy

Infestation cannot be forecast accurately enough to permit preventive applications. Curative applications should ensure that the soil surface is adequately wetted. Application of granules pre-sowing or pre-emergence is rarely effective. Treatments can be applied against first-stage larvae or against mature larvae overwintering in the soil. In the first case, sprays are most effective; in the second case, baits give better results. The main treatment consists of curative sprays, but baits present less risk for the environment.

Main insecticides

Sprays: alpha-cypermethrin, bifenthrin, chlorpyrifos, deltamethrin, lambda-cyhalothrin.

Baits (ready for use): carbaryl.

***Helicoverpa armigera* (cotton bollworm)**

General

This migrant species causes serious losses throughout its range. Cobs are invaded, and developing grain is consumed. There are two to three generations a year. *Helicoverpa armigera* overwinters as pupae in the soil. Adults appear from May until the end of October. Eggs are laid on plants at or near flowering. The principal host on which eggs are laid is maize, but other plants are also concerned, e.g. tomatoes, weeds, and, in certain areas, cotton. The feeding larvae can be seen on the surface of plants, but they are often hidden within plant organs. Bore holes may be visible, but otherwise it is necessary to cut open the plant to detect the pest. Secondary infections are common.

Basic strategy

Infestation can be forecast by use of sex-pheromone traps or light-traps. Sprays should be applied against first-stage larvae. Usually, a single application is not sufficient to cover the whole hatching period. Biological control, using *Trichogramma* spp., can give good results. Weed control may reduce problems with this pest.

Main insecticides

Sprays: alpha-cypermethrin, *Bacillus thuringiensis*, beta-cypermethrin, cypermethrin, deltamethrin, fenvalerate, lambda-cyhalothrin.

Aphids

General

Several species of aphids can be observed on maize (*Sitobion avenae*, *Metopolophium dirhodum*, *Rhopalosiphum padi*) but the damage they cause is of variable importance. *S. avenae* is a yellow to green or brownish-red aphid with long dark siphunculi. It causes relatively little damage to maize crops, the natural enemies present in maize fields often being sufficient to limit the populations of this aphid. *M. dirhodum* is a yellow-green to pinkish aphid with long clear siphunculi and a visible dorsal line, which migrates from small-grain cereals and grasses to maize at about BBCH growth stage 19. When feeding on maize, its toxic saliva produces yellow discoloration (mosaic) of plant tissues and may limit their growth. Finally, *R. padi* is usually the most damaging species. This green to black aphid with a reddish coloration at the basis of the abdomen generally appears on maize at the end of July. Populations are normally present on leaves and tassels. Damage is caused by feeding punctures on leaves and silks. As the production of honeydew is followed by the development of sooty mould, this may lead to yield reduction.

Basic strategy

Control strategy is based on monitoring of the crop, and a treatment is applied when a threshold is exceeded. Thresholds of 500 and 200 aphids per plant at growth stage 19 can be suggested, for *S. avenae* and *M. dirhodum* respectively. For *R. padi*, the suggested threshold for young plants is 10 winged aphids per plant with forming colonies of apterous aphids. However, flowering is the most sensitive period for the crop, which should be monitored at tassel emergence (BBCH 55), and a treatment applied if 50% of tassels are infested. Use of certain selective insecticides (e.g. pirimicarb) will favour natural enemies. If a seed treatment with imidacloprid has been made against other pests, it will also control aphids.

Main insecticides

Sprays: bifenthrin, ethiofencarb, imidacloprid, lambda-cyhalothrin, pirimicarb.

Seed treatments: imidacloprid.

***Ostrinia nubilalis* (European corn borer)**

General

Ostrinia nubilalis can be a serious pest of maize, especially in southern EPP0 countries. In infested

fields, tassels are broken (in general at the level of the upper leaf), and bored stems often break. In summer (end of June to the end of July), eggs are laid in clusters of 20-30, generally on the underside of the lower leaves. After an incubation of 5-15 days, young larvae penetrate into the upper leaves and feed through folded leaves, causing characteristic "windowing" (rounded holes). The caterpillars then very often damage tassels and, at flowering, penetrate into the stem near the leaf axil. The larvae tunnel stems, cob peduncles and the cob itself. In northern regions where *O. nubilalis* has one generation per year, after 3-4 weeks of active feeding, the larvae enter into diapause either in maize stems, debris or in the soil and overwinter. Pupation occurs in spring (end of May to the beginning of June), and adults emerge at the beginning of summer. In southern regions, *O. nubilalis* may have a second complete or incomplete generation.

Basic strategy

Cultural methods, such as destruction of crop residues to kill overwintering larvae and use of resistant or tolerant cultivars, can reduce populations. Chemical control is aimed at killing young larvae when they hatch and wander on the plant before they bore into the stem. It is important to try to obtain the longest period of protection of the plant against the pest, as a single treatment is usually not sufficient to cover the whole hatching period, and the first larvae are potentially more dangerous than those hatched at the end of adult flight. Applications of granular or liquid formulations can be made. For sprays, two applications may be recommended, when the crop reaches 1-1.20 m and at the middle of tassel emergence (BBCH 55). Biological control using *Trichogramma* spp. can also give good results. As these parasites are more efficient on young eggs, they should be released as soon as eggs are laid. Several releases of the parasite (e.g. two to three releases of 50000 to 200000 parasites per ha) may be necessary according to the pattern of pest emergence.

Main insecticides

Granules: bifenthrin, beta-cyfluthrin, chlorpyrifos-ethyl, cypermethrin, deltamethrin, permethrin, phoxim.

Sprays: alpha-cypermethrin, *Bacillus thuringiensis*, bifenthrin, cyfluthrin, cypermethrin, deltamethrin, diazinon, fenvalerate, lambda-cyhalothrin, teflubenzuron, thiodicarb, tralomethrin.

Sesamia nonagrioides

General

The annual cycle of *Sesamia nonagrioides* depends on climatic conditions and varies from two complete and a third partial generation in southern Europe to four generations in northern Africa. Larvae enter diapause at the end of autumn. They are very sensitive to cold and are killed by low temperatures (around -7°C).

However, dry climatic conditions at the end of winter and at the beginning of spring are favourable to their survival.

Larvae pupate at the beginning of spring. Adults of the first generation generally develop between the beginning of May and the end of June. Females lay their eggs (in groups of about 20) deep under the sheaths of the first still unfolded leaves of maize seedlings. The eggs hatch, about 10 per stem, and larvae then feed on the sheaths. Later, they penetrate into the stem close to a node to destroy the pith. From the third larval stage onwards and during the fourth larval stage, they infest neighbouring stems (mobile stages). The second flight period of the moths takes place during July and August.

Basic strategy

Risk assessment is done with pheromone traps and emergence cages. The break-up of harvest residues in autumn is recommended, followed by superficial tillage. Use of resistant cultivars can limit yield losses. When infestation occurs, chemical control is necessary. Chemical control is only justified if more than 3% of the stems are infested by the pest at the beginning of its mobile stages. Against the first generation, two spray treatments should be applied within 15-20 days around the peaks of flight activity. Against the second generation, one treatment should be applied at the peak of flight activity.

Main insecticides

Sprays: beta-cyfluthrin, bifenthrin, chlorpyrifos-ethyl, cyfluthrin, cypermethrin, deltamethrin, lambda-cyhalothrin, permethrin, tralomethrin.

Mites (*Tetranychus urticae*, *T. cinnabarinus* and *T. turkestanii*)

General

Several species of mites can be found on maize: *Tetranychus urticae*, *T. cinnabarinus* and *T. turkestanii*. Mite outbreaks seem to occur more frequently than in the past in some countries, and yield losses of 20-30% have been recorded. By their feeding punctures, mites empty the cells of epidermis and parenchyma, and yellow discoloration appears on leaves. Webs can also be observed on the underside of leaves. In case of heavy attacks, the discoloured zones wilt and become necrotic. The whole leaf may die and appears as if burnt. Leaf wilting and drying starts at the base of the plant and progressively reaches its upper part. In general, yield is affected when leaves around the cob are attacked by the pest between flowering (BBCH 67) and the dough stage (BBCH 85). The adult stage lasts 2-3 weeks, and each adult female can lay 40-50 eggs during that period. The development time of embryos and larvae mainly depends on temperature and is reduced by high temperatures (e.g. 12 days at 23 °C or

7 days at 28 °C). Apparently, three generations can develop on maize before maturity of the crop. Development of populations is favoured by warm dry periods and also by high plant turgescence resulting from heavy irrigation. Infestations very often start at the edges of the plot near uncultivated land, paths and roads, planted hedges or vineyards. Many weed species can act as reservoirs.

Basic strategy

In general, treatments are made with ovicidal and larvicidal acaricides when infestations are found. Monitoring should start at tassel emergence (BBCH 51). It is advisable to alternate products with different modes of action to reduce the risk of resistance.

Main acaricides

Ovicides: clofentezine, hexythiazox.

Larvicides: bifenthrin, cyhexatin, dicofol, propargite.

Weeds

General

Weeds are strong competitors for maize, mainly at the beginning of maize growth, when crop growth is particularly slow, especially at low temperatures, and the competitiveness is low. Weed control is therefore particularly important in these early stages. Sweet-corn cultivars are even less competitive than forage cultivars. The widespread use of herbicides and the changes in cropping patterns (development of continuous cropping, reduced tillage and cultivation, etc.) have induced modifications in the weed problems over the years. In particular, grass weeds have gained importance. The wide use of triazines has also favoured the propagation of resistant weeds.

Basic strategy

Resistance problems are manageable through the integrated use of available cultural methods and a diversity of herbicides with different modes of action. There are different strategies that combine mechanical control and the use of herbicides. Maize is normally grown in rows, allowing mechanical weed control. Pre-emergence harrowing and post-emergence, when the crop has two leaves (BBCH 12), is possible. After emergence, scuffling is possible, but the crop should at least have two to three leaves (BBCH 12-13), and damage to its roots by the scufflers should be avoided. Another mechanical weed control is usually necessary, e.g. at the growth stage 4-6 leaves (BBCH 14-16). If mechanical weeding is not satisfactory within the rows, a band treatment with a herbicide may be needed, especially on fields with high weed densities. Scuffling should be avoided on slopes due to possible erosion.

The following criteria are used when deciding whether a herbicide treatment is necessary: a) quantity of weed seed present in the plot before crop and weed emergence; b) composition and density of weeds after maize and weed emergence; c) development stage of weeds. Product activity should be relevant to the weed spectrum present. All herbicides are not effective against all weeds, so the use of herbicide mixtures is often necessary. Herbicides should be properly applied when weather conditions are favourable for herbicide action. The doses of products to be applied will also depend on the organic matter content of the soil. In some countries, it is recommended not to use more than 1500 g of atrazine, simazine or atrazine + simazine per ha during the growing season on susceptible weeds because of problems of groundwater contamination.

Weed resistance to triazines

Triazines should only be used if the weed population is susceptible. If only grass weeds are resistant and dicots are still susceptible, triazines should only be used in combination with other compounds. If both grass weeds and dicots are resistant, it is suggested to use a pre-emergence treatment with an anti-monocot herbicide having some effect on triazine-resistant dicots. In these cases, a post-emergence treatment will be necessary to eliminate dicots. The product will be chosen according to the predominant species found in the field.

Main herbicides¹

Pre-emergence

Pre-sowing: EPTC; propisochlor, tri-allate.

Pre-sowing or post-sowing: acetochlor, alachlor, atrazine, benoxacor, dimethenamid, metolachlor, simazine, terbuthylazine.

Post-sowing: alachlor, pendimethalin.

Post-emergence

Dicots (including those resistant to triazines): bentazone, bromoxynil, clopyralid, dicamba, nicosulfuron, pyridate, rimsulfuron, terbuthylazine, thifensulfuron-methyl.

Annual monocots and/or dicots: ametryn, atrazine, clopyralid, difenzoquat methylsulphate, nicosulfuron, pyridate, rimsulfuron, simazine, terbutryn.

Perennial weeds: clopyralid, dicamba, fluroxypyr, nicosulfuron, rimsulfuron.

¹ The herbicides listed are suitable for forage maize. They may not necessarily be suitable for use in sweet corn.