Organisation Européenne et Méditerranéenne pour la Protection des Plantes
European and Mediterranean Plant Protection Organization

Normes OEPP
EPPO Standards

Good plant protection practice
Bonne pratique phytosanitaire

PP 2/28(1)

Organisation Européenne et Méditerranéenne pour la Protection des Plantes
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Approval

EPPO Standards are approved by EPPO Council. The date of approval appears in each individual standard. In the terms of Article II of the IPPC, EPPO Standards are Regional Standards for the members of EPPO.

Review

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

Amendment record

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

Distribution

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

Scope

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

Outline of requirements

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

Existing EPPO standards in this series

Twenty-six EPPO standards on good plant protection practice have already been approved and published. Each standard is numbered in the style PP 2/4(1), meaning an EPPO Standard on Plant Protection Products (PP), in series no. 2 (guidelines on GPP), in this case standard no. 4, first version. The existing standards are:

PP 2/1(2) Principles of good plant protection practice. *Bulletin OEPP/EPPO Bulletin* **33**, 87–98
PP 2/2(2) Potato. *Bulletin OEPP/EPPO Bulletin* **31**, 183–200
PP 2/3(2) Lettuce under protected cultivation. *Bulletin OEPP/EPPO Bulletin* **31**, 201–210
PP 2/4(2) *Allium* crops. *Bulletin OEPP/EPPO Bulletin* **31**, 211–230
PP 2/5(1) Rodent control for crop protection and on farms. *Bulletin OEPP/EPPO Bulletin* **25**, 709–736
PP 2/6(1)* Hop. *Bulletin OEPP/EPPO Bulletin* **26**, 295–309
PP 2/7(1)* Vegetable brassicas. *Bulletin OEPP/EPPO Bulletin* **26**, 311–347
PP 2/8(1) Rape. *Bulletin OEPP/EPPO Bulletin* **26**, 349–367
PP 2/9(1) Strawberry. *Bulletin OEPP/EPPO Bulletin* **26**, 369–390
PP 2/10(1) Wheat. *Bulletin OEPP/EPPO Bulletin* **27**, 311–338
PP 2/11(1) Barley. *Bulletin OEPP/EPPO Bulletin* **27**, 339–362
PP 2/12(1) Beet. *Bulletin OEPP/EPPO Bulletin* **27**, 363–384
PP 2/13(1) Ornamental plants under protected cultivation. *Bulletin OEPP/EPPO Bulletin* **28**, 363–386
PP 2/14(1) Pea. *Bulletin OEPP/EPPO Bulletin* **28**, 387–410
PP 2/15(1) Tobacco. *Bulletin OEPP/EPPO Bulletin* **28**, 411–424
PP 2/16(1) Farm grassland. *Bulletin OEPP/EPPO Bulletin* **29**, 353–366
PP 2/17(1) Maize. *Bulletin OEPP/EPPO Bulletin* **29**, 367–378
PP 2/18(1) Pome fruits. *Bulletin OEPP/EPPO Bulletin* **29**, 379–406
PP 2/19(1) Rye. *Bulletin OEPP/EPPO Bulletin* **29**, 407–422
PP 2/20(1) Mushrooms. *Bulletin OEPP/EPPO Bulletin* **31**, 231–242
PP 2/21 (1) Sunflower. *Bulletin OEPP/EPPO Bulletin* **31**, 243–256
PP 2/22 (1) Umbelliferous crops. *Bulletin OEPP/EPPO Bulletin* **31**, 257–288
PP 2/23 (1) Grapevine. *Bulletin OEPP/EPPO Bulletin* **32,** 371–392
PP 2/24 (1) Oat. *Bulletin OEPP/EPPO Bulletin* **32**, 393–406
PP 2/25 (1) Leguminous forage crops. *Bulletin OEPP/EPPO Bulletin* **32**, 407–422
PP 2/26 (1) *Ribes* and *Rubus* crops. *Bulletin OEPP/EPPO Bulletin* **32**, 423–442

*Note that these two guidelines for hop and vegetable brassicas appeared in *Bulletin OEPP/EPPO Bulletin* as, respectively, numbers 5 and 6, whereas they are in fact numbers 6 and 7 respectively. This numbering error is now corrected.

These EPPO Standards have also been published together in a new publication, *Good Plant Protection Practice*, available from the EPPO Secretariat, 1 rue Le Nôtre, 75016 Paris (FR).

Good plant protection practice
Bonne pratique phytosanitaire

Cotton

Specific scope
This standard describes good plant protection practice for cotton.

Specific approval and amendment
First approved in 2003-09.

This Standard on GPP for cotton 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(2) Principles of good plant protection practice. It covers methods for controlling pests (including pathogens and weeds) of cotton (*Gossypium hirsutum*).

GPP for the control of pests of cotton is based on numerous generally inter-related elements, of which the following are the most important. The cultivar should be chosen in relation to the area of cultivation (climate, soil, …), estimated duration of the growing season, quality requirements, and the presence of 'limiting' pathogens in the soil. Despite the existing tendency to grow cotton continuously in many areas, crop rotation should be preferred. Tillage practices should ensure that the field and its immediate surroundings are free from weeds before sowing. Presowing herbicides are generally used. Fertilizers should be rationally applied, especially in the case of nitrogen. Ridge-ploughing is recommended in winter.

The decision to apply treatments should be made in relation to observed populations of pests and natural enemies, by appropriate monitoring and taking treatment thresholds into account. Application equipment should be in good condition and treatments should be made in the cooler hours of the day, in the absence of wind, and with an appropriate spray volume per hectare, ensuring maximum efficacy. GPP for cotton depends on thorough training of the growers and on access to specialized extension services.

The main pests of cotton covered by this guideline are the following:
Soil fungi affecting seedlings
Verticillium dahliae
Aphis gossypii
Bemisia tabaci
Plant bugs
Agrotis segetum
Helicoverpa armigera
Pectinophora gossypiella
Spodoptera exigua
Spodoptera littoralis
Thrips
Tetranychus urticae
Growth regulators
Weeds
Haulm destruction

Explanatory note on active substances

The EPPO Panel on Good Plant Protection Practice, in preparing this standard, considered information on specific active substances used in plant protection products and how these relate to the basic GPP strategy. These details on active substances are included if backed by information on registered products in several EPPO countries. They thus represent current GPP at least in those countries. It is possible that, for any of numerous reasons, these active substances are not registered for that use, or are restricted, in other EPPO countries. This does not invalidate the basic strategy. EPPO recommends that, to follow the principles of GPP, only products registered in a country for a given purpose should be used. It may be noted that many active substances currently used in registered products in EPPO countries will no longer be authorized in the EU after 2003-07.

Soil fungi affecting seedlings

General

The complex known as 'damping-off' may be due to one or several of the following pathogens: *Thanatephorus cucumeris* (anamorph *Rhizoctonia solani*), *Pythium* spp. and *Thielaviopsis basicola*. Losses may affect the seed or the seedling, before

emergence or up to the stage when the young plant has several leaves. Symptoms are variable, but the most frequent is that the collar becomes necrotic and the seedlings usually die. This is reflected by a fall in stand density, which may even make it necessary to resow. Loss of seedlings is favoured by poor seed quality, by inadequate fungicide protection, and by wet cold soil during germination and establishment of the crop.

Basic strategy

The crop should be sown when no rain, or fall in temperature, is expected in the next 5 days. Good-quality seeds should be used, with a tested germination rate of at least 85% at 30 °C and 50% at 15 °C, and treated with an appropriate fungicide. Solarization has been shown to be an effective method of reducing fungal inoculum in the soil.

Main fungicides

Seed treatment: thiram, carboxin.

Verticillium dahliae

General

Since the appearance of the defoliating strain of the fungus *Verticillium dahliae*, verticillium wilt has become a key disease of cotton. The symptoms (interveinal chlorosis, defoliation, necrotic xylem vessels) can appear from the earliest stages of development, but their expression is inhibited by high temperatures in summer. The severity of losses corresponds to the earlier appearance of symptoms. *Verticillium dahliae* has a wide range of plant hosts, and can persist in the soil for many years, in plant debris or in the form of microsclerotia.

Basic strategy

There are currently no commercial cultivars resistant to *V. dahliae*, but some are tolerant. So choice of cultivar is the main method of control. Solarization is very effective, at least for the next two seasons. Complementary measures are to rotate with cereal crops, to increase planting density, to reduce nitrogen fertilization and to maintain a good level of potassium. There are no effective fungicide treatments.

Aphis gossypii

General

Of the various aphid species which attack cotton, *Aphis gossypii* is currently the most important. The insects are small (0.9–1.8 mm), without dorsal sclerotization. Colour varies from yellow to dark green, or even dull black, even within the same colony. The siphunculi are dark and the cauda somewhat lighter. Crops are affected during two periods, in May–June, then after mid-August, high temperatures being unfavourable to the aphids. Damage may be direct or indirect. The former is due to direct feeding, and takes the form of a general debilitation of the plants with deformation of the leaves. Such damage is particularly serious in the first period. If infestation is heavy, the plants may be defoliated, growth is slowed, and several internodes may be shortened. Indirect damage results from the production of honeydew, on which sooty mould fungi develop, hindering photosynthesis and soiling the lint.

Basic strategy

A scoring system can be used to determine the threshold for application of insecticide sprays, such as the following: (1) 1–10 aphids per leaf; (2) 11–30 aphids per leaf; (3) over 30 aphids per leaf. A sample of leaves from the upper third of the plant is taken from 50 random plants. Initially, the treatment threshold is a mean score of 1, but this can be raised to 2 if natural enemies are abundant. If appropriate, treatments can be localized (borders or foci). The main natural enemies are coccinellids: *Coccinella septempunctata* and *Hippodamia variegata*, but other insects may also be involved (syrphids, cecidomyiids, parasitic hymenoptera). After the initial phase of the crop, aphid control is not usually necessary, unless certain factors destabilize the system (use of broad-spectrum insecticides, low temperatures).

Problems with resistance

Aphis gossypii is resistant to many registered products, and this considerably limits the range of products available for its control.

Main insecticides

Sprays: benfuracarb, carbosulfan, propoxur.

Bemisia tabaci

General

The nymphs of the whitefly *Bemisia tabaci* are irregularly elliptical and rather flattened. In colour, they are initially translucent and difficult to see, becoming yellowish white. Only the first stage is mobile. The fourth develops inside the irregularly oval puparium, yellow, with inclined sides. The adult emerges through a characteristically T-shaped hole. *Bemisia tabaci* appears on cotton from June onwards, but severe attacks are not usually observed until the end of the summer, when temperatures begin to fall. Under favourable conditions, three generations can develop, and all stages can be found simultaneously. Direct feeding damage reduces the assimilates available for maturation of the plant. However, on cotton, it is the indirect damage which is most important. Honeydew produced by the nymphs is deposited on the leaves and serves as a substrate for sooty mould fungi. These can also affect the lint, which is then reduced in quality.

Basic strategy

Populations can be monitored by counting nymphs on the lower surface of a main leaf in the upper third of the plant, on 50 random plants. *Bemisia tabaci* is relatively restricted by the temperature and humidity of cotton-growing areas, and its impact is greater under humid conditions (along rivers, on slopes) or in mild years. Control, by application of insecticide sprays, should only be necessary under such conditions. Before September, levels over 20 nymphs per leaf have been found to be very damaging, but levels under five cannot be related to any symptoms on the crop. If treatments are done when populations are very high, all stages may be present including the relatively resistant puparia. The presence of the pest only on the lower surface of the leaf means that applications have to be made very carefully. Natural enemies include particularly *Eretmocerus mundus*, but also to a lesser extent *Orius* spp., *Chrysoperla carnea* and other general predators commonly found on cotton.

Main insecticides

Sprays: methomyl.

Plant bugs

General

The reduction in the number of treatments against other pests has led to some increase in populations of secondary pests such as plant bugs. *Creontiades pallidus* is yellowish green, broad (8 mm). The nymphs have long antennae with clearly marked red and pale bands, and black spots all over the body. *Lygus gemellatus* is variable in colour, although usually green, narrower (5–6 mm) and with a well-marked shield. The distal part of the wings is bent down from the cuneus. The nymph has five spots on its back, clearly visible at all stages except the smallest (only abdominal spot visible). These plant bugs appear on cotton in July, moving from natural vegetation or adjoining crops, and producing highest populations in August, with one or two generations. The eggs are laid inside the tissues of the plant, and can be detected only by the operculum visible from outside (0.25 mm). Both nymphs and adults feed on buds, and on seeds within the bolls, which they reach by insertion of the stylet from outside the boll. Buds may drop, but this is generally not important if the bugs enter the crop relatively late. The bolls are also damaged, with deformation and soiling of the lint. Severe attacks can reduce yield considerably.

Basic strategy

Insecticide sprays are not usually applied specifically against these bugs, unless the populations are very high (over 100–150 000 nymphs per ha, measured by collection on a sheet), since they are likely to destabilize control systems against more important pests.

Main insecticides

Sprays: chlorpyrifos, pyrethroids.

Agrotis segetum

General

Although larvae of other noctuid species (*Agrotis ipsilon*, *Agrotis crassa*, *Agrotis spinifera* and *Agrotis puta*) are occasionally found, those of *Agrotis segetum* are the commonest cutworms on cotton. The brownish adults lay singly or in clusters, usually on weeds such as *Sonchus* and *Convolvulus* spp. The larvae are plump and hairless. They are grey, mimicking the colour of the soil. They roll up when disturbed. Maximum length is 3–4 cm. Pupation takes place in the soil, in a burrow. Flight of males can be followed by use of pheromone traps, which show that, although there is reduced activity in winter, males can fly at any time of year, mainly from the beginning of March to mid-July, with oscillations that cannot clearly be related to successive generations. Flight falls to a low level in summer, then starts again in the second half of September In winter, these species are mostly encountered as last-instar larvae, which are inactive though not really in diapause. Damage is due to cutting of the young plants at soil level.

Basic strategy

In recent years, attacks have been sporadic, probably because fields and their borders are kept free from weeds before sowing. This is the best method of control. Besides, the general use of plastic at sowing accelerates development of the young plants, which escape attack during their most susceptible stage (up to 20 cm). If control with insecticides is really needed, it is best to apply them as baits. If an insecticide spray is used nevertheless, it should be applied at high volume, at dusk, and directed at the collar of the plants.

Main insecticides

Sprays: cyfluthrin, cypermethrin, deltamethrin, flucythrinate, trichlorfon (bait).

Helicoverpa armigera

General

Larvae of the noctuid *Helicoverpa armigera* attack buds and bolls, causing a direct loss of yield. The eggs are mostly laid in the clump of newly forming leaves. From the time of appearance of the first buds, three generations develop on the crop, the first two being the most damaging. This species has developed resistance to numerous insecticides and is currently considered to be the most serious pest of cotton in the EPPO region.

Basic strategy

Pheromone traps can be used to observe when the adults start to fly. Before any insecticide spray treatment is applied, observations should be made on 50 randomly selected plants per plot for the presence of eggs and especially larvae on the flowers and bolls. The decision to treat should be based on the numbers of small larvae (less than 1 cm). Suggested thresholds are 8000 small larvae per ha for the first generation, 15 000 for the second (this can be raised to 25 000 if natural enemies are abundant, and 20–30 000 for the third. Natural enemies include: *Chrysopa* sp., *Nabis* spp. and *Orius* spp., the last generally being the most important. High populations of *H. armigera* are usually associated with the use of broad-spectrum products against other pests, with harmful effects on the populations of natural enemies. Extreme, though not unusual, conditions of high temperature and low humidity will suppress populations of eggs and small larvae.

Main insecticides

Methomyl.

Pectinophora gossypiella

General

The adult of *Pectinophora gossypiella* (pink bollworm) is a small moth 15–20 mm in size. The larva is initially white, becoming pink as it grows to reach a size of 8–9 mm. The egg is reddish-white and flattened, about 0.5×0.25 mm, with a rough surface. It is very difficult to see. There are three generations and sometimes a partial fourth. The adults start flying in spring when there are not yet any buds on the plants, so they can only lay on the terminal shoots ('suicide generation'). On hatching, the larva enters the bud, and completes its development in the open flower, which takes the shape of a 'lantern'. The attacked bud is not usually damaged and produces a normal boll. The moths of following generations lay their eggs below the calyx of bolls at least 15–20 days old and the hatched larva rapidly enters the boll and feeds on the seeds. Moving from seed to seed, the larva damages the lint, reducing its quality. The fully grown larva emerges from the boll and drops to the ground to pupate. Some of the larvae of the last generation remain in the seed to overwinter, or may give rise to the partial fourth generation. In rainy years, or in crops which receive overhead irrigation, bolls with exit holes may rot completely.

Basic strategy

This pest currently occurs at rather low levels, and in particular varies considerably from one year to the next, except in certain specific areas. Destruction of the haulm, as generally practised, is fundamental for the control of *P. gossypiella*. Control is very difficult because the larva spends very little time outside the boll and, once inside, becomes inaccessible to both insecticides and natural enemies. Pyrethroids sprayed against adults at the time when bolls are susceptible, at the beginning of the second or third generations (as determined by pheromone trapping), are very effective, but eliminate many insect natural enemies affecting other pests. The sexual confusion technique, with the pheromone Gossyplure, has been found to be effective for areas over 40–50 ha.

Main insecticides

Alpha-cypermethrin, bifenthrin, cypermethrin, deltamethrin.

Spodoptera exigua

General

The adult of *Spodoptera exigua* is a brownish-grey moth which lays its eggs in large clumps (10–250) covered by a whitish deposit. The larvae are variable in colour but generally light green, or sometimes more yellowish or even reddish when the hairs are very sparse. They feed essentially on leaf tissue. *Spodoptera exigua* is fairly polyphagous, laying its eggs preferably on herbaceous weeds such as *Amaranthus retroflexus* and *Convolvulus arvensis*. The young larvae tend to aggregate, but this behaviour disappears as they grow. The species multiplies very variably, adults being captured from April to the end of October. Cotton is not generally much affected, unless there are heavy infestations on weeds.

Basic strategy

No treatment thresholds have been established, but it is clear that a very high population is needed before this species causes significant damage to well-grown cotton. Young plants are more susceptible, in view of their limited leaf area and the need for rapid growth. It is recommended to inspect any weeds that are present in the field and/or its edges, as well as adjoining crops (such as beet) which are also host plants. If attacks are seen on weeds or in specific parts of the field, such as its edges, localized insecticide spray treatments may be applied. In any case, such treatments should target small larvae.

Main insecticides

Sprays: chlorpyrifos, methomyl.

Spodoptera littoralis

General

The adult of *Spodoptera littoralis* is a moth with a wingspan of about 4 cm, with a variegated pattern against a grey and brown background. It lays its eggs in large clusters, covered with a brown deposit. The larvae can reach a size of 3.5 cm, and are light brown to grey or nearly black in colour, with a pair of black spots on the abdominal segments. The young larvae are

gregarious, but disperse as they grow older. *Spodoptera littoralis* is extremely polyphagous and has been recorded on a great number of crops (rice, tomato, beet, lucerne, maize). It is usually found on cotton at the end of the growing season. Although catches of adults in pheromone traps may be very high at that time, there is no correlation with the level of attack on the crop. Damage takes the form of defoliation, and bolls are rarely attacked.

Basic strategy

Since this pest is present only at the end of the season, it hardly has any effect on yield. Insecticide sprays would only be needed if attacks occurred on a cotton crop at an earlier stage of development, because of unusually early attack, or because a late cultivar is planted.

Main insecticides

Sprays: chlorpyrifos, methomyl.

Thrips

General

Thrips are small (1–3 mm) sucking insects, with two pairs of narrow fringed wings. *Thrips tabaci* and *Thrips angusticeps* have traditionally been considered as secondary pests of cotton, occasionally damaging seedlings. Although the symptoms may be conspicuous, they are not normally associated with any economic loss, and there is no need for insecticide treatment in most cases. The recently introduced *Frankliniella occidentalis* is polyphagous and adapts to various climatic conditions. The adult is about 1 mm long, pale golden colour in summer and darker in winter. The eggs (reniform, 0.2 mm, whitish) are laid in the tissues of leaves or bracts, etc. The larvae are yellowish and resemble the adults. The length of the life cycle depends on temperature and food supply, and is about 2 weeks at 26 °C and 3 weeks at 20 °C.

The different thrips species appear from the beginning of the growing season, but mainly in summer. *Frankliniella occidentalis* remains in the crop until the beginning of harvest, and can affect buds, flowers and bolls, although it mainly attacks the lower leaf surfaces, hardening them. It can affect both the quantity and the quality of yield. A prevalence of over 10 larvae per leaf is dangerous if the crop is still growing. However, it should also be noted that *F. occidentalis* is an active predator of the eggs of spider mites.

Basic strategy

Populations of *F. occidentalis* (and thus the risk of damage) can be reduced by elimination of other host plants such as *Convolvulus arvensis*, *Diplotaxis erucoides* and *Diplotaxis virgata*, bolting beet plants, etc., before sowing, or by cutting any adjacent fields of lucerne. Control, if needed, is difficult to achieve because natural enemies (*Orius*, *Aeolothrips*, phytoseiids, …) are not normally very effective and *F. occidentalis* is resistant to most insecticides. There are effective products, but they have to be sprayed several times, which may damage the crop and unbalance populations of other pests.

Main insecticides

Sprays: acrinathrin, formetanate, methiocarb.

Tetranychus urticae

General

Spider mites (*Tetranychus urticae*) are key pests of cotton. Populations readily build up, whether because of the disappearance of natural enemies after use of broad-spectrum insecticides or because of excess nitrogen, etc. Adults of *T. urticae* are 0.6 mm in size and red in colour. They are the most visible stage, and are therefore the basis for counts (number of mites on the lower surface of a main leaf in the upper third of the plant, on 50 plants taken at random). The eggs, round and 0.1 mm in size, are mostly laid on the lower leaf surface, where the colonies form. The adult mites overwinter on wild vegetation around the field or on debris from an earlier crop. In spring they pass to the crop, or appear as small foci in the crop. Spider mites tend to aggregate and do not pass to other cotton plants before they have completely colonized the first. In summer, they spread rapidly through the field by rapid multiplication (the life cycle is completed in 12 days at 25 °C and in 24 days at 20 °C). In feeding, the mites uncover and empty the cells of the surface tissues, allowing air to penetrate, so that they take on a silvery appearance. The plant is stressed both by reduced photosynthesis and by increased transpiration, which lead to a fall in yield and in the quality of the lint (length, resistance).

Basic strategy

Spider mites should be eliminated, before sowing, from any weeds growing along the edges or within the fields. Initially, only foci and/or the edges should be sprayed with acaricide. Once the mites have spread throughout the field, sprays should only be applied when a treatment threshold is reached, such as one adult mite per leaf, and then only when natural enemies are absent. Populations of *Orius* greater than 300 000 per ha (measured by collecting on a sheet) are generally sufficient to prevent further mite development. Control is facilitated by the correction of any factors which destabilize the system: full exploitation of numerous and effective natural enemies (*Orius*, *Nabis*, *Chrysoperla*, *Aeolothrips*), reduction of nitrogen to what is strictly necessary, use of selective insecticides against other pests or resurgences of mites; use of adequate equipment under appropriate conditions ensuring that products reach the lower surface of the leaves.

Main acaricides

Sprays: abamectin, bromopropylate, dicofol, propargite, tetradifon + dicofol.

Growth regulators

General

Yield results from a satisfactory balance of vegetative growth and fruiting. The plant regulates itself best if there is a high retention of bolls in the first positions. It may be necessary to control the level of retention of bolls, and internode length between the upper five nodes of the plant.

Basic strategy

Use of a growth regulator is not always necessary. If the history of the field and the characteristics of the cultivar are known, plant development can be forecast, although interference from other factors (climate, irrigation, fertilizer) requires monitoring of the crop through the growing season. Use of plastic increases the plant's tendency to develop vegetatively. The aim of maintaining internode length close to its optimal value should be attained by continuously adjusting the dose of regulator in the plant, not by acting *a posteriori* or trying to make use of water stress. Action is needed from the first signs of excess vigour, by low and continuing doses for as long as the conditions favouring vigour persist.

Products

Mepiquat chloride.

Weeds

General

Weeds can be a problem for a cotton crop in its early stages of growth (poor emergence, delayed growth), during development (competition for light, water and nutrients) and in the final stages (poor defoliation, spotting of the lint, …). All this results in a fall in yield and sometimes also in lint quality, not to speak of the role of weeds as alternative hosts of pests (red spider mites, cutworms, verticillium). Control is based on cultural practices and on the use of herbicides. The main difficulty arises from the tendency of the weed flora to shift towards species which are difficult to control (*Solanum*, *Cyperus*, *Xanthium*, …) and the appearance of new weeds such as *Abutilon*. Sowing under plastic creates additional difficulties for weed control.

Basic strategy

Weed control in cotton depends on the integration of cultural practices. When preparing the ground for sowing, weeds established during winter should be controlled by ploughing or herbicide application. Excess nitrogen fertilizer should be avoided, since this favours nitrophile weeds such as *Solanum nigrum*, *Chenopodium* spp. and *Amaranthus* spp. Although weed control in the field is mainly achieved by herbicide application, it may be necessary to use a cultivator to control weeds developing between the rows.

For the control of perennial weeds, especially heavy infestations of *Cyperus rotundus*, *Sorghum halepense* or *Convolvulus arvensis*, it is recommended to rotate with autumn/winter crops, not to plough during the fallow period and to apply a high low-volume dose of glyphosate at late flowering. These measures should be repeated in successive years. Any herbicides used should be safe for the alternating crop.

For sowing under plastic, any pre-emergence application of herbicide should be made along the sowing line, at low dose, and without additional incorporation. This application can replace, or complement, a presowing application.

Main herbicides

Presowing
If no tillage is done, weeds established during winter should be controlled with leaf-applied total herbicides. According to the distribution of the weeds, the application should be made to the whole plot or only to infested areas. Glyphosate is suitable for control of annual weeds (low dose) and perennials (high dose). If the infestation is principally of dicots, a mixture with MCPA can be used. Glufosinate-ammonium and diquat are suitable when the infestation is exclusively of annual weeds.

After tillage, residual herbicides are applied, generally with incorporation by presowing tillage or by water (rain, irrigation).
Monocots: benfuresate.
Dicots: isoxaben, pendimethalin.
Monocots and dicots: dinitramine, ethalfluralin, trifluralin.

Pre-emergence
Application after sowing but before emergence of the cotton, on moist ground, or in the absence of rain, with incorporation by light irrigation.
Monocots: metolachlor.
Dicots: fluometuron, pendimethalin, prometryn.

Post-emergence
If the herbicide poses any safety problems on cotton, the application should be done under the most favourable environmental conditions and at the most suitable stage of development, directed towards the soil and using protective shields.
Monocots: any registered foliar grass herbicide.
Dicots: fluometuron.
Monocots and dicots: oxyfluorfen.

Haulm destruction

General

Use of defoliating chemicals for haulm destruction is essential to obtain clean dry lint. Efficacy is reduced by: temperatures below 25 °C, high or late nitrogen fertilizer, late irrigation, high sowing density, plants with excessive vegetative growth and poor retention of bolls, etc.

Basic strategy

All practices avoiding the factors listed above will improve the efficacy of haulm destruction, so that the plants rapidly senesce. Thidiazuron should be applied when four or five green bolls remain to be harvested, above the first open boll. Daytime temperature should be over 26 °C and night-time 15 °C. If temperatures are lower, dimethipin should be used, applied at 70% open bolls.

Products

Dimethipin, thidiazuron.