◆ EPPO Standards ◆

GUIDELINES ON GOOD PLANT PROTECTION PRACTICE

RYE

PP 2/19(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 2/19(1) English

Guidelines on good plant protection practice

RYE

Specific scope

This standard describes good plant protection practice for rye.

Specific approval and amendment

First approved in September 1999.

This guideline on GPP for rye forms part of an EPPO programme to prepare such guidelines for all major crops of the EPPO region. It should be read in conjunction with EPPO Standard PP 2/1(1) Principles of Good Plant Protection Practice. The guideline covers methods for controlling pests (including pathogens and weeds) of rye *(Secale cereale).*

Rye is grown in the more temperate and Nordic parts of the EPPO region. The grain is mainly used for bread-making and consumption, particularly in countries with traditions of rye-bread consumption. Rye straw can be used for animal consumption.

Rye crops are generally sown in autumn. Seeds may be bought, certified or not, or may be produced directly by the farmer. Crop rotation with other cereals or field crops reduces the build-up of pest populations in the soil or in crop debris. In general, careful soil cultivation is recommended as an effective cultural control method. Minimal cultural practices such as direct drilling, although they may reduce labour costs, also favour the survival and build-up of pest populations in the soil. As rye is mainly grown for grain, the aim of protection against pests is to ensure a good quantity and quality of grain yield. To ensure good grain quality, with good possibilities for bread-making, it is important to keep the crop upright and harvest the crop as soon as it is ready.

Use of resistant cultivars, optimum time of sowing, good crop rotation, use of healthy seeds, well prepared seedbed and cultural operations, destroying or burying stubble are important elements in GPP for rye. Treatments with plant protection products may be necessary at any stage of development of the crop. The use of seed treatment is GPP when it is used against pests that cannot be controlled by foliar fungicides. It may also be GPP to use seed treatment against other pests, if the seed treatment results in fewer sprays and, thus, in a reduced amount of plant protection product early in the season. The products used for seed treatment should, if necessary, cover the full range of fungal or insect pests concerned. It is important that seeds should be uniformly treated with product.

Simultaneous application of two or more active substances as sprays or seed treatments is GPP if the pests to be controlled are indeed present or to be expected. The farmer or adviser should be familiar with the main pests, monitor fields regularly and make full use of existing early warning systems and economic thresholds. As soon as practical thresholds for weed infestation become available, these should be used. Dosages should relate to the pest spectrum observed, taking into account the individual effects and possible interactions. For fungal diseases in particular, it is GPP to select products and to time applications in an optimal way.

Except for spot application on perennial weeds and ULV insecticide applications early in the season, boom sprayers, mounted on or towed by tractors, are the only equipment advised for sprays. It is GPP to reduce drift and unwanted dispersal of plant protection products as much as possible by using drift-preventing nozzles and equipment that produces a good and uniform distribution across the spray boom.

The risk of developing resistance to fungicides, insecticides and herbicides is a real threat. It is GPP to avoid spraying a fungicide or insecticide later in the season if an active substance with the same mode of action has already been applied as a seed treatment. An active substance with a different mode of action should preferably be used. The same holds for the control of the important powdery mildew and rust diseases: active substances should be alternated or co-formulations containing products with different modes of action should be used as much as practicable.

The principal rye pests considered are the following:

- *Puccinia recondita* f.sp. *recondita* (brown rust);
- *Erysiphe graminis* (powdery mildew);
- *Urocystis occulta* (stripe smut);
- *Tapesia acuformis* (eyespot);
- *Gaeumannomyces graminis* (take-all);
- *Fusarium culmorum* and *Monographella nivalis* (foot rot and snow mould);
- *Rhynchosporium secalis* (scald);
- *Claviceps purpurea* (ergot);
- aphids;
- thrips;
- *Tipula* spp. (leatherjackets);
- wireworms and white grubs;
- *Delia coarctata* (wheat bulb fly);

- *Agromyza* spp. (leaf miners);
- *Oscinella frit* (frit fly);
- *Zabrus tenebrioides* (ground beetle);
- *Haplodiplosis marginata* (saddle gall midge);
- *Oulema melanopus*, *O. gallaeciana* (cereal leaf beetles);
- nematodes;
- slugs;
- weeds;
- plant growth regulators.

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.

Puccinia recondita f.sp. *recondita* (brown rust)

General

Rust fungi are highly specialized to their hosts, and rye is attacked by the forma specialis *recondita* of *Puccinia recondita*. In addition, pathotypes specialized to host resistance genotypes are common. The main source of infection is by air-borne urediniospores, which survive the harvest period on late tillers and spread successively to volunteer plants and to the autumn-sown crop. Crops may also be infected from air-borne urediniospores coming from other areas. Epidemics develop by repeated secondary urediniospore infection, and this is the stage which is subject to control. Infection from the aecial stage on alternate hosts is relatively unimportant. Brown rust forms orange-brown urediniospores which are irregularly spread over the entire leaf surface.

Basic strategy

There is a range of cultural practices that may reduce rust infection of rye. First, resistant cultivars should be grown or, at least, very susceptible cultivars should be avoided. Volunteer rye should be destroyed, and winter rye should not be sown too early. Excessive nitrogen application should be avoided to prevent too heavy and too dense a stand. If the risk of infection by rust becomes serious, application of a fungicide spray may be necessary. Normally, one or two applications are sufficient. In practice, thresholds may be used, e.g. 25% of plants attacked at BBCH 31. Alternatively, the advice of warning services (based on various forecasting models) should be followed.

Main fungicides

Sprays: azoxystrobin, cyproconazole, epoxiconazole, fenbuconazole, fenpropidin, fenpropimorph, fluquinconazole, flusilazole, flutriafol, propiconazole, tebuconazole, triadimefon, triadimenol.

Erysiphe graminis (powdery mildew)

General

Erysiphe graminis forms patches of superficial white, then greyish powdery mildew mycelium on leaves, leaf sheaths and ears of rye. Leaves remain green and active for some time after infection, then the infected areas gradually die. The conidia, formed in great quantities as a white powder on the mycelium, are wind-dispersed over considerable distances to infect healthy leaves. This air-borne inoculum is practically ubiquitous and uncontrollable. Infection by conidia requires high humidity but not free water on the leaf surface, while sporulation and spore dispersal are favoured by rather dry conditions. Powdery mildew is thus favoured by an alternation of wet and dry conditions, as often occurs in north-west Europe. Infected areas on leaves become chlorotic and cease to photosynthesize. Early mildew attack reduces tillering and later infection reduces "green leaf area", and thus grain yield. Cleistothecia may appear on old colonies as black points at BBCH 39-65, but these contribute relatively little to inoculum in the spring, which mainly comes from pustules on winter cereal crops.

Basic strategy

Rye is infected only by forma specialis *secalis* of *E. graminis*, so powdery mildew from wheat or barley cannot infect rye and vice versa. A range of cultural practices exists that may somewhat reduce the infection by *E. graminis*. The growing of resistant cultivars is recommended. If possible, winter rye should be sown late in regions favourable to powdery mildew. An open stand of rye reduces the incidence of powdery mildew as compared to a dense stand, heavily fertilized with nitrogen. If powdery mildew infection becomes serious, one or more fungicide sprays may be necessary; these should not be applied after BBCH 55. In most cases, it is not useful to treat winter rye in the autumn.

Problems with resistance

E. graminis has been reported to show reduced sensitivity to fungicides of the sterol-biosynthesis inhibitor group, but this has not led to loss of control.

Main fungicides

Sprays: bromuconazole, cyproconazole, cyprodinil, epoxiconazole, fenpropidin, fenpropimorph, flusilazole, flutriafol, kresoxim-methyl, prochloraz, propiconazole, tebuconazole, triadimefon, triadimenol, tridemorph, triforine.

Seed treatments: flutriafol, triadimenol.

***Urocystis occulta* (stripe smut)**

General

Urocystis occulta causes stem smut of rye. Seedlings are systemically infected by spores carried on the outside of the seeds or persisting in the soil. Smut symptoms appear, after stem extension, as long chlorotic stripes on the upper leaf blades and sheaths. Leaves and sheaths are often twisted; plants are stunted and may fail to produce ears. The stripes turn dark grey in colour as large numbers of black, powdery spores develop in sori. Some spore balls within the sori fall to the ground when the sori rupture, and provide inoculum to infect the following crop of rye shortly after seed germination. Spores can remain viable in the soil for more than 1 year. Spore balls are also released during harvest, resulting in contamination of seed. Both seed-borne and soil-borne infection are important in the epidemiology of the disease.

Basic strategy

Infection at the time of seed germination, whether resulting from soil-borne or seed-borne spores, can be prevented by the use of seed treatments. Seed treatment has been very effective in controlling this disease, which is now practically unknown in intensive cereal cultivation in Europe. However, where untreated seed is used, the disease may reappear. It is important to test seed and to treat if the pathogen is present. Use of untreated and untested seed is not GPP.

Main fungicides

Seed treatments: bitertanol, difenoconazole, fenpiclonil, fludioxonil, tebuconazole, triadimenol, triticonazole.

***Tapesia acuformis* (eyespot)**

General

Eyespot of rye is caused by *Tapesia acuformis* (anamorph *Ramulispora acuformis*, syn. *Pseudocercosporella herpotrichoides* var. *acuformis*), rather than the related *T. yallundae* (mainly on wheat). Spores produced on the stubble of a previous cereal crop are the main source of inoculum. The stem base is infected mainly during the autumn and winter, but this can continue into the spring. Plants are affected via leaf sheaths, and the pathogen gradually progresses through successive leaf sheaths to the stem. In the stem, it produces a lens-shaped spot with a darker border. Lesions restricts water and nutrient flow to the ear, which may result in premature ripening and may also weaken the stem sufficiently to lead to a risk of crop lodging. The disease is most severe in crops sown early in the autumn.

Basic strategy

A number of factors predispose rye crops to eyespot including early sowing, cereal as preceding crop, cultivar, dense sowing, excessive tiller production. Where the previous crop was wheat, barley or rye, winter rye should be sown rather late providing that this is not incompatible with good crop establishment. A 2-year break between cereal crops will reduce the risk of eyespot, but will not remove all risk. Cultivars with a certain degree of resistance are available. If, at the start of stem elongation (BBCH 31), lesions are visible on more than a threshold percentage of tillers, a fungicide spray should be applied. This threshold varies according to climatic conditions and cultivar resistance between 15 and 35%. The advice of local warning services should be followed, if available. Use of plant growth regulators to shorten the length of the stem may reduce the incidence of lodging associated with eyespot lesions.

Problems with resistance

Resistance to the benzimidazole group of fungicides is common in *T. acuformis*. Resistance to triazoles (which, in any case, are less effective against the slow-growing strains) and prochloraz has also been found in certain areas.

Main fungicides

Sprays: cyprodinil, prochloraz.

***Gaeumannomyces graminis* (take-all)**

General

Gaeumannomyces graminis is a soil fungus that infects the roots of rye, on which it forms a characteristic black superficial mycelium. The infection may spread to the collar and lower leaf sheaths. The root system is partly or entirely destroyed, and infected plants produce bleached inflorescence (whiteheads) with either shrivelled grain or no grain at all, especially under hot, dry conditions. The fungus persists as saprophytic mycelium in crop debris, which infects new roots directly. The air-borne phase is of little importance in the epidemiology of take-all. The disease tends to occur as patches in the crop. Take-all is one of the most serious causes of yield loss in intensive wheat crops, but is less important on rye.

Basic strategy

As a root-infecting soil fungus, *G. graminis* is practically inaccessible to treatment with fungicides. Because the fungus does not persist very long in debris, control is achieved by 3-year crop rotation, for example with rape, field bean or potatoes.

***Fusarium culmorum* and *Monographella nivalis* (foot rot and snow mould)**

General

Fusarium culmorum and *Monographella nivalis* are soil fungi that infect the foot of rye plants. Both can infect seedlings, and *M. nivalis*, in particular, can cause serious seedling losses. Both may be seed-borne, but the two fungi can also infect the roots of young plants directly from the soil. Under suitable conditions, root infection can spread to the stem base, which can be seriously damaged. In the case of *F. culmorum*, this spread is favoured by rather dry warm weather, and the disease is mostly known from central and southern Europe. The base of the tillers turns brown or develops large brown spots; the tillers bend, and the crop lodges. In the case of *M. nivalis*, this spread occurs at low temperatures, characteristically under melting snow cover during the winter. The spots are lighter in colour. *F. culmorum* is an unspecialized pathogen, able to infect the roots of many plants and to persist saprophytically. Similarly, *M. nivalis* attacks many other *Poaceae* and persists in the soil. Seedlings and young plants can be protected from primary root infection by treating the seeds with fungicide. Another member of the foot-rot complex, *Ceratobasidium cereale* (anamorph *Rhizoctonia cerealis*), has symptoms resembling eyespot but is less important. Other *Fusarium* spp. (e.g. *Gibberella avenacea)* also belong to this complex.

Basic strategy

Because of the build-up of inoculum on a preceding cereal crop, rotation will reduce foot-rot incidence to a certain extent. However, both pathogens remain as part of the natural soil microflora, and rotation is not as effective as against *Gaeumannomyces graminis*. Soil conditions should be optimal, and the seeds used should be disease-free. Use of a fungicidal seed treatment against these fungi is effective routine GPP for rye. Dense stands should be avoided. In the case of serious seedling losses, additional fertilization in the spring time is recommended.

Main fungicides

Seed treatments: benomyl, bitertanol, carbendazim, fludioxonil, flutriafol, fuberidazole, guazatine, prochloraz, triadimenol.

***Rhynchosporium secalis* (scald)**

General

Rhynchosporium secalis is a common leaf pathogen that persists in crop debris. The leaf lesions appear as blue-green spots which turn grey with a clear brown edge. The disease develops already in autumn and spreads by splashing during elongation. Lesions often occur at the base of the leaf sheath which stops further activity in the leaf.

Basic strategy

Differences in susceptibility between cultivars are well known. Volunteer rye plants, grass weeds and remnants of nearby rye crops should be destroyed. Late sowing reduces the incidence of the disease. The level of disease should be assessed in early spring and one or two treatments, as spray applications, may be needed, especially if the crop is grown under wet conditions. A warning system based on precipitation can be used to decide when to spray.

Main fungicides

Sprays: azoxystrobin, bromuconazole, cyproconazole, epoxiconazole, fluquinconazole, flusilazole, propiconazole, prochloraz, tebuconazole.

***Claviceps purpurea* (ergot)**

General

The ergot fungus can parasitize a wide range of cereals and grasses, and rye is very susceptible. It causes a disease that affects only the flowering part of the host plant. Affected plants produce ergots or sclerotia which completely replace the grain in the ears. The ergots often fall to the ground before harvest or, in some cases, they may be harvested and either sown again with the seed or, possibly, eaten directly by animals. Ergots contain toxic substances, mainly alkaloids, which are harmful to animal and humans if eaten. They also have medical value. Cereal grain has to meet official health standards for ergot contamination.

When ergots fall to the soil, they remain in this state until the following year when, if they are on or near the surface, they germinate at the time the cereal crops come into flower with stromatal heads containing many perithecia with ascospores. Spread of the ascospores to neighbouring flowers is by insects, rain splash or wind.

Basic strategy

The disease rarely achieves economic importance on most cultivars and in most countries. Varietal resistance has been demonstrated, and pathogenic races are known. The susceptibility of various hosts may be related to the length of time the flower remains open. Hybrid rye has in some years had substantial attack,

which has given rise to both a big loss of seed during cleaning as well as problems with selling the seed for animal feed. The use of ergot-free seed is most important, and this can be achieved by a flotation method using solutions of sodium chloride. Deep ploughing and rotation of crops are effective remedies because ergots buried about 25 cm deep do not germinate and rot away after a year. Control of grass weeds, particularly *Alopecurus myosuroides*, in and around crops is important in preventing spread into cereal crops. Treatment of seed with triadimenol can reduce the germination of any contaminating ergots, thus reducing inoculum for infection of poaceous hosts, including rye. There is no satisfactory chemical treatment for use in the field.

Aphids

General

Aphids, especially *Sitobion avenae*, *Metopolophium dirhodum* and *Rhopalosiphum padi*, may become numerous on leaves of rye and may inflict direct feeding damage or indirect damage because of the formation of sooty moulds or transmission of virus diseases, especially *Barley yellow dwarf luteovirus* (BYDV). The quality of grain is also affected by aphid infestation, but aphids rarely infest the ears of rye in northern Europe.

Basic strategy

Aphids are rarely a serious problem in rye. For the control of direct aphid damage on winter rye, the rye crop should be regularly inspected in spring and an insecticide spray application should be made if numbers reach a certain level. Use of selective insecticides (e.g. pirimicarb) will favour natural enemies. Various threshold levels are recommended, for example: 20-30% of tillers infested before BBCH 37; 40% of tillers infested after BBCH 37. Numbers must be increasing or likely to pass the threshold a few days after assessment to justify treatment. A single spray is usually sufficient. When controlling aphids as vectors in spring, application in the autumn may be necessary using lower thresholds than for direct damage. Seed treatment is also possible.

Main insecticides

Seed treatments: imidacloprid.

Sprays: alpha-cypermethrin, beta-cyfluthrin, bifenthrin, chlorpyrifos, cyfluthrin, cypermethrin, deltamethrin, demeton-S-methyl, dimethoate, esfenvalerate, fenvalerate, formothion, heptenophos, lambda-cyhalothrin, pirimicarb, thiometon.

Thrips

General

Many species of thrips (*Limothrips cerealium, L. denticornis, Stenothrips graminum, Haplothrips aculeatus, Thrips angusticeps, Haplothrips tritici, Aptinothrips elegans, Anaphothrips obscurus)* feed on rye leaves, causing a silvery look of the upper leaf sheath; infested leaves may turn brown. Feeding on the ear during emergence causes whitish, empty grains. Thrips are only a problem in the northern part of the EPPO region.

Basic strategy

Thrips can be controlled by spray application of insecticides, but this is normally not necessary. A single treatment may be applied before flowering (BBCH 61), if numbers exceed a certain threshold, e.g. four adults per ear. Thorough inspection is necessary, for the insects are minute and difficult to see. Sprays should not be applied after the milky ripe stage (BBCH 75). Certain treatments applied against aphids will give incidental control of thrips.

Main insecticides

Sprays: alpha-cypermethrin, deltamethrin, esfenvalerate, fenvalerate, lambda-cyhalothrin.

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

Rye crops may be damaged when following grassland or uncultivated land. In general, this rotation should be avoided if possible. The presence of larvae can be checked before ploughing the grassland either by 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. Winter rye is less at risk from leatherjackets because the crop usually establishes before the main feeding period of the larvae. No specific threshold has been expressed. Attacks may be prevented by ploughing out grassland so that the soil is bare from July to August. It is GPP to apply a soil insecticide treatment by overall spray at high water volume before or soon after ploughing grassland or uncultivated land. An overall spray at high water volume can also be applied to a growing crop if damage is seen. Spraying before rainfall can improve the distribution in the upper soil layer.

Main insecticides

Overall sprays: *Bacillus thuringiensis* var. *israelensis*, chlorpyrifos, dimethoate, etrimfos, fenitrothion, lindane, triazophos.

Seed treatment with imidacloprid is also possible.

Wireworms and white grubs

General

The larvae of certain *Elateridae* (*Agriotes* spp., wireworms) and *Melolonthidae* (*Melolontha* spp., white grubs) damage the stem bases and the roots of rye plants. These become yellow and the main shoot turns brown. Development of wireworms takes 5 years, and adults and larvae of different ages co-exist each year. Development of white grubs takes 4 years and is generally synchronized. The most serious damage normally only occurs the third year after adult flight.

Basic strategy

Grassland or uncultivated land as a preceding crop should be avoided. However, if a rye crop is grown in such a high-risk rotation, an overall soil spray treatment as well as a seed treatment may be justified. The level of population of wireworms and white grubs in the soil is needed to make an informed decision on treatment and should be determined by soil sampling.

Main insecticides

Overall sprays: chlorpyrifos, diazinon, fonofos, lindane, tefluthrin, terbufos.

Seed treatments: carbofuran, carbosulfan, fonofos, lindane, imidacloprid.

***Delia coarctata* (wheat bulb fly)**

General

Eggs of *Delia coarctata* are laid during the summer months in bare soil or in soil under a root crop. The eggs hatch in the following spring, and the larvae bore into the rye plant. Both winter and early sown spring rye may be damaged. The central shoot of the attacked plant dies, turning yellow, although the outer leaves remain green. The larvae move from tiller to tiller on the same plant and sometimes through the soil to another plant. Damage is common and can be serious.

Basic strategy

Damage can be reduced effectively by cultural methods. The crop rotation can be chosen so that wheat does not follow a fallow or crop that provides suitable egg-laying conditions (bare soil during July and August). If the crop follows grass, ploughing out can be delayed to reduce egg-laying. Land lying bare after harvest should not be tilled in early August as this will encourage egg-laying. In high-risk situations, early drilling with an increase in seed rate is recommended.

Control with insecticides is normal GPP against *D. coarctata*. The type of treatment is decided on the basis of previous cropping, crop-sowing date and the perceived level of risk based on sampling for eggs. Insecticides are preferably applied as seed treatments, but may also be applied as seedbed sprays at or soon after sowing, as sprays at the start of egg hatch or at peak egg hatch, and as sprays at the onset of plant damage. If a soil or seed treatment has been applied against wireworms, this may also have action against *D. coarctata*, according to the insecticide used.

Main insecticides

Seed treatments: chlorfenvinphos, fonofos.

Sprays: chlorfenvinphos, chlorpyrifos, dimethoate, fonofos, omethoate, pirimiphos-methyl.

***Agromyza* spp. (leaf miners)**

General

Agromyza spp. are small flies (3-5 mm long) that emerge in spring. The females feed by puncturing leaves along the veins. The eggs are deposited between the two epidermes of the leaves, and the larvae mine the mesophyll. The mines often become confluent, giving a typical appearance (mesophyll tissues in the upper third of the leaf are completely destroyed). *Agromyza* spp. are locally important in northern Europe.

Basic strategy

Moderate levels of attack do not cause losses. Insecticide sprays may be applied from BBCH 31 in the case of heavy attacks, or if a threshold of more than 20% mining on lower leaves accompanied with puncturing of upper leaves is reached at BBCH 55. Aphid control has an incidental effect on *Agromyza* spp.

Main insecticides

Sprays: alpha-cypermethrin, bifenthrin, cypermethrin, deltamethrin, dimethoate, esfenvalerate, lambda-cyhalothrin, permethrin, tau-fluvalinate.

***Oscinella frit* (frit fly)**

General

The larvae of *Oscinella frit* are 3-4 mm long, white, legless and lack a distinct head (although with black mouths). There are normally three generations a year, but only the autumn generation attacks rye when it is sown after infested grass. The larvae migrate from the

ploughed-in grass to invade the rye plant, the centre leaf of which turns yellow and dies.

Basic strategy

If winter rye is sown after grass, the land should be ploughed early and at least 4 weeks before sowing. Similarly, grass-infested stubble should be ploughed soon after harvest. The risk of damage to rye is only slight in most years and does not justify routine insecticide spray treatment unless regular damage has occurred previously. Egg-laying takes place at the 1- to 2-leaf stage (BBCH 11-12). If this coincides with high intensity of flying revealed through monitoring, a spray is justified. Crops at risk should be examined from emergence and sprayed if a threshold of damaged shoots, e.g. 10%, is exceeded. Seed treatments are also effective.

Main insecticides

Seed treatment: chlorfenvinphos, fonofos.

Sprays: alpha-cypermethrin, chlorpyrifos, cypermethrin, deltamethrin, esfenvalerate, fenitrothion, lambda-cyhalothrin, dimethoate, permethrin, pirimiphos-methyl, triazophos.

***Zabrus tenebrioides* (ground beetle)**

General

The larvae of *Zabrus tenebrioides* live in the soil in a self-made tube. Leaves of young rye plants are pulled down into the tube. The larvae eat only the leaf blade. Damage can be detected from the remains of the leaves in the tubes. The pest tends to occur and damage plants in patches. The larvae are active in spring and on mild winter days, and their development ends at the beginning of heading. *Z. tenebrioides* is mainly important in central and eastern Europe. It has one generation every 2 years in the northern part of its range and one generation per year in the southern part. It can survive on volunteer cereals.

Basic strategy

Cultural control can be used to reduce the risk of attack: early harvesting of straw and destruction of volunteer cereals. In areas of heavy infestation, an overall insecticide treatment of soil is recommended before sowing. Seed treatments may be used but are less effective. If infestations are nevertheless observed, a corrective spray treatment may be applied. It is advisable to treat in the morning or in the evening, as the larvae do not feed during daytime. *Z. tenebrioides* can also occur sporadically in other areas of Europe. In this case, a spray treatment when damage is seen is sufficient.

Main insecticides

Overall pre-planting treatments: chlorpyrifos, diazinon, fonofos, lindane, tefluthrin, terbufos.

Seed treatments: endosulfan, lindane.

Sprays: chlorpyrifos, deltamethrin, parathion-methyl.

***Haplodiplosis marginata* (saddle gall midge)**

General

In May and June, female midges deposit their eggs on the surface of rye leaves. The whitish, later orange-red larvae attack the stems under the leaf sheaths. Larval feeding results in the formation of saddle-shaped galls. Spring-sown crops are more susceptible to damage than those sown in the autumn. Infestations are common but at low levels.

Basic strategy

The pest is associated with frequent cereal-growing on heavy land. It can be avoided by practising a wide crop rotation and controlling grass weeds wherever possible. In high-risk areas, insecticide sprays are necessary and should be directed against newly hatched larvae. If 10% or more of tillers have eggs present, an insecticide should be applied at egg hatch. Only one application is necessary.

Main insecticides

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

***Oulema melanopus* and *O. gallaeciana* (cereal leaf beetles)**

General

Oulema melanopus and *O. gallaeciana* (syn. *O. lichenis*) are shiny blue beetles which feed on rye leaves, causing elongated holes. The yellow larvae are covered by a blackish, sticky substance and may be mistaken for small slugs. The larvae skeletonize the leaves, causing long white stripes.

Basic strategy

Damage is commonly seen, but is often not very important. Chemical treatment is justified after reaching a threshold such as 15 adults per m^2 just before oviposition, or 0.5-1 larvae per stem. Sprays may be combined with those against aphids, in which case suitable active substances should be used.

Main insecticides

Sprays: alpha-cypermethrin, bensultap, beta-cyfluthrin, cypermethrin, deltamethrin, dimethoate, endosulfan, esfenvalerate, lambda-cyhalothrin.

Nematodes

General

Two nematodes feed on the roots of rye: *Meloidogyne naasi* (cereal root-knot nematode) which induces the formation of many extra roots and elongated root knots, and *Heterodera avenae* (cereal cyst nematode), which causes strong root branching and deformation, with cysts visible later in the season. Attacks are visible in the field as spots where crop growth is retarded. Stem nematode *Ditylenchus dipsaci* is a migratory endoparasite, and all development stages can invade rye. Affected plants are stunted, swollen and distorted, with proliferation of tillers. Severely infected plants are killed so that infested crops frequently have bare patches. *D. dipsaci* populations persist in the soil, in debris from decaying plants, for many years.

Basic strategy

Crop rotation is useful, reducing the proportion of cereals and grass seed crops. Maize is not a host plant and can safely be grown. No treatment is recommended specifically against these nematodes. Soil disinfection in other crops such as potatoes has a good effect against root nematodes, but is not necessarily GPP (see EPPO Standard PP 2/2(1) Guideline on GPP for potato). The rye race of *D. dipsaci* is controlled by growing non-hosts.

Slugs

General

Slugs (e.g. *Agriolimax arvensis*, *Deroceras reticulatum*) damage rye seedlings and hollow out rye seeds and the problem is increasing with direct drilling and after fallow. Early slug damage can be very important. Later leaf feeding is not important. Slugs are largely a problem on medium- to heavy-textured soils in wet seasons.

Basic strategy

A firmly consolidated seedbed will restrict slug movement and encourage rapid seedling growth. The surface should be clod-free. To assess the risk of slug damage and the need for and time of molluscicide treatments, test baiting is advised when the soil surface is moist. The normal method of treatment is to scatter molluscicide formulated as a bait, and it is applied most effectively after seedbed preparation but a few days prior to drilling. Bait pellets can also be mixed with the seed. As slugs are often at the borders of the field, spot treatment is sometimes possible.

Main molluscicides

Metaldehyde, methiocarb, thiodicarb.

Weeds

Basic strategy

Although chemical weed control is the most widely used method of weed control in rye, there are opportunities to use cultural methods before sowing the crop and during crop growth. It is GPP to destroy emerged grass and broad-leaved weeds by mechanical cultivation or use of herbicides in the stubble of the preceding crop. This is particularly useful where it is intended to prepare the seedbed without ploughing. Normally, it is GPP to cultivate, e.g. to plough and harrow, before sowing the rye crop, with a light harrowing and/or rolling after drilling to consolidate the seedbed, if necessary. Seedbed preparation methods depend on soil type, soil conditions and the time of the year. The objective is to remove remnants of the previous crop, destroy weed populations and prepare a seedbed in optimal conditions to encourage rapid germination of a full, competitive stand of rye and to provide a level clod-free surface for maximum activity of a residual herbicide.

Herbicides can be applied pre-sowing, pre-emergence, post-emergence and pre-harvest. Weed control decisions should be based on economic damage thresholds if available including the risk of seed return of aggressive weed species, or on past knowledge of the field, if a treatment before weed emergence is planned. Annual grass and dicotyledonous weeds may be controlled in the autumn provided that it is likely that weed thresholds may be exceeded; a suitable combination of residual and foliar-acting herbicides should be used. Late-sown crops or crops with low weed populations may not need herbicide treatment before the spring. Spring applications of suitable foliar-acting herbicides should be made only where annual grass or dicotyledonous weed thresholds are likely to be exceeded, where weeds have escaped the autumn treatment, or where spring-germinating weeds predominate.

It is GPP to ensure that conditions favourable for active growth of crop and weeds exist in the spring before the application of a foliar herbicide. Crop and weed growth stages should be followed carefully to avoid inefficient use of herbicides on large weeds and crop damage. The risk of a carry-over effect to a succeeding crop should also be considered.

In order to delay or minimize the development of herbicide resistance, guidelines are available and should be followed.

Perennial weeds such as *Elymus repens*, *Cirsium* spp. and volunteer potatoes can be controlled shortly before harvest with non-selective foliar herbicides, e.g. glyphosate. The crop should be almost dead at this time and the grain nearly ripe, and the weeds should be alive and well exposed. Spot treatment with ropewick applicators is also possible at this time for some weeds.

Main herbicides

The numerous herbicides available for control in rye can be classified by their time of application (pre-sowing, pre-emergence or post-emergence) and their main target (annual grass weeds, dicotyledonous), as follows.

Annual grasses only

Pre-sowing and pre-emergence: tri-allate.

Post-emergence: clodinafop-propargyl +cloquintocet-mexyl, difenzoquat, fenoxaprop-P-ethyl.

Grasses/dicots

Pre-emergence: chlorotoluron, diflufenican, isoproturon, methabenzthiazuron, pendimethalin, prosulfocarb, terbutryn, trifluralin.

Post-emergence: carfentrazone-ethyl, carfentrazone-ethyl + flupyrsulfuron-methyl, chlorotoluron, diflufenican, imazamethabenz-methyl, isoproturon, methabenzthiazuron, metoxuron, metsulfuron-methyl, prosulfocarb.

Pre-harvest: diquat, glyphosate.

Dicots only

Pre-emergence: isoxaben.

Post-emergence: 2,4-D, amidosulfuron, bentazone, bifenox, bromoxynil, dicamba, dichlorprop-P, fluoroglycofen-ethyl, fluroxypyr, ioxynil, MCPA, mecoprop-P, pyridate, thifensulfuron-methyl, triasulfuron, tribenuron-methyl.

Plant growth regulators

General

Because rye generally has tall weak straw, lodging can be very common. Under certain environmental and agronomic conditions (high nitrogen inputs, high density), rye can be prone to lodging. While leaning crops may not cause adverse effects, severely lodged crops can suffer from uneven ripening and reduction of grain quality. Difficulties in pick-up of lodged rye by the combine harvester reduce harvestable yield. Increased weed contamination causes further harvesting difficulties and increases the cost of drying the grain. It is therefore important to minimize lodging and, in particular, early lodging, which causes the greatest problems. Lodging can be reduced by various means, including the use of plant growth regulators in particular.

There is also varying evidence to suggest that some plant growth regulators when applied early in the life of the crop can improve root system development, and influence tiller number and the number surviving to bear heads. It is claimed that these can improve yield.

Basic strategy

The potential for lodging should be reduced by avoiding early sowing, by careful nitrogen fertilization and by avoidance of excessive seed rates. Cultivars with short or stiff straw are more resistant to lodging and can be grown without, or with reduced use of, plant growth regulators. The need to use growth regulators is increased if the soil mineral nitrogen supply produces lush growth in the absence of, or with reduced, fertilizer nitrogen. Hybrid ryes tend to have shorter straw, lodge less and produce higher grain yields.

Plant growth regulators used for reduction of lodging are generally applied, as sprays, during the early stem extension stage (BBCH 20-32) as either single or split-dose applications, in order to shorten and strengthen the lower internodes. Applications may also be made later during stem extension (BBCH 32-45) to shorten the upper internodes, thereby helping to reduce overall height. The use of plant growth regulators should be avoided if crops are under stress, e.g. drought, as the heading of plants may be inhibited.

Main plant growth regulators

Early stem extension (BBCH 20-32): chlormequat chloride.

Later stem extension (BBCH 32-45): ethephon, mepiquat chloride.

Wider range of stem extension timings (BBCH 30-39/45): ethephon, trinexapac-ethyl.

The following combinations are more efficient than ethephon on its own : ethephon + CCC or ethephon + mepiquat chloride.