INVENTORY OF PESTS AND DISEASES OF ROSES (*ROSA*)

This guide is produced by the Proefcentrum voor Sierteelt (PCS) (Ornamental Plant Research) as part of the TIS project 'Encouraging the use of identification aids for controlling pests and diseases in nurseries, landscaping and public green spaces', supported by the IWT (Institute for the Promotion of Innovation by Science and Technology) in Flanders.

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1. Introduction

This guide gives an overview of the main pests and diseases that can occur on roses. Recognising these pests and diseases correctly, is an important step in efficiently controlling them. The pests and diseases that occur only sporadically, are not discussed in detail. The symptoms of deficiencies are also explained. Finally, the control options of the most common pests and diseases on roses are described.

2. Fungi

2.1 Rose powdery mildew (Sphaerotheca pannosa)

Rose powdery mildew is one of the most common diseases of protected and field-grown roses. This species of powdery mildew is a parasite by nature, and can only grow on roses.

The mildew absorbs nutrients using feeding tubes (haustoria) that penetrate the leaf (the upper cell layers in particular) before forming spore bearing structures. Asexual fungal spores (conidiospores) form chains and are visible as a white, fine powder. Sexual spores are very uncommon. The mildew prefers to develop on young, healthy leaves. Growth is best in warm (22°C) and dry weather, yet sufficient moisture is needed for spore germination and development (spores germinate best at a relative humidity of 80%). But the fungus can also develop at a temperature of 6°C.

Although high humidity increases spore production, rain or the presence of a continuous water film on the leaves will rinse the spores off, or slow their development. This fungus overwinters in buds and young shoots.

Early infestations are characterised by small, red dots on the upper leaf surface. This is followed by spots consisting of white fungal threads (mycelium) on the leaves, stems and flower buds. The affected leaves often curl up and become covered with a 'white powder', sometimes the plants will display purple spots (depending on variety). Powdery mildew grows superficially and can be rubbed off with the finger.

Some preventive measures:

- *Avoid fluctuations in sap pressure by keeping humidity as constant as possible, and preventing poor air movement.*
- *Spray with sulphur repeatedly and regularly.*
- *Avoid dew periods followed by drought as far as possible.*
- *Do not plant mildew-prone crops in draughty places.*
- *Crops that are very prone to mildew can benefit from a water spray.*
- *Apply nitrogen fertiliser moderately.*

2.2 Rose black spot (Diplocarpon/Marssonina rosae)

Rose black spot occurs only in the open air, the fungus is not found in greenhouses. Rose varieties vary greatly in susceptibility to this fungus. *Diplocarpon* and *Marssonina* are the respective sexual and asexual form of black spot.

It is mainly the asexual form of this fungus that is found in infected leaf tissue during the growing season. Asexual spores develop in the spot, forming small, wart-like structures (acervulvi). Sexual spores are extremely rare. Infestation starts at the bottom of the plant on the oldest leaves, unlike downy mildew. The fungus spreads through water and thrives best in humid and wet weather. Infection is caused by conidiospores, which hibernate on affected plant parts or fallen leaves. The spores require leaves to be wet for several hours to germinate. The fungus is usually most active at the end of summer. The disease spreads rapidly; in autumn, the bushes are largely bare. If affected leaves are not removed after winter pruning, they can be a source of the first spores.

The dark purple, later black spots on the leaves are characteristic. The tissue around the spots turns yellow. Purple-brown spots can also occur on the stem. The spots are often circular with expanding black rays and are therefore reminiscent of stars. When the leaf spots are veined at the edge, it is a symptom of rose black spot (the veining is not always clearly visible). Yellowing of parts of the leaf surface often takes place, which is followed by leaf drop.

Some preventive measures:

- *Remove and burn affected leaves as much as possible.*
- *Avoid overly wet conditions and space plants.*
- *Avoid prolonged periods of leaf wetness.*
- *Provide ventilation in greenhouses as much as possible.*

2.3 Downy mildew (Pseudoperonospora sparsa)

Downy mildew is very host plant-specific, and the symptoms can vary greatly from variety to variety.

The mildew overwinters on plant material or in the ground in the form of spores and mycelium. Germination can start as early as spring, and there may be several cycles per year. The spores are formed on the underside of the leaf. This fungus grows internally via hyphae. Cool and humid conditions are ideal for development. Development requires water and minimum period of leaf wetness.

Yellow, later becoming reddish-brown irregular spots appear on the upper leaf surface. Eventually, grey fungal sporulation will develop on the underside of the leaf. It is often confused with black spot, but the first symptoms are visible on the young leaves and at the top (not lower down in the plant as with black spot).

Some preventive measures:

- *Carefully clean up the diseased leaves and shoots.*
- *Avoid stagnant moist air by ventilation or use of heat in greenhouses.*

2.4 Rust (Phragmidium spp.)

Rust development is highly dependant on the plant's sensitivity and is host plant-specific.

Five different types of spores are formed during one growing season: hence rust clusters can have different colours, ranging from black to orange. Spores can be found on the underside of the leaves, sometimes also on the stems. Symptoms can differ: small and round on the leaf surfaces and elongated on the veins, petioles and stems. Abscission of the deformed leaves and severe stem damage occur at the latter stages.

Temperatures around 18°C are ideal for the development of rust, and the presence of water is required on the leaf for the spores to germinate. The spores produced are dispersed via air movement and water splash and infect other leaves via stomata.

Some preventive measures:

- *Collect and remove rust-affected leaves as much as possible.*
- *Apply a balanced fertiliser programme, do not apply excessive nitrogen.*

2.5 Grey mould (Botrytis cinerea)

Grey mould is non-host plant-specific (it can occur on all ornamental plants) and is a weak parasite that can cause problems especially in humid weather.

Botrytis is an above-ground mould that spreads from dead organic matter or through wounds. The fungus produces a large amount of spores that are spread via air movement and water splash. These spores can only germinate on dead tissue or through wounds. A relative humidity of at least 90% for at least 12 hours is required for the germination of spores. The fungal threads secrete substances that allow the further development of mycelium within plant tissue. The mycelium produces spore carriers (conidiophores) bearing clusters of spores (conidia). Sclerotia may be formed under exceptional circumstances. These are survival structures that allow the fungus to bridge less favourable environmental periods. However, this is rare in our regions.

In cool and rainy weather, rose buds often fail to open, and do not develop. The most characteristic symptom is the grey fungal growth that develops on the affected parts (hence the name grey mould). This grey fluffy growth consists of conidiophores and spores. A spore cloud can be noticed following disturbance of sporulating infected material.

Some preventive measures:

- *Avoid a dense crop canopy.*
- *Employ good ventilation to prevent periods of high humidity allowing the crop to remain wet for long periods of time allowing the fungus to develop.*
- *Adopt good greenhouse hygiene: remove any broken shoots, leaves, etc.*
- *Excessive nitrogen fertiliser applications can encourage soft, disease susceptible growth.*

2.6 Rose spot anthracnose (Elsinoë – Sphaceloma rosarum)

This disease has a strong resemblance to black spot, but the spots are generally smaller: numerous dark purple to reddish spots with a central dot appear on the leaves. The central dot turns grey; a hole may even form in this spot. The bark of young shoots can also be affected. Not much is known about the life cycle of the disease; it appears to be spread by water. The leaves can eventually turn yellow and abscise, just like with rose black spot.

2.7 Rose hip disease (Glomerella cingulata – Colletotrichum – Gloeosporium)

This fungus leads to the death of the rosehips, which initially show sunken spots during infection.

2.8 Wilt (Verticillium)

Infection originates from the soil or from infected planting material. The mycelium of this fungal parasite grows inside the vascular tissue of the plant, interrupting sap circulation.
During full growth, certain stems wither. The bark initially turns yellow and wrinkly over an extended section, then dark brown. A white-grey fungus develops locally on the dead bark.
Wilt can also be caused by *Fusarium* and *Pythium* fungi, and root nematodes can be the primary vector. Avoid damp and cold soils.

2.9 Bark spot disease/cankers

Brown spots develop on the bark and diseased shoots die off, including: *Melanomma coniothyrium (Coniothyrium fuckelii), Conionthytium wensdorffiae, Coniothyrium rosarum, Cryptosporenlla umbrina, Gryphosphaeria corticola.*

A *Coniothyrium fuckelii* infection leads to a purple-brown restriction of the stem, causing it to die higher up. This fungus occurs mainly under humid conditions or after a hailstorm (wounds create a gateway for spores).

2.10 Alternaria, Phoma, Phomopsis, Septoria

These fungi are generally weak parasites. The inflicted damage is difficult to differentiate from each other, laboratory analysis is therefore necessary to determine which parasite is involved.

3. Insects

3.1 Aphids

Aphids are small, pear-shaped, sap-sucking insects that produce an abundance of honeydew. Both wings, if any, are membrane-like and are usually held overlapping. At the end of the abdomen are so-called 'horns' or siphunculi that secrete a waxy substance. Most aphids have an complicated life cycle with both winged and wingless forms. In winter, most species have an egg stage, but many can remain active during mild winters. Spring aphids are female and mostly wingless, most produce live offspring without laying eggs. From late spring onwards, winged forms occur that spread to other plants.

3.1.1 Rose aphid (*Macrosiphum rosae*)

The colour of the rose aphid varies from green through to pink and reddish-brown. The body, antennae, legs and black siphunculi are long.

In autumn, these aphids deposit winter eggs on roses, so overwintering is achieved as an egg. Under favourable conditions, adults can also survive (e.g. in heated structures) and start new colonies when the roses are planted. Upon bud development in spring, female aphids emerge, these are viviparous and only give birth to live female offspring. During the season, several generations develop (i.e. thousands of aphids). In summer, winged forms also emerge that spread to other rose bushes or secondary host plants (e.g. *Ilex*). During late summer - early autumn, males are born which mate with the females, which then lay winter eggs.

A severe infestation inhibits the growth and development of the buds and new shoots. The aphids are mainly attracted by the higher concentration of nitrogen present in these young plant parts. There are therefore lots of white moulted skins on young shoots. In addition, the aphids secrete honeydew, on which sooty mould develops.

3.1.2 Potato aphid (*Macrosiphum euphorbiae*)

Potato aphids are usually green coloured, but can also be red-orange to brown in colour (2.5 to 4.0 mm in size). The nymphs have a dark green longitudinal stripe on the back, and red eyes. The antennae are generally about as long as the body and the siphunculi are very long with a dark end.

These aphids do not do much damage, and produce relatively little honeydew. Sometimes, deformation of the leaves can occur.

3.1.3 Glasshouse-potato aphid (*Aulacorthum solani*)

This greenish-yellow aphid is 1.8 to 3 mm in size and can easily be recognised by a striking brownish-green to dark green spot around the two siphunculi.
The damage is not always conspicuous; sometimes deformed upper leaves or even severe stunted growth, and honeydew production.

3.1.4 Black bean aphid (*Aphis fabae*)

The black bean aphid is a yellow, green to velvety black aphid and is about 1.5 to 3 mm long. Clearly visible white wax deposits can be distinguished on the abdomen. The antennae are shorter than the body, the siphunculi are always black, the legs are white.
The black bean aphid is a highly polyphagous species (many host plants). It causes curling of the leaves and of the young shoots. They also appear on flower buds and stems on summer host plants. This striking aphid produces considerable amounts of honeydew and is mainly found in greenhouses, but also on outdoor crops too.

3.2 Cicadas

If forewings are present in cicadas, they are membranous or more rigid. The wings are usually held like a roof over the body. The antennae of cicadas are short and brush-like. Cicadas are cell sap suckers, creating small, white spots.

3.2.1 Rose leafhopper (*Edwardsiana rosae*)

The adult insect is greenish, yellow-white in colour, (3.5 mm long) and has white wings. The larvae are glassy white with several dark dots.

In the autumn, adults lay eggs in the leaf tissue on young shoots. During spring, the larvae emerge and feed on the underside of leaves. The first adults can be observed in late May or early June, and they also feed on the underside of the leaf. Most adults migrate to summer host plants, such as fruit trees, but some remain on roses and lay eggs in the leaf tissue. There are two generations a year.

As a result of larval and adult feeding on the underside of leaves, white dots become visible on the upper leaf surface (the leaf cell contents, when emptied, become replaced by air). Buds can also be affected. With severe infestations, in warm and dry locations, leaves may turn completely silvery-white and they can dry out. With a low level infestation, the crop can be cut back, and the infestation can even be reduced by a heavy rainstorm.

3.2.2 Meadow spittlebug (*Philaenus spumarius*)

Adult spittlebugs are brownish in colour and grow to about 5 mm in length. The eggs are laid on the stem of the plant in autumn, they hatch in the next growing season around April. The nymphs are quite noticeable because they are shrouded in a foam mass for protection. They use this foam (or spit) to protect themselves from drying out or predators. After five larval stages, the winged adults emerge in June.

These spittlebugs can occur en masse, but the feeding damage of the larvae is usually limited. However, deformity of leaves, shoots or flowers can occur in response to high levels of larval feeding activity.
If the damage is limited, the crop can be cut back. If the foam affects the ornamental value of the plant, the plants can be cleaned using a high pressure water jet.

3.3 Thrips

Thrips are very small, mostly dark coloured insects with a very narrow body and with two pairs of small feathery wings (some species are wingless). They are common in flowers where they tap into cells to suck out the contents. The females have a curved, saw-like serrated ovipositor to lay eggs in the plants. The males usually have a rounded abdomen. The general visible damage is silvery spots on the leaves and leaf deformity. In addition, the leaf surface can also be dotted with their black faeces.

3.3.1 Greenhouse thrips (*Heliothrips haemorrhoidalis*)

Adult greenhouse thrips are dark brown with an orange dot on the abdomen and light yellow antennae. Greenhouse thrips (1.2 to 1.8 mm) occur both outside and in the greenhouse, but cannot overwinter outdoors. The yellow-brown larvae secret red drops on the leaves of the host plants on which fungi can develop. Feeding damage manifests itself as silvery, white spots on leaves and flowers. Leaves may even abscise in the case of severe damage.

3.3.2 Western flower thrips (*Frankliniella occidentalis*)

Western flower thrips are very small (0.8 to 1 mm), winged and light brown. Eggs are laid in the soft plant tissue with an ovipositor. The orange-coloured larvae emerge after only a few days. Development includes pre-pupa, pupa and finally adult. Damage occurs mainly on protected plants and is especially visible on the flowers (worn petals with numerous white spots on the sepals).

3.3.3 Rose thrips (*Thrips fuscipennis*)

The females are brown to brownish-black and have two pairs of fringed wings. They overwinter and become active again outdoors from May. Eggs are laid in the soft plant tissue with an ovipositor. The larvae are wingless and yellowish-white in colour, and can be found on the host plants from May to August. There are four generations a year. These thrips also overwinter in heated greenhouses. In November, the thrips hide in crop debris or in the soil, and become active again around the end of February.
Rose thrips are very polyphagous (feeding on various flowering plants). Both larvae and adults pierce plant cells and empty out their contents giving a silvery appearance to leaves. With a more severe infestation, deformity and discoloration of leaves and flowers can occur. Usually, the damage is limited.

3.4 Leaf- and sawflies

This type of wasp differs from others in the absence of a 'waist'; the abdomen has little or no narrowing at the front. Sawflies are mostly vegetarian; they drink nectar and eat pollen. Sawfly larvae are eruciform; in that they resemble the caterpillars of butterflies, but are not real caterpillars. The **eruciform** larva has a spherical round head, has three pairs of true legs, six to nine pairs of prolegs and has 1 legless segment free between the true legs and prolegs. With an eruciform larva you will never find crochets (hooks) on the abdominal legs, in butterfly caterpillars you will.

3.4.1 Rose sawfly (*Arge rosae*)

The eruciform larvae have a bright orange head and a greenish-yellow to bluish-yellow body dotted with black spots. The adult wasp is orange with striking black edges on the front edge of the wing. The larvae feed on the leaf edges, and shoots can become curved due to the holes drilled side-by-side for egg laying. The damage is limited.

3.4.2 Roseslug (*Endelomyia aethiops*)

This eruciform larva is greenish-yellow, slightly translucent and resembles a slug. The damage manifests itself in the scraping away of the leaf tissue, causing leaf scorching and silvery spots. It's not all that common.

3.4.3 Rose leaf-rolling sawfly (*Blennocampa pusilla*)

The eruciform larvae of the rose leafrolling sawfly are white to light green with dark spots and a brown head. The adult wasp is 4 to 5 mm in size and black in colour. The rose leaves are rolled up by the larvae, eventually yellowing and drying. Stems with affected leaves should be pruned back to unaffected parts (burn the pruned wood). The damage is usually negligible.

3.4.4 Rose tip sawfly (*Ardis brunniventris*)

The rose tip sawfly is a black sawfly of about 6 mm. The female lays her eggs in the top of a rose shoot. The larva, which hatches a few days later, eats its way several centimetres down through the shoot. The larva is yellowish-brown with a dark head. When the larva is fully grown (after about three weeks) it eats itself out of the shoot, and drops to the ground. It overwinters as a larva and pupation occurs in the spring. The adult insects crawl out of the ground and mate. There's only one generation a year.

3.4.5 *Caliroa aethiops* and *C. rosae*

On the leaves, green slime-covered eruciform larvae scrape away the leaf tissue. The eggs are deposited on the underside of leaves. There is only one generation per year.

3.4.6 Other

Allantus cinctus, Arge ochropus, Cladius pectinicornis, Priophorus padi etc.

3.5 Gall wasps

Some gall wasps are wingless, but all cause the formation of galls. The female lays her eggs in the plant, and when the eggs hatch, the tissues swell around the larvae to finally form the gall. The insects always pupate in the galls, and usually spend the winter as pupae. Many species have complex life cycles.

3.5.1 Mossy rose gall (*Diplolepis rosae*)

The spherical gall (mossy rose gall) is completely covered with long, branched, hairy red or green coloured appendages ranging from a few mm to 50 mm in size. Inside are small, intergrown chambers (containing the larvae) with a hard casing. The galls can develop from many of the rose's organs. Most often they grow from newly emerged leaves and then they are located at the end of stems. These grow into the biggest galls. But they can also grow on the leaves themselves, and on sepals and flower petals, and even on the stamen. They then remain very small and usually single-chambered. They are mainly found on wild roses. The damage caused by these galls is negligible, affected parts can be removed if necessary.

3.6 Beetles

Beetles are easily recognisable by the tough and horny forewings or elytra that cover the abdomen. They meet without overlapping along the centre line. The hindwings are transparent membranous and are folded in under the elytra. Confusion is only possible with shield bugs, but with these the forewings overlap, and the tip is more or less membranous. Shield bugs have sucking mouth parts, practically all beetles have biting mouth parts. The shape of the antennae is very important in determining the species.

The larvae of weevils have a distinct head, are legless, and their body is slightly curved. The larvae of beetles have three pairs of breast legs and a distinct head with jaws. The larvae of the black vine weevil are white to cream-coloured, legless larvae. They have a reddish-brown head and a typical curved C-shape.

3.6.1 Weevils (*Phyllobius and Polydrusus*)

These matt to silvery-green beetles (4 to 10 mm) emerge in spring and early summer. They eat the leaves, buds and shoots during the day. Characteristic of weevils is their curved, snout-shaped elongated head on which the antennae are located. The eggs are laid in the ground, and after hatching the larvae eat at the roots during the summer. The legless larvae are creamy white with a brown head. After a rest period, the larvae pupate and hatch in the spring. The damage is usually limited.

3.6.2 Black vine weevil (*Otiorhynchus sulcatus*)

Black vine weevils are grey-black and typically have angled, forward-facing antennae. Their elytra have pale yellow spots and longitudinal grooves. The milky white larvae have a reddish-brown head and have a typical curved C-shape. Larvae feeding manifests mainly itself in damage when they gnaw at the roots. Angular feeding holes are created in the leaf edges by the weevils.

3.6.3 Garden chafer (*Phyllopertha horticola*)

These beetles, similar to small cockchafers, are chestnut to reddish brown in colour. The grubs (with six breast legs) are beige-white, strongly curved larvae with a pocket-shaped abdomen. The larvae (grubs) eat the roots (especially of lawns), the adult beetles eat leaves and buds.

3.7 Shield bugs

The richness of shapes within the order of the bugs is huge, but they all have the sucking mouth parts with which they consume plant juices. Shield bugs usually have 2 pairs of wings, the front ones usually slightly hardened. However, many species are wingless. In the heteroptera (shield bugs), the forewings, if fully developed, are clearly separated into two areas: a horny or leathery part and a membranous tip. The forewings cover each other at rest. The hindwings are always membranous and are folded flat on the abdomen at rest.

3.7.1 Common green capsid (*Lygus pabulinus*)

The adult winged shield bugs are about 6 to 8 mm in size, bright green in colour, with long antennae. The wingless nymphs are very similar to green aphids and are often confused with them, but do not have siphunculi.

Overwintering occurs as an egg. The nymphs (L1) emerge from the eggs in spring. There are five nymph stages in total. At the end of May – early June, the L5 larva moults into the adult stage. The female shield bugs lay their eggs at the beginning of June. The subsequent five larval stages of the second generation appear in late June-early July. At the end of July, adults will be present again. These winged, adult shield bugs fly back to the winter host plants to lay their eggs from the beginning of August to the end of September. The nymphs puncture and feed on the plants' growing points. When the leaves unfurl, this results in small, brown spots or holes or frayed, deformed leaves. Growth is somewhat hampered due to the deformed growing points.

3.8 Butterflies and moths

Butterflies generally have two pairs of membranous wings that are covered with very small scales. The mouth parts of butterflies always consist of a slender tube or rolled tongue with which they drink nectar from flowers.
Some species overwinter as the egg stage, but in most the eggs hatch within a few weeks and the caterpillars begin to feed. Caterpillars have three pairs of true legs on the thorax and four pairs of prolegs on the abdomen and one pair of anal claspers (back pair of legs). Between the true legs and prolegs, there are 2 legless segments. Inchworms (looper caterpillars) also have three pairs of true legs, but have 5 legless segments and a single pair of prolegs and anal claspers. They move by securing the front pair of legs and placing the two pairs of prolegs just behind them, this gives the typical curved body movement of the inchworms.
After a number of moults, the caterpillar turns into a pupa. Overwintering usually occurs as a pupa, but some also hibernate as caterpillars or as butterflies.

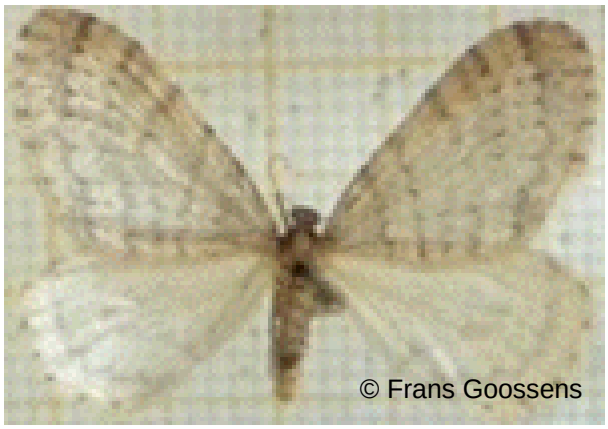
3.8.1 Vapourer moth (*Orgyia antiqua*)

These caterpillars are hairy (with one black and four yellow distinctive hair tufts on the back) with red spots. The male moth is orange brown with a striking white spot on each of the wings. The female has greatly reduced wings and can no longer fly. She is an inconspicuous, grey colour.

After mating in autumn, the female deposits eggs on her own cocoon (egg clutch). The caterpillars emerge the following spring. The male moths are active during June-July. The caterpillars of the second generation can be found during July and August. The caterpillars will eat away the leaves: usually with the exception of the main vein and possibly some larger lateral veins.

3.8.2 Winter moth (*Operophtera brumata*)

Overwintering occurs as an egg. The caterpillars hatch from the eggs from April onwards, and crop damage is due to their feeding. The greenish-yellow caterpillars have yellow longitudinal stripes and yellow transverse stripes and a striking, dark dorsal stripe. The pupal phase extends over the rest of the summer; the moths can be seen in November-December. The female is grey-brown and almost wingless.



3.9 Leaf miner moths

3.9.1 *Nepticula* and other species

Narrow winding tunnels are eaten in the leaves by the small miner caterpillars. Eradication is rarely necessary.

3.10 Leafrollers

Leaves, shoots and flower buds are eaten and spun together by the small caterpillars. Various species may occur: *Cacoecia rosana, C. variegana, C. Xylosteana, C. eristana, Archips podana, Clepsis spectrana, T. bergmanniana, Argyroploce runiana etc.*

3.11 Gall midges

3.11.1 Red bud borer (*Thomasiniana oculiperda*)

The midges are attracted by the sap of fresh wounds, so eggs are deposited on newly budded roses, for instance. Small pinkish-yellow maggots feed between the bud and cambium of the rootstock. The larvae bore into the tissue beyond the budded area. Pupation occurs in the ground.
The deformation of the budded area is a consequence of the infestation; this causes the eye to die or develop slowly with a weak shoot.

3.12 Other

3.12.1 Patchwork leafcutter bee (*Megachile centuncularis*)

This bee cuts pieces from the leaf (especially roses) to create the cells in which the larvae develop. Occurs occasionally.

3.12.2 Honeysuckle whitefly (*Aleyrodes lonicera*)

Adults are recognisable by the grey triangle on the tip of the forewings.

4. Mites

Mites are arachnids that differ from insects in the following ways:

- eight legs (there are exceptions);
- body in two parts: cephalothorax and abdomen;
- no wings;
- special mouth parts to suck out prey or plant cells;
- no antennae;
- no complex eyes.

The larvae are often very different from the adults, growth occurs over a number of moults. The first larva to emerge from the egg has only three pairs of legs. After moulting, the nymph stages commence (four pairs of legs). Eventually, an adult develops from the second stage nymph.

Damage to plants is usually caused by brush-like stylets that pierce the cells of plants, after which the cell contents are ingested through the mouth.

4.1 Two-spotted spider mite (*Tetranychus urticae*)

The colour of the two-spotted spider mite can vary from yellowish-orange to light-dark green. Two black dots on the side of the body are typical of this mite. The adult mite is 0.5 mm. The eggs are translucent at first and then turn whitish-yellow and are scattered on the underside of the leaves. The initially colourless larvae develop colour depending on the food they ingest.

In addition to temperature, the relative humidity, the crop type and the age of the leaf have an influence on development. Development from egg to adult mite is about 17 days at a temperature of 20°C (dry and warm weather conditions are best for development). The fertilised females overwinter by hiding behind bark, in crevices in the ground, etc. Temperature determines, among other things, the start of diapause (overwintering), and also when the mite becomes active again after winter.

In the case of a developing infestation, many small, yellowish-white dots are visible on the upper leaf surface. On the underside of the leaf, plant cells are drained and become air-filled and the leaf acquires a yellow-white desiccated appearance. The mites also produce webbing underneath the leaves and on shoot tips.

4.2 Tarsonemid mites (*Tarsonemidae*)

Tarsonemid mites are very small mites, and are even difficult to find with a magnifying glass. Tarsonemid mites need high humidity to survive. They are mainly found in growing points. Plant cells are pierced and contents drained and leaves can curl inwards. There may be many other damage symptoms.

5. Nematodes

The body of nematodes is cylindrical and plant tissue is pierced with the mouth stylet and the cell contents consumed. All forms of multiplication occur in nematodes. The fertilised egg divides within the egg shell. A number of moults occur before the adult form is reached.

5.1 Root lesion nematode (Pratylenchus penetrans)

The root lesion nematode is mainly found in open ground. This soil nematode can penetrate the roots; root rot is often detected in these places. Plant growth can be severely hampered and even completely stopped. It is striking that the damage always occurs in a localised manner. The root system is extremely weakly developed and there are very few root hairs present.

5.2 Root-knot nematodes (Meloidogyne spp.)

Root-knot nematodes also penetrate the roots of plants and cause the formation of giant cells or nodules within which they can feed. In the case of severe damage, the functioning of the root system is compromised, resulting in growth inhibition, leaf abscission and limited bud formation.

6. Bacteria

6.1 Crown gall (Agrobacterium tumefaciens)

Crown gall manifests itself in wart-like galls that arise on the base of the stem, as well as on the roots and root collar.

7. Viruses

7.1 Mosaic virus

Plants affected by mosaic virus show yellow marbled spots with necrotic tissue. The transmission of this virus is via aphids, leafhoppers, etc.

8. Deficiency symptoms

In order to clearly determine deficiencies or excess symptoms, a soil sample and/or leaf sample is an absolute requirement. The following are some general characteristics in the event of a deficiency or excess of an element.

8.1 Nitrogen

Deficiency: The oldest leaves turn yellow, growth is stunted, leaves and buds remain small and grow on short shoots.

Excess: Excessively lush growth, more susceptible to diseases.

8.2 Phosphorus

Deficiency: Stunted growth, stems and petioles are coloured red to purple. The oldest leaves turn yellow to reddish-brown and dry out. The flowers are mediocre in size.

Excess: Rarely occurs, chlorosis develops.

8.3 Potassium

Deficiency: Leaf edge chlorosis: yellow leaf edges that eventually die. The plant has a limp appearance. The shoots are short. The flowers are small and wither.

Excess: Scorching, as with a salt excess.

8.4 Magnesium

Deficiency: Interveinal leaf yellowing with necrotic spotting. Leaves can also abscise. The flowers have a lighter colour than usual.

Excess: Does not show specific symptoms.

8.5 Calcium

Deficiency: Deficiency first becomes visible in the growing points, with deformity of the leaf edges, brown, curled upper leaves, later yellow discolouration of the entire plant, increasingly thin growth.

Excess: The uptake of iron and other trace elements is hampered, chlorosis of the plant. The interveinal yellowing of the youngest leaves, veins remain green.

8.6 Iron

Deficiency: Shoots and leaves, or even the entire plant goes yellow-green to intense yellow, with veins remaining green. Sometimes there are also necrotic brown spots in the leaves (with a severe iron deficiency).

8.7 Manganese

Deficiency: Pale green to yellow discolouration of the leaves (edges and leaf veins between the main veins).

Excess: The veins turn brown-black locally (especially the leaf underside) plus brownish-black spots on the leaves.

8.8 Boron

Deficiency: Deformed, young yellow leaves, because new shoots keep on dying, the plant acquires a bushy appearance at the top.

Excess: The veins are much lighter in colour than the surrounding leaf tissue.

9. Some forms of non-chemical control

By nature, there are always a number of **natural enemies** in crops that can partially reduce the population of harmful insects. The most famous example are ladybirds that can contain aphid populations. The two best known species are the seven-spot ladybird (*Coccinella septempunctata)* and the two-spot ladybird (*Adalia bipunctata*). In addition, aphid colonies are also predated by green lacewings, hoverfly larvae and parasitised by parasitic wasps and gall midges, among other things. Natural enemies can be attracted by planting mixed hedges and the presence of flowering plants.

The cultivation of **marigolds (*Tagetes*)** has a strong deterring effect on **root lesion nematodes**. It takes two to three months for the top soil to be intensively rooted through and for *Tagetes* to do its remedial work. Weed control in this slow-growing crop requires a lot of attention because the root lesion nematodes would otherwise multiply on the weeds, increasing the infestation even further. The eradicative effect of marigolds on nematodes (*Pratylenchus* species) is based on the reaction of root cells in the endodermis. Sulphur compounds (thiophenes) occur in the endodermis. When a nematode enters this cell, the plant forms peroxidase. The combination of peroxidase and the sulphur compound causes the formation of ozone (O_3). This aggressive form of oxygen leads to 'scorching' of the nematode.

The **biological control of black vine weevils** is done by applying **parasitic nematodes** (*Heterorhabditis megidis, H. bacteriophora* or *Steinernema kraussei*). These nematodes require sufficient moisture and a minimum soil temperature of 12°C that must be maintained for at least 14 days after treatment! Depending on the prevailing temperature, this treatment is possible until the end of September. The nematodes remain active for up to four weeks after application if sufficient soil moisture is present. A second treatment is generally not necessary. *Steinernema kraussei* has the advantage that it is effective from 5°C, so it can be used both in early spring and late autumn. In addition to temperature, moisture is also very important. All parasitic nematodes need moisture for their movement in the soil.

Garden chafer grubs (*Phyllopertha horticola*) can be controlled with the **nematode *Heterorhabditis bacteriophora.*** The larvae are vulnerable when they are young. Control with nematodes should therefore be carried out from the end of July to August; then the larvae are still located just below the turf. In autumn, they will crawl deeper into the ground

Before application, it is important that the soil is sufficiently moist, otherwise it is useful to irrigate beforehand, because the nematodes are very sensitive to dehydration and exposure to sunlight. The nematodes are therefore best applied in cloudy weather and preferably in the evening. After application, the nematodes must be irrigated on.

Biological control of **thrips** in protected rose crops is possible with the predatory mite ***Amblyseius cucumeris, Hypoaspis miles*** and the predatory bug ***Orius***. In addition, ***Amblyseius swirski*** and ***Amblyseius californicus*** can also be used against thrips.

Amblyseius cucumeris is a beige predatory mite of less than 1 mm. Eggs are laid on the underside of the leaves. The duration of development from egg to adult mite lasts eight-11 days (at 25°C and 20°C respectively). These mites pierce their prey and suck out the body fluids. Since thrips larvae are larger and can defend themselves well, the thrips predatory mite prefers the first larval stage of thrips. *Amblyseius* should therefore be released preventively.

Hypoaspis miles is a brown coloured predatory mite, about 1 mm in size. This predator lives in the upper soil layer (1 to 4 cm deep) and feeds on harmful soil insects such as springtails, the pupae of thrips and sciarid fly larvae. Females lay eggs in the ground. The development from egg to adult stage lasts 10 to 13 days at 25°C. Three immature stages are completed. *Hypoaspis miles* prefers moist soil (growing media) and can go up to seven weeks without food. The predatory mite is active at temperatures above 10°C.

Different *Orius* species are available for the biological control of thrips. *Orius* are sometimes called flower bugs and they are small, flattened bugs with a long probiscis that can be folded under the body. The red eyes are characteristic. The developmental duration from egg to adult lasts about three weeks, but this can be longer at low temperatures. *Orius* predatory bugs feed on all the mobile stages of thrips. They find their prey by touch, hold it with the front legs and feed on the body fluids using their piercing mouthparts.

Spider mites can easily be controlled with natural enemies. Predators include the predatory mites ***Phytoseiulus persimilis*** and ***Amblyseius californicus*** and the gall midge ***Feltiella acarisuga***. Predatory mites have a small range, they must therefore be applied where the spider mites are located. Gall midges can fly and seek out the spider mite populations themselves.

Caterpillars can be controlled with ***Bacillus*** preparations**.** The caterpillars become infected by eating plant parts sprayed with the bacteria. In the digestive system, the bacterium then produces spores and protein crystals. A toxin is released during the breakdown of the crystals in the digestive system. The toxin attacks the intestinal wall and causes paralysis of the caterpillar's jaw muscles, so it stops eating several hours after ingestion. Infected caterpillars move slowly, discolour and shrivel. About two to five days after ingestion of the bacterium, they die. Dead specimens hang from the leaves by the front legs.

Aphids can be **biologically controlled** in greenhouses by deploying the predatory gall midge ***Aphidoletes aphidimyza*** and the parasitic wasp ***Aphidius colemani***. In addition, ***Aphidius ervi*** and ***Aphelinus abdominalis*** can also be used. In outdoor crops, natural enemies (including green lacewings and ladybirds) can often control infestations of the common rose aphid well.
Aphidoletes aphidimyza is a 2.5 mm long gall mite, with long legs and a slender body. As the larva does not seek its prey further than 6 cm from its place of birth, the female gall midge prefers to lay her eggs in sufficiently large colonies. One larva needs at least five aphids to develop. The larva first injects a poison into the aphid, paralysing it and dissolving its contents within 10 minutes.
Aphidius colemani is a slender, black parasitic wasp with brown legs, long antennae and distinctive veins on the wings. To lay an egg in the aphid, the female bends her abdomen under her legs and injects it with her ovipositor. Eventually, the larva of the parasitic wasp eats the parasitised aphid from the inside out. Seven days after parasitisation, the *Aphidius* larva firmly attaches the aphid to the leaf and forms a silk cocoon in the aphid so that it swells. The outside turns brown and leathery, and this is called a mummy. The adult parasitic wasp leaves the mummy via a round hole cut into the shell of the aphid.

Crop rotation is a method to control **many soil diseases and pests,** including *Verticillium*. Some agricultural and horticultural crops are particularly sensitive to *Verticillium* and leave a potentially infested soil: potatoes, strawberries, hops, cauliflowers, chrysanthemums etc.

10. Chemical control

For an overview of chemical pesticides that can be used to treat the pests and diseases of roses, please visit Phytoweb (www.fytoweb.be).