Recognise major pests and diseases in carrots

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Foreword

Dear reader,

Carrots can be affected by many different pests and diseases both in the field and in storage, this can adversely affect the yield and quality of a crop. The successful crop production depends in part on the prevention and effective control of pests and diseases.

This brochure, published by Bejo Zaden, describes the main pests and diseases of carrots. It also offers pointers as to how to prevent or control these pests and diseases. Bejo is working hard to develop new and even better quality hybrids, with resistances to important pests and diseases.

For advice about carrot varieties and their resistance to diseases, please contact our sales manager/crop consultant in your area. Other useful sources of information include the Bejo product catalogue and the Bejo website at www.bejo.com.

This publication does not include information about pesticides. Please contact your pesticide supplier for approved treatments and their safety requirements.

Bejo Zaden hope that this brochure will prove useful, and wishes you a successful crop.

Bejo Zaden B.V.

Contents

Alternaria Leaf Blight (Fungus)

Alternaria dauci

Alternaria dauci is the most common type of leaf blight in carrots. The loss of assimilating leaf surface resulting from an attack by this fungus can result in a considerably reduced yield.

Symptoms

The fungus causes irregular dark brown to black spots with yellow borders to form on the leaves. The infection starts at the edge of the leaf. In bad cases the spots can merge, causing the leaf to wither and die. As a result of this, the crop gives the impression of having been burnt. In cool and humid conditions, hyphal threads and spore formation can be seen. Older leaves are more susceptible to infection than young leaves. The carrot itself generally remains unaffected. Infected leaves easily break off, causing problems with mechanical harvesting systems.

Development and infection

After harvesting, the fungus can remain in the soil on plant debris and hibernate. In humid conditions, the fungus will sporulate profusely at temperatures between 20 and 30°C. The fungus is also able to form spores under cooler conditions (below 8°C). The spores are spread by wind, water, humans and machines. Moisture is a prerequisite for the spores to germinate. The optimum temperature for infection is 28°C. Even so, the disease mainly occurs during cool and (extended periods of) humid weather conditions, characteristics of the autumn.

Prevention and control

Maintain good crop rotation, and try to maintain a well growing crop. Foliar feed ensures vigorous leaves that will be less susceptible to disease. During the latter stages of the growing season, foliar feed can promote regrowth of leaves to simplify mechanical harvesting. After harvesting, any plant debris must be quickly removed or incorporated in order to minimize the risk of infectious material being transferred to subsequent crops.

Black Rot (Fungus)

Alternaria radicina

Symptoms

Infection of *Alternaria radicina* results in black spots that can appear on any part of the carrot's surface. The size and shape of the spots can vary from minute linear markings to very large round patches. The spots can sometimes be noticed in the field, on the shoulder of the carrot. The marks on leaves and leaf stems resemble those of *Alternaria dauci*: irregular black lesions, in particular along the edges of older leaves. On the petioles the infection can penetrate the vascular bundle, causing the leaf to turn yellow, wither, and finally die. Leaf infections by *Alternaria radicina* tend to be less serious than those caused by *Alternaria dauci*. The effects of the disease are found mainly on carrots in storage.

Development and infection

From the leaves, the spores also reach the subsurface part of the carrot. In addition, infections can also enter from the soil through the root hairs or through direct contact with the main root. *Alternaria radicina* develops at temperatures ranging from –0.5 to +34°C. This means that the infection can spread in storage areas at low temperatures, provided the moisture content of the air is at least 92%. Affected carrots can also infect any surrounding healthy carrots. Leaves trapped between the product during harvesting form a major source of infection.

Prevention and control

Make sure plant debris decomposes rapidly. Remove any infected carrots and plant debris before the carrots are stored. Thoroughly clean the storage area and conveyor belts between processing different batches. Good crop rotation can also prove effective.

Grey Mould (Fungus)

Botrytis cinerea

Symptoms

During the early stages of storage, clearly defined, brownish black lesions are formed without any sign of mould. The susceptibility to *Botrytis* increases with length of time in storage. Infected tissue quickly becomes overgrown with mould in which sclerotia can subsequently develop. In cool conditions the mycelia will remain white, causing the signs to resemble those of *Sclerotinia*. In most cases the fungus is easily recognized by its characteristic grey spore mass.

Development and infection

The fungus survives in the soil, on plant debris, and in the form of sclerotia. Infection occurs during humid periods in the autumn. The leaves are infected by direct contact or by sporulation. Spores can spread to the carrot itself from the leaves. Freshly stored carrots are not susceptible to infection, however as the tissue loses moisture, it becomes easier to infect. Early symptoms can be seen at the tip of the carrot. At storage temperatures above 5°C, new leaves will be formed which are also easily infected. The disease can spread throughout the storage area as a result of sporulation and direct contact.

Prevention and control

Lift the crop in dry weather to limit the amount of excessive soil. Prevent damage during and after harvesting. Minimize loss of moisture and prevent condensation in the storage.

Early Leaf Blight (Fungus)

Cercospora carotae

Symptoms

Infection by *Cercospora carotae* can be recognized by the small, circular to oval shaped spots on leaves and leaf stems. The eye shaped spots have a straw-coloured center with a dark brown edge and are generally easiest to spot on the leaf stems. In serious cases the spots will merge, which may cause parts of the leaf to rapidly die off. The fungus prefers young leaves and consequently occurs earlier than *Alternaria dauci*.

Development and infection

The fungus hibernates/survives on carrot plant debris and on wild host plants. Germinating spores enter the leaf through natural openings such as stomata. The optimum conditions for fungal development is 28°C and a leaf wetness period of between 24 and 48 hours. Depending on the temperature, the disease sporulates 10 days after infection. *Cercospora carotae* is more common in fields used for the intensive cultivation of carrot crops.

Prevention and control

Keep the crop as strong and healthy as possible by ensuring optimum growth, and apply foliar feed if necessary. Check the crop at regular intervals of 14 days for symptoms of the disease. Maintain good crop rotation.

Black Root Rot (Fungus)

Chalaropsis thielavioides, Thielaviopsis basicola, Chalara elegans

Symptoms

Black root rot can be recognized by irregular black surface spots, which can cover the whole carrot within a few days. The problem occurs after the carrots have been washed, packed in plastic and kept in unrefrigerated storage. The black spots are the result of profuse sporulation. Sporulation rarely occurs on infected carrots not packed in plastic, although they may have a soiled appearance. The affected surface is very sensitive to secondary infection by bacteria. *Chalaropsis* is a serious disease of the harvested crop. The symptoms have sporadically been observed on carrots in the field.

Development and infection

The fungus survives in the soil and on plant debris as dormant spores. The disease occurs across the world and has a wide range of host plants. It also attacks potatoes and *Cucurbitaceae*. Little is known about the infection process.

Prevention and control

Avoid damaging the carrots during and after harvesting. Before sorting the carrots, remove as much of the adhering soil as possible. After harvesting, refrigerate the product as quickly as possible, and store the carrots at a temperature of 5°C or lower. Washing with recycled water encourages cross contaminations. The use of clean water in the last step of the washing process can prevent development of black root rot.

Powdery Mildew (Fungus)

Erysiphe heracleï

Symptoms

Erysiphe heracleï occurs in particular during dry and warm weather. Leaves of infected plants become covered in white, powdery mycelium and spores, and often turn chlorotic. Despite the infection, the foliage eventually tolerates the presence of the fungus. If the mycelium covered leaves are exposed to humid conditions for several days, this can have serious consequences for the condition of the leaf; the weakened leaves are much more susceptible to secondary pathogens.

Development and infection

The fungus thrives in dry, warm weather, but also needs some moisture.
The growth and development of powdery mildew is stimulated by periods of high humidity during the night and the early morning.

Prevention and control

Keep the crop as strong and healthy as possible by ensuring optimum growth, and use foliar sprays if necessary.

Crater Rot (Fungus)

Fibularhizoctonia carotae

Symptoms

After some time in storage, small, crater-like pits appear, which are covered with a whitish mould. Later the craters may increase in diameter and depth. In its latter stages, the affected area may become yellowish, sometimes showing small (1- 3 mm), brown to black sclerotia. After washing, the mycelium is difficult to find, leaving a carrot covered with dark craters.

Development and infection

The dormant structures (sclerotia) remain in the soil. Harvested carrots can carry the infection in the form of sclerotia. Another major source is the wooden storage boxes used in cold stores. The fungus develops rapidly in humid conditions. Even at temperatures around 0°C the growth continues at a steady pace. A film of moisture on the carrots (condensation) accelerates the growth of the fungus. A secondary infection with bacteria or other fungi often occurs.

Prevention and control

Good hygiene is very important. It is advisable to disinfect storage crates, particularly wooden ones. Avoid temperature changes in storage.

Dry Rot (Fungus)

Fusarium avenaceum

Symptoms

Fusarium causes dry rot, usually where the leaves emerge from the crown and on the side of the carrot. The affected parts become dry and turn a pale brown colour. As the rot progresses, these parts can dry out and harden. In humid conditions, a pinkish red mycelium develops. In many cases, the rot starting in the leaf crown, will transfer to the other parts of the carrot. In addition to *Fusarium avenaceum*, other species of *Fusarium* can cause similar infections, including *F. acuminatum, F. equiseti, F. oxysporum, F. redolens* and *F. solani.*

Development and infection

These species of *Fusarium* mostly occur in the soil, on plant parts both above and below ground, and on harvest waste. *Fusarium avenaceum* is a major leaf pathogen in cereals. The straw used for covering may act as a source of infection. The fungus survives in the form of mycelium, as spores, or as asexual dormant spores. Infection generally occurs at temperatures between 7 and 20°C. At lower temperatures (around 0°C) and in dry conditions, the damage may be limited. Minimizing damage to the carrots during harvesting will limit the occurrence of dry rot during storage.

Prevention and control

Minimize any damage to the carrots during harvesting.

Violet Root Rot (Fungus)

Helicobasidium purpureum, *Rhizoctonia crocorum*

Symptoms

Helicobasidium purpureum can be recognized by a network of dark purple mycelium containing many small, dark infection points. Infected carrots tend to retain soil when lifted. The infection itself remains on the surface, but the underlying tissue can start to rot. Infected plants are easy to spot as they have pale leaves and show signs of wilting. Above the ground the mycelium becomes pronounced, with a white to bright purple colour. The fungus can spread from carrot to carrot in the ground.

Development and infection

This soil borne fungus has a wide range of host plants which includes potato, chicory, beetroot, carrot, bean, celery and cabbage. *Helicobasidium purpureum* is a slow growing fungus, its optimum temperature is between 20 and 25°C. Growth is practically halted below 5°C. The infection occurs at an early growth stage, but it takes many weeks for the first symptoms to become visible.

Prevention and control

Ensure good crop rotation, preferably with cereals and grasses. Remove and destroy infected carrots. Ensure fields have good drainage. Keep weeds well under control. Ensure good crop husbandry. A controlled use of fertilizers plays an important role in this respect.

Liquorice Rot (Fungus)

Mycocentrospora acerina

Symptoms

Mycocentrospora acerina occurs mainly in temperate climates. The infection produces spots across the entire surface of the carrot and sunken black heads which are the distinguishing feature. In the early stages of disease development the tissue is wet and brown, than the spots rapidly turn black with watery, brown edges. The symptoms resemble those of the storage rot caused by *Alternaria*; microscopic examination is needed to clearly identify either fungus.

Development and infection

The optimum temperature for this fungus is between 17 and 20°C. Although mycelium growth starts at 0°C. Generally, an infection does not become apparent until late in storage. Up to that point, development of the fungus remains very limited. After several months, the infection can take on serious proportions even at low storage temperatures. The fungus survives in the soil in the form of thick-walled dormant spores. When exposed to daylight a type of spore (conidia) develops that is easily spread by wind and water. Starting in the leaves, the fungus can also infect the carrot shoulder. Damage caused during and after harvesting allow openings of infection for this fungus.

Prevention and control

Restrict leaf growth by limiting nitrogen application, and maintain healthy foliage. When drawing up a cropping programme, avoid other host plants such as celery and parsley. Prevent damage during (field) operations, harvesting and storing.
A healing period for skin damage, however short, can considerably limit the scale of the infection. It is recommended to take test samples a number of weeks before and after harvesting, storing these at 10°C.

Phytophthora Root Rot or Rubbery Brown Rot

(Fungus)

Phytophthora porri, *P. megasperma*, *P. cactorum*

Symptoms

An infection by *Phytophthora* results in firm, dark brown, watery sections in broad bands halfway down or near the shoulder of the carrot. The affected tissue remains rubbery or can become soft. The signs of infection can sometimes be seen in the field, but in most cases the symptoms are not seen even at harvesting. The disease continues to develop even in storage at low temperatures. In humid conditions, a dense, white mould develops. *Phytophthora* rot is thought to be associated with badly drained soil.

Development and infection

The fungus survives in the soil in the form of thick-walled dormant spores. Infection occurs only at high levels of humidity.

Prevention and control

Avoid high humidity stress caused by long periods of sprinkling or irrigation. Store the carrots at a low temperature and a relative humidity of less than 95%.

Cavity Spot (Fungus)

Pythium spp.

Symptoms

Cavity spot causes small, in some cases sunken lesions to appear on the carrot. These start as oval spots under the skin, with a greyish brown to almost normal carrot skin colour. The infected area later increases in size due to the natural growth in length and girth of the carrot, and the outer skin will rupture, to leave an oval, open cavity with a frayed edge. Corky scar tissue grows in and around the affected area.

Development and infection

Cavity spot is caused by a number of species of *Pythium*, of which *Pythium violae* is one of the most important. The fungi rest in the form of mycelium on organic matter and plant debris, or dormant structures (oogonia). These dormant structures can survive in soil for long periods. By entering the carrot the fungus brings about a hyper sensitive response which prevents further growth of the fungus. In most cases, cavity spot becomes visible only after a growth period of at least 12 weeks. The actual infection is suspected to occur at an early stage. As the carrot matures, its susceptibility to cavity spot increases. In the optimal conditions (moisture and a moderate temperature), a fully mature carrot can be severely affected in a short time. Secondary pathogens can use the affected areas as a point of entry and speed up the decay. The optimum temperature for the various species of *Pythium* varies from 18°C to 25°C. The level of infection on a given plot of land can vary greatly from year to year. Cavity spot is thought to be connected with high levels of fertilizer, with high soil moisture content early in the growing season, and with high soil moisture as the carrot matures. According to some publications soils above pH 8 will suppress cavity spot but other sources report otherwise.

Prevention and control

Unrestricted growth reduces the occurrence of cavity spot. Researchers vary in opinion as to the importance of good crop rotation. However, it can be safely assumed that this is an method for reducing the risk of cavity spot.

Pythium violae has a number of symptomless host plants, including broccoli, cauliflower, celery and beetroot. Onion is a good preceding crop. Calcium carbonate is known to have significant inhibitory effects on cavity spot. Liming however will increase the risk of scab (*Streptomyces scabies*). Good drainage is important.

Rhexocercosporidium Black Spot Disease (Fungus)

Rhexocercosporidium carotae

Symptoms

Rhexocercosporidium is a slow-growing fungus that can affect both the carrot and the leaves. The infection starts with small, dark spots across the surface of the carrot. These spots gradually develop into circular, dark brown to almost black lesions. The spots coalesce and eventually cover the entire surface of the carrot. The affected area is firm, shallow and clearly defined. In humid conditions an olive-green mycelium will develop on the surface. Initially, the disease forms circular to irregular spots on the leaves that vary in colour from grey to almost black. The spots appear to be sharply defined, but under a magnifying glass it appears that the infected area radiates into the healthy tissue. The spots can increase in number and size until they merge, after which whole sections of the leaf will die off. The fungus appears to prefer older tissue. In the field, the disease is difficult to distinguish from both *Cercospora* and *Alternaria dauci*.

Cercospora prefers younger leaves. *Alternaria dauci* starts mainly along the leaf edges. *Rhexocercosporidium* infection can cause loss of seedlings. The subsurface parts turn dark brown to black, while the cotyledons remain green. During humid spells the surviving plants exhibit by necrotic leaf spots.

Development and infection
Infection can occur via soil and airborn spores. The fungus develops at temperatures ranging from below freezing up to 25°C, with an optimum around 18°C. As far as is known, carrots are the only host plants.

Prevention and control
The best way of preventing or controlling this disease is unclear. It is suspected that a wet autumn promotes the development of this fungus.

Rhizoctonia (Fungus)

Rhizoctonia solani

Symptoms

In the field, patches occur where development is prematurely retarded and the leaves die off. Leaf stems and crown die off and the carrot shows dark brown, sunken patches. The patches on the carrot resemble the symptoms of Cavity spot. If symptoms on the foliage are absent the two diseases can easily be confused.

Development and infection

Rhizoctonia solani is a widely occurring soil fungus that survives as sclerotia and mycelium on plant debris. The presence of *Rhizoctonia* is related to high organic matter contents in the soil. Infection can occur at any moment during growth and development provided there is enough moisture and high enough temperatures (> 18°C). The disease easily spreads from plant to plant. High planting densities create a favourable microclimate and contribute to its rapid spread in the field. If no symptoms are visible above the surface, the infection may only become apparent at harvest or during storage. The infection process can continue during storage. Secondary infections contribute to the level of damage.

Prevention and control

This fungus can rapidly colonize fresh organic material. It is therefore inadvisable to sow on plots where organic material (for example green manure) has recently been worked into the soil. Avoid damage to the crown and ensure the soil is well drained.

Cottony Rot or White Mould (Fungus)

Sclerotinia sclerotiorum

Symptoms

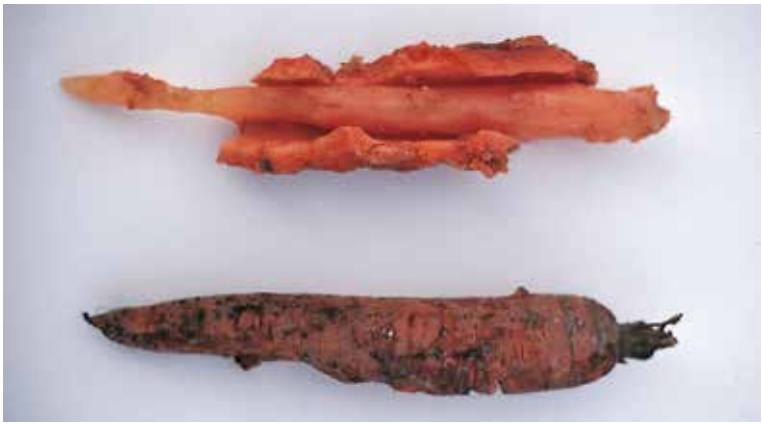
In storage, infected carrots are covered with a blanket of white mycelia in which black dormant structures (sclerotia) are formed. *Sclerotinia sclerotiorum* has a wide range of host plants. The disease can also cause leaves to wither.

Development and infection

The sclerotia germinate in the soil under continuous cool and wet conditions. From the emerging mushroom-shaped fruiting bodies, the fungus spreads its spores by wind and rain. The initial infections are at the base of the petiole. These rapidly spread into the leaf. Infected leaves are dark brown and are often overgrown by a characteristic white mycelia in which, after a while, black dormant structures are formed. These may be found in crops in the field. Initially, crops may not show signs of infection but after a period of time in storage damage may occur.

Prevention and control

Good weed control is important, since many are host plants to *Sclerotinia*. Good rotation crops are onion, beetroot, spinach, cereals and maize. Keep this in mind when drawing up your cropping program. Cool the carrots rapidly after harvesting and maintain a stable storage temperature to prevent condensation.



Erwinia Wet Rot (Bacterium)

Erwinia carotovora subsp. *carotovora*

Symptoms

Erwinia wet rot causes the parenchyma in the vascular bundles to disintegrate very rapidly. The tissue changes into a soft, watery and slimy mass, while the epidermis initially remains intact. The putrefaction is usually accompanied by a fetid smell caused by secondary growth of bacteria. Symptoms rarely become visible in the field, and are thought to be mostly associated with extremely wet conditions. In most cases, infection will become apparent only during transport and in storage.

Development and infection

Erwinia wet rot is widespread in soil, surviving on plant debris. The bacterium is a secondary pathogen that can easily enter the carrot through damage caused by harvesting, fungal infections, frost or insects. Storage conditions often determine if problems are likely to occur. Growth of bacteria on carrots in packing and/or processing facilities can give rise to severe rot problems, in particular if the carrots are packed in film and stored unrefrigerated. *Erwinia carotovora* is often mentioned in conjunction with soft rot, but it is certainly not the only bacterium to cause these problems. In addition to other species of *Erwinia*, *Pseudomonas marginalis* can also infect the carrot. The latter even thrives at nearfreezing temperatures.

Prevention and control

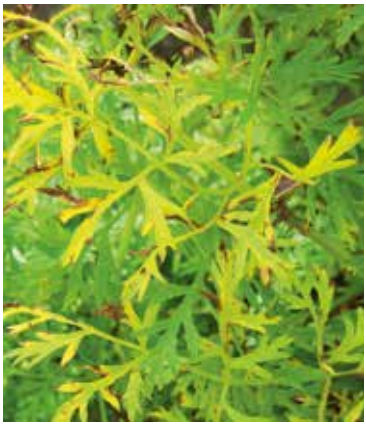
Prevent and limit damage during and after harvesting. After washing, rapidly dry the carrots, and maintain a low storage temperature. Change the washing water at regular intervals. Regularly disinfect the storage area, the washing system and the crates. Do not grow carrots in poorly drained soil.

Scab (Bacterium)
Streptomyces scabies

Symptoms
Characteristic, cork-like structures appear in the infected area, often in a band around the carrot. Scab occurs mostly in soils with a high PH, in particular if it is very dry.

Development and infection
Scab lesions occur when the bacterium induces abnormal growth in the infected cells. *Streptomyces scabies* has a number of host plants, including beetroot, potato, turnip, radish and parsnip.

Prevention and control
Irrigate when necessary, in particular during the period when the carrots start to increase in girth. Avoid land used for growing potatoes.



Bacterial Leaf Blight (Bacterium)

Xanthomonas hortorum pv. *carotae*

Symptoms

The *Xanthomonas* bacterium causes irregular brown spots to appear on the leaf. To a lesser degree, elongated, dark brown, watery streaks appear on the leaf stems. The first symptoms on the leaves are small yellow spots that rapidly increase in size. The centre of the spot quickly becomes dry and has an irregular, conspicuous, yellow ring. *Xanthomonas* thrives best in areas with high temperatures and high humidity. The bacterial infection makes mechanical harvesting more difficult because it reduces the strength of the leaf.

Development and infection

The bacterium can survive in the soil, given the proper conditions. During periods of rain or irrigation, the bacterium is carried into the air by splashes, enabling it to spread over large distances in the wind. It is also known that insects can carry the bacterium. In humid and warm conditions (25-30°C) the bacterium can multiply rapidly. In order to be able to infect the leaf interior, the bacterium requires the presence of a continuous film of moisture reaching through natural pores into the inner tissues. After entering the leaf, the bacterium can multiply rapidly in the cavities between the cells, disrupting the functions of the surrounding cells. Once the infection has established itself, it is difficult, if not impossible to find adequate measures of control.

Prevention and control

Maintain good crop rotation.

Carrot Red Leaf Virus (CRLV) (Virus)

Symptoms
Carrot Red Leaf Virus (CRLV)) initially produces a yellowing of the leaves, giving the plant the appearance of suffering from a nutrient deficiency. The yellow soon changes to red, and infected plants may also exhibit stunting.

Development and infection
The virus infects only umbeliferous crops and weeds. CRLV usually occurs in combination with *Carrot Mottle Virus* (CMoV). This causes the disease known as "motley dwarf" in which symptoms are more heavily expressed. CRLV acts as a helper virus for CMoV without which transmission (of CMoV) is not possible. Not all aphid species are capable of transmission. The major vector is the willow carrot aphid which transmits the virus in persistant manner. The aphid has to feed on an infected plant for at least 30 minutes before the virus is systemically acquired. After a latent period of 16-18 hours the virus is transmittable by the aphid for a long period. A feeding period of only 2 minutes could be sufficient for effective transmission from aphid to plant.

Prevention and control
Control of aphids is practically not effective as transmission is established in a very short period.

Parsnip Yellow Fleck Virus (PYFV) (Virus)

Symptoms
The carrot plants die from the core outwards. The youngest leaves wilt while the older ones initially remain healthy in appearance. Plants infected at an early age can rapidly die and often escape notice in a dense crop. In older plants, the necrosis is accompanied by curvature of the leaf stem and yellowing of the older leaves. In addition, the root tip and the hairy side roots die off.

Development and infection
The disease is caused by an infection with the *Anthriscus* strain of the *Parsnip Yellow Fleck Virus*. It also occurs in chervil, dill, coriander and especially in wild *Umbelliferae*. The virus is carried by the willow carrot aphid, in a semi-persistent manner; the aphid becoming infected after extended contact with the phloem of an infected plant. Following an incubation period, the virus can be transferred to healthy plants by the infected aphid for the entire duration of the life of the aphid. This is different to non persistent viruses, which may be transferred immediately after a brief and superficial contact with the insect's proboscis, but become inactive after a while. The willow carrot aphid can pick up the virus only if the plants are also infected with *Anthriscus* yellowing virus, which, like the *Parsnip Yellow Fleck Virus*, often occurs in cow-parsley without symptoms. The carrot is not a host plant to this helper virus. Consequently, the *Parsnip Yellow Fleck Virus* can be transferred from cow-parsley to carrots, but not from carrots to cow-parsley or from carrots to carrots. In view of the way the aphid transfers the virus, the application of insecticides has little effect on the way the virus spreads.

Prevention and control
There is no known effective means of control.

Aster Yellows (Phytoplasma)

Symptoms
Aster Yellows starts with a yellowing of the young leaves. The plant appears to suffer from a deficiency of essential nutrients. This is later followed by development of a mass of new shoots from the crown. Finally, the older leaves turn a conspicuous red colour. The underground part of the carrot has a rough appearance.

Development and infection
The disease is caused by phytoplasma, an irregularly shaped, bacterium-like organism surrounded by a membrane with no real cell wall. The pathogen is transferred from plant to plant, mainly by the aster leafhopper. The phytoplasmas feed from the transport vessels in the phloem of the plant. Aster Yellows is a common carrot disease, which is considered of minor importance in most of the carrot-producing countries. The loss of production, which is minor in many cases, does not justify the cost of controlling the grasshoppers that transfer the pathogen. The pathogen has a wide range of host plants among commercial crops, including celery, onion, lettuce and endive.

Prevention and control
Control the number of (susceptible) weeds (e.g. clover) in and around the field. These weeds form a source of food and shelter for insects. Immediately after harvest, work any crop debris back into the soil. Avoid growing susceptible crops on adjoining land.

Infected and healthy carrot (Photo BASF)

Close up of a young, white cyst (Photo INRA)

Carrot Cyst Nematode (Nematode)

Heterodera carotae

Symptoms

The presence of the nematode is characterized by patches of retarded development among the crop. The leaves of infected plants are stunted and can even die off. The subsurface parts of the plant have numerous radicles, which gives plants lifted from the soil a bearded appearance (hairy root). The main root grows slower and white or brown cysts are visible on the root system. With a high frequency of carrots in the rotation, the extent of the poorly growing patches will increase during each year of cultivation.

Development and infection

The larvae of the nematode enter the young carrot via existing wounds or by using their hollow stylet to pierce the epidermis of the carrot. After a short time feeding, the male larvae leave the carrot, while the females will burrow into the tissue for the remainder of their active lives. Here the females produce between 200-600 eggs, which are contained in their body. This causes the body to swell and form a lemon shaped cyst. The cyst is white initially and later turns brown. When the carrots are lifted most of the cysts are left behind in the soil. When a new crop of carrots is sown on the same plot the cysts release the larvae which are attracted by substances released by the carrots. The cycle subsequently starts again. Carrot cyst nematode larvae persist in the soil within cysts and can survive without host material for many years. The carrot cyst nematode has a very small range of host plants, which is virtually restricted to carrots (*Daucus carota*) and other *Daucus* spp. The nematode is spread via adhering soil, humans or machinery.

Prevention and control

Carrots are highly susceptible to damage caused by this nematode. Crop rotation can reduce the population density of the nematode. In view of the high survival rate of the larvae in the cyst, a rotation cycle of at least 4 to 6 years is recommended.

Root-Knot Nematode (Nematode)

Meloidogyne hapla

Symptoms

The carrot is deformed, with side shoots, constrictions and blunt ends. The side roots carry many knots several millimetres in size. Severe cases of early infection can almost wipe out the seedlings. Infected plants are difficult to pull up as a result of the extensive root system.

Development and infection

The nematode is found in the soil and is attracted by chemicals exuded by the carrot during germination and cell elongation. The larvae invade the root and attach their head parts to the phloem tissue, stimulating the surrounding cells into gigantism. The females grow very large, changing from the slender, mobile immature state into static, spherical adults. As a result of the migration and development of the nematode inside the carrot, the surrounding tissue goes through a number of morphological changes, causing swellings and knots. Finally, the tissue around the rear of the female ruptures, releasing a gelatinous mass containing several hundred eggs from which larvae develop. The root-knot nematode has a large number of host plants and multiplies on salsify, potato, pea, clover, lettuce and carrot. In many cases, the crop is affected in patches.

Prevention and control

Use a good crop rotation of at least 1:5.

Healthy carrot
(Photo BLGG)

Infected carrot
(Photo BLGG)

Root Lesion Nematode (Nematode)

Pratylenchus penetrans

Symptoms

Small, reddish orange to brown rust patches on the main root and root hairs. With heavy infection the patches can merge and start to turn black. Constrictions may also occur all over the carrot. Nematodes are microscopic in size and the damage to parts of the plant below ground is hardly visible, consequently, a nematode infection is often difficult to recognize. Moreover, the symptoms above ground resemble those of other soil diseases. High population densities of the nematode can cause dwarfing and disturb nutrient and water uptake.

Development and infection

An adult nematode is less than a millimetre in length. The nematode has a hollow stylet which punctures the plant cells and extracts the nutrients. The root lesion nematode can penetrate the carrot at any random point. Once it has burrowed into the tissue, it moves in the cavities between the cells. The nematodes can multiply very rapidly inside the carrot. They 'rest' in infected parts of the plant. They are spread when the soil is tilled and in particular by transport of infected soil and plant tissue.

Prevention and control

Carrots are highly susceptible to damage caused by this nematode. The nematode has a wide host range, which limits the possibilities of crop rotation. In brassicas (cabbage, rapeseed, mustard etc.) and members of the *chenopodiaceae* family (sugar beet, spinach) there is little multiplication of nematodes. There is higher multiplication in potato, maize, *papilionaceae*, leek and onion. Preventing the disease is better than curing it. Once nematodes have infested a crop, they are very difficult to control.

Turnip Moth, Common Cutworm (Insect)

Agrotis segetum

The Turnip Moth is a moth of the *Noctuidae* family or owlet moths.

Description and symptoms

The forewings are highly variable in color ranging from pale yellowish beige through to almost black. The hind wings are very pale, white in the males, and grey in the females. The wingspan is 32-42 mm. The destructive grey larvae are up to 50 mm long, feed on herbaceous plants and many root vegetables. Cutworm, the name which was given to the subterranean caterpillar life-stage, cuts clean fairly circular holes in carrot and other *Umbelliferae* roots below the crown. Damage occurs most years in warm dry months.

Development and infection

Two broods are produced each year, flying in May to June, and again in August and September. The females deposit their eggs singly or in small clusters underneath wild plants, on stems as well as on the ground. The first larval generation develops from June to July. The young caterpillar feeds at night, gnawing the foliage and cutting the petioles. During the day, it hides by rolling up under a lump of earth or slightly below the ground surface. It pupates in the ground in early spring, sometimes giving rise to a second generation of adults in late summer. At the end of the season the larva becomes less active, overwinters as a caterpillar and pupates early spring.

Prevention and control

In many cases the damage is discovered at a late stage. Risk can be reduced by good weed control. Irrigation or heavy rain occasionally will kill cutworms on the foliage during the period of feeding above the ground. In general fewer problems with cutworms will occur when the crop is irrigated regularly.

Aphids, e.g. Willow carrot aphid (Insect)

Cavariella aegopodii (willow carrot aphid)

Symptoms

Aphids are often found on the underside of the leaf and on young leaves. Although the leaf can start to curl and turn yellow, the direct damage is of little importance. However these aphids can spread several types of viral infections which may cause problems.

Willow carrot aphid

The willow carrot aphid is a common species of aphid. It hibernates on willows and on perennial host plants. The insect itself is hard to spot in vegetation, mostly being recognised by the skins shed by the insects. These give the soil below the plants the appearance of being sprinkled with cigarette ash. The main importance of the willow carrot aphid is as a carrier of a number of carrot viruses.

Carrot Miner Fly (Insect)

Napomyza carotae

Symptoms

The carrot miner fly deposits its eggs on leaves and leaf stems. The larvae that emerge from these eggs burrow into the plant, in particular into the shoulder of the carrot.

Development and infection

Before the carrot miner fly lays its eggs, it pierces the underside of the leaf margin to obtain sap. These feeding punctures are visible on the leaf. After a period of about one week, white larvae emerge from the eggs. The larvae eat into the leaf stem, creating twisted, superficial burrows that lead to the carrot itself. Once inside the carrot root shoulder, the larvae burrow into the carrot, in a horizontal direction. The larva pupates in the carrot, at the end of a tunnel. The carrot miner fly has two generations each year. The first generation is from late May until late July, the second generation from late August into October. The larvae resulting from the first generation cause the most damage. The larvae of the second generation often fail to reach the carrot before the crop is lifted.

Prevention and control

Covering with soil substantially reduces the effects of an attack. The shoulder of the carrot must remain covered with soil for the entire duration of its growth, so it may be necessary to bank up (ridge) the crop at least twice. Check the leaf for miner burrows at regular intervals. This is the easiest way to detect the activities of the carrot miner fly.

Carrot Root Aphid (Insect)

Pemphigus phenax

Symptoms

The aphids form a white woolly layer of wax on the carrot.

Development and infection

This infection generally has little or no effect on the growth of the carrot. Growth is only reduced if a massive infection attacks the plants at a young stage. This pest is universal. Eggs are laid in the winter on poplar trees. The first generation develops in leaf galls on these trees. In June/July the adult, winged females migrate from the poplars to umbelliferous plants. They deposit their wingless offspring on these plants. These nestle as root aphids on the carrot. A typical characteristic is the woolly threads they excrete. The aphids excrete no toxic substances and do not lead to deformed carrots. Another, less common, aphid is the *Dysaphis crataegi*. This aphid also forms woolly threads, but is found more on the neck of the carrot. This aphid only causes damage to young plants. In the winter months, the hawthorn is host to *Dysaphis crataegi*, while during the summer umbelliferous plants act as a host.

Prevention and control

As the presence of aphids does not generally cause damage, even if they are present in large populations, controlling aphids is not necessary.

Photo: Manabu Kamimura WUR

Flea Beetle (Insect)

Phyllotreta nemorum, *Phyllotreta undulata*

Symptoms

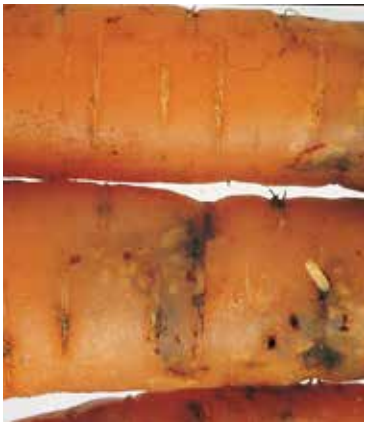
Small, rounded, irregular holes appear in the leaves. In case of a heavy infestation, the leaves appear to be full of 'shot-holes'.

Development and infection

Flea beetles are small (2 to 3 mm), shiny, dark and highly mobile beetles. They have powerful hind legs that enable them to jump large distances. The adult beetles cause the most damage, as they feed on the underside of leaves. In sunny, dry weather, this insect can cause considerable damage to the young crops. In the early summer the eggs are deposited a number of centimetres below the soil surface. After hatching, the larvae feed on the roots of plants, usually without any visible damage. An adult insect overwinters on weeds and dead organic material. The beetles reappear in the early spring and feed on weeds before moving into the host crop as it starts to grow. They become more difficult to control as the supply of weeds as a source of nutrition starts to become depleted.

Prevention and control

Flea beetles prefer cruciferous crops (cabbage, radish etc), but damage has also been seen in carrots. Ensure optimum crop growth so that the most susceptible stage of young plant growth is passed as quickly as possible. Planting a crop that attracts flea beetles (e.g. mustard cabbage) between crops or around the field can give good results. As the beetle overwinters on weeds, ploughing grass, broad leaved weeds and crop debris into the soil before the winter can help.



Carrot Root Fly Or Carrot Rust Fly (Insect)

Psila rosae

Symptoms

Carrot root fly is one of the most common carrot pests. The white larvae eat their way into the carrot, especially near the skin. The burrows turn rust brown. Early infections can lead to loss of seedlings. Older larvae enter through the main root, burrow into the lower half of the carrot and cause forking, stunted growth and fibrous carrots.

Development and infection

The carrot root fly hibernates in the soil in the form of a pupa. The first full-grown insects hatch mid April, seeking sheltered spots (like hedgerows or shrubs) in which to feed and mate. The fly can travel great distances., The females leave their sheltered spots late in the afternoon to deposit eggs on or in the soil around the base of the plant. The eggs are left for the wind and rain to carry them into the soil and into a favourable environment for further development. After approximately eight days the larvae hatch from the eggs. The young larvae feed on the fine lateral roots. Later they will also attack and enter the main root. They can even burrow into the core of the carrot. During their growth, larvae will cast their skin twice. Before every casting, the larvae emerge from the carrot. After casting they will burrow into the same carrot again or into a neighbouring carrot. Each larva can attack several plants. This results in the typical, bowl shaped hot spots in a carrot field. Once the larva is fully grown, it leaves the carrot to pupate in the soil.

In the Netherlands, the carrot fly has three generations:
- Spring generation : mid April - late June
- Summer generation : late July - September
- Autumn generation : September - late October

Carrots that are sown early can be attacked as early as mid May. The carrot fly can be present in the field from mid April until October. During this period they can continuously lay eggs in the fields. Therefore the crop must be constantly protected against larvae.

Prevention and control

Use insecticide-coated seed. This offers good protection against the first generation of the carrot fly. Insecticide coating is recommended for sowings from April onwards. Sticky traps may be used to detect further generations. Ensure the number of sheltered spots, such as hedgerows or shrubs, near the production field is kept to a minimum, and keep the verges mown short. These measures limit the possibilities for mating and consequently, the presence of the carrot fly. Irrigating during dry spells can accelerate the hatching of the eggs and stimulate larval activity. Collecting and removing as much carrot debris as possible during the harvest reduces the number of larvae left in the field. This reduces population of the carrot fly the following spring. Lift the crop in good time. Once the carrots show small rust spots on the main roots, they should be lifted within seven to ten days.

Carrot Psyllid (Insect)

Trioza apicalis

Symptoms

Strongly curled leaves and complete cessation of growth. The carrot psyllid is approximately 3 mm long and can be recognized by its pale green colour and black antennae. This jumping insect has red eyes and virtually transparent wings. The psyllid overwinters as an adult insect in conifers. At the end of May it migrates to other hosts which include carrots. The seedlings are particularly sensitive to the toxic froth secreted by the psyllid (a strong reaction occurs after the plants have been pierced). Older plants are more able to withstand infestation. The eggs are deposited from May until the end of June. After 25 days the fairly static larvae crawl from the eggs, then after a further 4 weeks they develop into adult psyllids.

Prevention and control

As it overwinters on conifers in the winter, the carrot psyllid is a small and localised problem, particularly in Scandinavian countries. Using a seed coated with insecticide can help reduce the pest pressure. After the four leaf stage, an infection will no longer have a major impact on the yield.

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