CANNA
The solution for growth and bloom

PEST & DISEASE
MANAGEMENT GUIDE

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The solution for growth and bloom

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PESTS & DISEASES
Keeping plants healthy requires having a solid understanding of their common pests and diseases, mitigation techniques, and prevention efforts. The CANNA Pests and Diseases Guide gives an overview of the typical suspects, patterns they follow, and recommendations for solutions and prevention.

CANNA CONTROL
As a solution to pest and disease infestations, CANNA developed CANNA CONTROL. CANNA Control effectively manages a wide range of pests, including botrytis, mildew, mites, thrips, bacteria, aphids, gnats, and whiteflies.



CANNA Control is naturally derived and made of only three ingredients. It is suitable for greenhouses, nurseries, fruit and vegetable crops, orchards, tree fruit, vineyards, hops, clones, and agricultural hemp.

Still looking for more information?
CANNA representatives and our research team are happy to share their expertise, contact us via **www.cannagardening.com**.

Mites

What are common mite pests?
Two of the most common problematic pests from the mite family, Eriophyidae, are the spider mite and the russet mite. Spider mites are not insects and are in fact more closely related to spiders. They belong to a class called *Arachnida*.

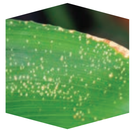
What are the symptoms of mites?
Spider mites and russet mites have needle-like sucking mouthparts that penetrate plant tissue, leaving small, yellowish or white specks of dead spots. Spots can coalesce till the leaf wilts and falls off. Spider mites also spin a silk webbing, used to move around plants.

With russet mites, leaves can curl upward along the edges, become dull, brittle, and droopy. There may be stunted growth as the plants are being sapped. As an infestation grows, yellow or brown spots may appear on leaves and stems may become bronze in color. Russet mites are extremely small – much smaller than the spider mite and cannot be seen without magnification.

About mites in brief
Spider mites affect many crops worldwide. There are well over 1200 species of spider mite, of which more than a hundred can be considered as a pest, and about ten of those as a major pest. The most well-known and problematic spider mite is Tetranychus urticae (common names include two-spotted spider mite and red spider mite). Their ability to reproduce extremely rapidly enables them to cause enormous damage in a short period of time.

Russet mites can only crawl very short distances and are particularly immobile during immature stages. Adults are capable of crawling to the edges of leaves where they can be picked up and carried on air currents or by fans to quickly spread to other areas.

Biological cycle of mites
A female mite can lay about 10-20 eggs per day and 80-120 altogether during its 4-week life cycle. Eggs can be laid in silk webbing and take 3-15 days to hatch, emerging as almost colorless larvae with bright red eyes. After 4-5 days and three moltings they turn from a protonymph, deutonymph, to finally an adult. Both adults and nymphs have eight legs.



SPIDER MITES USE THEIR PIERCING MOUTH PARTS TO CREATE SPECKLED DAMAGE ON THE LEAF SURFACE

Prevention techniques
To minimize the risk and rapid spread of mite infestations, try to keep the temperature lower (<77°F) and humidity higher (>60%), since this will slow the rate of reproduction. Higher humidity is also needed for the predators of these mites. Keep your growing areas clean and remove all leaf litter. Adequate irrigation is important, because water-stressed plants are more likely to suffer damage.

Solutions for controlling mites
Remove the affected leaves. Spray the plant thoroughly with a horticultural oil, such as a thyme oil application, or a mixture of alcohol and soap. Repeat this treatment several times a week. With both russet mite and spider mite infestations, discard infested plants. Natural enemies such as predatory mites (*Amblyseius* and *Neosilus*), lady beetles, and lacewings can also be introduced.



SPIDER MITES SPIN A WEB USED TO TRAVEL FROM ONE PLANT TO ANOTHER AND AS A SIGHT FOR LAYING EGGS

Thrips



THRIPS LARVAE FEED ON PLANT LEAVES, RESULTING IN WHITE SCRAPE MARKS

What are thrips?
When we use the term thrips, we are referring to a wide group of insects of the order Thysanoptera.

What are the symptoms of thrips?
Larvae cause most of the damage seen by thrips by feeding on plant tissues, while adults primarily feed on pollen. The larvae suck the liquid from plant cells, mainly from the leaves, but also the petals, shoots and fruits. Early symptoms include an almost transparent or clear discoloration of the leaf with black dots (which are caused by fecal secretions).

Thrips larvae have rasping, sucking mouthparts that look like combs. They penetrate the top layer of leaves and a clear, undisturbed window of tissue is left behind. The saliva contains toxins that may cause deformations in shoots or flowers. Severe infestation causes dried leaves.

Because certain toxic substances are present in the saliva of thrips, some deformations may occur in the shoots or flowers of affected plants. In cases of very severe infestation, the leaves may dry up entirely. At the same time, some thrips like *Frankliniella occidentalis* secrete a few drops of a substance when they are threatened by predators. These excretions contain decyl acetate and dodecyl acetate – pheromones that serve as a warning signal for other nearby thrips.

About thrips in brief
Thrips are recognizable by their small size and long flat shape. The adult thrips has four feathery wings. They can vary in color from gray to yellow or brown. Thrips are carriers of viruses, mainly of the genus Tospovirus.

Biological cycle of thrips
Thrips eggs are laid in plant tissue, where they emerge and begin eating the surrounding tissue. Eggs hatch more quickly in warmer temperatures. During the pre-pupal stage, they fall to the soil/substrate or lower leaves for the transition from pupa to an adult with wings. The whole life cycle is a few weeks long.

Prevention techniques
Monitor thrips by using adhesive traps. Blue is more attractive to thrips, while yellow traps are also suitable and may be easier to detect. Examine the traps every few days.

Solutions for controlling thrips
If you detect thrips, appropriate treatments include horticultural plant extract applications, such as thyme oil, or ecological insecticides such as potassium soap, can be applied. Plants must be sprayed thoroughly all over because the thrips will take refuge under the veins of the leaves, making it difficult for the insecticide to come into contact with all the insects.



AN ADULT THRIPS

It is also possible to use entomophagous fungi to combat thrips, such as *Beauveria bassiana*. Parasitoids from the families Eulophidae and Trichogrammatidae, anthocorid bugs of the genus Orius, and phytoseiid mites can also help. It is also important to make sure that you clean up and remove any plant or soil residues from the floor or worktops.



THRIPS DAMAGE TO BARLEY LEAVES

Aphids

What are aphids?
When we refer to aphids, or plant lice, we usually mean a super family of insects which includes over 4,000 species of plant-specific parasites.

What are the symptoms of aphids?
Aphids use their stylus to pierce and suck on phloem sap, which can weaken the plant, causing leaves to yellow, curl, or can be a vector for introducing toxins and viruses. Root aphids may be associated with off-coloration of lower leaves. After feeding, aphids release a substance called honeydew, which can serve as an ideal culture for various fungi that can cause additional plant harm.

About aphids in brief
Aphids are no longer than about 4 mm, have a bulbous abdomen and can be many different colors. They are among the most destructive pests to affect cultivated plants in temperate regions. Winged aphids are especially dangerous for your crops, since they destroy plants much faster than regular aphids. While root aphids have historically been found on grasses (hence the name, *rice root aphid*) they have also been found on crops in indoor production.

Biological cycle of aphids
Females can live for 25 days, during which they can each produce up to 80 new aphids. Spring and Summer reproduction occurs asexually - without males. Aphids can be birthed with or without wings. As populations grow and space becomes limited, lack of space can trigger the birth of a winged generation.

Root aphids in particular reproduce entirely asexually; no males are produced and females give live birth to genetically identical daughter root aphids. Root aphids will also develop in winged or wingless form. There tend to be more of the wingless form and these are associated with the plant roots.

Prevention techniques
Keep the production area free from weeds that can serve as a reservoir of eggs and adults. Avoid using an excess of nitrogen fertilizer, since this can result in fleshier plants which are more attractive to aphids as a food source. Insect nets can also be used to cover crops.

Solutions for controlling aphids
Horticultural oil applications containing thyme oil can reduce aphid populations. Natural enemies that can be introduced as beneficials include lady beetles and lacewings. Green lacewing larvae (Chrysoperla sp.) are voracious predators of aphids. Entomopathogenic fungi such as Beauveria bassiana, and soil dwelling generalist predators, such as *Stratiolaelaps scimitus*, have also been used for root aphids.



AN ADULT APHID



LADYBUG LARVA EATING AN APHID



LACEWING LARVAE EATING AN APHID



LARGE POPULATION OF APHIDS ON A LEAF; THESE CONDITIONS LEAD TO THE PRODUCTION OF A WINGED GENERATION OF APHID SUCH THAT IT CAN FLY TO SPREAD ITS POPULATIONS

Powdery Mildew



CLOSE UP VIEW OF POWDERY MILDEW INFECTION

What is powdery mildew?
Powdery mildew can come from several different types of genera such as Erysiphe, Golovinomyces, Oidium. Podosphaera, or others. Each genera is highly specific, meaning that they only infect specific plant species. For example, the powdery mildew that infects squash plants will not infect roses. All powdery mildew fungi are obligate parasites, meaning they can only grow on living plant tissue.

What are the symptoms of mildew?
In general, mildew is found on the leaves, shoots, and sometimes flowers and fruits appearing as if those plant parts had been dusted with powder. The mildew inhibits photosynthesis and causes leaves to turn yellow, twist, distort, die, and fall off.

About powdery mildew in brief
Powdery mildew is visually distinct with its powdery, white to gray colored mycelium growth on the surfaces of leaves and sometimes other plant parts. While it can be seen commonly, keep in mind that it tends to be plant-specific, which fortunately can limit its broad impact.

Biological cycle of powdery mildew
The mycelia, or vegetative structure of the mildew, grows on the surface of the plant host. Powdery mildews produce microscopic structure called appressoria that help attach mycelia to the plant surfaces. From there, specialized hyphal outgrowths called haustoria penetrate host cells to absorb nutrients. Some species of fungus form hyphae that grow within host tissue itself, making it more challenging to eradicate from the plant.

Powdery mildew reproduces rapidly via asexual reproduction, producing conidia (asexual spores) within a short 3-7 days of infection, contributing to exponential growth. Sexual reproduction of powdery mildew often comes later in the growing season or after flowering, resulting in the production of ascocarps containing spores. Ascocarps are resistant to low temperatures, drought, and can survive harsh conditions. After an irrigation event, the ascocarps will release their spores.

Powdery mildew can survive through the winter as ascocarps or from dormant mycelium within infected plants.

Powdery mildew prefers a highrelative humidity at night, low humidity during the day, and warm temperature between 70-80°F. The spores are carried by air currents and germinate on the leaf surface.

Prevention techniques
The best treatment against powdery mildew is prevention, since it can be difficult to eradicate completely. Maintain a clean growing area, clothes, footwear, equipment, and wash hands thoroughly before entering a grow area and periodically while working.



POWDERY MILDEW PREVENTS PHOTOSYNTHESIS ON THE LEAF, EVENTUALLY TURNING THE LEAF YELLOW AND DYING

Avoid applying excess fertilizer, to limit the production of succulent tissue, which is more susceptible to powdery mildew. When conditions are favorable for powdery mildew, heat and ventilate in the late afternoon to reduce humidity during the night hours. Prune plants to allow greater airflow and ventilation within the plant canopy. Ensure the entire grow area is sufficiently ventilated.

Solutions for controlling powdery mildew
Remove infected materials from the growing area, seal completely, and dispose of it promptly. Horticultural oil applications containing thyme oil can reduce mildew. Additional application options include milk spray, baking soda spray, or apple cider vinegar spray. Sulfur burners can also be used.

Botrytis Cinerea

What is Botrytis?
Botrytis cinerea is a necrotrophic fungus, which means that it kills its host to obtain all the nutrients it needs.

What are the symptoms of botrytis?
The fungal infection in flowers is not visible initially. The tissue on which it develops becomes dark, soft, translucent, brown/gray, and may look wet, due to the death of the host cells. In time, a layer of furry gray mold will form on these dark spots.

About Botrytis in brief
In nature it helps the nutrient recycling process of breaking down dead plant material. The fungus can also result in 'noble rot' on wine grapes, which occurs when wet conditions are followed by dry and can result in distinctive sweet dessert wines.

Biological cycle of Botrytis
Botrytis infection is favorable in high humidity, wet conditions of at least 6 hours, and mild temperatures of 60-70F. After a plant has been infected, vegetative fungal threads called mycelia grow inside the plant causing lesions. The fungus then creates spores, which can spread by air, water, or other physical movement. Overwintering reproductive structures called, sclerotia, can affect future crops after emerging from a dormant state.

Prevention techniques
Remove any infected plant parts and properly dispose of them away from the production site. Wash hands and change clothes after disposal. Minimize any potential for the spread of spores, since the slightest contact can send clouds of gray spores to cast on otherwise healthy plants.

Maintain adequate spacing, air flow, and ventilation in order to create a slightly lower humidity around the leaves and flowers. For outdoor crops, growing under tunnels allows for plant coverage and prevents plants from getting wet during rain events. It is also important to be vigilant against insect pests that can cause chewing damage the cuticle, since this allows Botrytis to infect the plant more easily.



BOTRYTIS IS A COMMON FUNGAL DISEASE ON TOMATOES

Solutions for controlling Botrytis
Horticultural oil applications containing thyme oil can reduce botrytis. Several micro-organisms have proven successful in controlling *B. cinerea* in a wide variety of crops. *Clonostachys rosea* (AKA *Gliocladium roseum*) is a fungus that is used to combat and prevent botrytis attacks because of its ability to suppress the production of spores. Certain strains of Trichoderma harzianum have been shown to be helpful as well as bacteria of the genus Bacillus that are capable of producing substances that inhibit the growth of B. cinerea.



BOTRYTIS INFECTED STRAWBERRY PLANT



NOBLE ROT, BOTRYTIS INFECTION ON WINE GRAPES

Fungus Gnats



YELLOW STICKY TRAPS CAN HELP MONITOR AND CAPTURE FUNGUS GNATS

What are fungus gnats?
Fungus gnats (families Mycetophilidae and Sciaridae) are a common pest affecting indoor plants, especially where humidity and moisture levels are high.

What are the symptoms of fungus gnats?
They are usually first noticed when the harmless adults are seen flying. Plant symptoms that indicate fungal gnats include sudden wilting, loss of vigor, poor growth, and yellowing of the leaves.

About fungus gnats in brief
The adult fungus gnat is a small black fly, about 3-4 mm in length. They are attracted to humidity and decomposing organic matter, which serve as ideal conditions for their larvae. The larvae feed on organic matter, roots, and plant stems.

Biological cycle of fungus gnats
The entire life cycle from egg to adult may be completed in as little as 3-4 weeks, depending on the temperature. Eggs take 4-6 days to emerge into the larval stage, which lasts about 2 weeks till the pupal stage. This stage lasts about 3-4 days till becoming a young adult, which lasts about a week. Each adult female can lay up to 300 eggs. Due to fungus gnats' relatively short gestation period, multiple generations can be hosted at once, requiring repeated removal techniques till there are no surviving eggs.

Prevention techniques
Fungus gnats do best in damp soils; be careful not to over water, especially during cooler periods when plants require less water. Be sure to promote sufficient air circulation to prevent stagnant, humid air. When introducing new plants, inspect the plants thoroughly prior to purchasing and look for signs of insect pests. Turn up the soil carefully and look for the glossy, clear larvae of fungus gnats.

Solutions for controlling fungus gnats
Allow the soil/substrate to dry to a depth of one to two inches between watering events. This not only kills the larvae and inhibits the development of eggs, it also makes the soil less attractive to egg-laying females.



AN ADULT FUNGUS GNAT

Use yellow sticky traps placed horizontally at the soil surface to capture large numbers of egg laying adults. The gnats are attracted to yellow and can easily be removed by the trap before they can lay more eggs.



Hop Latent Viroid Disease

What is hop latent viroid disease?
Viruses consists of genetic material made from DNA or RNA surrounded by a protein coating called a capsid. A viroid is a little different from a virus, in that it is a single stranded RNA molecule and does not have a protective coating. Both viroids and viruses only replicate inside living cells, using the host cell's metabolism to fuel their replication. Hop latent viroid was discovered in the early 1970s in Japanese hops and then in Spain and Germany.

What are the symptoms of hop latent viroid disease?
Hop latent viroid disease often shows no symptoms, hence the term 'latent' as the viroid remains within the plant unseen. Visible symptoms include stunting, malformation, chlorosis, brittle stems, and a reduction in yield and potency. Some symptoms, such as discoloration and mottling, can be confused with herbicide drift damage.

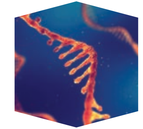
About hop latent viroid disease in brief
Hop latent viroid disease is a single- stranded RNA molecule that was first discovered on hops and is widespread in all hop-growing regions worldwide. Infected plants can be asymptomatic, latent carriers of the disease and still pass it on to other plants.

Biological cycle of hop latent viroid disease
Hop latent viroid disease is primarily transmitted through infected propagation material or across trimmers and shears that move from an infected plant to an uninfected plant while pruning or harvesting. Transmission via seed is typically very low. Once the viroid is within the plant, it integrates into the plant and replicates itself using the plant's metabolism to fuel this process. As a result, genetic culturing is needed to fully remove the viroid from the plant.

Prevention techniques
Prevention through cleanliness and hygiene is crucial for hop latent viroid disease. Start with clean plant material that is viroid and virus-free. Use clean, disinfected tools and fresh gloves when working between different plants. To guarantee that the plant stock is clean, have the material tested at a laboratory. Since plants can be asymptomatic yet still infected, multiple sample submissions, 1-2 times per month, are required per plant in order to confidently deterine that the plant is virus-free. Remove any infected plants and dispose of them off-site.

Solutions for controlling hop latent viroid disease
Remove infected plants and keep growing areas clean. Research from Oregon State University found that bleach and hypochlorous acid cleaning agents can inactiviate hop latent viroid disease.

Send any suspect plants to a lab to peform a polymerase chain reaction (PCR) test, which works to detect the presence or absence of specific DNA or RNA sequences to see if HLVd is present. In order to save a plant variety that has become infected, work with a lab to clean the genetic material. Labs have developed their own techniques for this procedure, which essentially involves heat and/or cold treatments used on meristem or nodal tissue in order to clean the sample. Then, the cleaned plant tissue cells are grown on specialized growth media and propagated to create disease-free rooted shoots referred to as a "plantlet". The cleaned stock material can then be used for future propagation.



SINGLE STRAND RNA VIROID



HOP LATENT VIROID CAN CAUSE TWISTED, DISTORTED PLANT GROWTH