Alternaria Blight

Alternaria blight may also be called Alternaria leaf spot, or Alternaria stem rot. It is caused by the fungus *Alternaria panax*.

Alternaria blight is one of the most common ginseng diseases, and is found wherever ginseng is grown. Regular fungicide sprays are required to prevent serious losses.

SYMPTOMS OF ALTERNARIA

The first obvious symptoms of Alternaria infection are brown spots up to 2.5 cm (1 in.) in diameter that develop on ginseng leaves and stems. The leaf spots are often first observed as round, water-soaked spots. These usually become papery dry with a deep yellow margin, and in some cases develop an alternating pattern of light and dark brown rings resembling a target board. The centres of these leaf spots may fall out giving a shot-hole appearance.

Ginseng stems are often infected near the base of the stem. Classic symptoms are elongate, red to brown lesions. These lesions will usually girdle the stem, causing the leaves to wilt, turn yellow to reddish-brown, and die. Premature defoliation will reduce root growth (and yield), although plants will produce leaves the following year if the bud developed before defoliation occurred, or if the plant had adequate energy reserves.

Seedlings infected at an early stage usually die. Seed heads can also be infected by *Alternaria panax*, but it has not been confirmed if this fungus causes root infection.

Even small lesions can produce spores. Under some conditions the presence of spores may be observed as a brown velvet mass. However, spores are usually present even if the brown velvet mat is not evident, and these spores are able to cause new infections. Therefore, early detection of the leaf spots or stem spots is essential.

DISEASE CYCLE

Alternaria panax overwinters on infested crop debris, and possibly on straw. It may also be introduced on ginseng seed. The fungus appears to become active early in the season as plants begin to grow. Wind, rain and irrigation splashing disperse the fungal spores to plant stems and leaves. The disease can keep cycling from plant to plant as each leaf or stem lesion produces new spores. Stems are often infected earlier in the season than leaf spots, so watch the stems carefully.

Wet weather associated with poor air circulation promotes Alternaria blight. A film of moisture on the leaf surface from dew, rainfall or irrigation is required for *Alternaria* to infect a leaf or stem. If conditions become hot and dry with low humidity, disease spread and development slows down.

Third and fourth year crops are at a greater risk from infection because their dense foliage promotes higher humidity and poorer air circulation. The latter hampers fungicide penetration.

Management Practices to Prevent Alternaria Blight

- Follow recommended seeding rates. High plant densities reduce air movement and increase relative humidity which promote disease.
- Monitor the garden regularly throughout the growing season to catch diseases early. Wet conditions play a major role in disease outbreaks. Irrigate early in the day so leaves have the opportunity to dry off in the morning. Keep foliage as dry as possible.
- Extensive areas under shade cloth restrict air movement causing dead air spaces in the centre of the ginseng garden. The dead air spaces increase temperature and humidity in these spots which contributes to plant stress and disease. Smaller gardens or methods for opening and venting the shade cloth are advisable.
- Avoid using high levels of fertilizer or manure which promote excessive leaf growth that is more susceptible to disease and reduces the ability of fungicides to penetrate the crop canopy.
- Alternaria spores can be tracked on sprayers and other types of equipment. When there is the option, avoid moving equipment through the garden when the leaves are wet.
- Alternaria spores can also be spread by the movement of people. Avoid going into uninfected areas after walking through diseased plants.

Control of Alternaria Blight

Once the disease has been identified, begin control steps immediately.

Restrict the movement of equipment and workers from infested gardens to non-infested gardens.

If the initial outbreak is in a small area, do a spot treatment with one of the fungicides registered for Alternaria blight. Include the surrounding area. See the sample fungicide program on page 100 as a guide.

If the outbreak started in several areas, or occurred in a large area, protect the entire garden with one of the registered fungicides. These fungicides do not eradicate existing infection. They will only protect the existing leaves and stems from new infections. Thoroughly spray the foliage, including upper and lower leaf surfaces and stems, to provide the best protection.

Four fungicides are registered in Canada to control Alternaria blight. Aliette will provide some level of control but should not be relied upon for complete control.

- mancozeb as Dithane DG
- iprodione as Rovral
- anilazine as Dyrene 50WP
- chlorothalonil as Bravo 500F

Use Dithane at ½ rates per hectare on one-year olds and two-year olds to prevent damage.

Apply Dyrene only in early spring in the evening, early morning or on cloudy days to reduce the possibility of plant damage. Use it earlier in the year when temperatures are lower. It is no longer being produced. Existing supplies may be used up.

If Alternaria blight occurred during the summer, consider removing the infected stems during the fall. *Alternaria panax* mycelium can be seen on these infected stems as large black patches. Spores are continually produced from these patches during wet conditions in the spring. Table 22 gives some basic information on the four registered chemicals for *Alternaria* on ginseng.

Note: ***Good coverage is essential for controlling this disease. Use a dye to determine the efficacy of your application. Calibrate your sprayer. See "Pesticide Application Options" on page 149.***

TABLE 22. Pest control products for *Alternaria* control on ginseng

Material	Active Ingredient	Registrant	Pest Controlled	Rate	Comments/Restrictions
Dithane DG PCP #20553	mancozeb	Dow	*Alternaria* Leaf Blight	4.4 kg/ha in 2,000 L water	Apply at 2 week intervals. Do not apply within 30 days of harvest.
Rovral PCP #15213	iprodione	Bayer Inc.	*Alternaria* Leaf Blight	1.1 kg/ha	Alternate with other fungicides to avoid resistance resistance. Make no more than 3 applications per season. Do not apply within 30 days of harvest.
Dyrene 50 WP* PCP #6731	anilazine	Bayer Inc.	*Alternaria* Leaf Blight	4.4 kg/ha in 2,000 L water	Apply at first sign of disease and follow with 2 subsequent sprays at 4 week intervals. May cause leaf injury if applied improperly or in adverse weather conditions. Do not apply within 30 days of harvest.
Bravo 500F PCP #15723	chlorothalonil	Syngenta	Alternaria Leaf Blight *Botrytis* Grey Mold	2.4 – 4.8 L/ha	Start applications when disease threatens and repeat at 7 – 10 day intervals. Maximum of 6 applications per year. Do not apply within 14 days of harvest.

** There will be no new supplies of Dyrene in Canada. Growers may still use existing stocks.*

Registered Fungicides: Always refer to the pesticide label for use and safety information.
Source: Adapted from the Ontario Ministry of Agriculture and Rural Affairs information titled "1995 Ginseng Pest Control Recommendations."

Botrytis Blight

Botrytis blight has caused leaf spots, flower rots and seed rot of ginseng in British Columbia. Symptoms often start in areas where the plants have been injured or where the canopy is dense. Older, dying plant tissue is particularly susceptible.

SYMPTOMS

Leaf blotches are initially olive-green and water soaked. They become tan-coloured and brittle when dry. Blotches often start at the leaf edge as a V-shaped lesion. The spots can also appear as concentric rings. When infected lesions are in a moist environment, the fungus can produce spores. These are apparent as grey, fuzzy growth.

Infected stems have reddish-brown lesions near the base. The lesion may restrict the flow of water and nutrients to the leaves causing them to wilt.

Young flowers turn brown and dry up when infected. Frequently, berries will not develop if the flower has been infected. Green berries turn brown after infection and a grey fuzzy mold may appear on mature or immature berries. Hundreds and hundreds of spores are produced in this fuzzy growth.

DISEASE CYCLE

Botrytis blight is caused by the fungus *Botrytis cinerea*. This is a very common fungus that can attack many plant species including weeds. It overwinters on previously infected plant debris, especially stems that do not rot down.

In the spring, the fungus begins to grow and produces many spores which can spread by wind or splashing water. *Botrytis* spores landing on plant tissue need a film of moisture on the plant surface before they can germinate. Infection on most crops can generally occur between 0-26 degrees Celcius, but the exact temperature range is not known for ginseng. Under cold conditions, the germination process takes longer, which means the fungus requires a film of free moisture for a longer period than during warmer conditions. Optimal temperatures for *Botrytis* development on most crops is 18-23 degrees Celcius. Wounded or dying plant tissue can be infected more easily.

CONTRIBUTING FACTORS

Practices which promote continued leaf wetness enhance disease development. This includes poorly vented gardens, dense plantings of ginseng or excessive fertilization which promotes the growth of leaves causing a dense, humid canopy.

Any type of mechanical damage such as wind or mechanical damage provides easier entry for the fungus. Use tire guards and provide enough space between rows for the movement of equipment.

DISEASE CONTROL

Infection may be reduced by removing infected stems during the winter but this has not been well-studied. Bravo 500 is specifically registered for control of Botrytis blight on ginseng, although Rovral, Dithane and Dyrene will also control it. Good coverage is recommended during the bloom period. CAUTION: Some strains of Botrytis are no longer sensitive to Rovral, so it is important to rotate the use of Rovral with other fungicides. See Bravo in Table 23, for basic information, and refer to Table 22 for information on the other fungicides.

Note:: *Refer to individual pesticide data sheets pages 151 – 164 in appendix.*

TABLE 23. Pest control guidelines for control of Botrytis disease on ginseng

Material	Ingredient	Registrant	Active Controlled	Rate	Pest Comments/Restrictions
Bravo 500F PCP #15723	chlorothalonil	Syngenta	Alternaria Leaf Blight Botrytis Grey Mold	2.4-4.8 L/ha	Start applications when disease threatens and repeat at 7-10 day intervals. Maximum of 6 applications per year. Do not apply within 14 days of harvest.

Registered Fungicide: Always refer to the pesticide label for use and safety information.

Source: The Ontario Ministry of Agriculture and Rural Affairs information titled "1995 Ginseng Pest Control Recommendations."

If you have the Ontario Ministry of Agriculture and Rural Affairs factsheet on “Botrytis Blight of Ginseng,” by Dr. R. Brammall and Pam Fisher, please add it into this document at this point. It is a good reference document on Botrytis with colour pictures and text to support this information.

Damping-off of Seeds and Young Seedlings

There are many beneficial microorganisms such as bacteria and fungi that naturally inhabit the soil. There are also plant pathogenic fungi that live in the soil. It is some of these fungi that infect the seeds and young seedlings causing the disease "damping-off." Species of *Rhizoctonia*, *Pythium*, *Cylindrocarpon* and *Fusarium* alone or in combination are the primary causes of damping-off in ginseng.

SYMPTOMS

Damping-off can be a serious disease of ginseng seed and young seedlings early in the growing season. It is first observed as scattered, bare patches throughout the garden. Lower, wet spots may be infected more frequently. Yields can be drastically reduced, and roots may become misshapen.

In the early stages of germination, seeds that are infected by the damping-off fungi fail to sprout. Seedlings that are killed before they emerge from the soil are said to have "pre-emergence damping-off." Young seedlings which topple over and die just after they emerge, have "post-emergence damping-off."

Prolonged cool, wet weather provides ideal conditions for the damping-off fungi to thrive. The onset of warmer, drier weather slows the incidence of damping-off. Seedlings from seeds that are deeply buried are more prone to damping-off because they must develop long stems and spend all their energy to grow to the surface. They have little extra energy to resist the fungi. Plant tissues are most susceptible to damping-off when very young but develop more resistance as they age. Infected seedlings which survive damping-off have poorly developed roots and may be more susceptible to root rot later on.

Pythium will usually cause a soft, water-soaked rot of the roots. Above ground symptoms of this infection are wilting and death of the seedling. *Pythium* may also infect the stem at the soil-line, girdling it and affecting the ability of the plant to transport food and water. The seedling wilts and dies.

Rhizoctonia solani usually attacks the seedlings by girdling it at the soil-line which again affects the ability of the plant to move food and water. The symptoms of wilting and death can resemble those of *Pythium*. *Rhizoctonia* tends to be more common in sandier soils than *Pythium*. See the discussion under Rhizoctonia diseases of ginseng for further information.

Cylindrocarpon will cause an orange-brown infection of the root, often starting at the tip. The fungus grows upward through the root until much of the root is destroyed. Infected plants will grow very slowly and many will survive if the plant can develop new roots before the winter. Harvested root from these plants may be small and misshapen, although this depends on how the new roots develop. Infected seedlings are very sensitive to dry conditions, and will wilt easily.

There is little known about the role of *Fusarium* in damping-off.

DISEASE CYCLE

Damping-off fungi have resilient resting structures and spores that allow them to survive in the soil for years. They exist naturally in the soil or can move to new areas with water runoff, workers, and equipment. The fungi remain dormant during the cold winter weather, but become active when the ginseng starts to grow. Plant to plant disease spread occurs by windborn, rain, or irrigation splashed spores or growth of the fungus body.

CONTRIBUTING FACTORS

Conditions in a ginseng garden are often favourable to damping-off, but management practices can reduce disease severity. Consider the following:

- Heavy soils and low, wet sites are high hazard areas for damping-off. Prolonged cool and wet soils promote the problem especially in the spring as plants emerge.
- Excessive seed rates lead to overcrowding, poor air circulation and plant stress. Damping-off is easily transmitted from plant to plant by the close root contact.
- Extra thick straw mulch keeps the soil cool and wet which are good conditions for increasing the risk of damping-off. It also reduces the ability of fungicides to penetrate into the soil where the damping-off fungi live.
- The shade cloth prolongs cool, wet soil conditions in the spring after it is erected. Delay erecting shade cloth for as long as possible to encourage warming of the soil. This is tricky because the shade cloth must be up when the seedlings emerge to prevent sun and frost damage.
- Good soil drainage helps reduce factors contributing to damping-off. Select sites with good soil drainage, and grow ginseng in raised beds to reduce the risk of damping-off and root diseases.
- Damping-off and root rot by *Rhizoctonia* is a concern on sites where alfalfa was previously grown. Preparing the site, and leaving it fallow for the year preceding planting will reduce the potential for problems.

- Good soil fertility and optimal pH (5.5 to 7.5) contributes to healthy ginseng which is more disease tolerant. Excessive chemical fertilizer or manure will force lush growth which is often more susceptible to diseases.
- Optimal soil temperatures for ginseng are 15 to 18°C during the growing season. *Rhizoctonia* is active in moist soils at 8°C. Soil temperatures of 15°C are rarely reached in a ginseng garden, even in the Lytton area from April to June so conditions favour *Rhizoctonia* development over ginseng.

MANAGEMENT AND ESTABLISHMENT PRACTICES TO REDUCE DAMPING-OFF

Create raised beds that are sufficiently high, 30 cm (1 ft) for improved soil drainage. Plant seed at an optimal density of approximately 5 cm apart in the row (2 in) and rows 12 cm apart (5 in) to allow for adequate space and air circulation. See the section on seeding ginseng gardens (page 64).

Research has not been specifically done to demonstrate that fumigation will control soilborne ginseng diseases. However, work done on other crops has shown that fumigation may provide some control of diseases such as *Pythium*, *Rhizoctonia* and *Verticillium*. Pre-plant fumigation is effective for controlling nematodes in most soils. See the nematode disease section for further information. Telone C-17, Telone II, Vapam, Busan 1020 and Basamid have activity in controlling soilborne diseases and may reduce damage from damping-off (See table 10, pg 38.) Check specific labels for rates and application procedures.

Research has shown that a plant in-row spacing of 7.6 cm (3 in) reduced the rate of spread of *Rhizoctonia* compared to closer spacings of 1.2 to 5 cm (0.5 to 2 in). Use the recommended seeding depth of 1.25 to 2.5 cm (0.5 to 1 in). Deep seeding prolongs plant emergence in the spring which depletes seed reserves and increases exposure to damping-off. Seed planted too shallow, as the opposite extreme, has a greater chance of drying out.

Irrigation management of seedlings is challenging. The trick is to avoid wet soil, but prevent drying out. Therefore it is important to monitor soil moisture at 2.5 cm (1 in) by feeling it, or measuring it with soil moisture probes. If damping-off occurs, do not drastically cut back on the water in an attempt to dry the soil out. The plants infected with damping-off have reduced root systems and will wilt easier in dry soils. Healthy plants still require a minimum of soil moisture to grow, and will be adversely affected by dry soil. Gardens in Ontario generally are not irrigated in the first or second year, but that is because their growing conditions are naturally wetter and more humid than British Columbia.

Common sense in conjunction with monitoring soil moisture is the best guide. Don't copy your neighbour; their conditions will be different from yours.

PREVENTION OF DAMPING-OFF WITH FUNGICIDES

Quadris applied after seeding and before bud-break will reduce Rhizoctonia damping-off. Quadris can be applied after the straw is in place and the label information states after September 30. See page 159 for label information.

TABLE 24. Pest control chemicals for crown rot and damping-off diseases on ginseng

Material	Active Ingredient	Registrant	Pest Controlled	Rate	Comments/Restrictions*
Quadris ®	azoxystrobin	Syngenta Crop Protection Canada Inc.	Rhizoctonia	1.12 L/ha in fall after seeding, and 1.12 L/ha in spring of 1st yr only, before May1. Use 4000 L/ha water for both applications	In 2002-2003 is an emergency registration only. Only registered for fall at seeding time after September 30 and in the spring of the first (year 1) growing season. Phytotoxic to some apple varieties.

Note: *Refer to Quadris data sheet pages 159 in appendix.*

DISEASE IDENTIFICATION AND TREATMENT

Routinely monitor the crop for any unusual symptoms and keep accurate records of your observation. Focus especially on low, wet areas or the centre of large gardens where air circulation is poor. Check seedling emergence by counting several sample grids of 25 cm x 25 cm per garden.

Ensure an accurate identification of ginseng problems by submitting diseased plants to a diagnostic lab.

Clean equipment, tools and footwear after working in infested gardens. Hose down equipment with a high pressure stream of water and allow it to dry thoroughly before moving to the next garden. Footwear and hand tools can be disinfected with a 1:10 solution of household bleach and water. Keep spray bottles filled with this mixture at the end of every few rows for convenience.

Ensure your field scouts have easy access to disinfectants.

Ridomil 2E applied for the control of *Phytophthora* Root Rot just prior to the time the plants begin growing in the spring should provide some protection against *Pythium* damping-off.

Rovral may have some effect in controlling *Rhizoctonia*, but not when applied as a foliar spray. Rovral, a locally systemic chemical, does not move far within the plant so it would have to be applied to the base of the plant as a high volume drench to be effective.

The formaldehyde soil treatment is no longer registered.

There are no registered fungicides to control *Cylindrocarpon* or *Fusarium* damping-off problems though Quadris applied for Rhizoctonia may help.

Disappearing Root Rot

Disappearing root rot is caused by the fungus *Cylindrocarpon destructans*. It has been detected at some sites in British Columbia where it typically causes roots to be downgraded to number two grade. In Ontario, it occurs in a wide range of soil types.

SYMPTOMS

Early symptoms of disappearing root rot are small gold to brown lesions on the roots. The infection does not penetrate deeply at this stage. Later, the disease moves inside the root with infected areas under the skin becoming reddish-brown and spongy. The infection may develop to a level where the entire root under the skin rots, leaving only the skeleton of the skin. In some cases, the top of the root remains.

As the root becomes more and more infected, the leaves turn red, wilt and die. If you pull up the plant by the dead leaves, the leaf stem will break off from the crown. Diseased plants often occur in patches.

DISEASECYCLE

This fungus spreads by spores that are produced on the surface of the rotted roots. Spread will occur when soil is moved by equipment, shoes or other means. *Cylindrocarpon destructans* produces structures that can overwinter in the soil or plant residue.

CONTROL

Control strategies for disappearing root rot have not been studied under British Columbia conditions. Experience from Ontario suggests that soil fumigation before planting may reduce the incidence of disappearing root rot and that the disease is less severe in soils where the pH is below 6.5.

Nematodes

Nematodes are microscopic worms that are not visible without magnification. Their feeding on the roots greatly reduces plant stand and vigour. In the case of root crops such as ginseng they can decrease yields and downgrade the quality of the produce. Nematodes are usually spread by planting contaminated stock or by moving contaminated equipment (with adhering soil) from an infested field to a clean one.

Since ginseng is a crop that stays in the ground for several years it is an ideal target for nematodes. The root lesion nematode *Pratylenchus penetrans* and the root knot nematodes *Meloidogyne* spp. are found in many parts of British Columbia, so it is wise to have a soil sample done for these pests. If the economic threshold of 100 nematodes per 100 ml soil is exceeded for the lesion nematode a lab might recommend that you fumigate before you seed the crop. Nothing can be done after ginseng plants are in the ground.

Alfalfa is an excellent host for both root-knot and root-lesion nematodes. The grasses are hosts of the root-lesion nematode only. Of the two nematodes, root-knot nematode (*Meloidogyne hapla*) is more harmful to ginseng. If the northern root-knot nematode is present in a field with alfalfa, the nematode will increase in density to its carrying capacity. It makes little difference if there are grasses in the field mixed with the alfalfa; the nematode will be there in large number when the ginseng is planted.

It is difficult to recommend a crop rotation. If a grower knows several years in advance that he or she is going to plant ginseng, the grower would do well to have several crops of oats cv Saia or rye cv Wheeler in the one or two years preceding the planting. This will practically eliminate root-knot nematodes if they are present, and give the least multiplication of root-lesion nematodes.

Always sample areas for nematodes where susceptible crops are to be planted. Nematodes tend to be very spotty in their distribution in a field, making it very difficult to collect a representative soil sample. For this reason, careful sampling is of extreme importance if harmful nematodes are to be detected. Procedures for how and when to sample for nematodes before planting ginseng are found in the soil preparation section of this guide as they must be controlled before ginseng is planted.

Looking at a Lab Report Sheet from a nematode detection laboratory that analyzes soil samples for ginseng, the numbers are interesting but what do they mean? After a long discussion we came to one conclusion, that there isn't much to base a recommendation on in British Columbia and it may be better to be safe than sorry, given small numbers of certain nematodes. The one exception is Dr. Vrain's work on Root-Lesion nematodes where he recommends fumigation when over 100/100 cc of soil are found. A count of 500 was shown to cause plant stress and root size reduction in his trials.

The other nematode where we have some knowledge of, from Wisconsin, is the Root-Knot nematode. This one causes visible bumps on the smaller roots and probably reduces root size. These are found in hot spots in a field, so when any are found in a sample you know some spots are quite heavily infested. These are being found in some British Columbia Ginseng gardens. A good reference for the root knot nematode as well as ginseng diseases is the Wisconsin publication 'Diseases of cultivated ginseng.'

As far as other nematodes are concerned and there are a few that are potential problems, we have no knowledge base to work from and research is needed to establish thresholds, as well as to determine if they will even affect ginseng. Since this information is not available, we err somewhat on the side of caution. Stem and bulb nematodes trigger fumigation in some crops at very low numbers as do Dagger and Cyst nematodes. If these latter two are found as low as one or two in some crops, fumigation is done. Some others like Pin and Spiral nematodes although parasitic, don't trigger a fumigation response until 10,000 or more are present. See table 24A below.

TABLE 24A. Nematode and fumigation recommendations

The following are a representation of the species of nematodes that are found when sampling soils in British Columbia and some comments on the recommendation of fumigation prior to seeding ginseng.

Type of Nematode	# of worms /100 cc of soil	Do they affect Ginseng?	Fumigation Recommended
Root Lesion	>100	Yes	Yes
Spiral	<10,000	?	No
Pin	<10,000	?	No
Stem and Bulb	10 - 20	?	Yes, based on damage to other crops
Root-Knot	> 1	Yes	If any are found, it indicates hot spots in the field and it should be fumigated.
Dagger	> 1	?	Are very destructive in some crops and probably should fumigate.
Cyst	> 1	?	Are very destructive in some crops and probably should fumigate.

Notes: ***1.*** *The above is not an exhaustive list.*

2. *We need more research on nematodes found in our soils to determine the effect of some nematodes on ginseng.*

3. *A test should be done to determine what nematodes are present and at what concentrations in areas where ginseng might be grown.*

4. *The decision to fumigate may be based on more than the presence of nematodes. E.g., disease, insect or weed control could be part of a decision to fumigate.*

Control — See the Site Preparation section for the fumigation procedures and products, for control of nematodes as this must be done before ginseng is seeded (page 38).

Phytophthora Foliar Blight

SYMPTOMS OF *PHYTOPHTHORA* FOLIAR BLIGHT

Entire leaflets wilt so they hang limply from the erect stem. Large, water-soaked blotches are present upon close examination. Under humid conditions, a faint white powder (spores) may be visible. Infected leaves eventually become brown and dry up.

DISEASE CYCLE

Phytophthora cactorum is a fungus-like organism that can cause foliar blight and root rot. It is soilborne and can survive in the soil for many years. Spores present in the soil can be splashed onto leaves by rain, irrigation and the movement of equipment and workers. The foliar blight phase is promoted by cool and wet or humid conditions. Most foliar infections occurred from late May to early July in British Columbia in 1996. Leaves must be wet for several hours for infection to occur. *Phytophthora cactorum* grows at 16-28 °C in lab tests, with the optimum at 24 °C.

MANAGEMENT PRACTICES TO PREVENT *PHYTOPHTHORA* FOLIAR BLIGHT

Disease patches are often associated with areas where soil is splashed onto leaves due to waterfilled trenches between beds and/or where there is poor straw cover. If you can see through the straw to the soil below there is not enough straw. Have a minimum of 5 cm (2 inches) all over, including the wheel rows and bed edges. The maximum recommended depth is 10 cm (4 inches). Avoid moving through the garden when plants are wet.

CONTROL OF *PHYTOPHTHORA* FOLIAR BLIGHT

Aliette is registered for control of *Phytophthora* foliar blight. Ridomil is also effect against *Phytophthora* foliar blight. See the control section under *Phytophthora* root rot and Table 25 for further information. Dithane DG applied for *Alternaria* blight will help reduce *Phytophthora* foliar blight.

Phytophthora Root Rot

Phytophthora root rot can be a serious disease of ginseng, especially because the crop is in the ground for an average of four years before harvest. It is caused by a fungus-like organism that is technically classified as a protist. The name of the organism is *Phytophthora cactorum*, and it is quite closely related to *Pythium* which causes damping-off. *Phytophthora cactorum* is present in some British Columbia soils, and is the same organism that causes crown rot of tree fruit.

Another phase of this disease (*Phytophthora leaf blight)* occurs when leaves are infected by this organism. Symptoms may appear similar to *Alternaria* leaf spot. Water-soaked spots form on the leaf surface and then become brown and dry. Leaves with *Phytophthora* infection develop larger brown irregular-shaped blotches but do not develop the concentric ring pattern or target-board pattern associated with *Alternaria* leaf spot. Infected leaves become discoloured, wilt and die. *Phytophthora* spores are spread from plant to plant by wind, rain and irrigation splashing.

SYMPTOMS OF *PHYTOPHTHORA* ROOT ROT

The first symptoms of *Phytophthora* root rot are usually reddening of the leaves. As the root rot progresses, the leaves may wilt, turn brown and die. The red leaf symptoms reflect the poor nutrient uptake due to the damaged roots. When the root has become severely rotten, it cannot obtain enough water; hence the wilting and death.

Root tissue can be infected anywhere on the root although symptoms may appear on the crown first and then extend down the root. Affected areas vary from pale brown to dark brown patches. The exterior of the root usually remains smooth. Inside, the rotted root is cream-coloured with a cheesy texture. A diagnostic test is to squeeze the root. It should feel soft, and the inner core may squeeze out like toothpaste from a tube. A strong odour may accompany these symptoms if bacteria have invaded the rotted tissue. When root is dried, any infected areas become sunken and blue-black in colour. It can be an unpleasant surprise to see these discoloured areas as *Phytophthora*-infected roots can look quite normal before drying.

Root rot symptoms will often appear in wet areas first, such as pockets of heavier soil, compacted areas, along the edges of raised beds where water pools, at sites where water drips or anywhere else with poor drainage. Symptoms may follow patterns of water drainage. *Phytophthora cactorum* also has a motile spore stage for moving short distances between adjacent roots in soil moisture. Excess soil moisture would enhance this mobility.

DISEASE CYCLE

Phytophthora cactorum is soilborne and can survive in the soil for many years. Its distribution is not fully known but may be found at old orchards as it causes crown rot of tree fruit. *Phytophthora* will increase upon infection of a susceptible plant, such as ginseng. Resting structures of this organism produced in infected root tissue survive in the soil for long periods.

Roots will be infected from the *Phytophthora cactorum* propagules that are already present in the soil, or through the movement of soil water, carrying spores of *Phytophthora* and it may also be present in irrigation water.

MANAGEMENT PRACTICES TO PREVENT *PHYTOPHTHORA* ROOT ROT

- Prevent potential problems by careful site selection.
- Avoid poorly drained sites and heavy clay soils.
- Avoid old orchard land.
- Soil compaction will reduce the drainage of water so where possible avoid driving heavy machinery on wet soil.
- Ridge the beds to improve drainage, and design the beds to utilize the contours of the land to prevent low spots in the troughs where water will accumulate.
- Monitor the shade cloth to keep water dripping to a minimum.
- Keep the irrigation equipment maintained so that there are no leaks or uneven irrigation patterns that could contribute to wet areas.
- Subsoiling prior to seeding may be helpful (see Site Preparation section page 21).
- Do not purchase seed from a garden that has had Phytophthora foliar blight.
- Closely monitor the crop through the season for signs of disease.

CONTROL OF *PHYTOPHTHORA* ROOT ROT

If the zone of infection is small, dig the infected plants out and dispose of them off the site. This will reduce the potential for further disease spread. Try to correct any problems that are contributing to root rot, i.e., water accumulation, dripping water.

Clean equipment, tools and footwear after working in infested gardens. Hose down equipment with a high pressure stream of water and allow it to dry thoroughly before moving to the next garden. Footwear and hand tools can be disinfected with a 1:10 solution of household bleach and water. Keep spray bottles filled with this mixture at the end of every few rows for convenience. Ensure your field scouts have easy access to disinfectants.

FUNGICIDE RECOMMENDATIONS FOR *PHYTOPHTHORA* CONTROL

Apply Ridomil 2G uniformly as a broadcast application, using a suitable granular spreader, to the mulched beds of ginseng. Apply at the rate of 31.25 kg of Ridomil 2G per hectare. Make one application in the spring just prior to the time the plants begin growing. Apply Aliette at full canopy. Under persistent wet weather, make the next Ridomil application six weeks after the first one. If wet weather continues to provide conditions for foliar blight and/or root rot is present, apply the second Aliette application. The third Ridomil application depends on the weather and disease situation; it will probably not be needed where there has been no root rot or foliar blight. Likewise, with the third Aliette application. We do not know much about the development of foliar Phytophthora in British Columbia, and how long plants will need to be protected during the summer. If root rot has been a problem, apply Aliette for root protection through the fall when the first signs of senescence occur. Aliette must be applied while the plant is still active.

Do not apply Ridomil within nine days of harvest. Do not make more than three applications per year. Do not apply with other products containing metalaxyl to ginseng. Ridomil is a systemic fungicide that is taken up by the plant. However, its activity in the plant does not kill the *Phytophthora*, but only suppresses it. Once the concentration of Ridomil drops, the fungus can resume growth. Do not apply Aliette within 31 days of harvest and do not apply more than 5 times per year. Apply at 5.5 kg per hectare in a minimum of 200 L of water per hectare. See "Pesticide Application Options" on page 149 and Table 25 for further information.

Note: *Some strains of* Phytophthora *are now resistant to Ridomil, i.e., it does not control the disease any more. Over-application increases the chance for these strains to develop. Follow the label.*

Note: *Refer to individual pesticide data sheets pages 151 – 164 in appendix.*

TABLE 25. Fungicides for *Phytopthora* control on ginseng

Material	Active Ingredient	Registered	Pest Controlled	Rate	Comments/Restrictions
Ridomil 2G PCP #24037	metalaxyl	Syngenta	Phytopthora Root Rot	31.25 kg/ha	Only three applications/year. One pre-emergence in the Spring. Second six weeks later and third six weeks after second. Do not apply within 9 days of harvest.
Aliette WDG PCP # 24458	fosetyl-Al	Bayer, Inc.	Phytophthora foliar and root rot	5.5 kg/ha	No more than 5 applications/year. Apply first application at full emergence. Final application should be made when foliage is still green. Do not apply within 31 days of harvest.

Source: The Ontario Ministry of Agriculture and Rural Affairs information titled "1995 Ginseng Pest Control Recommendations."

Note: *Ridomil 240 EC (emulsifiable concentrate) is also registered for use on ginseng, PCP No. 17274. However, it is preferable to use the granular formulation for better straw penetration, slow release and resistance management.*

Powdery Mildew of Ginseng

Powdery mildew of ginseng was reported for the first time in British Columbia in the fall of 1995. It has also shown up in Ontario. It appears as a fine white powder on the surface of the leaves. There are many different types of powdery mildew fungi, and they are usually identified based upon the size and shape of their overwintering spore-producing structure. However, we do not know which type of powdery mildew fungus has infected ginseng because it has not produced this spore structure yet. Therefore, we do not know what other plants will be infected by it, and could potentially be a source of further infection. Powdery mildew can cause yield loss by premature senescence of the crop.

Powdery mildew fungi generally like humid conditions, although they do not require a film of water on the leaf for infection. Most of the growth of the fungus is on the surface of the leaf, and special structures called haustoria grow into the leaf cells to obtain nutrients. Regular spores are produced on the white, powdery growth. Healthy plants are infected when these spores are blown from diseased leaves. Powdery mildews survive the winter as special overwintering spore-producing structures, or they survive as mycelium in plant tissue. Nothing is specifically registered for controlling powdery mildew of ginseng.

Rhizoctonia Disease of Ginseng

SYMPTOMS OF RHIZOCTONIA

Rhizoctonia solani is a fungus that survives in the soil. Generally, *Rhizoctonia* is more severe in soils that are moderately wet instead of waterlogged soils, and seems to be more common in ginseng growing areas in the Interior Plateau than the Okanagan Valley. It can cause damping-off, crown/bud rot, and root rot of ginseng. See the section on damping-off for more information on this disease. Crown/bud rot appears as a firm rusty-orange rot at the top of the root that may include bud tissue. When the bud tissue is rotted, the plant usually cannot produce a new bud in the following spring.

DISEASE CYCLE

The fungus survives from year to year on infected roots, and will also be present in the soil for long periods. It may infect ginseng seed in the seed-box and be introduced to new gardens on infested seed. Any activity that moves contaminated soil may allow *Rhizoctonia* to be introduced.

CONTROL OF RHIZOCTONIA ROOT ROT

See Table 24, page 107 for control as rhizoctonia is one of the damping-off pests.

Keep the shade cloth off as long as possible in the spring prior to plant emergence to allow the soil to warm up in the spring.

Clean equipment, tools and footwear after working in infested gardens. Hose down equipment with a high pressure stream of water and allow it to dry thoroughly before moving to the next garden. See also the section of this guide on General Pesticides and Safety for information on external washing of equipment on page 86. Footwear and hand tools can be disinfected with a 1:10 solution of household bleach and water. Keep spray bottles filled with this mixture at the end of every few rows for convenience. Ensure your field scouts have easy access to disinfectants.

Rusty Root

In the last few years it has been determined that Rusty Root is not a disease but rather a physiological disorder. You will find disease organisms in the damaged tissue but they are secondary only and do not cause the problem.

So what is the problem? This is still a debatable question and there may be more than one cause. One that has been shown to cause Rusty Root is cold injury. Soil temperatures below 0°C are common in British Columbia and damage has shown to start at -3°C and gets worse as temperatures drop.

But it is not that simple; the years when soil did not freeze, Rusty Root still appeared. Some other factors that may play a part in this are:

- soil chemistry
- nutrient imbalance
- soil type
- moisture stress
- heat stress
- OR any combination of the above (?)

There is also some strong evidence that genetics may play a large part in Rusty Root. Different seed sources have been shown to be more or less susceptible.

The process seems to be a breakdown of the outer layer of cells on the root. This dies after damaged and leaves a scabby area which sloughs off. Often the damaged area will heal over leaving a depressed area, but sometimes other organisms take over and do various levels of damage.

The affected areas can be very small to covering most of a root. Not every root will be affected and there may be from 0-100% root involvement in a garden. Seldom is there no Rusty Root in a garden.

Sclerotinia White Mold

On rare occasions, white mold caused by *Sclerotinia sclerotiorum* infects ginseng roots and stems. Infected foliage turns red, wilts and dies. Diseased roots are not discoloured, but become soft and watery. Large black structures that resemble mouse droppings are often produced on the rotted roots. These structures, called sclerotia, can survive in the soil for years during which time they can infect new roots. To avoid a buildup of *Sclerotinia sclerotiorum* in the soil, remove infected roots before they have time to develop sclerotia.

Slime Mold

Slime molds are fungus-like organisms that may be seen during moist conditions in the fall or spring. There are different types of slime molds, that are many different colours. The most common colours are yellow, white, grey, brown, and black.

Slime molds are saprophytes that feed on other microorganisms and organic litter. They do not directly feed on the plants and only use the straw and plants to support their growth. They reproduce by spores which spread by wind, water and equipment. The spores often remain dormant where they land until the moist conditions they need for germination occur.

Ginseng plants are not generally affected by slime molds. Their leaves may turn yellow if covered for too long by the slime mold. Generally, the slime molds just dry up into a crusty layer that gets broken up.

Stromatinia Rot

Also called stromatinia black root rot, this disease is uncommon in British Columbia. It is caused by the fungus *Stromatinia panacis* (formerly known as *Sclerotinia panacis*), which may also infect false solomon's seal (*Smilacina racemosa*).

There are no leaf symptoms, but infected plants may fail to emerge in the spring. When the roots are examined, they are tar-black and have not disintegrated. Black bumps may form on the surface of the roots. These are sclerotia, whose main role is survival and spread of the fungus. The inside root tissue is white, watery and spongy. Black sclerotia may be present inside the root also.

Stromatinia favours cool conditions, so most infections occur during the spring and fall when moisture levels are high. Infection occurs from germinated sclerotia.

This disease is not normally severe. Infected roots should be removed and destroyed so the sclerotia will not remain in the soil to cause further infection. Avoid spreading soil that may be contaminated to healthy gardens.

Verticillium Wilt

A small amount of harvested ginseng root has been found to have chocolate brown discoloration of the vascular tissue. The fungus *Verticillium albo-atrum* was isolated from symptomatic vascular tissue.

Verticillium wilt (caused by *Verticillium* dahliae) has been reported from the northern United States but not in Canada. Symptoms on ginseng includes wilting of the foliage, with leaves drooping parallel to the stem. Infected plants eventually die. The fungus grows in the xylem vessels and clogs them up. This restricts water movement from the roots to the leaves. Infected roots are firm but vascular tissue is conspicuously discolored yellow. Earlier references on ginseng diseases refer to this disease as Acrostalagmus Wilt.

DISEASE CYCLE

Verticillium species have a wide host range and may persist on symptomless weed hosts. One reference suggests that optimum temperatures for *Verticillium dahliae* are generally below 20 °C. Another reference suggests that high soil temperatures (22-27 °C) favor *dahliae* while *albo-atrum* has a broader temperature range (16-27 °C).

Verticillium albo-atrum survives as resistant, dark thick-walled mycelium in infected plant debris. A four- to five-year crop rotation between susceptible crops allows infested plant material to decompose in the soil. Long rotations will help reduce the level of fungal inoculum in the fields. Grain is a good part of the rotation.

Verticillium albo-atrum also causes Verticillium wilt of alfalfa. It is widespread in south-central British Columbia. Resistant cultivars of alfalfa are used to reduce disease, but the cultivars are not completely resistant. Symptoms on alfalfa include temporary flagging of upper leaves during warm weather and eventual wilting and desiccation of lower leaves and shoots. Numerous spores are produced under cool, moist conditions. They can be spread by running water, wind, footwear, harvest equipment, alfalfa hay, alfalfa seed and trash and insects such as the pea aphid. Infection occurs through the roots. Some nematodes can increase the incidence and severity of Verticillium wilt on potato. Soil fumigation may reduce levels of Verticillium and nematodes.

Submit suspect plants to a diagnostic lab for culturing to determine if *Verticillium* is present.

Ginseng Viruses

Currently, viruses have not been reported to cause problems in ginseng. Further research may be required as the need arises. Any plants with mottled or patterned leaves, bushy and/or stunted growth should be collected and submitted to a plant diagnostic laboratory.

Pesticide Use for Disease Control

Pesticide use is controlled by the *Pest Control Products Act* administered by Health Canada and the *Pesticide Control Act* administered by the Ministry of Water, Land and Air Protection.

Concerns about pesticide use are related to potential contamination of air, soil and surface and groundwater. Pesticides may pollute air and water by means of:

- vapour drift
- runoff carrying pesticides
- leaching of pesticides through the soil into groundwater
- aquifers
- pesticide spills

Those factors which affect pesticide movement in the environment also determine the risk of contamination by pesticide use. Movement of pesticides is dependent on:

- pesticide characteristics
- site characteristics
- pest management practices

Pesticides differ in their chemical structure. The characteristics of the active ingredients in pesticides have implications for the risk of environmental contamination.

When you have a choice among pesticides, those with low solubility, high capacity to bind in the soil, low volatility and short breakdown period are better environmental choices.

The environmental impact of pesticides that leach into groundwater, or enter waterways via runoff can be severe. A number of factors influence the probability of pesticides entering aquatic systems, including the climatic conditions and physical characteristics of pesticides being used on the farm.

Soil factors influencing the probability of pesticide contamination include:

- Soil physical properties, including the relative percentages of sand, silt, clay and organic matter, influence water movement and the mobility of pesti-

cides. Water moves easily through coarse-textured soils (higher % of sand), and pesticides may be transported to groundwater with little retention.

- Fine-textured soils, such as clays, not only impede the movement of water, but have a higher ability to bind chemicals and thus take them out of the solution.
- The higher the organic component in a soil, the greater its ability to hold water and chemicals and thus reduce the likelihood of migration.

The processes that influence the fate of pesticides in soils are adsorption, runoff, leaching, absorption and breakdown (microbial, chemical and photodegradation).

Adsorption is the binding of pesticides to soil particles. This may affect both the application rate and breakdown rate of the pesticide.

Runoff is the movement of pesticides in water over a sloping surface. The pesticides are either mixed in the water or bound to eroding soil. The amount of pesticide runoff depends on slope, soil texture, soil moisture content, irrigation or rainfall and type of pesticide used.

Runoff from areas treated with pesticides can pollute streams, ponds, lakes and wells. Pesticide residues in surface water can harm plants and animals and contaminate groundwater. Water contamination can affect livestock and crops downstream.

Pesticide runoff can be reduced by using minimum tillage techniques, reducing steepness of slopes, dyking to contain runoff and developing a vegetative buffer.

Leaching is the movement of pesticides in water through the soil. Leaching occurs downward, upward and sideways. Leaching is increased when the pesticide is water soluble, the soil is sandy, irrigation or rain occurs shortly after application and the pesticide is not strongly adsorbed to the soil. Groundwater may be contaminated if pesticides leach from treated fields, mixing sites, washing sites or waste disposal areas.

Absorption is the movement of pesticides into plants and microorganisms. Breakdown of plant or microbial tissue may release pesticides back to the soil.

Breakdown of pesticides occurs by either microbes, chemical reactions or light. When pesticides are broken down, they are no longer toxic. This is good for eliminating pesticide residues from soil or crops. However, when pesticides break down too rapidly, they may not control a pest or may provide only short-term control.

- Microbial breakdown is the use of pesticides as food by microorganisms such as fungi and bacteria. Microbial breakdown tends to increase when the temperatures are warm, the soil pH is favourable, the soil moisture and oxygen are adequate and the soil fertility is good.

  Microbial breakdown is one of the ways pesticides are more readily destroyed in soils. Sometimes you need to use the higher application rate on a pesticide label to make up for rapid microbial breakdown. In a few cases, certain pesticides are no longer useful because the microbes break them down so fast they do not have time to work.
- Chemical reaction is the breakdown of pesticides by chemical reactions in the soil. The rate and type of chemical reactions that occur are influenced by the binding of pesticides to the soil, the soil temperatures, the pH levels and moisture. Many pesticides, especially the organophosphate insecticides, break down more rapidly in alkaline soils or in spray tank water with a high pH level.
- Photodegradation is the breakdown of pesticides by sunlight. Some pesticides are rapidly broken down by photodegradation. This is why some labels direct you to disc or water a pesticide into the soil.

Site conditions affecting the probability of pesticide contamination include:

- Permeability of various geological deposits between the soil surface and groundwater, affecting the speed and movement of water and pesticides to groundwater. For example, layers of gravel move water fairly quickly in a downward direction.
- Depth to groundwater; the closer the water-table is to the surface, the greater the probability of contamination.
- Slope of the ground surface controls the direction of contaminant movement.
- Proximity of surface water bodies.

Pesticide properties that influence the possibility of water contamination:

- Water solubility is critical, the higher the solubility in water, the greater the likelihood of contamination.
- Soil adsorption which is a factor of both the soil and pesticides.
- Degradation rate in soil is critical, the faster a pesticide degrades in the soil, the less likely it is to be carried to aquatic systems and groundwater in large quantities.

A typical washer sorter unit with roots being loaded on trays to go into dryer.

A section of a large dryer. Notice the floor with holes for air flow up through the traps.