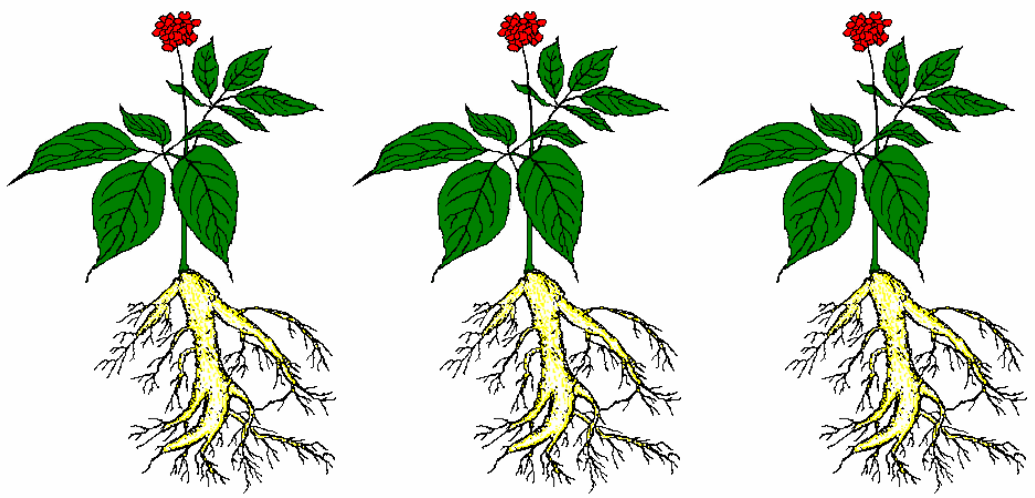
# PEST MANAGEMENT IN THE FUTURE

## A Strategic Plan for the Michigan and Wisconsin Ginseng Industry



## Workshop Summary
## April 12, 2007
## Michigan State University
## East Lansing, Michigan

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# EXECUTIVE SUMMARY

The purpose of this meeting was to update the Pest Management Strategic Plan (PMSP) developed from an initial meeting of the Michigan and Wisconsin ginseng industry representatives, researchers, and other stakeholders on April 13, 2004. This follow-up meeting provided an opportunity for the industry to redefine their priorities in light of recent research advances. The meeting was well attended with representation from the Michigan and Wisconsin industry (8 growers), Michigan State University and Cornell University (13 research/university faculty and staff), the chemical industry (3 representatives) and officials from state government (4 attendees) and the USDA (1 attendee).

Researchers had the opportunity to highlight new information from research studies that were funded through the USDA CSREES Pest Management Alternatives Program Award 2003-34381-13522 and the USDA IR-4 Project. Growers discussed areas of concern, problems newly recognized and strategized on ways to improve current practices. Over the course of the workshop, it became clear that some of the priorities established by the PMSP process in 2004 have been achieved as a result of the strides made through regional collaboration.

The top three research priorities identified during the 2007 PSMP Workshop include the following: 1) Identify pathogens that may be seedborne and identify effective treatments; 2) Identify new active ingredients effective against grubs, cutworms and wireworms; and 3) Develop management strategies for root rot diseases, including *Phytophthora*, *Cylindrocarpon*, and *Fusarium*. The top two regulatory priorities include: 1) Retain the use of broad spectrum fungicides (i.e., mancozeb [Dithane, Section 18], thiophanate-methyl [Topsin, Special Local Need 24 (c)], and chlorothalonil [Bravo, Section 18]), for use in an alternation program with strobilurin fungicides; and 2) Maintain availability of the insecticide diazinon for ginseng growers until comparable replacement products are identified and speed those products' registration. The top two educational priorities include: 1) Information on newly available pest management products is needed to define their activity and optimal use pattern; and 2) Continue educational workshops that highlight effective management programs and establish optimal application techniques.

New active ingredients have been added to the updated plan to reflect industry advances and include; *Beauveria bassiana,* cyfluthrin, deltamethrin, garlic juice extacts, kaolin, petroleum

oil, thiamethoxam, harpin protein, boscalid, captan, chitosan, chlorothalonil (Section 18 label), copper ammonium complex, copper salt of octanoic acid, copper sulfate, mancozeb (Section 18 label), mancozeb/zoxamide (Section 18 label), polyoxin D zinc salt, thiophanate-methyl (24C label), trifloxystrobin, ammonium salts of fatty acids, clethodim, DCPA, diquat dibromide and pelargonic acid. The Elevate 70WDG label (fenhexamid) has been changed from non-food use to allow application during the harvest year. Captan 50W and Endorse 2.5WP (polyoxin D zinc salt) are registered for non-food use on ginseng.

## WORKSHOP PARTICIPANTS

| | |
|---|---|
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# TOP PRIORITIES OF THE GINSENG INDUSTRY

**RESEARCH:** Top 6

1. **Identify new active ingredients effective against grubs, cutworms and wireworms (diazinon replacement).**
2. **Identify pathogens that may be seedborne and identify effective seed treatments.**
3. **Develop management strategies for root rot diseases, including *Phytophthora, Cylindrocarpon,* and *Fusarium*.**

4. Identify an effective postemergence broad spectrum herbicide that is safe on ginseng.
5. Develop management strategies for foliar blights, including *Botrytis* and *Alternaria*.
6. Refine the optimal nutrient management program, including application methods and impact on disease susceptibility.

**REGULATORY:** Top 6

1. **Broad spectrum fungicides (i.e., mancozeb [Dithane, Section 18], thiophanate-methyl [Topsin, Special Local Need 24(c)], and chlorothalonil [Bravo, Section 18]), are needed for use in an alternation program with strobilurin fungicides.**
2. **Maintain availability of the insecticide diazinon for ginseng growers until comparable replacement products are identified and speed those products' registration.**

3. Develop improved relations (by crop grouping) with the plant protection industry to facilitate needed information and product availability.
4. Partner with IR-4 to speed registration of needed products for food use.
5. Utilize products labeled in the same crop grouping as ginseng to establish tolerance levels and speed registration.
6. Utilize a non-food use registration whenever possible to speed availability of needed products to the industry.

**EDUCATIONAL:** Top 4

1. As new pest management products become available, information is needed regarding their activity and optimal use pattern.
2. Continue educational workshops that highlight effective management programs and establish optimal application techniques.
3. Develop fact sheets needed to identify pests and the resulting crop damage, describe the life stages of the pest, and provide control recommendations.
4. Provide plant nutrient education and management programs associated with new laws/regulations.

## BACKGROUND

"Panax" is a Greek word that means "panakeia" or all-healing, and refers to the reputed medicinal value of ginseng which has been used extensively in oriental countries as a traditional medicine (Anonymous, 2000). In addition to having aphrodisiac properties, ginseng is considered to have curative activity for a number of human ailments, including short-term memory loss. The Food and Drug Administration classifies ginseng as a "generally recognized safe food" (Harrison et al., 2000). The root may be sold whole and intact, or as crystals, extract, or powder capsules. In some countries, the ginseng root is used in a variety of products, including toothpaste, soft drinks, tea, candy, chewing gum, and cigarettes. In the U.S., ginseng and ginseng products may be found in Asian food and health food stores.

American ginseng (*Panax quinquefolius* L.) is a perennial herb native to parts of the United States and Canada. Ginseng roots from native forests are most desirable and valuable. Woods-grown ginseng takes from 6 to 10 years to mature, at which time the roots are harvested. The limited supply of this type of ginseng and increasing demand led to cultivation in shaded "gardens" which began in the 1800s. Cultivated ginseng is grown in raised mulched beds under shaded conditions provided by wood lath or black polypropylene. Many ginseng gardens are small and typically less than one acre. Cultivated (artificial shade-grown) ginseng matures in 3 to 4 years with a production cost of $26,000/acre (Brun, 1999).

In Wisconsin, most growers harvest ginseng the third or fourth year after planting from seed (Harrison et al., 2000). In Michigan, woods-grown ginseng may be harvested as a more mature crop (i.e., 7 years or more). The roots are mechanically dug in the fall and vigorously washed to remove surface soil. It is important to handle the roots carefully to keep the branching forks intact and maintain the natural color and circular markings. Ginseng roots are dried on wire-netting shelves in a heated, well-ventilated room (Harrison et al., 2000). Since overheating destroys color and texture, the roots are dried at a temperature between 60°F and 80°F for the first few days, and then the temperature is gradually increased to about 90°F for three to six weeks. The drying roots are turned frequently. The roots are stored in a dry, well-ventilated, rodent-proof container just above freezing.

In mid-May to early June, growers begin applying products for pest control. Ginseng growers apply fungicides every 5 to 10 days until the middle of September. Since sprays (insect, disease, and foliar fertilizers) may be applied separately, growers typically make more than one pass through a garden each week to apply the needed products. Most growers will have a labor crew remove the weeds in July. The size of the weed crew is dependent on the amount of acreage that needs to be weeded and the severity of infestation. Weed crews work in the gardens for two to three days. Seed harvest also requires a labor force, generally the same personnel as the weeding crews. Finally, harvest requires additional labor. Harvest begins as early as September and may continue into November. Although harvesting is accomplished mechanically through the use of a modified potato digger, personnel are needed to retrieve roots that have been missed or dropped.

More than 90% of the cultivated ginseng grown in the U.S. is grown in Wisconsin (Drilias, 2002). Wisconsin's 400 growers cultivate 2,100 acres of ginseng, producing 500 to 1,700 lb/acre which represents 10% of the world's supply of ginseng root. At an approximate average of $20/lb, ginseng is a high value crop for Wisconsin, totaling approximately $50 to $75 million annually. While production is concentrated in the north-central part of the state (Marathon County), 37 other Wisconsin counties also have acreage devoted to ginseng

cultivation. Woods-grown ginseng is a relatively new crop for Michigan, with the first seedlings (Wisconsin transplants) being planted in 1995. Most of the ginseng production is located in Michigan's Upper Peninsula (Houghton County). Michigan has approximately 135 acres of woods-grown ginseng at various stages of maturity and 15 acres of cultivated ginseng. Woods-grown ginseng has a higher market value (up to 10 times) than that of cultivated ginseng. Based on current prices, this represents a Michigan inventory of over $50 million. In 2007 Michigan harvested approximately 2,100 pounds of woods-grown ginseng at various stages of maturity and 15 acres of cultivated ginseng. Current prices for woods-grown ginseng are $80 per green pound and $320 per dry pound. Canada is also a significant producer of ginseng with approximately 8,000 acres grown in Alberta, British Columbia, and Ontario (Anonymous, 2000). Several states including West Virginia (Scott et al., 1995), North Carolina (Davis, 1997), New York (Friedlander, 1997), Washington (Brun, 1999), and Oregon have small but thriving ginseng industries.

Cultivated ginseng is established in early fall with seed that is planted into 5' wide raised beds that are 9" to 12" high. The following spring, woven panels providing 80% shade are suspended via 8-10 ft. posts in cultivated gardens to mimic wood-lot conditions. The microenvironment created through this culture, including reduced air movement, increased relative humidity, and increased duration of leaf wetness, is highly conducive to disease. Foliar blights caused by *Alternaria panax* and *Botrytis cinerea* are a primary problem for ginseng growers in Wisconsin (Parke and Shotwell, 1989) and Michigan (Hausbeck, 2003). When left uncontrolled, diseases can cause premature defoliation that affects plant growth and survival, resulting in small, poor quality roots with reduced market value. Premature defoliation as a result of foliar disease predisposes the root to soilborne pathogens.

*Alternaria panax* is the most common pathogen of ginseng throughout the world (Li and Utkhede, 1993). It can attack shoots, leaves, and stems on plants of all ages. Senescing tissue and nutrient deficient plants are especially susceptible to infection by *A. panax*. The leaf blight includes lesions with yellow-green halos, dark brown margins and pale brown centers. Established lesions may have a "shot-hole" appearance after the tissue in the center disintegrates. Stems can also become blighted and collapse. The potential for repeated widespread and devastating epidemics is great because *A. panax* produces large numbers of conidia (spores) on the surface of diseased leaves and stems. When weather is favorable (humid and wet), blight symptoms and reproduction of the fungus can occur in 5 to 7 days (Uchida, 2003). Outbreaks of *A. panax* in one season greatly increase the potential for epidemics in subsequent seasons, since the fungus overwinters in the infested plant debris. In the spring, conidia that overwintered can spread to the newly emerging healthy plants via rain or splashing water and begin the disease cycle for the new growing season. Conidia can travel via air currents, resulting in spread of *A. panax* from a diseased garden to nearby healthy gardens. Workers may also contribute to the spread of this fungus via contact with clothing and equipment (Uchida, 2003).

If Alternaria leaf and stem blight is not controlled, it can reach epidemic proportions within a month after the plants have emerged in the spring, destroying all of the foliage. This loss of foliage retards root growth in maturing crops, resulting in reduced root yields at harvest. Also, defoliation of young plants makes them more susceptible to winter kill. Repeated outbreaks in subsequent years can reduce yields further. The loss of yield reported by Wisconsin growers when the disease is uncontrolled range from 50 to 100%, with the majority of those surveyed reporting losses of 75 to 100% (Drilias, 2002). In addition, Alternaria leaf and stem blight can damage or destroy the seed crop normally harvested from 3-year-old ginseng gardens.

In other ginseng-growing regions including Alberta (Chang et al., 1997; Chang et al., 1998), West Virginia (Scott et al., 1995), and North Carolina (Davis, 1997), Alternaria leaf and stem blight is recognized as the most devastating disease. Recently, *A. panax* was reported as a pathogen on ginseng in Oregon and Washington (Putnam and DuToit, 2002).

The fungicide iprodione (Rovral) was once very effective at controlling Alternaria leaf and stem blight in ginseng. However, Rovral failed to control Alternaria blight in mid-season in 1987 throughout Wisconsin. Laboratory tests confirmed the existence of an *Alternaria* population which had become resistant to iprodione, the active ingredient in Rovral. Consequently, a severe epidemic of stem blight eliminated many gardens and significantly reduced the yields of most gardens. The copper hydroxide fungicide, Kocide, was made available in 1988 to be mixed with Rovral for control of Alternaria leaf blight in harvestable gardens where use of mancozeb (Dithane) was prohibited. Rovral/Kocide does not provide adequate disease control throughout the season, and should not be used prior to the harvest year, as it will allow a buildup of inoculum. When high inoculum levels are present at the time of plant emergence the following spring, the potential for an epidemic is greatly increased, because it is difficult to protect ginseng stems as they emerge through the infested mulch. Furthermore, the Rovral/Kocide combination appears to reduce the seed yield of treated plants.

Azoxystrobin (Quadris), trifloxystrobin (Flint) and pyraclostrobin (Cabrio) are labeled for control of *Alternaria* and must be used in alternation with protectant fungicides (i.e., Dithane, Bravo) to delay the development of pathogen resistance. Mancozeb (Dithane) and chlorothalonil (Bravo) are critical fungicides for control of *Alternaria* and must be applied frequently over the course of the season to maintain adequate protection. These products have been available to ginseng growers through yearly Specific Exemptions to Section 18 of FIFRA or through a state-issued crisis exemption.

*Botrytis cinerea* is extremely common and can grow and survive on virtually any dead plant material found in a ginseng garden (Brammal and Fisher, 1993). Also called gray mold, this fungus is the same pathogen that causes crop loss on greenhouse bedding plants and cut flowers (Hausbeck and Moorman, 1996). Traditionally, ginseng growers considered *B. cinerea* a pathogen of flowers and fruits only, resulting in reduced seed yields. Infection of the flowers and fruit leads to discoloration, followed by abortion of these plant parts or infection of the developing seed. Without fungicides to protect against Botrytis blight, growers could lose up to 80-100% of their crop, especially if seedling gardens are affected.

In recent years, ginseng growers in Michigan and Wisconsin have reported an increased occurrence of leaf blight caused by *B. cinerea* (Drilias, 2002; M. Peever, Former Research Director, Ginseng Board of Wisconsin, *personal communication*). Botrytis leaf blight is the most common foliar disease affecting ginseng in Washington where the cool, cloudy weather, and frequent rainy periods are ideal conditions for pathogen development and spread (Brun, 1999). Typical symptoms include water-soaked, tan lesions that often have concentric rings, giving them the appearance of a bull's eye. Lesions often start at the leaf tips and proceed back along the leaf mid-rib. *Botrytis cinerea* can infect stems late in the growing season and may form small black bodies (sclerotia) on affected tissues that allow the fungus to overwinter. During periods of high humidity, the fungus produces high numbers of small, single-celled, colorless conidia on diseased or dead plant tissue. Conidia are released and disseminated when infected leaves or fruit clusters are disturbed by air currents or human activities. Field observations also suggest that the fungus can grow from leaf to leaf in densely planted gardens when diseased and healthy leaves come into contact. Senescent leaf tissue can overlap healthy

leaves that can serve as the extra food source needed for *B. cinerea* to successfully infect intact, healthy plant tissue.

There are few modes of action or fungicide classes available for control of *B. cinerea*. Resistance of *B. cinerea* to fungicides severely limits chemical control options. Resistance to benomyl and cross-resistance to other benzimidazole fungicides in *Botrytis* populations are now common, while multiple resistancse to both benzimidazole and dicarboximide fungicides is not unusual. Iprodione (Rovral) is a dicarboximide fungicide.

Resistant and sensitive strains of *B. cinerea* are often similar in fitness. Vali (1991) found that dicarboximide-resistant and -sensitive strains of *Botrytis* differ only slightly in fitness. Therefore, the resistant portion of the population does not decline significantly when the fungicide is no longer used. It was reported that a *Botrytis* population in a greenhouse where benzimidazole use ceased in the 1970s still exhibited resistance 12 years later. Alternating fungicides is ineffective in suppressing resistant *Botrytis* populations because the population does not decline significantly during the relatively short period of time that the fungicide is not present. Mixing chemicals with different modes of action is also ineffective in managing resistance if the chemical to which the fungus is resistant is included in the mixture. Although most of the fungicide-sensitive conidia will be killed with such a mixture, the remaining fungicide-resistant conidia will not be completely controlled. Surviving resistant conidia will germinate, infect, and give rise to many more conidia resistant to the fungicide. Thus, there is no management benefit from using the fungicide once resistance is present.

Fenhexamid (Elevate), for *Botrytis* control, but has not been locally available through pesticide distributors. A maximum of four applications may be made. Azoxystrobin (Quadris), trifloxystrobin (Flint) and pyraclostrobin (Cabrio) are labeled for control of *Alternaria* only but offer limited *Botrytis* suppression. These products must be used judiciously and in alternation with protectant fungicides to delay the development of pathogen resistance.

Chlorothalonil (Bravo Weather Stik 6SC) is available as Daconil for use on ornamentals in the greenhouse where *Botrytis cinerea* is a persistent problem. Historically, chlorothalonil (Bravo) has not been available to ginseng growers. However, the unusually wet and cold spring and summer necessitated a crisis exemption for Michigan and Wisconsin. Chlorothalonil will be available through a Specific Exemption to Section 18 of FIFRA for use on *Alternaria* in Michigan and Wisconsin for 2007. Michigan State University has conducted numerous trials over several years and demonstrated that chlorothalonil is a superior product for *B. cinerea* control. The protectant fungicide mancozeb (Dithane) does not offer the needed level of *Botrytis* control when environmental conditions favor disease. Chlorothalonil also has excellent activity against *Alternaria*.

Powdery mildew was a common problem in Wisconsin ginseng gardens during the 2004 growing season. Symptoms of powdery mildew, caused by the fungus *Erysiphe* sp., include powdery, white, superficial spots of conidia on the upper surface of leaves. Infected tissue turns reddish purple, and infected leaves turn yellow and may drop. Severe disease early in the season may reduce seed production, root fresh weight and winter hardiness (Chang, et al., 1999). Powdery mildew pathogens overwinter on infested plant debris. Conidia are produced throughout the summer when the environment favors fungal growth. Incidence is likely more severe during cool, cloudy weather (Howard et al., 1994).

Root rots are a primary concern of ginseng growers and include *Rhizoctonia solani*, *Fusarium* spp., *Pythium* spp., and *Phytophthora cactorum* (Chang et al., 1997 and 1998). *Cylindrocarpon destructans* also plays a significant role in declining gardens and replant

problems and has been isolated from many Wisconsin root samples (Hausbeck, unpublished data). *Rhexocercosporidium panacis sp. nov.* has recently been identified as a probable causal agent of rusty root (Reeleder et al., 2006) along with *C. destructans* and *Fusarium* spp. Rusty root is characterized by slightly raised reddish-brown to black lesions of varying size. Lesions remain superficial, but the outer layer of root tissue is ruptured and sloughed off, giving roots a scabbed appearance (Reeleder, et al., 2006).

*Fusarium* spp., *Pythium* spp., *P. cactorum*, and *R. solani* are soilborne fungi that cause preemergence damping-off and postemergence seedling root rot, especially in 1- and 2-year-old ginseng plants (Chang et al., 1997 and 1998). *Rhizoctonia solani* causes damping-off, and crown and bud rot. Once the crown becomes infected, winter kill of the plant is likely, preventing emergence in the spring. Damping-off fungi can occur early in production by causing a seed rot and attacking seedlings before they emerge from the soil. Postemergence damping-off is more readily recognized because the damping-off fungus attacks at the soil line after the seedling emerges from the soil. Wilting of the seedling occurs when stems are infected, which causes water-soaking, and constriction. Seedlings collapse at the point of constriction. *Fusarium* spp. and *Pythium* spp. can produce spores on ginseng debris. Some pathogens use the straw mulch to spread from plant to plant, and some spread through the soil as saprophytes until they contact the ginseng plants (Howard et al., 1994).

*Phytophthora cactorum* is a serious threat to growing ginseng in Michigan and Wisconsin. This pathogen is favored during wet weather and can destroy entire ginseng plantings within a few weeks. Initial symptoms include a bronzing and wilting of the foliage with infected roots becoming discolored and spongy and eventually disintegrating. While *P. cactorum* is a soilborne pathogen, there is a foliar blight phase that results in severe damage to the leaves.

This pathogen is a common, widely distributed, soilborne fungus with a very wide host range, attacking about 200 different species of plants in over 80 genera. *Phytophthora cactorum* can be found in agricultural and nonagricultural soils, including those near apple orchards and forests. Since ginseng is typically established in woodlots or on recently cleared land, *P. cactorum* may be endemic in some instances. The pathogen overwinters as mycelium in diseased roots or may survive for several years as thick-walled oospores or chlamydospores in the soil. These thick-walled structures resist periods of unfavorable environment such as drought or freezing temperatures and are relatively resistant to chemical treatment. The fungus can also form sporangia and zoospores that may be splashed to foliage causing blight. The ability to produce large numbers of spores (primarily zoospores) allows the *Phytophthora* fungus to build up to high levels rapidly. This pathogen may also be seedborne.

Metalaxyl or mefenoxam (Ridomil 2E or Ridomil Gold) applied as a preemergent fungicide has been relied on by the ginseng industry for many years to control Phytophthora leaf and root rot. Other fungicides such as copper and Dithane are inadequate against this oomycete pathogen when disease pressure is moderate to severe, oomycete pathogens require a fungicide that specifically targets them. A protectant such as mancozeb will provide limited suppression of the foliar phase of disease, but under moderate disease pressure will not provide commercial control. *Phytophthora* spp., in general, affect a number of crops and in those situations, fungicides specific for the oomycete pathogens have been needed to avert epidemics.

In 2003, Michigan State University received diseased ginseng roots from growers in Michigan and Wisconsin. Over 100 *P. cactorum* isolates were obtained from diseased ginseng plants. These isolates have been screened for resistance to the fungicide Ridomil Gold and 85

(76%) of them have been found to be fully resistant to Ridomil Gold. This coincides with the observations of growers in both states who believe that they have had control failure during the last several years resulting in losses of catastrophic proportions. Resistance to Ridomil Gold is unlikely to lessen, and we anticipate continued resistance to this fungicide.

The soilborne fungus, *Verticillium dahliae*, causes plant wilting and death, and is a sporadic problem. This fungus can infect other crops besides ginseng, including eggplant, tomato and potato (Sherf and MacNab, 1986). It generally affects older ginseng plants. Ginseng leaves wilt and droop parallel to the stem, and the plant eventually dies. Roots remain firm, but the vascular tissue is discolored yellow. Symptoms often appear later in the season when plants become senescent. *Verticillium dahliae* overwinters as microsclerotia in infected plant debris. The fungus penetrates into the vascular tissue of ginseng at the sites of leaf scars, and can likely penetrate the roots directly. It grows and spreads through the xylem vessels blocking movement of water in the plant, and forms microsclerotia in dead tissues. Disease development in ginseng is favored by temperatures below 20°C. The fungus can be spread by infested soil, farm machinery and irrigation water. *Verticillium* can persist in the soil as microsclerotia (Howard et al., 1994). Currently, there are no registered fungicides to control this pathogen.

The fungus, *Cylindrocarpon destructans*, causes disappearing root rot, a disease that affects plants of all ages. The disease affects all underground plant parts causing near total destruction. *Cylindrocarpon destructans* causes infections near the root tip, progressing upwards until most of the root is infected. This pathogen can also cause a crown rot and root "stubbing." *Cylindrocarpon destructans* is common in soils of coniferous woodlands, and occurs in a wide range of soil types. Initial infections appear as small, gold to brown areas on the root surface which enlarge rapidly and deepen into a reddish-brown, spongy rot. The root exterior becomes dark brown at infection sites. Lateral rootlets may be affected, producing a distorted taproot, and the infection can advance into the crown and stem. Only fragments of the root tissues remain in advanced stages of the disease. Diseased plants may fail to emerge. Foliar symptoms include wilting that is often one-sided. Foliage can turn red to brown after repeated wilting, with aerial portions of the plant often dying. The disease appears in ginseng gardens as concentrically expanding patches of wilting or dead plants. Conidia form on the surface of rotted roots and can be spread on clothing or machinery or in infested soil. Dense plant populations may allow the pathogen to spread through direct contact of roots. *Cylindrocarpon* is believed to overwinter as thick-walled chlamydospores in soil or on infested plant residue (Howard et al., 1994). Despite the devastating losses caused by this pathogen, registered fungicides are not available.

*Sclerotinia sclerotiorum*, causes white mold, a stem and root rot of ginseng. This fungus has a wide host range. Symptoms of Sclerotinia white mold include foliage that wilts, and becomes discolored and desiccated. Roots appear soft and watery. Black sclerotia form on infected plant parts, and these can survive for ≥5 years in soil and ginseng debris. The fungus thrives in moist, cool conditions. Sclerotia within 2-5 cm of the soil surface produce apothecia (which contain ascospores) after several weeks at about 4°C. The ascospores are released into the air. The spores need 48-72 hours of wetness to infect, and disease can develop rapidly at 20-25°C. Mycelium can spread between plant parts that are in contact (Howard, et al., 1994.

Stromatinia black rot is caused by the fungus, *Stromatina panacis*, which also has been known to infect false solomon's seal, a woodland plant. Growth of *Stromatinia* is favored by cool moist conditions and most infections occur in the spring and fall. There are no leaf symptoms, but infected plants fail to emerge in the spring. Roots are intact, but are black and may have bumps (sclerotia) on the surface. The inside tissue is white, watery and spongy, and

may have sclerotia present (Anonymous, 2003). Little detail is known about this disease and the fungus that causes it. Another species of this genus, *S. gladioli*, causes corm rot of gladiolus, and information about this disease is applicable to ginseng. Stromatinia black rot is found during periods of cool, wet weather and produces a dry rot of all below-ground plant parts (Pfleger and Gould, 2002). Rotting of the leaf bases often results in premature yellowing and death of the tops (Pataky, 1983). Often plants are infected in groups as the fungus spreads from the original infected plant. Diseased roots characteristically have many small lesions ranging in size from pinpoints to about ½ inch in diameter. The lesions are minute and reddish brown at first, usually developing on the side and lower half of the root, but frequently appear on the upper half as well. The line separating the healthy and diseased tissue is rather sharp. As the lesions enlarge, the centers become sunken and usually turn black with definite, slightly raised margins. The lesions often merge into large irregular areas. Very small black sclerotia form in infected tissue. When infected roots are cut vertically in half, blackened vascular strands can be seen that extend from the core to the surface of the root. The decayed tissue is corky in texture and mummification of the roots often occurs in storage.

Very little is known about the ginseng disease caused by *Septonema* sp. This fungus has been isolated from diseased buds, roots, seeds, and seedlings of ginseng grown in Michigan and Wisconsin. Infected roots have a brown to tan superficial discoloration. This fungus is not reported as a pathogen on other crops.

Fusarium root rot (*Fusarium* spp.) results in disease of the stem, crown, roots, and foliage. Vascular discoloration is a common symptom of infection, and is typically preceded by the leaves wilting. *Fusarium* has been isolated from untreated ginseng seed and can cause damping-off of emerging seedlings. In general, the level of control offered by available fungicides is helpful but additional control measures are needed.

Several insects are known pests of ginseng. Cutworms are the larvae of several species of night-flying moths in the family Noctuidae. Larvae can be recognized by their habit of curling into a "C" when they are disturbed. Larvae feed in the evenings on stems of young plants, girdling and chewing the tops as they emerge. Some species overwinter as eggs, whereas some adults fly in from the south yearly. Most damage in ginseng occurs on the outer edges of the garden (Schooley, 2000). Typical cutworm damage includes a wilted young 1- or 2-year old plant that has fallen over, and separated from the root (Anonymous, 2003). The variegated cutworm is a major pest of concern for ginseng growers, especially in the first year of production.

Four-lined plant bugs cause economic damage on ginseng seedlings, but feed on plants of all ages. These insects are approximately 7 mm in length, and have four black stripes that extend the length of the wings, contrasted with a bright green to yellow color. Nymphs do not have wings, and have brightly colored markings of red to yellow. Sharp mouth parts pierce the ginseng leaf and suck the leaf contents leaving the upper and lower epidermis. Fresh feeding spots (1-2 mm diameter) are initially dark colored, but quickly become white or tan and papery. Spots can coalesce if feeding is intense, which can prevent photosynthesis. Eggs overwinter, and nymphs appear in late May. Adults are very mobile and most active in ginseng in late June and July, depending on temperature (Schooley, 2000).

The leaf roller is the larva of a small moth (*Archips purpurana*), usually less than an inch in length. Adults lay eggs on ginseng leaves, and the larva folds a leaf around itself, by partially chewing the petiole to allow the leaf to droop and become easier to manipulate. One larva

occupies each rolled leaf. The larva feeds on ginseng during the day and seeks shelter in the rolled leaf at night (Schooley, 2000).

Wireworms are yellowish-brown, shiny, slender, hard-bodied worms up to 1 inch long. Wireworms bore into seeds and seedlings, destroying them and, in heavy infestations, may feed on established plants (Anonymous, 2003).

Aphids are small, soft-bodied insects with piercing-sucking mouthparts. They cause damage by piercing the foliage and sucking the plant sap. Feeding can twist and distort new growth. Aphids can also transmit viruses in many different crops (Howard et al., 1994).

Cultivated ginseng is highly susceptible to slug damage in the spring when the weather is cool and damp. Slugs have rasping mouthparts, and ragged holes in the leaves and mucus trails are characteristic symptoms of slug feeding. A very small amount of slug feeding on developing leaves probably has very little effect on eventual root yield (Brun, 1999). Slugs can shelter in tall grass, under litter or mulch, or can burrow into the soil. Most slug feeding occurs at night or on cloudy days, when it is cool and humid. During dry conditions, they can protect their bodies with mucus secretions. Overwintered slug eggs hatch early in the spring. Slugs are hermaphroditic (have both male and female organs); male organs usually develop first, then they mate. After the male organs degenerate, the slugs become female, and lay 30-150 eggs in the fall (Howard et al., 1994).

The northern root-knot nematode causes mature ginseng roots to be deformed, short, and branched, with secondary roots that are abnormally branched and hairy. A high density of nematodes in soil causes areas of missing or stunted plants in a ginseng garden. Leaves usually appear healthy, but they may be smaller and light colored, or may have a reddish tinge on the back of the leaves. Older leaves can turn yellow and dry prematurely. Infected plants senesce early. Small swellings and branches become visible on the lateral roots a few weeks after planting, and tap root development is delayed. Marketable yields and quality are reduced. Northern root-knot nematode attacks many different vegetable crops. The second stage juveniles are attracted by root secretions and migrate to roots and penetrate the root tips soon after seed germination and root elongation. They induce formation of giant cells (knots) which they feed on. Females lay eggs in brown gelatinous masses (which appear the size of a small pin head to the naked eye) on the surface of the knots within a few weeks at soil temperatures around 20 °C. The second stage juveniles develop in about 2 weeks, and can reinfect new roots (Howard et al., 1994).

The impact ratings for the majority of ginseng pest management tools on natural enemies of pests are unknown; however, those which are known are summarized here. Pest management tools are evaluated for acute and residual toxicity to parasitoids, predators and predator mites, and whether this toxicity would be lowered depending on timing of pesticide sprays, etc. *Bacillus subtilis* (Serenade) is rated low in toxicity for all categories. Diazinon is rated medium-high for acute toxicity to parasitoids/predator mites and for residual toxicity to predators; medium for acute toxicity to predators and for residual toxicity to parasitoids/predator mites. Imidacloprid (Admire, Impulse, Alias, Couraze, Provado) is rated medium-high for acute toxicity to predators; low-medium for acute toxicity to parasitoids; and low for acute toxicity to predator mites and residual toxicity to parasitoids/predators/predator mites. In-season oil (Glacial Spray Fluid) is rated low-medium for acute toxicity to predator mites; and low for acute toxicity to parasitoids/predators and residual toxicity to parasitoids/predators/predator mites. Pyrethrins (Bug Buster-O, PyGanic, Pyrellin, Pyrenone, Pyreth-It, Pyronyl) are rated medium-high for acute toxicity to parasitoids/predators; medium for acute toxicity to predator mites; low-

medium for residual toxicity to parasitoids; and low for residual toxicity to predators/predator mites. The cultural tool of removal of infested plant parts (for leafrollers) is rated low in toxicity for all categories. The impacts of these pest management tools (*Bacillus subtilis*, diazinon, imidacloprid, in-season oil, pyrethrins, and removal of infested plant parts) do not change depending on timing of sprays, etc.

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## OUTLINE OF PLAN

Following is an alphabetical pest by pest analysis of the current role of pesticides registered for use in ginseng production with emphasis on those classified as organophosphates, carbamates, and B2 carcinogens. Other pest management tools (chemical, cultural, etc.) that offer some control or are important in pest resistance management, but are not "stand alone" tools, are also discussed. In some instances, products that have been identified as effective through preliminary research, but are currently unavailable for use on ginseng, are discussed under the heading "pipeline pest management tools." Immediately following each pest analysis is a "to do" list for research, regulatory, and educational needs.

## INSECT PESTS and other invertebrates

### 1. APHIDS (Family Aphididae)

Aphids infest the berries and leaves and feed via sucking. They are an occasional problem later in the season, especially when gardens are located near an alfalfa field. Affects seed crops by causing damage to seed clusters. Not a problem in Michigan.

**Organophospate insecticides currently registered for aphids:**

- Diazinon (Diazinon 5WB [MI only], Diazinon AG500, Diazinon AG600 WBC): Efficacy – unknown.

**Carbamate insecticides currently registered for aphids:**

- None identified.

**Other insecticides currently registered for aphids:**

- Azadirachtin (Aza-Direct, Ecozin 3%EC [MI only], Neemix 4.5 [MI only]): Efficacy – potentially fair to poor, feeding repellent. Not tested on ginseng. Classified as a biopesticide. Not used by growers.
- *Beauveria bassiana* (Mycotrol O): Efficacy – unknown. Classified as a biopesticide.
- Deltamethrin (Battalion 0.2EC, Decis 0.2EC, Decis 1.5EC [WI only], Delta Gold): Efficacy – unknown.
- Imidacloprid (Admire 2F, Admire Pro Systemic Protectant, AgriStar Impulse 1.6FL [WI only], Alias 2F [WI only], Couraze 2F [WI only], Provado 1.6F): Efficacy – Good. Not tested on ginseng. Classified as an OP alternative.
- Petroleum oil (Glacial Spray Fluid): Efficacy – unknown.
- Pyrethrins (Bug Buster-O, PyGanic EC 1.4, Pyrellin E.C. [MI only], Pyrenone Crop Spray, Pyreth-It, Pyronyl Crop Spray): Efficacy – potentially good. Not tested on ginseng. Only foliar insecticide used.
- Thiamethoxam (Actara, Platinum): Efficacy – good.

**Other pest management aids for aphids:**

- Site selection: Do not plant near an alfalfa field.
- Scout and spot-treat infested area.

**Pipeline pest management tools for aphids:**

- Pymetrozine (Fulfill): Efficacy – good. New product. Oregon has a 24(c) label for ginseng grown for seed. Labeled for potato and other tuberous root and corm vegetables but not ginseng.

**"To do" list for aphids:**

**Research needs for aphids:**

- Conduct a survey to determine the species that affect ginseng.
- Test registered and unregistered products for efficacy and crop safety.

**Regulatory needs for aphids:**

- None identified.

**Educational needs for aphids:**

- Demonstration plots with commercial growers needed.
- Determine the population of aphids that can be tolerated without negatively impacting yield or quality.

## 2. CUTWORMS (Family Noctuidae) (Likely variegated cutworm, *Peridroma saucia*)

Cutworms are one of the top three insect problems affecting ginseng. Cutworms, the larvae of night-flying moths, feed on stems, girdling young plants and chewing ginseng tops. This insect is a particularly troubling pest in seedling beds. Problem in Wisconsin in spring.

**Organophospate insecticides currently registered for cutworms:**

- Diazinon (Diazinon 14G, Diazinon G-14 [MI only]): Efficacy – good to excellent. Granular formulation is effective only against variegated cutworm. Used widely by growers. Note only one year of protection is necessary. Won't be available at the end of 2008. Existing stocks may be sold or used until they are depleted.

**Carbamate insecticides currently registered for cutworms:**

- None identified.

**Other insecticides currently registered for cutworms:**

- Azadirachtin (Aza-Direct, Ecozin 3%EC [MI only], Neemix 4.5 [MI only]): Efficacy – potentially poor. Not tested on ginseng. Classified as a biopesticide.
- Cyfluthrin (Baythroid 2, Baythroid XL, Renounce 20WP [WI only]): Efficacy – unknown (N/A for soil cutworms).
- Deltamethrin (Admire PRO Systemic Protectant, AgriStar Impulse 1.6FL [WI only], Battalion 0.2EC, Decis 0.2EC, Decis 1.5EC [WI only], Couraze 2F [WI only], Provado 1.6F): Efficacy – unknown.
- Pyrethrins (Pyreth-It, Pyrenone Crop Spray, Pyronyl Crop Spray): Efficacy – unknown.

**Other pest management aids for cutworms:**

- Choose an uninfested site (following a cereal crop is recommended [i.e. oats, rye]).
- Till the site thoroughly.

**Pipeline pest management tools for cutworms:**

- Lambda-cyhalothrin (Warrior): Efficacy – unknown. Not tested on ginseng. Classified as an OP alternative. Not widely used by growers.

**"To do" list for cutworms:**

**Research needs for cutworms:**

- Determine which cutworm species are the primary pests.
- Test products that are registered and unregistered for efficacy and crop safety.
- Find effective products.
- Test insecticide baits.

**Regulatory needs for cutworms:**

- Retain the use of diazinon for ginseng production until cost effective and safe replacements are identified and registered.

**Educational needs for cutworms:**

- Provide educational programs to help growers identify which cutworms are affecting their ginseng so that appropriate control measures are used.

## 3. FOUR-LINED PLANT BUGS (*Poecilocapsus lineatus*)

Four-lined plant bugs cause economic damage on ginseng seedlings. Sharp mouth parts pierce the ginseng leaf and suck the leaf contents leaving the upper and lower epidermis. Fresh feeding spots (1-2 mm diameter) are initially dark colored, but quickly become white or tan and papery. Spots can coalesce if feeding is significant, which can prevent

photosynthesis. Not a significant problem in Wisconsin and Michigan. Possibly a problem associated with an alfalfa rotation. Problem if there is an outbreak.

**Organophospate insecticides currently registered for four-lined plant bugs:**

- None identified.

**Carbamate insecticides currently registered for four-lined plant bugs:**

- None identified.

**Other insecticides currently registered for four-lined plant bugs:**

- Azadirachtin (Aza-Direct, Ecozin 3%EC [MI only], Neemix 4.5 [MI only]): Efficacy – unknown. Not tested on ginseng. Classified as a biopesticide. Acts as a feeding repellent.
- *Beauveria bassiana* (Mycotrol O): Efficacy – unknown. Classified as a biopesticide.
- Deltamethrin (Battalion 0.2EC, Decis 0.2EC, Decis 1.5EC [WI only], Delta Gold): Efficacy – unknown.
- Diazinon (Diazinon AG500, Diazinon AG600 WBC, Diazinon 5WB [MI only]): Efficacy – unknown.
- Garlic juice extracts (Allityn, Garlic Barrier AG+): Efficacy – unknown.
- Pyrethrins (Bug Buster-O, PyGanic EC 1.4, Pyrellin E.C. [MI only], Pyreth-It, Pyrenone Crop Spray, Pyronyl Crop Spray): Efficacy – good.

**Other pest management aids for four-lined plant bugs:**

- None identified.

**Pipeline pest management tools for four-lined plant bugs:**

- None identified.

**"To do" list for four-lined plant bugs:**

**Research needs for four-lined plant bugs:**

- Conduct efficacy studies to determine which products are effective and ensure crop safety.

**Regulatory needs for four-lined plant bugs:**

- None identified.

**Educational needs for four-lined plant bugs:**

- Train growers how to scout for this pest.
- Provide educational programs to help growers identify the four-lined plant bug so it can be determined whether this is a broadly distributed pest.

### 4. LEAF ROLLERS (*Archips purpurana*)

Can be a problem in Michigan's production of ginseng in woodlots, although it is not a problem in Wisconsin. The larva folds a leaf around itself by partially chewing the petiole to allow the leaf to droop and become easier to manipulate. The larva will feed on ginseng during the day and seek shelter in the rolled leaf at night.

**Organophospate insecticides currently registered for leaf rollers:**

- None identified.

**Carbamate insecticides currently registered for leaf rollers:**

- None identified.

**Other insecticides currently registered for leaf rollers:**

- Azadirachtin (Aza-Direct, Ecozin 3%EC [MI only], Neemix 4.5 [MI only]): Efficacy – potentially poor. Not tested on ginseng. Classified as a biopesticide.
- Garlic juice extracts (Allityn, Garlic Barrier AG+): Efficacy – unknown.
- Pyrethrins (Bug Buster-O, PyGanic EC 1.4, Pyreth-It, Pyrenone Crop Spray, Pyronyl Crop Spray): Efficacy – good.

**Other pest management aids for leaf rollers:**

- Manually remove affected leaf.
- Scout and spot treat as needed.

**Pipeline pest management tools for leaf rollers:**

- None identified.

**"To do" list for leaf rollers:**

**Research needs for leaf rollers:**

- Conduct a survey to determine which species are common problems.

**Regulatory needs for leaf rollers:**

- None identified.

**Educational needs for leaf rollers:**

- Help growers identify the species causing the infestation.
- Provide specific education on the use and efficacy of registered products.

## 5. MILLIPEDES (Class Diplopoda)

Commonly observed in ginseng gardens. Typically considered to be innocuous feeders of composting vegetation. Since higher populations are observed in areas where plants are suffering from root rot, growers sometimes associate their presence with problems such as root feeding. Problem in Wisconsin, especially on seed.

**Organophospate insecticides currently registered for millipedes:**

- None identified.

**Carbamate insecticides currently registered for millipedes:**

- None identified.

**Other insecticides currently registered for millipedes:**

- Non identified.

**Other pest management aids for millipedes:**

- Pyrethrins (PyGanic, Pyrenone Crop Spray): Efficacy – unknown.

**Pipeline pest management tools for millipedes:**

- Chlorpyrifos (Dursban, Empire, Lorsban): Efficacy – unknown.
- Diazinon (Diazinon AG500, Diazinon AG600 WBC, Diazinon 5WB [MI only]): Efficacy – unknown. Not labeled for use on millipedes.

**"To do" list for millipedes:**

**Research needs for millipedes:**

- Look at home use products for control: chlorpyrifos (Dursban).
- Ethoprop (Mocap).

**Regulatory needs for millipedes:**

- Seed treatments – thiamethoxam (Cruiser).

**Educational needs for millipedes:**

- Describe the feeding pattern to growers to help them determine when conditions may allow millipedes to cause damage.

## 6. SLUGS (Order Anaspidea)

Considered to be one of the top insect problems. Ragged holes in the leaves and mucus trails are the characteristic symptoms of slug feeding. Most slug feeding occurs at night.

**Organophospate insecticides currently registered for slugs:**

- None identified.

**Carbamate insecticides currently registered for slugs:**

- None identified.

**Other insecticides currently registered for slugs:**

- Garlic juice extracts (Allityn, Garlic Barrier AG+): Efficacy – unknown. Tends to be difficult to apply.
- Metaldehyde (Deadline various products, Durham Metaldehyde Granules 7.5, No Escape Slug & Snail Killer [MI only], OR-CAL Slug & Snail Bait, Slug-fest All Weather Formula [MI only], Slug-It Concentrate, different sizes, Trails End 3.5 and LG [MI only]): Efficacy – good. Widely used by growers and applied monthly during the growing season.

**Other pest management aids for slugs:**

- Sawdust mulch, delay shading the garden until it is dry, till/sawdust surrounding area mulch. Eliminate shady, damp areas; clean cultivation and removal of sheltering sites along hedgerows/fences; do not plant in low, flat, wet or recently plowed ground that has been left idle for several years. Beer is an attractant and can be used to monitor populations (Brown, 2001).
- Diatomaceous earth is fossilized diatoms (which contain silica) that are ground into microscopic sharp particles that penetrate insect cuticles and slug epidermis causing dehydration and death, but are harmless to animals and humans. Needs to be reapplied after rain.
- Remove weeds around gardens to reduce favorable slug habitat.

**Pipeline pest management tools for slugs:**

- None identified.

**"To do" list for slugs:**

**Research needs for slugs:**

- Identify and test potentially effective products. In particular, explore those products that have a granular formulation.
- Look at buffer zones.

**Regulatory needs for slugs:**

- Another form of metaldehyde (Trails End LG) is desired for more uniform dispersal and enhanced efficacy.
- Rapid registration of additional products that are shown to be effective and safe on ginseng.

**Educational needs for slugs:**

- None identified.

## 7. SPITTLE BUGS (Family Cercopidae)

Can be an occasional problem in Michigan ginseng production in woodlots, less of a problem in Wisconsin. Destroys the flower head and damages the seed.

**Organophospate insecticides currently registered for spittle bugs:**

- None identified.

**Carbamate insecticides currently registered for spittle bugs:**

- None identified.

**Other insecticides currently registered for spittle bugs:**

- Azadirachtin (Aza-Direct, Ecozin 3%EC [MI only], Neemix 4.5 [MI only]): Efficacy – unknown. Not tested on ginseng. Classified as a biopesticide. Acts as a feeding repellent.
- *Beauveria bassiana* (Mycotrol O): Efficacy – unknown. Classified as a biopesticide.
- Deltamethrin (Battalion 0.2EC, Decis 0.2EC, Decis 1.5EC [WI only], Delta Gold): Efficacy – unknown.
- Diazinon (Diazinon AG500, Diazinon AG600 WBC, Diazinon 5WB [MI only]): Efficacy – unknown.
- Garlic juice extracts (Allityn, Garlic Barrier AG+): Efficacy – unknown.
- Pyrethrins (Bug Buster-O, PyGanic EC 1.4, Pyrellin E.C. [MI only], Pyreth-It, Pyrenone Crop Spray, Pyronyl Crop Spray): Efficacy – unknown.

**Other pest management aids for spittle bugs:**

- Scouting coupled with spot treatment as needed.

**Pipeline pest management tools for spittle bugs:**

- None identified.

**"To do" list for spittle bugs:**

**Research needs for spittle bugs:**

- Determine the economic impact of an infestation.
- Determine the population level that triggers a treatment.

**Regulatory needs for spittle bugs:**

- None identified.

**Educational needs for spittle bugs:**

- None identified.

## 8. THRIPS (Order Thysanoptera)

Growers are uncertain as to whether this insect is a major problem for the industry. There was a discussion that included the potential for thrips in the flowers and a possibility of thrips feeding injury providing an entry for *Botrytis* infection.

**Organophospate insecticides currently registered for thrips:**

- None identified.

**Carbamate insecticides currently registered for thrips:**

- None identified.

**Other insecticides currently registered for thrips:**

- Azadirachtin (Aza-Direct, Ecozin 3%EC [MI only], Neemix 4.5 [MI only]): Efficacy – unknown. Classified as a biopesticide.
- *Beauveria bassiana* (Mycotrol O): Efficacy – unknown. Classified as a biopesticide.
- Garlic juice extracts (Allityn, Garlic Barrier AG+): Efficacy – unknown. Classified as a biopesticide.

- Petroleum oil (Glacial Spray Fluid): Efficacy – unknown.
- Pyrethrins (Bug Buster-O, PyGanic EC 1.4, Pyrellin E.C. [MI only], Pyreth-It, Pyrenone Crop Spray, Pyronyl Crop Spray): Efficacy – unknown.
- Spinosad (Entrust Naturalyte Insect Control [WI only], SpinTor 2SC): Efficacy – unknown.

**Other pest management aids for thrips:**

- None identified.

**Pipeline pest management tools for thrips:**

- None identified.

**"To do" list for thrips:**

**Research needs for thrips:**

- Determine the potential for thrips to be a significant problem or vector of disease.
- Conduct a survey to determine which thrip species are potential threats to ginseng.

**Regulatory needs for thrips:**

- None identified.

**Educational needs for thrips:**

- Help growers learn where to look for thrips and identify them.

## 9. WHITE GRUBS (Family Scarabidae)

Grubs feed on the root, resulting in a "hollowing out" of the root. They have a long life cycle, and are a common problem in Michigan and Wisconsin.

**Organophospate insecticides currently registered for white grubs:**

- Diazinon (Diazinon 14G, Diazinon G-14 [MI only]): Efficacy – good. Used widely by growers. Note only one year of protection is necessary. Won't be available at the end of 2008. Existing stocks may be sold or used until they are depleted.

**Carbamate insecticides currently registered for white grubs:**

- None identified.

**Other insecticides currently registered for white grubs:**

- None identified.

**Other pest management aids for white grubs:**

- Imidacloprid (Admire, Provado): Efficacy – unknown. Labeled to control aphids, fleabeetles, leafhoppers and whiteflies in ginseng only (not white grubs).

**Pipeline pest management tools for white grubs:**

- None identified.

**"To do" list for white grubs:**

**Research needs for white grubs:**

- Determine which white grub species are the primary pests.
- Determine whether trap crops or rotational practices can reduce white grub pressure and damage.
- Test products that are registered and new, unregistered products for efficacy, including entomopathic nematodes.
- Pest identification tools.

**Regulatory needs for white grubs:**

- Retain the use of diazinon for ginseng production until cost effective and safe replacements are identified and registered.

**Educational needs for white grubs:**

- As new cultural and chemical tools are identified, instruct growers on their uses as they become available.

## 10. WIREWORMS (Family Elateridae)

Wireworms feed on roots and ungerminated or newly germinated seeds, especially of cereal crops. Big issue for Wisconsin

**B2 carcinogenic insecticides currently registered for wireworms:**

- 1,3-Dichloropropene (Telone II, EC [MI only]): Efficacy – potentially good. Not tested on ginseng. Classified as a partial methyl bromide alternative. Expensive.
- 1,3-Dichloropropene/chloropicrin (Telone C-17, C-35): Efficacy – potentially good. Not tested on ginseng. Classified as a partial methyl bromide alternative by IR-4. Expensive.

**Organophospate insecticides currently registered for wireworms:**

- Diazinon (Diazinon 14G, Diazinon G-14 [MI only]): Efficacy – good. Used widely by growers. Note only one year of protection is necessary. Won't be available at the end of 2008. Existing stocks may be sold or used until they are depleted.

**Carbamate insecticides currently registered for wireworms:**

- None identified.

**Other insecticides currently registered for wireworms:**

- Garlic juice extracts (Garlic Barrier AG+): Efficacy – unknown.

**Other pest management aids for wireworms:**

- Cover crops may be helpful, although cereal crops should be avoided since they are preferred for feeding.
- Scouting (use corn or oats to bait).
- Choose sites that have not recently hosted cereal crops.
- Imidacloprid (Admire, Provado): Efficacy – unknown. Labeled to control aphids, fleabeetles, leafhoppers and whiteflies in ginseng (not wireworms).

**Pipeline pest management tools for wireworms:**

- None identified.

**"To do" list for wireworms:**

**Research needs for wireworms:**

- Survey and sample ginseng gardens to assess the level of infestation.
- Determine the level of damage caused by this pest.
- Determine whether fumigation is cost effective.

**Regulatory needs for wireworms:**

- None identified.

**Educational needs for wireworms:**

- None identified.

# FUNGAL PATHOGENS

## 1. ALTERNARIA BLIGHT (*Alternaria panax*)

Above-ground symptoms include lesions with yellow-green haloes, dark brown margins and pale brown centers. Brown lesions often develop just above the soil line and girdle the stem. Alternaria blight is a common and yearly problem. This *Alternaria* species is especially aggressive and can cause total plant death within three weeks if left untreated. Weather conditions drive the severity of the disease. Frequent rainfall and high humidity are especially favorable for Alternaria blight, and necessitate frequent fungicide applications. Serious problem yearly in Michigan and Wisconsin.

**B2 carcinogenic fungicides currently registered for Alternaria blight:**

- Captan (Captan 50W): Efficacy – fair. Classified as a B2 carcinogen. Registered for *Botrytis*, *Cylindrocarpon*, *Phytophthora*, *Pythium*, *Rhizoctonia*. Available for non-food use only. Label does not include *Alternaria*.
- Iprodione (Iprodione 50WP AG, 4L AG, Rovral 4FL, 75WG): Efficacy – fair. Classified as a B2 carcinogen. Documented pathogen resistance makes this a risky product to use. When used, it should be alternated with products that have a different mode of action. Used with great caution due to resistance issues. Used heavily in 1980s-90s. Used in tank mix.

**Other fungicides currently registered for Alternaria blight:**

- Aluminum tris (Aliette WDG): Efficacy – poor. Often used with other products. Most often used for *Phytophthora* in Wisconsin. In Michigan it is used in rotation. Used to control oomycetes.
- Azoxystrobin (Quadris F, Amistar 50WG): Efficacy – good to excellent. Classified as a reduced-risk fungicide. Widely used. Development of pathogen resistance is a significant concern. To delay the development of resistance, this fungicide needs to be used in alternation with a fungicide with a different mode of action. Resistance concerns for *A. panax*.
- *Bacillus subtilis* (Serenade ASO, Serenade Max WP): Efficacy – poor. Classified as a biopesticide. Not typically used by growers.
- Boscalid (Endura): Efficacy – excellent. Classified as a reduced-risk fungicide. Expand studies regarding its efficacy and overall crop safety. Initial field tests look promising. Needs to be used in a program with a rotational partner to delay the development of resistance.
- Copper ammonium complex (Copper Count-N, Liqui-Cop Copper Fungicidal Garden Spray): Efficacy – fair to good. Phytotoxicity can be a problem. Tank mixes with Aliette are a concern.
- Copper hydroxide (AgriStar Nu-Cop 3L, AgriStar Nu-Cop 50WP, Champ Dry Prill, Champ Formula 2, Champion WP, Kocide 101, Kocide 2000 54DF, Kocide 3000 46DF, Kocide 4.5FL, Kocide DF): Efficacy – fair to poor. May be tank mixed with other fungicides or used alone. May help limit disease, but will be overwhelmed when disease pressure is significant. Frequent use of copper is of significant concern to ginseng growers because of potential phytotoxicity. Used in early season when disease pressure is not as high.

- Copper salt of octanoic acid (Soap-Shield Flowable Liquid Copper Fungicide): Efficacy – fair to poor. Used in early season when disease pressure is not as high. Limited efficacy on significant disease pressure.
- Copper sulfate (Cuprofix Ultra 40D Disperss): Efficacy – fair. Used in early season when disease pressure is not as high.
- Hydrogen dioxide (OxiDate): Efficacy – potentially poor. Not tested on ginseng. Classified as a biopesticide. Not used by growers.
- Neem oil (Trilogy): Efficacy – potentially poor. Not tested on ginseng. Classified as a biopesticide. Not typically used by growers.
- Polyoxin D zinc salt (Endorse 2.5WP): Efficacy – good to fair. Classified as a biopesticide. Endorse has the potential to serve as a rotational product for the strobilurins. Available for non-food use only.
- Pyraclostrobin (Cabrio 20EG): Efficacy – good to excellent. Widely used. Classified as a reduced-risk fungicide. Development of pathogen resistance is a significant concern. To delay the development of resistance, this fungicide needs to be used in alternation with a fungicide with a different mode of action. Growers rotate this product with Bravo.
- Trifloxystrobin (Flint 50WG): Efficacy – good to excellent. Classified as a reduced-risk fungicide. Development of pathogen resistance is a significant concern. To delay the development of resistance, this fungicide needs to be used in alternation with a fungicide with a different mode of action. Not used by growers.

**Other pest management aids for Alternaria blight:**

- Limit garden size to enhance air flow and movement to reduce the environmental conditions that favor disease development.
- Monitor the environment and treat preventively when environmental conditions favor disease development.
- Rotate crops to avoid pathogen buildup.
- Monitoring spores with traps. Environmental monitoring.

**Pipeline pest management tools for Alternaria blight:**

- Boscalid/pyraclostrobin (Pristine 38WG): Efficacy – good to excellent.
- Chlorothalonil (Bravo Weatherstik): Efficacy – good to excellent. Classified as a B2 carcinogen. Available through a Specific Exemption to Section 18 of FIFRA for use on *Botrytis* in Michigan and Wisconsin for 2007. Considered a priority for registration through IR-4.
- Fluazinam (Omega 500F): Efficacy – good to fair. Considered a priority for registration through IR-4. Classified as a reduced-risk fungicide. Waiting for EPA (est. 2008).
- Fludioxonil (Cannonball 50WP): Efficacy – good to fair. Considered a priority for registration through IR-4. Classified as a reduced-risk fungicide.
- Fludioxonil/cyprodinil (Switch 62.5WG): Efficacy – fair.
- Mancozeb (Dithane): Efficacy – good to fair. Classified as a B2 carcinogen. Available through a Specific Exemption to Section 18 of FIFRA for use on *Alternaria* in Michigan and Wisconsin for 2007. Label pending with EPA. Used in Michigan and Wisconsin.

- Pyrimethanil (Scala SC): Efficacy – good to excellent. Considered a priority for registration through IR-4. Classified as a reduced-risk fungicide.

**"To do" list for Alternaria blight:**

**Research needs for Alternaria blight:**

- Develop a forecasting model to characterize the environmental conditions that favor disease progression, and time sprays accordingly.
- Research efficacy of fungicide cyprodinil/fludioxonil (Switch 62.5WDG).
- Survey of *Alternaria* species.

**Regulatory needs for Alternaria blight:**

- Speed the registration of protectant products for use in alternation with the strobilurins. Broad spectrum products such as chlorothalonil (Bravo) and mancozeb (Dithane) are both needed as cornerstone products for foliar blight control. This is a top priority among ginseng growers.
- Chlorothalonil (Bravo): Speed registration for use as a rotational product with the strobilurin fungicides (azoxystrobin, pyraclostrobin, trifloxystrobin). Currently available as a Specific Exemption to Section 18 of FIFRA for use on *Alternaria* in Michigan and Wisconsin for 2007.
- Mancozeb (Dithane): Speed registration to reduce the yearly uncertainty regarding the use of this product. This product is needed as a rotational product with the strobilurin fungicides (azoxystrobin, pyraclostrobin, trifloxystrobin). Currently available as a Specific Exemption to Section 18 of FIFRA for use on *Alternaria* in Michigan and Wisconsin for 2007.
- Pyraclostrobin/boscalid (Pristine): Classified as a reduced-risk fungicide. Expand studies regarding its efficacy and overall crop safety. Initial field tests look promising. Needs to be used in a program with a rotational partner to delay the development of resistance.

**Educational needs for Alternaria blight:**

- As disease forecasting systems or other management tools are developed, provide workshops and demonstration plots.
- Emphasize the importance of alternating fungicides in a program, especially when using azoxystrobin, pyraclostrobin or trifloxystrobin.
- Develop web site with disease identification assistance.

## 2. BOTRYTIS BLIGHT (*Botrytis cinerea*)

The pathogen affects the leaves, flowers, and fruit, leading to defoliation of plants and poor seed set. When conditions are favorable, plant death occurs. Symptoms include rapidly enlarging, water-soaked lesions, often starting at the leaf tip and spreading back along the midrib. The fungus often sporulates on the diseased tissue, producing a fuzzy gray mold. This disease is a particularly severe problem in plantings older than 2 years. Big concern for growers.

**B2 carcinogenic fungicides currently registered for Botrytis blight:**

- Captan (Captan 50W): Efficacy – good to fair. Available for non-food use only.
- Iprodione (Iprodione, Rovral): Efficacy – fair to poor. Documented pathogen resistance makes this a risky product to use. When used, it should be alternated with products that have a different mode of action. This product is labeled for use on ginseng; however, it is not labeled for control of *Botrytis.*

**Other fungicides currently registered for Botrytis blight:**

- Azoxystrobin (Quadris F, Amistar 50WG): Efficacy – fair. Classified as a reduced-risk fungicide. Label does not include *Botrytis*. Must be used in alternation with fungicides of varying modes of action to delay resistance. Must be used in alternation with a highly effective *Botrytis*-controlling fungicide.
- Boscalid (Endura): Efficacy – good. Classified as a reduced-risk fungicide. Needs to be used in a program with a rotational partner to delay the development of resistance.
- Fenhexamid (Elevate 50WDG): Efficacy – good. Classified as a reduced-risk pesticide. Must be used preventively and frequently when weather conditions favor disease. Should be used in alternation with other products to delay pathogen resistance. Only four applications are allowed per season. This product is not readily available to growers because local suppliers do not carry it in stock, as it is not used on other crops in the region.
- *Bacillus subtilis* (Serenade ASO, Serenade Max WP): Efficacy – poor. Classified as a biopesticide. Not used by growers.
- Chitosan (Elexa 4): Efficacy – unknown. Classified as a biopesticide. Not typically used by growers.
- Copper salt of octanoic acid (Soap-Shield Flowable Liquid Copper Fungicide): Efficacy – fair (Michigan). Not used in Wisconsin.
- Copper hydroxide (Kocide 2000): Efficacy – fair. Label does not include *Botrytis*. Not used for *Botrytis* control.
- Neem oil (Trilogy): Efficacy – poor. Classified as a biopesticide.
- Polyoxin D zinc salt (Endorse 2.5WP): Efficacy – good. Classified as a biopesticide. Can serve as a rotational product for the strobilurins (azoxystrobin, pyraclostrobin, trifloxystrobin) and other fungicides with potential resistance concerns. Available for non-food use only.
- Pyraclostrobin (Cabrio): Efficacy – fair. Classified as a reduced-risk fungicide. Label does not include *Botrytis*.
- Trifloxystrobin (Flint 50WG): Efficacy – fair. Classified as a reduced-risk fungicide. Label does not include *Botrytis*.

**Other pest management aids for Botrytis blight:**

- Growers currently limit garden size to enhance air flow and movement to reduce the environmental conditions that favor disease development.
- Scout and time the initiation of fungicide sprays to the occurrence of first disease symptoms.
- Apply fungicide sprays preventively when weather favors disease. Frequent rainfall, high humidity and an extended duration of leaf wetness exacerbate disease.
- Rotate crops to avoid pathogen buildup.

**Pipeline pest management tools for Botrytis blight:**

- Boscalid/pyraclostrobin (Pristine): Efficacy – good. Classified as a reduced-risk fungicide. Needs to be used in a program with a rotational partner to delay the development of resistance.
- Chlorothalonil (Bravo Weather Stik SC): Efficacy – good to excellent. Classified as a B2 carcinogen. Available through a Specific Exemption to Section 18 of FIFRA

for use on *Botrytis* in Michigan and Wisconsin for 2007. Must be applied preventively and frequently when weather favors disease. A maximum of six applications is allowed. Growers used this product widely in 2004 through a crisis exemption label issued by the state departments in Michigan and Wisconsin. Considered a priority for registration through IR-4.

- Fluazinam (Omega): Efficacy – good. Classified as a reduced-risk pesticide. Registration is pending through completion of an IR-4 project.
- Fludioxonil (Cannonball 70WP): Efficacy – fair. Classified as a reduced-risk fungicide. Considered a priority for registration through IR-4.
- Fludioxonil/cyprodinil (Switch 62.5WG): Efficacy – fair.
- Mancozeb (Dithane): Efficacy – fair. Classified as a B2 carcinogen. Available through a Specific Exemption to Section 18 of FIFRA for use on *Alternaria* in Michigan and Wisconsin for 2007. Label does not list *Botrytis*. Waiting for EPA to make a decision on registration. Most often used for *Alternaria* control.
- Pyrimethanil (Scala SC): Efficacy – good. Classified as a reduced-risk fungicide. Considered a priority for registration through IR-4.
- Thiophanate-methyl (Topsin M WSB): Efficacy – good. Classified as a B2 carcinogen. Available as a Special Local Needs Label under Section 24(c) of FIFRA for use on *Cylindrocarpon*, *Rhizoctonia*, and *Sclerotinia* in Michigan and Wisconsin for 2007. Pest resistance is a significant concern. Must be used in rotation with fungicides of varying modes of action to delay the development of resistance. Considered a priority for registration through IR-4.

**"To do" list for Botrytis blight:**

**Research needs for Botrytis blight:**

- Boscalid/pyraclostrobin (Pristine): expand studies regarding its efficacy and overall crop safety. Initial field tests look promising
- Develop a forecasting model to characterize the environmental conditions necessary for disease progression, and time sprays accordingly.
- Test efficacy of new products not registered for ginseng.

**Regulatory needs for Botrytis blight:**

- Chlorothalonil (Bravo): Speed registration for use against *Botrytis* as a rotational product with other fungicides. Currently, no effective product is labeled for use during the harvest year. Registration is pending through completion of an IR-4 project. This product should be the cornerstone of a foliar blight management program with access to 8 or more applications.
- Products that allow several applications are needed to maintain protection throughout the growing season (May into October).

**Educational needs for Botrytis blight:**

- Assist growers (website) in correctly distinguishing Botrytis blight from Alternaria blight.
- As forecasting systems and other management strategies are developed, provide training workshops and establish demonstration plots.

### 3. DAMPING-OFF (*Cylindrocarpon destructans*, *Fusarium* spp., *Pythium* spp., *Rhizoctonia solani*)

Root damage may be extensive in seedling and first-year ginseng gardens. Widespread damping-off leads to a significant reduction in plant stands. The pathogens causing this disease are often not identified and therefore have not been well studied. This occurs, in part, because the seedling is so small when infected that the tissue decays rapidly, making it difficult to isolate the pathogen. This disease is a major problem for growers.

**B2 carcinogenic fungicides currently registered for damping-off:**

- 1,3-Dichloropropene (Telone II, EC [MI only]): Efficacy – potentially good. Not tested on ginseng. Classified as a partial methyl bromide alternative.
- 1,3-Dichloropropene/chloropicrin (Telone C-17, C-35): Efficacy – potentially good. Not tested on ginseng. Classified as a partial methyl bromide alternative.
- Captan (Captan 50W): Efficacy – goodon *Pythium* and *Cylindrocarpon*. Effective against *Phytophthora* and appears to suppress *Rhizoctonia*. Available for non-food use only. Registered for *Cylindrocarpon*, *Pythium*, *Rhizoctonia*. Need efficacy data for *Fusarium*.
- Dazomet (Basamid Granular Soil Fumigant): Efficacy – fair.

**Other fungicides currently registered for damping-off:**

- Aluminum tris (Aliette WDG): Efficacy – poor. Often used with other products. Most often used for *Phytophthora* in Wisconsin. In Michigan it is used in rotation. Used to control oomycetes.
- Azoxystrobin (Quadris F, Amistar): Efficacy – good on *Cylindrocarpon*. Not tested for damping-off on ginseng. Classified as a reduced-risk pesticide. Registered for *Rhizoctonia*, *Pythium*. May have limited activity, but efficacy data are not available.
- Copper hydroxide (Kocide 2000): Efficacy – fair.
- Fenamidone (Reason 500SC): Efficacy – good. Considered a priority for registration through IR-4. Classified as a reduced-risk fungicide.
- Fludioxonil (Maxim 4FS): Efficacy – unknown. Not tested for damping-off on ginseng. Classified as a reduced-risk pesticide. May suppress *Rhizoctonia* and *Fusarium*. Applied as a seed treatment.
- *Gliocladium virens* (SoilGard 12G): Efficacy – poor.
- Mancozeb/zoxamide (Gavel): Efficacy – good to fair. Classified as a B2 carcinogen. Available through a Specific Exemption to Section 18 of FIFRA for use on *Phytophthora* in Michigan and Wisconsin for 2007. Considered a priority for registration through IR-4.
- Mefenoxam (Ridomil Gold EC, GR, SL): Efficacy – good. Pathogen resistance has been documented and is prevalent in Wisconsin. Classified as a reduced-risk pesticide.
- Metam sodium (Metam sodium, Sectagon 42, Vapam HL): Efficacy – good. Registered for *Rhizoctonia* and *Pythium*. Classified as a carbamate.
- Neem oil (Trilogy): Efficacy – unknown. Classified as a biopesticide.
- Phosphorous acid salts (Agrisolutions Topaz, Fosphite, Phostrol): Efficacy – fair. Classified as a biopesticide.

- Polyoxin D zinc salt (Endorse 2.5WP): Efficacy – excellent for *Rhizoctonia*, poor for *Fusarium*, no control of *Pythium*. Classified as a biopesticide. Registered for *Cylindrocarpon*, *Rhizoctonia*. Available for non-food use only.

**Other pest management aids for damping-off:**

- Select well-drained sites for garden establishment.
- Rotate crops to avoid pathogen buildup.

**Pipeline pest management tools for damping-off:**

- Cyazofamid (Ranman 400SC): Efficacy – fair on *Pythium*.
- Etridiazole (Terramaster): Efficacy – good on *Pythium*.
- Fluazinam (Omega): Efficacy – good for *Rhizoctonia*. Classified as a reduced-risk pesticide. May suppress *Fusarium*. Registration is pending through completion of an IR-4 project.
- Fludioxonil (Cannonball 50WP): Efficacy – good to fair. Classified as a reduced-risk fungicide. Considered a priority for registration through IR-4.
- Thiophanate-methyl (Topsin M WSB): Efficacy – poor for *Rhizoctonia*, good on *Cylindrocarpon*. Classified as a B2 carcinogen. Available as a Special Local Needs Label under Section 24(c) of FIFRA for use on *Cylindrocarpon*, *Rhizoctonia*, and *Sclerotinia* in Michigan and Wisconsin for 2007. Pest resistance is a significant concern. Must be used in rotation with fungicides of varying modes of action to delay the development of resistance. Considered a priority for registration through IR-4.

**"To do" list for damping-off:**

**Research needs for damping-off:**

- Identification of the primary pathogen(s) associated with damping-off.
- Flutolanil (Moncut): Effective against *Rhizoctonia*. Data needed for *Fusarium* and other damping-off pathogens.
- Iprodione (Iprodione, Rovral): Data needed on effectiveness when sprayed on seedlings following emergence. Classified as a B2 carcinogen. May suppress *Rhizoctonia*.
- Determine which products can be used effectively as seed treatments and are safe for emerging seedlings.
- Determine the compatibility of biological agents used as seed treatments with chemical fungicides.

**Regulatory needs for damping-off:**

- Speed registration of effective products using crop groupings whenever possible.
- Obtain new products through a non-food use label whenever possible to expedite their availability.

**Educational needs for damping-off:**

- Emphasize the importance of diagnostics as a tool in identifying and managing damping-off.
- Explain the connection between seed quality, seed processing, and damping-off pathogens.

## 4. DISAPPEARING ROOT ROT (*Cylindrocarpon destructans*)

This is a major pathogen of cultivated ginseng and occurs yearly. The pathogen infects only the roots. Diseased plants often fail to emerge in the spring. Small, discolored, gold to brown areas appear on the root surface in the early stages of infection. The root develops a dark brown discoloration at the infection site during the more advanced stages of the disease. This pathogen is responsible for widespread, devastating plant losses. This pathogen is emerging as a leading cause of root rot.

**B2 carcinogenic fungicides currently registered for disappearing root rot:**

- 1,3-Dichloropropene/chloropicrin (Telone C-17, C-35): Efficacy – unknown. Not tested on ginseng. Classified as a partial methyl bromide alternative. Not used or easily available. Chemical is expensive. Not available for Class A soils.
- Captan (Captan 50W): Efficacy – good. Available for non-food use only.
- Dazomet (Basamid Granular Soil Fumigant): Efficacy – fair.

**Other fungicides currently registered for disappearing root rot:**

- Azoxystrobin (Quadris 2.08SC, Amistar 50WG): Efficacy – good. Classified as a reduced-risk fungicide. Considered a priority for registration through IR-4. Labeled for use on ginseng, however, *Cylindrocarpon* is not on the label. Possible use as a seed treatment.
- Boscalid (Endura 70WG): Efficacy – good. Classified as a reduced-risk fungicide. Labeled for use on ginseng however, *Cylindrocarpon* is not on the label.
- Metam sodium (Metam Sodium, Sectagon 42, Vapam HL (used by growers in Wisconsin): Efficacy – good.
- Polyoxin D zinc salt (Endorse 2.5WP): Efficacy – poor. Classified as a biopesticide. Available for non-food use only.
- Pyraclostrobin (Cabrio EG): Efficacy – poor. Classified as a reduced-risk fungicide. Labeled for use on ginseng, but does not list *C. destructans*.
- *Gliocladium virens* (SoilGard 12G): Efficacy – poor.

**Other pest management aids for disappearing root rot:**

- Rotate crops to avoid pathogen buildup.

**Pipeline pest management tools for disappearing root rot:**

- Fludioxonil (Cannonball 50WP): Efficacy – good. Classified as a reduced-risk fungicide. Considered a priority for registration through IR-4.
- Thiophanate-methyl (Topsin M WSB): Efficacy – good. Classified as a B2 carcinogen. Available as a Special Local Needs Label under Section 24(c) of FIFRA for use on *Cylindrocarpon*, *Rhizoctonia*, and *Sclerotinia* in Michigan and Wisconsin for 2007. Pest resistance is a significant concern. Must be used in rotation with fungicides of varying modes of action to delay the development of resistance. Considered a priority for registration through IR-4.

**"To do" list for disappearing root rot:**

**Research needs for disappearing root rot:**

- Research the epidemiology of the pathogen to better develop effective management strategies.
- Increase research on this pathogen.
- Test registered and unregistered products for efficacy.

- Determine efficient and effective methods of applying fungicides to the root zone.
- Determine whether this pathogen is endemic or introduced.
- Do not use straw grown on ground previously planted with ginseng to mulch new beds, due to potential for pathogen spread.
- Investigate different types of mulches and determine whether they impact disease development.

**Regulatory needs for disappearing root rot:**

- Obtain a non-food use of fludioxonil (Cannonball 50WP) as soon as possible and pursue a food use label through IR-4. This is a top priority among ginseng growers.
- Speed registration of products determined to be effective against this pathogen.
- Several fungicides are needed to ensure protection throughout the growing season.
- Continue Section 18s for disease control.

**Educational needs for disappearing root rot:**

- Work closely with growers to implement new management tools as soon as they are developed.
- Utilize demonstration plots with grower cooperators to highlight effective products and management strategies.

## 5. PHYTOPHTHORA FOLIAR BLIGHT AND ROOT ROT (*Phytophthora cactorum*)

This disease is one of the most serious problems of ginseng. Both the roots and the foliage can become infected. Infection of the roots results in a light brown water-soaked lesion on the surface of the root that expands rapidly and completely destroys the root. If the leaflets become infected, the plant will collapse downward from the base of the petiole. This pathogen can be seedborne. Pathogen resistance to fungicides is a primary concern.

**B2 carcinogenic fungicides currently registered for Phytophthora foliar blight and root rot:**

- 1,3-Dichloropropene/chloropicrin (Telone C-17, C-35): Efficacy – unknown. Not tested on ginseng. Classified as a partial methyl bromide alternative.
- Captan (Captan 50W): Efficacy – good. Available for non-food use only.
- Dazomet (Basamid Granular Soil Fumigant): Efficacy – fair.

**Other fungicides currently registered for Phytophthora foliar blight and root rot:**

- Aluminum tris (Aliette WDG): Efficacy – fair. Specific to oomycetes and does not have broad-spectrum activity. Should be alternated with products with a different mode of action.
- Copper hydroxide (Kocide 2000): Efficacy – fair. Not labeled for *Phytophthora*. Considered a priority for registration through IR-4.
- *Gliocladium virens* (SoilGard 12G): Efficacy – poor.
- Mefenoxam (Ridomil Gold EC, GR, SL): Efficacy – good. Pathogen resistance has been documented and is prevalent in Wisconsin. Classified as a reduced-risk pesticide.

- Metam sodium (Metam Sodium, Sectagon 42, Vapam HL [used by growers in Wisconsin]): Efficacy – good. Should be applied at lower temperatures.
- Neem oil (Trilogy): Efficacy – poor. Classified as a biopesticide. Not used.
- Phosphorous acid salts (Agri-Fos, Agrisolutions Topaz, Fosphite, Helena ProPhyt, Phostrol): Efficacy – fair. Classified as a biopesticide. Specific to oomycetes and does not have broad-spectrum activity.

**Other pest management aids for Phytophthora foliar blight and root rot:**

- Utilize only clean, treated, disease-free seed.
- Site selection is important to ensure good drainage and ventilation.
- Clean equipment after working in an infested garden to limit spread among gardens.
- Do not plant in a site where ginseng was previously grown.
- Rotate crops to avoid pathogen buildup.

**Pipeline pest management tools for Phytophthora foliar blight and root rot:**

- Dimethomorph (Acrobat 50WP): Efficacy – good. Especially helpful for the foliar blight phase of this disease. Also effective against root rot when used as a drench. Registration is pending through completion of an IR-4 project.
- Fenamidone (Reason 500SC): Efficacy – good. Considered a priority for registration through IR-4. Classified as a reduced-risk fungicide.
- Mancozeb (Dithane 75DF): Efficacy – fair. Classified as a B2 carcinogen. Available through a Specific Exemption to Section 18 of FIFRA for use on *Alternaria* in Michigan and Wisconsin for 2007. Considered a priority for registration through IR-4.
- Mancozeb/zoxamide (Gavel): Efficacy – good. Classified as a B2 carcinogen. Especially helpful for the foliar blight phase of this disease. Also helpful in suppressing root rot when applied as a drench. Available through a Specific Exemption to Section 18 of FIFRA for use on *Phytophthora* in Michigan and Wisconsin for 2007. Considered a priority for registration through IR-4.
- Mandipropamid: Efficacy – good. Continued research needed.
- Mandipropamid/difenconazole: Efficacy – unknown. Data needed.

**"To do" list for Phytophthora foliar blight and root rot:**

**Research needs for Phytophthora foliar blight and root rot:**

- Test registered and unregistered products for efficacy.
- Seed treatment for *Phytophthora*.
- Determine the specific environmental conditions that favor Phytophthora foliar blight and root rot.
- Identify effective, efficient methods of applying fungicides to the root zone (i.e., drip application).
- Determine whether fumigants can be used as a disease management tool.
- Establish a seed testing and treatment program.

**Regulatory needs for Phytophthora foliar blight and root rot:**

- Pursue a food use label for Captan through IR-4. This is a top priority among ginseng growers.
- Speed registration of products as they are identified as effective and safe.
- Several fungicides are needed to alternate in a program for season-long control to reduce the risk of pathogen resistance.

- Products that allow several applications are needed to maintain protection throughout the growing season (May into October).

**Educational needs for Phytophthora foliar blight and root rot:**

- Emphasize the importance of correct and timely pathogen diagnosis to ensure appropriate fungicide selection.
- Instruct growers on good field sanitation to limit pathogen spread.
- Provide education regarding the development and management of pathogen resistance to fungicides.
- Distribute information regarding *Phytophthora* as a potential seed contaminant.
- Provide an in-depth workshop regarding the biology of the pathogen so control measures can be understood and better implemented.

## 6. POWDERY MILDEW (*Erysiphe* sp.)

Symptoms include powdery, white, superficial spots on the upper leaf surfaces. Infected tissue turns reddish purple. Leaves become yellow and may drop. Early and severe infection may reduce seed production, fresh weight and winter hardiness. Currently this disease is being managed through Botrytis and Alternaria blight management programs. Favored by cool temperatures in the spring and limited by warmer temperatures of July and August. Not currently an issue.

**B2 carcinogenic fungicides currently registered for powdery mildew:**

- None identified.

**Other fungicides currently registered for powdery mildew:**

- Azoxystrobin (Quadris F, Amistar 50WG): Efficacy – good. Classified as a reduced-risk fungicide. Widely used for control of Alternaria blight. Development of pathogen resistance is a significant concern. To delay the development of resistance, this fungicide needs to be used in alternation with a fungicide with a different mode of action.
- *Bacillus subtilis* (Serenade ASO, Max WP): Efficacy – unknown. Classified as a biopesticide.
- Boscalid (Endura): Efficacy – excellent. Classified as a reduced-risk fungicide. Needs to be used in a program with a rotational partner to delay the development of resistance.
- Chitosan (Elexa 4): Efficacy – unknown. Classified as a biopesticide.
- Copper salt of octanoic acid (Soap-Shield Flowable Liquid Copper Fungicide): Efficacy – unknown.
- Neem oil (Trilogy): Efficacy – potentially fair to poor. Not tested on ginseng. Classified as a biopesticide. Not used by growers.
- Pyraclostrobin (Cabrio 20EG): Efficacy – good. Widely used to control Alternaria blight. Classified as a reduced-risk fungicide. Development of pathogen resistance is a significant concern. To delay the development of resistance, this fungicide needs to be used in alternation with a fungicide with a different mode of action.
- Trifloxystrobin (Flint 50WG): Efficacy – unknown. Classified as a reduced-risk pesticide.

**Other pest management aids for powdery mildew:**

- Management programs currently in place for *Botrytis* and *Alternaria* management are highly effective for powdery mildew control.
- Growers currently limit garden size to enhance air flow and movement to reduce the environmental conditions that favor disease development.
- Scout and time initiation of spraying to first disease symptoms.
- Rotate crops to avoid pathogen buildup.

**Pipeline pest management tools for powdery mildew:**

- Chlorothalonil (Bravo): Efficacy – good to excellent. Classified as a B2 carcinogen. Also has good activity against Alternaria and Botrytis blights. Available through a Specific Exemption to Section 18 of FIFRA for use on *Botrytis* in Michigan and Wisconsin for 2007. Must be applied preventively and frequently when weather favors disease. A maximum of six applications is allowed. Registration is pending through completion of an IR-4 project.
- Fluazinam (Omega): Efficacy – good to excellent. Classified as a reduced-risk pesticide. Registration is pending through completion of an IR-4 project.
- Mancozeb (Dithane): Efficacy – good. Classified as a B2 carcinogen. Historically has been available through a Specific Exemption to Section 18 of FIFRA for *Alternaria*.
- Thiophanate-methyl (Topsin M WSB): Efficacy – good. Classified as a B2 carcinogen. Available as a Special Local Needs Label under Section 24(c) of FIFRA for use on *Cylindrocarpon*, *Rhizoctonia*, and *Sclerotinia* in Michigan and Wisconsin for 2007. Pest resistance is a significant concern. Must be used in rotation with fungicides of varying modes of action to delay the development of resistance. Considered a priority for registration through IR-4.

**"To do" list for powdery mildew:**

**Research needs for powdery mildew:**

- Investigate the epidemiology of this pathogen.

**Regulatory needs for powdery mildew:**

- Speed registration of broad spectrum fungicides such as chlorothalonil (Bravo) and mancozeb (Dithane).
- None identified as long as the products relied on for other foliar blights are maintained.

**Educational needs for powdery mildew:**

- Alert growers that without a solid foliar blight management program, powdery mildew could become a significant problem.

## 7. Rusty Root (*Cylindrocarpon destructans*, *Fusarium* spp., *Rhexocercosporidium panacis* sp. nov.)

This disease causes small reddish and brown lesions to develop on ginseng roots. Crowns of roots may also become infected. Major problem in Wisconsin and Michigan.

**B2 carcinogenic fungicides currently registered for rusty root:**

- 1,3-Dichloropropene/chloropicrin (Telone C-17, C-35): Efficacy – potentially good. Not tested on ginseng. Classified as a partial methyl bromide alternative by IR-4. Expensive.

- Captan (Captan 50W): Efficacy – good on *Cylindrocarpon*. Classified as a B2 carcinogen. Available for non-food use only. Registered for *Cylindrocarpon*.

**Other fungicides currently registered for rusty root:**

- Azoxystrobin (Quadris F, Amistar 50WG): Efficacy – good. Classified as a reduced-risk fungicide. Widely used for control of Alternaria blight. Development of pathogen resistance is a significant concern. To delay the development of resistance, this fungicide needs to be used in alternation with a fungicide with a different mode of action.

**Other pest management aids for rusty root:**

- None identified.

**Pipeline pest management tools for rusty root:**

- Fludioxonil (Cannonball 50WP): Efficacy – good on Cylindrocarpon. Classified as a reduced-risk fungicide. Considered a priority for registration through IR-4.
- Thiophanate-methyl (Topsin M WSB): Efficacy – Fair. Classified as a B2 carcinogen. Available as a Special Local Needs Label under Section 24(c) of FIFRA for use on *Cylindrocarpon*, *Rhizoctonia*, and *Sclerotinia* in Michigan and Wisconsin for 2007. Pest resistance is a significant concern. Must be used in rotation with fungicides of varying modes of action to delay the development of resistance. Considered a priority for registration through IR-4.

**"To do" list for rusty root:**

**Research needs for rusty root:**

- Determine effective fungicides (captan, thiophanate-methyl, fluazinam, fluidioxonil, etc.).
- Isolate and complete epidemiological studies.
- Determine economic losses due to this pathogen.

**Regulatory needs for rusty root:**

- Work with EPA on getting products labeled or Section 18s for this disease.

**Educational needs for rusty root:**

- Inform growers on disease and possible control methods.
- Develop web site with disease identification assistance.
- Work with EPA to teach about the potential loss associated with this pathogen.

## 8. SCLEROTINIA WHITE MOLD (*Sclerotinia sclerotiorum*)

This disease causes a stem and root rot of ginseng. Infected foliage wilts, becomes discolored, dried and shriveled. Black sclerotia often form on infected plant parts. The pathogen is a major problem in Michigan woodlots. Not a constant problem, but when present, can be devastating.

**B2 carcinogenic fungicides currently registered for Sclerotinia white mold:**

- 1,3-Dichloropropene/chloropicrin (Telone C-17, C-35): Efficacy – unknown. Not tested on ginseng. Classified as a partial methyl bromide alternative.

**Other fungicides currently registered for Sclerotinia white mold:**

- Boscalid (Endura): Efficacy – excellent. Classified as a reduced-risk fungicide. Needs to be used in a program with a rotational partner to delay the development of resistance.
- *Gliocladium virens* (SoilGard 12G): Efficacy – poor.

- Metam sodium (Metam sodium, Sectagon 42, Vapam HL): Efficacy – good. Classified as a carbamate.

**Other pest management aids for Sclerotinia white mold:**

- Rotate crops to avoid pathogen buildup.
- Avoid rotation with beans.

**Pipeline pest management tools for Sclerotinia white mold:**

- Fluazinam (Omega): Efficacy – excellent on other crops. Not tested on ginseng. Classified as a reduced-risk pesticide. Registration is pending through completion of an IR-4 project.
- Thiophanate-methyl (Topsin M WSB): Efficacy – good. Classified as a B2 carcinogen. Available as a Special Local Needs Label under Section 24(c) of FIFRA for use on *Cylindrocarpon*, *Rhizoctonia*, and *Sclerotinia* in Michigan and Wisconsin for 2007. Pest resistance is a significant concern. Must be used in rotation with fungicides of varying modes of action to delay the development of resistance. Considered a priority for registration through IR-4.

**"To do" list for Sclerotinia white mold:**

**Research needs for Sclerotinia white mold:**

- Determine environmental conditions that favor white mold.
- Determine if soybean rotation increases ginseng infection.
- Efficacy of products needs to be determined.
- Determine timing for sprays.
- Develop effective and efficient methods of applying fungicides to the root zone (i.e., drip application).

**Regulatory needs for Sclerotinia white mold:**

- Speed registration of products determined to be effective and safe.

**Educational needs for Sclerotinia white mold:**

- Provide education regarding the biology of the pathogen and other potential hosts.
- Emphasize the importance of correct and timely diagnosis.

## 9. SEPTONEMA DISEASE (*Septonema* sp.)

*Septonema* sp. has been isolated from buds, roots and seedlings of Wisconsin ginseng.

**B2 carcinogenic fungicides currently registered for Septonema disease:**

- 1,3-Dichloropropene/chloropicrin (Telone C-17, C-35): Efficacy – potentially good. Not tested on ginseng. Classified as a partial methyl bromide alternative by IR-4. Expensive.

**Other fungicides currently registered for Septonema disease:**

- None identified.

**Other pest management aids for Septonema disease:**

- None identified.

**Pipeline pest management tools for Septonema disease:**

- None identified.

**"To do" list for Septonema disease:**

**Research needs for Septonema disease:**

- Determine whether this pathogen is a significant threat to ginseng. Develop information regarding its epidemiology. If this fungus is an important pathogen, then test fungicides for efficacy and develop cultural methods of control.

**Regulatory needs for Septonema disease:**

- None identified.

**Educational needs for Septonema disease:**

- Inform growers of the presence of this fungus and any relevant management strategies.

## 10. STROMATINIA BLACK ROT (*Stromatinia panacis*)

A serious problem in Michigan woodlots. This pathogen also infects false solomon's seal, a woodland plant. Minor problem in Wisconsin.

**B2 carcinogenic fungicides currently registered for Stromatinia black rot:**

- 1,3-Dichloropropene/chloropicrin (Telone C-17, C-35): Efficacy – potentially good. Not tested on ginseng. Classified as a partial methyl bromide alternative by IR-4. Expensive.

**Other fungicides currently registered for Stromatinia black rot:**

- None identified.

**Other pest management aids for Stromatinia black rot:**

- Rotate crops to avoid pathogen buildup.

**Pipeline pest management tools for Stromatinia black rot:**

- None identified.

**"To do" list for Stromatinia black rot:**

**Research needs for Stromatinia black rot:**

- Determine whether registered and unregistered products are effective.
- Develop the information necessary to better understand the disease cycle.

**Regulatory needs for Stromatinia black rot:**

- Speed registration of products that are effective and safe.

**Educational needs for Stromatinia black rot:**

- None identified.

## 11. VERTICILLIUM WILT (*Verticillium dahliae*)

Affected plants display wilting foliage, and the plant eventually dies. The vascular tissue of infected plants is discolored and yellow. This disease is considered a rare problem.

**B2 carcinogenic fungicides currently registered for Verticillium wilt:**

- 1,3-Dichloropropene/chloropicrin (Telone C-17, C-35): Efficacy – unknown. Not tested on ginseng. Classified as a partial methyl bromide alternative.

**Other fungicides currently registered for Verticillium wilt:**

- Metam sodium (Metam sodium, Sectagon 42, Vapam HL): Efficacy – good.

**Other pest management aids for Verticillium wilt:**

- Rotate crops to avoid pathogen buildup.

**Pipeline pest management tools for Verticillium wilt:**

- None identified.

**"To do" list for Verticillium wilt:**

**Research needs for Verticillium wilt:**

- Determine whether the pathogen represents a significant economic threat.

**Regulatory needs for Verticillium wilt:**

- None identified.

**Educational needs for Verticillium wilt:**

- None identified.

## NEMATODES

Pressure is decreased because of cultural methods. Fumigation is also beneficial (lesion and root-knot).

### 1. ROOT-KNOT NEMATODE (*Meloidogyne hapla*)

Mature roots may be deformed, short and branched, and secondary roots abnormally branched and hairy.

**Organophospate nematicides currently registered:**

- None identified.

**Carbamate nematicides currently registered:**

- Metam sodium (Metam Sodium, Sectagon 42, Vapam HL): Efficacy – good if applied correctly (water and temperature are a concern).

**B2 carcinogenic nematicides currently registered:**

- 1,3-Dichloropropene (Telone II, Telone EC [MI only]): Efficacy – good to fair. Classified as a partial methyl bromide alternative.
- 1,3-Dichloropropene/chloropicrin (Telone C-17, C-35): Efficacy – good to fair. Classified as a partial methyl bromide alternative.
- Dazomet (Basamid Granular Soil Fumigant): Efficacy – fair.

**Other nematicides currently registered:**

- Azadirachtin (Ecozin 3% EC [MI only]): Efficacy – not being used. Classified as a biopesticide.
- Harpin protein (N-Hibit, N-Hibit CST): Efficacy – not being used. Classified as a biopesticide.
- *Myrothecium verrucaria* (DiTera WDG): Efficacy – unknown. Not tested on ginseng. Supplemental label available for use on ginseng only in Wisconsin. Not used by growers. Classified as a partial methyl bromide alternative and a biopesticide.

**Other pest management aids:**

- Crop rotation.
- Trap crops (oil seed radish – not applicable for root-knot nematode).

**Pipeline pest management tools:**

- None identified.

**"To do" list for nematodes:**

**Research needs for nematodes:**

- Conduct a survey to identify and determine the nematodes present in Wisconsin's and Michigan's ginseng production.
- Characterize nematode biodiversity.
- Test fumigants and fumigant alternatives for their ability to limit parasitic nematode populations.
- Test non-host crops.
- Determine a cover crop for pre-plant use (1 year).

**Regulatory needs for nematodes:**

- None identified.

**Educational needs for nematodes:**

- Growers are interested in learning which nematodes negatively or positively impact ginseng production.

## WILDLIFE PESTS

### 1. DEER, RACOONS, SKUNKS, TURKEYS

**Pest management tools:**

- Fencing, balloons, cannon (noise makers).

**Pipeline pest management tools for wildlife pests:**

- None identified.

**"To do" list for wildlife pests:**

**Research needs for wildlife pests:**

- Study the pattern of turkey movement.
- Develop efficient and effective methods to disturb the nesting habits of turkeys.
- Test raccoon repellents.
- Need interior (in garden) baiting material.

**Regulatory needs for wildlife pests:**

- None identified.

**Educational needs for wildlife pests:**

- None identified.

## WEEDS

Grasses, yellow nutsedge, dandelion, creeping jennie, lambsquarter, broadleaf weeds, sedges, pigweed, thistles, and raspberry (Michigan only). Grasses are easy to control. Really expensive to control by hand.

### 1. PRE-PLANT HERBICIDES

- Dazomet (Basamid Granular Soil Fumigant): Efficacy – fair.
- Diquat dibromide (Reglone Dessicant): Efficacy – unknown.

- Glyphosate (Agrisolutions Cornerstone, Agrisolutions Conrnerstone Plus, Buccaneer, Bucaneer Plus, ClearOut 41 Plus, Gly-4 Plus, Glyfos, Glyfos X-tra, Glyphogan, Glyphomax Plus, Gly Star 5, Gly Star 5 Extra, Gly Star Plus, Gordon's Big n' Tuff Nonselective Agricultural Herbicide [WI only], Grandslam 4XS, Mirage, Mirage Plus, Rascal, Rascal Plus, Roundup Original, Roundup Original Max, Roundup Ultra Dry, Roundup Ultra Max RT, Roundup Weather Max [MI only], Touchdown Herbicide, Touchdown HiTech, Touchdown Total, Wise Up Plus Glyphosphate Herbicide): Efficacy – good to excellent. Kills emerged weeds, very effective against most green plants. Cannot be applied during the harvest year.
- Pelargonic acid (Scythe): Efficacy – not being used.
- Metam sodium (Vapam HL): Efficacy – good.

**2. POST-EMERGENCE HERBICIDES – BEFORE PLANTING**

- Glyphosate (Agrisolutions Cornerstone, Agrisolutions Conrnerstone Plus, Buccaneer, Bucaneer Plus, ClearOut 41 Plus, Gly-4 Plus, Glyfos, Glyfos X-tra, Glyphogan, Glyphomax Plus, Gly Star 5, Gly Star 5 Extra, Gly Star Plus, Gordon's Big n' Tuff Nonselective Agricultural Herbicide [WI only], Grandslam 4XS, Mirage, Mirage Plus, Rascal, Rascal Plus, Roundup Original, Roundup Original Max, Roundup Ultra Dry, Roundup Ultra Max RT, Roundup Weather Max [MI only], Touchdown Herbicide, Touchdown HiTech, Touchdown Total, Wise Up Plus Glyphosphate Herbicide): Efficacy – excellent. Kills emerged weeds, very effective against most green plants. No pre-activity. Cannot be applied during the harvest year.

**3. PRE- AND POST-EMERGENCE HERBICIDES**

- None identified.

**4. POST-EMERGENCE HERBICIDES**

- Ammonium salts of fatty acids (Weed-Aside Weed Killer [WI only]): Efficacy – not being used.
- Clethodim (AgriStar Trigger, Arrow 2EC, Clethodim 2EC, Section 2EC): Efficacy – unknown.
- Fluazifop (Fusilade): Efficacy – good. Kills most annual and perennial grasses. No pre-activity. Cannot be applied during the harvest year.

**Other weed management aids:**

- Straw mulch.
- Hand weeding – currently the main weed control tool, very expensive.

**Pipeline weed management tools:**

- DCPA (Dacthal W-75 [WI only (through special local need resgistration)]): Pre-emergent herbicide. Classified as a group C possible human carcinogen. Tolerance has been established and ginseng may be added to the label.
- More work with dicamba (Rifle), 2,4-D and mesotrione (Callisto).

**"To do" list for weeds:**

**Research needs for weeds:**

- Phenmedipham (Spin-Aid EC): Looked promising in a preliminary field trial as a post-emergent herbicide. More crop safety and efficacy data are needed.
- Test new chemistries for efficacy and crop safety.
- Test new techniques for applying fumigants.

- Test new fumigants, including new products for efficacy and crop safety.
- Test further dicamba (Rifle), 2,4-D and mesotrione (Callisto).

**Regulatory needs for weeds:**

- Explore non-food use registrations as soon as safe and effective products are identified.

**Educational needs for weeds:**

- When new products are identified and registered, establish demonstration trials to highlight research findings to growers.

**TABLE 1. CLASSIFICATION OF PESTICIDES**

| Chemical group | Human Risk Assessment |
|---|---|
| Carbamate | Acetylcholinesterase inhibitor; disrupts the nervous system. |
| Organophosphate | Acetylcholinesterase inhibitor; disrupts the nervous system. |
| B2 carcinogen | Likely human carcinogen. |
| C carcinogen | Possible human carcinogen for which there is limited animal evidence. |
| D carcinogen | There is inadequate evidence to determine carcinogenicity in humans. |
| E chemical | Evidence of non-carcinogenicity in humans. |

## TABLE 2. REGISTERED PESTICIDES FOR GINSENG

| Active ingredient | Trade name | Company |
|---|---|---|
| **PESTICIDES for INSECTS and other invertebrates** | | |
| azadirachtin | Aza-Direct | Gowan Company |
| | Ecozin 3%EC [MI only] | Amvac Chemical Corp. |
| | Neemix 4.5 [MI only] | Certis USA |
| *Beauveria bassiana* | Mycotrol O | Laverlam International Corp. |
| cyfluthrin | Baythroid 2, Baythroid XL, Renounce 20WP [WI only] | Bayer CropScience |
| deltamethrin | Battalion 0.2EC | Arysta LifeScience USA |
| | Decis 0.2EC, Decis 1.5EC [WI only] | Bayer CropScience |
| | Agrisolutions Delta Gold | Agriliance |
| diazinon | Diazinon 5WB [MI only] | Agriliance |
| | Diazinon 14G | Wilbur Ellis |
| | Diazinon AG500 | Makhteshim Agan of N. America |
| | Diazinon AG600 WBC, Diazinon G-14 [MI only] | UAP- Loveland Products, Inc. |
| garlic juice extracts | Allityn | Helena Chemical Co. |
| | Garlic Barrier AG+ | Garlic Research Labs |
| imidacloprid | Admire 2F, Admire PRO Systemic Protectant | Bayer CropScience |
| | AgriStar Impulse 1.6FL [WI only] | Albaugh, Inc. |
| | Alias 2F [WI only] | c |
| | Couraze 1.6F | Cheminova, Inc. |
| | Couraze 2F [WI only] | |
| | Provado 1.6F | Bayer CropScience |
| metaldehyde | DeadlineBullets, M-Ps, Durham Metaldehyde Granuals 7.5 | Amvac Chemical Corp. |
| | Hi-Yield Slug & Snail Bait | Voluntary Purchasing Goups, Inc. |
| | No Escape Slug and Snail Killer [MI only] | Bonide Products, Inc. |
| | OR-CAL Slug & Snail Bait [WI only], OR-CAL Slugfest All Weather Formula [MI only] | OR-CAL, Inc. |
| | Slug-It Concentrate | Monterey/Lawn & Garden Products, Inc. |
| | Trails End 3.5 [MI only], Trails End LG [MI only] | Amvac Chemical Corp. |
| petroleum oil | Glacial Spray Fluid | UAP – Loveland Products, Inc |
| pyrethrins | Bug Buster-O | Monterey/Lawn & Garden Products, Inc. |
| | PyGanic EC 1.4 | MGK Company |
| | Pyrellin E.C. [MI only] | Webb Wright Corp. |
| | Pyrenone Crop Spray | Bayer EC Professional Pest Control |
| | Pyreth-It | Whitmire Micro-Gen Research Lab |
| | Pyronyl Crop Spray | Prentiss Incorporated, Inc. |

## TABLE 2. REGISTERED PESTICIDES FOR GINSENG

| Active ingredient | Trade name | Company |
|---|---|---|
| spinosad | Entrust Naturalyte Insect Control [WI only], SpinTor 2SC | Dow AgroSciences |
| thiamethoxam | Actara, Platinum | Syngenta Crop Protection, Inc. |
| **NEMATICIDES** | | |
| 1,3-dichloropropene (fumigant) | Telone II, Telone EC [MI only] | Dow AgroSciences |
| 1,3-dichloropropene/ chloropicrin (fumigant) | Telone C-17, Telone C-35 | Dow AgroSciences |
| azadirachtin | Ecozin 3%EC [MI only] | Amvac Chemical Corp. |
| dazomet | Basamid Granular Soil Fumigant | BASF Corp. |
| harpin protein | N-Hibit, N-Hibit CST | EDEN Bioscience Corp. |
| metam sodium (fumigant) | Metam Sodium<br>Sectagon 42<br>Vapam HL | UAP- Loveland Products, Inc.<br>Tessenderlo Kerley<br>Amvac Chemical Corp. |
| *Myrothecium verrucaria* | DiTera WDG [WI only] | Valent U.S.A. Corp. |
| **FUNGICIDES** | | |
| aluminum tris | Aliette WDG | Bayer CropScience |
| azoxystrobin | Amistar 50WG, Quadris F | Syngenta Crop Protection, Inc. |
| *Bacillus subtilis* | Serenade ASO, Serenade Max WP | AgraQuest, Inc. |
| boscalid | Endura 70WG | BASF Corp. |
| captan | Captan 50W | Drexel Chemical Co. |
| chitosan | Elexa 4 | Plant Defense Boosters, Inc. |
| chlorothalonil | Bravo Weather Stik SC | Syngenta Crop Protection, Inc. |
| copper ammonium complex | Copper-Count-N<br>Liqui-Cop Copper Fungicidal Garden Spray | Chemical Specialties, Inc.<br>Monterey/Lawn & Garden Products, Inc. |
| copper hydroxide | AgriStar Nu-Cop 3L, AgriStar Nu-Cop 50WP<br>Champ Dry Prill, Champ Formula 2F, Champion WP<br>Kocide 101<br>Kocide 2000 54DF, Kocide 4.5LF<br>Kocide 3000 46DF, Kocide DF | Albaugh, Inc.<br>Nufarm, Inc.<br>DuPont Crop Protection |
| copper salt of octanoic acid | Soap-Shield Flowable Liquid Copper Fungicide | Gardens Alive! Inc. |
| copper sulfate | Cuprofix Ultra 40 Disperss | Cerexagri-Nisso, Inc. |
| dazomet | Basamid Granular Soil Fumigant | BASF Corp. |
| 1,3-dichloropropene | Telone II, EC | Dow AgroSciences |
| 1,3-dichloropropene/ chloropicrin | Telone C-17, C-35 | Dow AgroSciences |
| fenhexamid | Elevate 50WDG | Arysta LifeScience N. America |
| fludioxonil | Maxim 4FS | Syngenta Crop Protection, Inc. |
| *Gliocladium virens* | SoilGard | Certis USA |
| hydrogen dioxide | OxiDate | BioSafe Systems, Inc. |

## TABLE 2. REGISTERED PESTICIDES FOR GINSENG

| Active ingredient | Trade name | Company |
|---|---|---|
| iprodione | Iprodione 4L AG, Iprodione 50WP AG | Micro Flo Co. |
| | Rovral 75WG, Rovral 4FL | Bayer CropScience |
| mancozeb | Dithane DF Rainshield | Dow AgroSciences |
| mancozeb/zoxamide | Gavel 75DF | Dow AgroSciences |
| mefenoxam | Ridomil Gold EC, Ridomil Gold GR, Ridomil Gold SL | Syngenta Crop Protection, Inc. |
| neem oil | Trilogy | Certis USA |
| phosphorous acid salts | Agri-fos | Monterey/Lawn & Garden Products, Inc. |
| | Agrisolutions Topaz | Agriliance |
| | Fosphite | JH Biotech, Inc. |
| | Helena ProPhyt | Helena Chemical Company |
| | Phostrol | Nufarm Americas, Inc. |
| polyoxin D zinc salt | Endorse 2.5WP | Arysta LifeScience North America |
| pyraclostrobin | Cabrio 20EG | BASF, Inc. |
| thiophanate-methyl | Topsin M WSB | Cerexagri-Nisso |
| trifloxystrobin | Flint 50WG | Bayer CropScience |
| | **HERBICIDES** | |
| ammonium salts of fatty acids | Weed-Aside Weed Killer [WI only] | Gardens Alive! Inc. |
| clethodim | AgriStar Trigger | Albaugh, Inc. |
| | Arrow 2EC | Makhteshim Agan of N. America |
| | Clethodim 2EC | Micro Flo Co. |
| | Section 2EC | Agriliance |
| dazomet | Basamid Granular Soil Fumigant | BASF Corp. |
| DCPA | Dacthal W-75 [WI only] | Amvac Chemical Corp. |
| diquat dibromide | Reglone Dessicant | Syngenta Crop Protection, Inc. |
| fluazifop-p-butyl | Fusilade DX | Syngenta Crop Protection, Inc. |
| glyphosate | Agrisolutions Cornerstone, Agrisolutions Cornerstone Plus, Rascal, Rascal Plus | Agriliance |
| | Buccaneer, Bucaneer Plus | TENKOZ, Inc. |
| | ClearOut 41 Plus | Chemical Products Technologies |
| | Gly-4 Plus | Universal Crop Protection Alliance |
| | Glyfos, Glyfos X-tra | Cheminova, Inc. |
| | Glyphogan | Makhteshim Agan of N. America |
| | Glyphomax Plus | Dow AgroSciences |
| | Gly Star 5, Gly Star 5 Extra, Gly Star Plus | Albaugh, Inc. |
| | Gordon's Big n' Tuff Nonselective Agricultural Herbicide [WI only] | PBI/ Gordon Corp. |
| | Grandslam 4XS | Hide |
| | Mirage, Mirage Plus | UAP- Loveland Products, Inc. |

## TABLE 2. REGISTERED PESTICIDES FOR GINSENG

| Active ingredient | Trade name | Company |
|---|---|---|
| | Roundup Original, Roundup Original Max, Roundup Ultra Dry, Roundup Ultra Max RT, Roundup Weather Max [MI only] | Monsanto Co. |
| | Touchdown Herbicide, Touchdown HiTech, Touchdown Total | Syngenta Crop Protection, Inc. |
| | Wise Up Plus Glyphosphate Herbicide | Mey Corp. |
| pelargonic acid | Scythe | Dow AgroSciences |

## TABLE 3. UNREGISTERED PESTICIDES TESTED ON GINSENG IN MICHIGAN OR WISCONSIN

| Fungicides | Pathogens tested[1] | | | | | | |
|---|---|---|---|---|---|---|---|
| | ***Alt*** | ***Bot*** | ***Cyl*** | ***Fus*** | ***Phy*** | ***Rhi*** | ***Scl*** |
| chlorothalonil (Bravo Weather Stik 6F) | E | E | | | P | | |
| *Coniothyrium minitans* (Contans WG) | – | – | | | – | | ? |
| cyazofamid (Ranman 400SC) | – | – | | | F-P | | |
| cymoxanil (Curzate 60DF) | – | – | | | E | | |
| dimethomorph (Acrobat 50WP) | – | – | | | G | | |
| etridiazole (Terramaster 4EC) | – | – | | | P | | |
| famoxadone/cymoxanil (Tanos 50DF) | | | | | G | | |
| fenamidone (Reason 500SC) | | | | | G-F | | |
| fluazinam (Omega 500F) | E | E | P | – | P | G-F | ? |
| fludioxonil (Scholar) | E | G | G | ? | | G | |
| fludioxonil/cyprodinil (Switch 62.5WG) | | | | | | | |
| flutolanil (Moncut 70DF) | | | P | – | | G | |
| mancozeb (Dithane 75DF) | E-G | P | | | G-F | | – |
| mancozeb/zoxamide (Gavel 75DF) | G | | | | G | | |
| propamocarb (Previcur Flex 6F) | – | | | | P | | |
| pyraclostrobin/boscalid (Pristine 38WG) | E | E | | | P | G | – |
| thiophanate-methyl (Topsin) | P | G-F | G | ? | P | P | ? |
| triflumizole (Terraguard 50W) | – | | | | | F | |
| zoxamide (Zoxium 80WP) | – | – | | | F-P | | |

[1] Key for pathogens: *Alt* = *Alternaria*, *Bot* = *Botrytis*, *Cyl* = *Cylindrocarpon*, *Fus* = *Fusarium*, *Phy* = *Phytophthora, Rhi* = *Rhizoctonia*, *Scl* = *Sclerotium*.

[2] Efficacy rating symbols: E = excellent (90-100% control), G = good (75-89% control), F = fair (60-74%), P = poor (<60% control), ? = no data, but successful on related organisms, – = not applicable and /or used.

**TABLE 4. DESCRIPTION OF PESTS AND PATHOGENS OF GINSENG**

| Pest/Pathogen | Symptoms |
|---|---|
| **INSECT PESTS AND OTHER INVERTEBRATES** | |
| Aphids<br>Family Aphididae | Aphids pierce foliage and suck out the plant sap, and may cause twisting and distortion of new growth. |
| Cutworms<br>Family Noctuidea | Minor pest of ginseng. Damage occurs to foliage only. Cutworms feed on stems, girdling young plants and chewing ginseng tops. |
| Four-lined plant bugs<br>*Poecilocapsus lineatus* | Fresh feeding spots (1-2 mm diameter) on foliage are initially dark colored, but quickly become white or tan and papery. Spots can coalesce. |
| Leaf rollers<br>*Archips purpurana* | Larvae partially chew the petiole to allow the leaf to wilt, then fold the leaf around themselves. Larvae feed on ginseng during the day and shelter in the rolled leaf at night. |
| Millipedes<br>Class Diplopoda | An innocuous feeder of composting vegetation. |
| Slugs<br>Order Anaspidea | Ragged holes in the leaves and slime trails are symptoms of slug feeding. |
| Spittle bugs<br>Family Cercopidae | Spittle bugs suck plant sap. Larvae of spittle bugs produce and shelter in frothy "spittle" on plant stems. |
| Thrips<br>Order Thysanoptera | Minor pest of ginseng. Most damage occurs to flower heads. |
| Treehoppers<br>Family Membracidae | Feeding can cause seedlings to collapse. |
| White grubs<br>Family Scarabidae | Grubs feed below the surface on plant roots. |
| Wireworms<br>Family Elateridae | Wireworms feed below the surface on plant roots. |
| **DISEASE PATHOGENS** | |
| Alternaria blight<br>*Alternaria panax* | Disease affects production throughout North America and Asia. If not controlled can produce severe epidemics. Alternaria blight may kill young plants or limit the yield of harvested roots by causing premature defoliation. Lesions often appear to originate at the base of the stem. Leaves will collapse and turn red or yellow. In seedlings, the entire plant collapses resulting in a damped-off appearance. Can infect the fruit. |
| Botrytis blight<br>*Botrytis cinerea* | The pathogen affects the leaves, flowers, and fruit, leading to defoliation of plants and poor seed set. Symptoms include rapidly enlarging, water-soaked lesions, often starting at the leaf tip and spreading back along the midrib. The fungus often sporulates on the rotted tissue, producing a fuzzy gray mold. |

**TABLE 4. DESCRIPTION OF PESTS AND PATHOGENS OF GINSENG**

| Pest/Pathogen | Symptoms |
|---|---|
| Damping-off, seed decay *Cylindrocarpon destructans*, *Fusarium* spp., *Pythium* spp., *Rhizoctonia solani* | Root damage is often extensive in first-year ginseng gardens. Damping-off can lead to a significant reduction in plant stands. These diseases are often poorly diagnosed and have not been well studied. |
| Disappearing root rot *Cylindrocarpon destructans* | A major pathogen of cultivated ginseng. The disease infects only the root portions of the plant. Diseased plants often fail to emerge in the spring. Small, discolored, gold to brown areas appear on the root surface in the early stages of infection. The root develops a dark brown discoloration at the infection sites during the more advanced stages of the disease. |
| Phytophthora root rot *Phytophthora cactorum* | One of the most serious diseases of ginseng. Infection can occur both to the roots and to the foliage. Infection of the roots causes a light brown water-soaked lesion on the surface of the root that spreads rapidly and completely destroys the root. Leaflets on the infected plant collapse downward from the base of the petiole. |
| Powdery mildew *Erysiphe* sp. | Superficial, white, powdery growth on the upper leaf surfaces with infected tissue turning reddish purple. Leaves may turn yellow and drop. |
| Rusty root *Rhexocercosporidium panacis* sp. nov., *Cylindrocarpon destructans Fusarium* spp. | This disease causes small reddish and brown lesions on roots. Crowns of roots may also become infected. |
| Sclerotinia white mold *Sclerotinia sclerotiorum* | This disease causes a stem and root rot of ginseng. Infected foliage wilts, discolors and dries up. Black sclerotia often form on infected plant parts. |
| Septonema disease *Septonema* sp. | Not well understood. Appears to cause a superficial reddening of the root tissue, resulting in decreased value due to poor aesthetic appeal. Possibly involved in the damping-off complex. |
| Stromatinia black rot *Stromatinia panacis* | Infected plants may fail to emerge in the spring. Roots are intact and black on the surface, with white, watery and spongy interior. Black bumps (sclerotia) may form on the surface and in the interior. Problem in woodlots in Michigan. |
| Verticillium wilt *Verticillium dahliae* | Infected plants display wilting of the foliage. The wilting eventually kills the plant. The vascular tissue of infected plant materials is discolored yellow. |
| **NEMATODES** | |
| Northern root-knot nematode *Meloidogyne hapla* | Mature roots may be deformed, short and branched, and secondary roots abnormally branched and hairy. |

**TABLE 4. DESCRIPTION OF PESTS AND PATHOGENS OF GINSENG**

| Pest/Pathogen | Symptoms |
|---|---|
| **WILDLIFE PESTS** | |
| Deer | Bed down in ginseng gardens. |
| Racoons, skunks | Disrupt mulch, uproot seedlings. Dig 1,500-2,000 holes per night. |
| Turkeys | Disrupt mulch. Break crowns during scratching. |
| **WEEDS** | |
| Annuals | Grasses, lambsquarter. |
| Perennials | Grasses, dandelion, yellow nutsedge, creeping jennie, raspberry. |

**TABLE 5. ADVANTAGES AND DISADVANTAGES OF PESTICIDES FOR GINSENG**

| Active ingredient | Pest | Advantages/Disadvantages |
|---|---|---|
| **INSECTICIDES** | | |
| azadirachtin | aphid, cutworm, 4-lined plant bug, leaf roller, millipede, spittle bug, thrips, treehopper, white grub, wireworm | • biopesticide<br>• disrupts insect molting |
| *Beauveria bassiana* | aphids, bugs, thrips | • biopesticide<br>• nontoxic to mammals, birds and plants |
| cyfluthrin | cutworms | • pyrethroid |
| deltamethrin | aphids, bugs, cutworms | • organophosphate alternative |
| diazinon | aphids, bugs, cutworm, white grub, wireworms, | • organophosphate<br>• toxic to bees, fish<br>• long residual time, good efficacy |
| dichloropropene | wireworm | • B2 carcinogen<br>• cannot use on heavy soil<br>• worker personal protective equipment required<br>• water setbacks<br>• fumigant<br>• expensive, requires costly equipment<br>• specific temperature requirements limit its use<br>• also used to control soilborne diseases and<br>• nematodes |
| dichloropropene/ chloropicrin | wireworm | • B2 carcinogen<br>• worker personal protective equipment required<br>• water setbacks<br>• fumigant<br>• expensive, requires costly equipment<br>• specific temperature requirements limit its use<br>• also used to control soilborne diseases and nematodes |
| garlic juice extracts | bugs, leafrollers, thrips, white grubs, wireworms | • biopesticide |
| imidacloprid | aphids | • organophosphate alternative<br>• systemic soil treatment<br>• expensive |
| kaolin | flea beetles, grasshoppers, leafhoppers | • biopesticide |

**TABLE 5. ADVANTAGES AND DISADVANTAGES OF PESTICIDES FOR GINSENG**

| Active ingredient | Pest | Advantages/Disadvantages |
|---|---|---|
| metaldehyde | slug | • avoid contact with plants<br>• used between rows |
| petroleum oil | aphids, thrips | • potential for phytotoxicity especially under high temperatures |
| pyrethrins | aphids, bugs, cutworms, leafrollers, thrips | • limited efficacy |
| spinosad | thrips | • reduced-risk insecticide<br>• new product<br>• used in resistance management programs<br>• expensive<br>• short preharvest interval (1 day) |
| thiamethoxam | aphids | • broad-spectrum<br>• organophosphate alternative |
| **FUNGICIDES** | | |
| aluminum tris | Alternaria blight, Phytophthora foliar blight and root rot | • limited efficacy<br>• not effective against *Alternaria* |
| azoxystrobin | Alternaria blight damping-off (*Pythium*, *Rhizoctonia* ), powdery mildew | • reduced-risk fungicide<br>• potential resistance issues<br>• known control against *Alternaria* |
| *Bacillus subtilis* | Alternaria blight, Botrytis blight, damping-off, powdery Mildew | • biopesticide<br>• seed treatment only |
| boscalid | Alternaria blight, Botrytis blight, powdery mildew, white mold | • reduced-risk fungicide<br>• potential resistance issues |
| captan | Botrytis blight, disappearing root rot, Phytophthora root rot, Pythium root rot, Rhizoctonia root and crown rot | • B2 carcinogen<br>• non-food use only |
| chitosan | Botrytis blight, Powdery mildew | • biopesticide<br>• low toxicity potential |
| chlorothalonil | Botrytis blight | • B2 carcinogen<br>• very toxic to fish |

**TABLE 5. ADVANTAGES AND DISADVANTAGES OF PESTICIDES FOR GINSENG**

| Active ingredient | Pest | Advantages/Disadvantages |
|---|---|---|
| copper ammonium complex | Alternaria blight | • limited efficacy<br>• potential for phytotoxicity especially under high temperatures |
| copper hydroxide | Alternaria blight | • potential phytotoxicity<br>• limited control of *Alternaria* |
| copper salt of octanoic acid | Alternaria blight, Botrytis blight, powdery mildew | • limited efficacy<br>• potential for phytotoxicity especially under high temperatures |
| copper sulfate | Alternaria blight | • limited efficacy<br>• potential for phytotoxicity especially under high temperatures |
| dichloropropene | damping-off, disappearing root rot, Phytophthora foliar blight and root rot, Sclerotinia white rot, Verticillium wilt | • B2 carcinogen<br>• cannot use on heavy soil<br>• worker personal protective equipment required<br>• water setbacks<br>• fumigant<br>• expensive, requires costly equipment<br>• specific temperature requirements limit its use<br>• also used to control insects and nematodes |
| dichloropropene/ chloropicrin | damping-off, disappearing root rot, Phytophthora foliar blight and root rot, Sclerotinia white rot, Verticillium wilt | • B2 carcinogen<br>• worker personal protective equipment required<br>• water setbacks<br>• fumigant<br>• expensive, requires costly equipment<br>• specific temperature requirements limit its use<br>• also used to control insects and nematodes |
| fenhexamid | Botrytis leaf blight | • reduced-risk fungicide<br>• non-food use only<br>• cannot be used on crop to be harvested<br>• limited range of pathogens controlled<br>• only 4 applications allowed per season |
| fludioxonil | damping-off | • reduced-risk<br>• seed treatment only |
| hydrogen dioxide | Alternaria blight | • biopesticide<br>• not tested on ginseng<br>• not used by growers<br>• limited efficacy when tested on other crops |
| iprodione | Alternaria blight | • B2 carcinogen<br>• resistance issues<br>• effective against sensitive pathogen populations |

**TABLE 5. ADVANTAGES AND DISADVANTAGES OF PESTICIDES FOR GINSENG**

| Active ingredient | Pest | Advantages/Disadvantages |
|---|---|---|
| mancozeb | Alternaria blight | • B2 carcinogen |
| mancozeb/ zoxamide | Phytophthora foliar blight and root rot | • B2 carcinogen |
| mefenoxam | Phytophthora foliar blight and root rot | • reduced-risk fungicide<br>• resistance documented and widespread |
| neem oil | Alternaria blight | • biopesticide<br>• efficacy data and use pattern lacking for ginseng<br>• very limited efficacy demonstrated for the same pathogens on other crops |
| phosphorous acid salts | Phytophthora foliar blight and root rot | • biopesticide<br>• limited efficacy<br>• pathogen-specific |
| pyraclostrobin | Alternaria blight, powdery mildew | • reduced-risk fungicide<br>• broad-spectrum activity<br>• excellent efficacy<br>• potential for resistnace |
| trifloxystrobin | Alternaria blight | • reduced-risk fungicide<br>• excellent efficacy<br>• potential for resistance |
| **NEMATICIDES** | | |
| azadirachtin | nematodes | • biopesticide |
| dichloropropene | nematodes | • B2 carcinogen<br>• cannot use on heavy soil<br>• worker personal protective equipment required<br>• water setbacks<br>• fumigant<br>• expensive, requires costly equipment<br>• specific temperature requirements limit its use<br>• also used to control soilborne diseases and insects |
| dichloropropene/ chloropicrin | Nematodes | • B2 carcinogen<br>• worker personal protective equipment required<br>• water setbacks<br>• fumigant<br>• expensive, requires costly equipment<br>• specific temperature requirements limit its use<br>• also used to control soilborne diseases and insects |
| harpin protein | Nematodes | • biopesticide |

**TABLE 5. ADVANTAGES AND DISADVANTAGES OF PESTICIDES FOR GINSENG**

| Active ingredient | Pest | Advantages/Disadvantages |
|---|---|---|
| metam sodium | Nematodes | • carbamate<br>• highly efficient<br>• very expensive<br>• controls bacteria, fungi, weeds, soil insects<br>• fumigant or chemigant<br>• toxic to fish |
| *Myrothecium verrucaria* | Nematodes | • biopesticide and partial methyl bromide alternative<br>• supplemental label for use only in Wisconsin |
| **HERBICIDES** | | |
| ammonium salts of fatty acids | postemergence grasses and broadleaves | • biopesticide<br>• broad spectrum<br>• nonselective |
| clethodim | postemergence grasses | • only targets grasses |
| DCPA | preemergence grasses and broadleaves | • classified as a possible human carcinogen<br>• nontoxic to small mammals and birds<br>• slightly toxic to fish |
| fluazifop | postemergence grasses | • limits grasses for only 1 year<br>• limit 6 pt/A/year<br>• broadleaf crops are tolerant, but higher rate needed for quackgrass<br>• cannot apply during the harvest year |
| glyphosate | postemergence grasses and broadleaves | • limits weeds for only 2 weeks<br>• excellent efficacy, nonresidual<br>• broad spectrum, excellent on perennials<br>• slightly toxic to birds, practically nontoxic to fish, aquatics, honeybees<br>• apply before planting only |

## TABLE 6. EFFICACY OF PEST MANAGEMENT TOOLS FOR CONTROL OF INSECTS AND OTHER INVERTEBRATE PESTS ON GINSENG

| Management tool | Insect/invertebrate pests of ginseng[1] | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Ap | CW | 4L | LR | Mi | Sl | SB | Tp | TH | WG | WW |
| **REGISTERED B2 CARCINOGENIC INSECTICIDES** | | | | | | | | | | | |
| dichloropropene (Telone II) | –[2] | – | – | – | – | – | – | – | – | – | G |
| dichloropropene/chloropicrin (Telone C-17, C-35) | – | – | – | – | – | – | – | – | – | – | G |
| **REGISTERED ORGANOPHOSPHATE INSECTICIDES** | | | | | | | | | | | |
| diazinon (Diazinon G) | – | E-G | – | – | U | – | – | – | – | G | – |
| **OTHER REGISTERED INSECTICIDES** | | | | | | | | | | | |
| azadirachtin (Neemix 4.5) | F-P | P | U | P | P | – | F-P | U | P | P | P |
| imidacloprid (Admire, Provado) | G | P | U | P | P | – | G | U | G | G | F |
| metaldehyde (Deadline, Slugfest) | – | – | – | – | – | G | – | – | – | – | – |
| pyrethrins/piperonyl butoxide (Pyrenone) | G | – | – | – | – | – | F-P | – | G | P | P |
| spinosad (SpinTor) | U | G | U | G | P | – | G | – | G | P | P |
| **PIPELINE PEST MANAGEMENT TOOLS** | | | | | | | | | | | |
| lambda-cyhalothrin (Warrior) | ? | ? | ? | ? | – | – | ? | ? | ? | – | – |
| pymetrozine (Fulfill) | ? | – | – | – | – | – | – | – | – | – | – |
| thiamethoxam (Actara, Platinum) | ? | ? | ? | ? | – | – | ? | – | ? | – | – |
| **OTHER PEST MANAGEMENT AIDS** | | | | | | | | | | | |
| cover crops | – | – | – | – | – | – | – | – | – | – | – |
| diatomaceous earth | – | – | – | – | – | F | – | – | – | – | – |
| fumigation | – | – | – | – | ? | – | – | – | – | ? | – |
| remove weeds around gardens | ? | ? | – | – | – | ? | – | – | – | – | – |
| sawdust mulch | – | – | – | – | – | F | – | – | – | – | – |
| scouting | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? |
| site selection | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? | ? |
| till site before planting | – | – | – | – | – | – | – | – | – | ? | – |

[1] Key to insect/invertebrate pests: Ap = aphids, CW = cutworms, 4L = four-lined plant bugs, Mi = millipedes, Sl = slugs, SB = spittle bugs, Tp = thrips, TH = treehoppers, WG = white grubs, WW = wireworms.

[2] Efficacy rating symbols: E = excellent (90-100% control), G = good (75-89% control), F = fair (60-74%), P = poor (<60% control), ? = no data, but successful on related organisms, – = not applicable and /or used, U = unknown.

## TABLE 7. EFFICACY OF PEST MANAGEMENT TOOLS FOR CONTROL OF FUNGAL PATHOGENS ON GINSENG

| Management tool | Diseases of ginseng | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Alt | Bot | DO | DRR | Phy | PM | RR | Scl | SBR | Vert |
| **REGISTERED B2 CARCINOGENIC FUNGICIDES** | | | | | | | | | | |
| dichloropropene (Telone II) | –[1] | – | ? | ? | ? | – | | ? | ? | ? |
| dichloropropene/chloropicrin (Telone C-17/C-35) | – | – | ? | ? | ? | – | | ? | ? | ? |
| iprodione (Rovral) | E-G | G-F | – | – | – | – | | – | – | – |
| **OTHER REGISTERED FUNGICIDES** | | | | | | | | | | |
| azoxystrobin (Quadris, Amistar) | E | F | – | – | – | E | | – | – | – |
| *Bacillus subtilis* (Serenade) seed treatment | – | – | ? | – | – | – | | – | – | – |
| boscalid (Endura) | E | E | – | – | – | E | – | E | – | – |
| captan (Captan) | G-F | E | ? | E | E | – | ? | – | – | – |
| copper hydroxide (Champ, Kocide, Nu-Cop) | G-F | F | – | – | – | G | | – | – | – |
| fenhexamid (Elevate) | – | E | – | – | – | – | | – | – | – |
| fludioxonil (Maxim) seed treatment | – | – | ? | – | – | – | | – | – | – |
| fosetyl-al (Aliette) | – | – | – | – | F | – | | – | – | – |
| *Gliocladium virens* (SoilGard) in-furrow | – | – | – | – | – | – | | – | – | – |
| hydrogen dioxide (OxiDate) | P | – | – | – | – | – | | – | – | – |
| mefenoxam (Ridomil) | – | – | E-P | – | E-P | – | | – | – | – |
| neem oil (Trilogy) | P | – | – | – | – | – | | – | – | – |
| polyoxin D zinc salt (Endorse) | | | | | | | | | | |
| pyraclostrobin (Cabrio WG) | E | F | ? | P | – | E | | – | – | – |
| phosphorous acid salts (Agri-Fos, Phostrol) | – | – | – | – | F | – | | – | – | – |
| **PIPELINE PEST MANAGEMENT TOOLS** | | | | | | | | | | |
| chlorothalonil (Bravo) | E | E | – | – | P | E | | – | – | – |
| dimethomorph (Acrobat) | – | – | P | – | G | – | | – | – | – |
| fluazinam (Omega) | E | E | P | P | P | E | | – | – | – |
| mancozeb (Dithane) | G | F-P | – | – | F-P | E | | – | – | – |
| mancozeb/zoxamide (Gavel) | G | F-P | G | – | G | E | | – | – | – |
| thiophanate-methyl (Topsin) | P | F | F-P | G | – | E | | – | – | – |
| **OTHER PEST MANAGEMENT AIDS** | | | | | | | | | | |
| good ventilation | F | F | – | – | F | F | | F | – | – |
| increased drainage | F | F | F | F | F | – | | F | – | – |
| limit garden size | F | F | – | – | F | F | | – | – | – |
| sanitation | – | – | F | F | F | – | | F | – | F |
| scouting | F | F | – | – | F | F | | – | – | – |
| seed treatments | | | | | | | | | | |
| time sprays to initial disease occurrence | P | P | P | P | P | F | | P | P | P |

[1] Key for diseases: Alt = Alternaria leaf blight; Bot = Botrytis leaf blight; DO = damping-off (including *Rhizoctonia*, *Pythium*); DRR = disappearing root rot; Phy = Phytophthora foliar blight and root rot; PM = powdery mildew; RR= rusty root; Scl = Sclerotinia white mold; SBR = Stromatinia black rot; Vert=Verticillium wilt.

[2] Efficacy rating symbols: E = excellent (90-100% control), G = good (75-89% control), F = fair (60-74%), P = poor (<60% control), ? = no data, but successful on related other crops, – = not applicable and /or used.

## TABLE 8. EFFICACY OF PEST MANAGEMENT TOOLS FOR CONTROL OF NEMATODE PESTS ON GINSENG

| Management tool | Northern root-knot nematode |
|---|---|
| **REGISTERED B2 CARCINOGENIC NEMATICIDES** | |
| dichloropropene (Telone II) | G-F[1] |
| dichloropropene/chloropicrin (Telone C-17/C-35) | G-F |
| **REGISTERED CARBAMATE NEMATICIDES** | |
| metam sodium (Vapam) | G-F |
| **OTHER REGISTERED NEMATICIDES** | |
| dazomet (Basamid) | U |
| *Myrothecium verrucaria* (DiTera WDG) | U |

[1] Efficacy rating symbols: Efficacy rating symbols: E = excellent (90-100% control), G = good (75-89% control), F = fair (60-74%), P = poor (<60% control), ? = no data, but successful on related organisms, – = not applicable and /or used, u = unknown.

## TABLE 9. EFFICACY OF PEST MANAGEMENT TOOLS FOR CONTROL OF WEEDS ON GINSENG

| Management tool | Annual weeds | | Perennial weeds | |
|---|---|---|---|---|
| | Broadleaf | Grass | Broadleaf | Grass |
| **REGISTERED PRE-PLANT HERBICIDES** | | | | |
| glyphosate (Roundup, Glyphomax Plus, Touchdown) | G[1] | G | G | G |
| **REGISTERED POST-EMERGENCE HERBICIDES – Before Planting** | | | | |
| glyphosate (Roundup, Glyphomax Plus, Touchdown) | G | G | G | G |
| **REGISTERED POST-EMERGENCE HERBICIDES** | | | | |
| fluazifop (Fusilade DX) | none | G | none | G |
| **OTHER PEST MANAGEMENT PRACTICES** | | | | |
| cover crops | ? | ? | ? | ? |
| wind breaks | – | – | – | – |
| crop rotation | ? | ? | ? | ? |
| fall tillage (in conjunction with herbicide treatment) | ? | ? | ? | ? |
| herbicide rotation to reduce resistance | – | – | – | – |
| straw mulch | F | F | F | F |
| hand weeding | E | E | E | E |

[1] Efficacy rating symbols: E = excellent (90-100% control), G = good (75-89% control), F = fair (60-74%), P = poor (<60% control), ? = no data, but successful on related organisms, – = not applicable and /or used, * = no control over composites, wild carrot and nutsedge, ** = effective on only some grasses, *** = weak on quack grass and no nutsedge control.

## TABLE 10. GENERAL TIMELINE FOR CROP STAGES AND WORKER ACTIVITIES

| Prior to planting | Mar | | Apr | | May | | Jun | | Jul | | Aug | | Sep | | Oct | | Nov | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Site selection, soil sampling, soil survey (several years prior) | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | |
| Soil prep (two years prior) | | | | | | | | | | | | | | | | ■ | ■ | |
| Roundup (1-2 years prior) | | | | | ■ | ■ | | | ■ | | | | ■ | ■ | | | | |
| **Year 0 (planting)** | **Mar** | | **Apr** | | **May** | | **Jun** | | **Jul** | | **Aug** | | **Sep** | | **Oct** | | **Nov** | |
| Fumigation | | | | | | | ■ | ■ | | | | | | | | | | |
| Fertilization | | | | | | | ■ | ■ | | | | | | | | ■ | ■ | |
| Land prep (Michigan) | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | | |
| Posts | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Bed formation | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Planting (seeding) | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Straw mulch | | | | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Diazinon, slug bait (1-2 appl) | | | | | | | | ■ | ■ | ■ | ■ | ■ | | | | | | |
| Herbicide application (grass) | | | | | | | | | | | | | ■ | ■ | | | | |
| Roundup | | | | | | | | | | | | | ■ | ■ | | | | |
| **Year 1 (seedling)** | **Mar** | | **Apr** | | **May** | | **Jun** | | **Jul** | | **Aug** | | **Sep** | | **Oct** | | **Nov** | |
| Slug bait (diazinon) | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | |
| Fertilization | | | ■ | ■ | ■ | ■ | | | | | | | | | | | | |
| Shade cloth | | | | ■ | ■ | ■ | | | | | | | | | | | | |
| Fill gutters with gravel | | | | ■ | ■ | | | | | | | | | | | | | |
| Foliar fungicide program | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | |
| Root rot fungicides | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | |
| Weed control (herbicide) | | | | | | | ■ | ■ | ■ | ■ | ■ | | | | | | | |
| Weed control (Dacthal) | | | | ■ | | | | | ■ | ■ | | | | | | | | |
| Hand weeding (Wisconsin) | | | | | | | | ■ | ■ | ■ | ■ | ■ | | | | | | |
| Hand weeding (Michigan) | | | | | | | | | ■ | ■ | ■ | ■ | | | | | | |
| Roundup | | | | | | | | | | | | | | | | ■ | ■ | |
| Shade removed | | | | | | | | | | | | | | ■ | ■ | | | |
| Fertilization (soil sampling) | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ |
| **Years 2-3 (2-3 year old plants)** | **Mar** | | **Apr** | | **May** | | **Jun** | | **Jul** | | **Aug** | | **Sep** | | **Oct** | | **Nov** | |
| Plant emergence | | | | ■ | ■ | | | | | | | | | | | | | |
| Slug bait (diazinon) | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | | |
| Bloom | | | | | | | | ■ | ■ | | | | | | | | | |
| Pyrenones not widely used (toxic to bees) | | | | | | | | ■ | ■ | ■ | | | | | | | | |
| Shade cloth | | | | ■ | ■ | ■ | | | | | | | | | | | | |
| Fill gutters | | | | ■ | ■ | | | | | | | | | | | | | |
| Foliar fungicide program | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Root rot fungicides | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | |
| Weed control 2 year (herbicide) | | | | | | | ■ | ■ | ■ | ■ | | | | | | | | |
| Weed control (Dacthal) | | | | ■ | | | | | ■ | ■ | | | | | | | | |
| Hand weeding | | | | | | | | ■ | ■ | ■ | ■ | ■ | | | | | | |
| Roundup | | | ■ | | | | | | | | | | | | | ■ | ■ | |
| Shade removed | | | | | | | | | | | | | | ■ | ■ | | | |
| Fertilization (soil sampling) | | | | | | | | | | | | | | | ■ | ■ | ■ | ■ |

| Years 2-3 (2-3 year old plants) | Mar | | Apr | | May | | Jun | | Jul | | Aug | | Sep | | Oct | | Nov | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Bloom period | | | | | | | | | | | | | | | | | | |
| Seed harvested (3 year olds) | | | | | | | | | | | | | | | | | | |
| Straw removed prior to harvest (mechanical) | | | | | | | | | | | | | | | | | | |
| 3 year old roots harvested | | | | | | | | | | | | | | | | | | |
| **Years 4 and beyond (4 year and older plants)** | **Mar** | | **Apr** | | **May** | | **Jun** | | **Jul** | | **Aug** | | **Sep** | | **Oct** | | **Nov** | |
| Plant emergence | | | | | | | | | | | | | | | | | | |
| Slug bait (diazinon) | | | | | | | | | | | | | | | | | | |
| Bloom | | | | | | | | | | | | | | | | | | |
| Pyrenones not widely used (toxic to bees) | | | | | | | | | | | | | | | | | | |
| Shade cloth | | | | | | | | | | | | | | | | | | |
| Fill gutters | | | | | | | | | | | | | | | | | | |
| Foliar fungicide program | | | | | | | | | | | | | | | | | | |
| Root rot fungicides | | | | | | | | | | | | | | | | | | |
| Weed control (herbicide) | | | | | | | | | | | | | | | | | | |
| Weed control (Dacthal) | | | | | | | | | | | | | | | | | | |
| Hand weeding | | | | | | | | | | | | | | | | | | |
| Roundup | | | | | | | | | | | | | | | | | | |
| Shade removed | | | | | | | | | | | | | | | | | | |
| Fertiliztion (soil sampling) | | | | | | | | | | | | | | | | | | |
| Bloom period | | | | | | | | | | | | | | | | | | |
| Seed harvested | | | | | | | | | | | | | | | | | | |
| Straw removed prior to harvest (mechanical) | | | | | | | | | | | | | | | | | | |
| Roots harvested | | | | | | | | | | | | | | | | | | |

## TABLE 11. GENERAL TIMELINE OF DISEASE, INSECT, NEMATODE AND WEED PESTS

| Diseases | Apr | | May | | Jun | | Jul | | Aug | | Sep | | Oct | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Alternaria blight | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Botrytis blight | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Damping-off | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | | |
| Disappearing root rot | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Phytophthora | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Powdery mildew | | ■ | ■ | ■ | ■ | ■ | ■ | | | | | | | |
| Rusty root | | | | | | | | | | | | | | |
| Sclerotinia white mold | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Stromatinia black rot | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Verticillium wilt | | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| **Insects, etc.** | **Apr** | | **May** | | **Jun** | | **Jul** | | **Aug** | | **Sep** | | **Oct** | |
| Aphids | | | | | | | | ■ | ■ | ■ | | | | |
| Cutworms | | | ■ | ■ | ■ | | | | | | | | | |
| Four-lined plant bugs | | | | | | | | ■ | ■ | | | | | |
| Leaf rollers | | | | | ■ | ■ | ■ | | | | | | | |
| Millipedes | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | |
| Slugs | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | | |
| Spittle bugs | | | | | | ■ | ■ | ■ | ■ | ■ | ■ | | | |
| Treehoppers | | | | | | ■ | ■ | ■ | | | | | | |
| White grubs | | | ■ | ■ | ■ | | | | | | | | | |
| Wireworms | | | ■ | ■ | ■ | | | | | | | | | |
| **Nematodes** | **Apr** | | **May** | | **Jun** | | **Jul** | | **Aug** | | **Sep** | | **Oct** | |
| Root-knot nematode | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| **Weeds** | **Apr** | | **May** | | **Jun** | | **Jul** | | **Aug** | | **Sep** | | **Oct** | |
| Grasses | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Broadleaf weeds | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Raspberry (Michigan) | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Sedges | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Creeping jennie | | | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Dandelions | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Pigweed | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Lambsquarter | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |
| Thistles | | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ |
| Yellow nutsedge | | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | ■ | | |