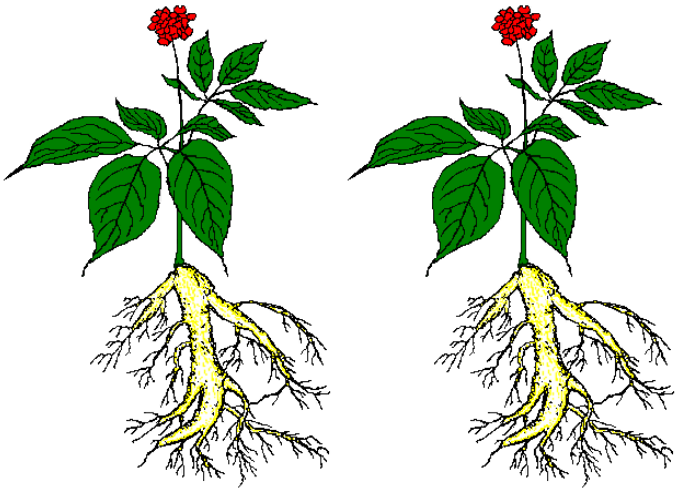
PEST MANAGEMENT IN THE FUTURE

A Strategic Plan for the Michigan and Wisconsin Ginseng Industry



Workshop Summary
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Holiday Inn Downtown Grand Rapids
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PREVIOUS PMSP

Dr. Mary Hausbeck, Department of Plant Pathology, Michigan State University, was approached by the Ginseng Board of Wisconsin in 2002 for guidance in indentifying and managing ginseng diseases. Michigan and Wisconsin ginseng industry representatives, researchers, and other stakeholders attended a meeting hosted by Dr. Hausbeck on April 13, 2004, in East Lansing, MI. As a result of this meeting, Dr. Hausbeck developed the first Pest Management Strategic Plan for the Michigan and Wisconsin Ginseng Industry. This PMSP was revised at similar meetings on April 12, 2007 in East Lansing, MI and on December 6, 2010 in Grand Rapids, MI. A fourth meeting was help on December 9th, 2013 in Grand Rapids, MI to again revise the Ginseng Pest Management Strategic Plan and provide an opportunity for the industry to redefine their priorities in light of recent research and pesticide registrations.

Ginseng research has resulted in publications which can be found at Dr. Hausbeck's website (http://veggies.msu.edu/Publications.html). These include four refereed scientific journal articles, seven abstracts, 25 Plant Disease Management Reports/Fungicide and Nematicide Tests, three graduate student theses and one dissertation.

Several of the pipeline pest management tools listed in the previous PMSPs are now either labeled for use on ginseng or currently in the IR-4 program for future registration. Chlorothalonil (Bravo Weather Stik), mancozeb (Dithane, Penncozeb), dimethomorph (Stature SC), fenamidone (Reason SC), fluazinam (Omega), Fludioxonil (Cannonball), were all previous IR-4 "A" priorities and are now fully labeled. Captan (captan) was an "A" priority and now has a nonfood use label. Cyprodinil/fludioxonil (Switch), penthiopyrad (Fontelis) and fluopicolide (Presidio) were recently labeled for use on ginseng using crop grouping data. Thiophanate-methyl (Topsin), also listed as an important pipeline tool has been available to growers under a 24(c) Special Local Need label.

Several of the educational needs from the 2010 PMSP were addressed over the past three years. From 2010 through 2013, a minimum of two educational programs per year have been presented with the aid of The Ginseng Board of Wisconsin. These educational programs have ranged from in-depth workshops on pathogen and insect biology to sprayer calibration and nozzle selection.

OUTCOMES

Listed below are the 2010 PMSP Research Priorities that, when discussed by ginseng growers at the 2013 PMSP meeting, were determined to be at least partially met.

RESEARCH:

1. **Identify new active ingredients (granular formulations whenever possible) effective against grubs, cutworms and wireworms to replace diazinon.**
   - Bifenthrin and carbaryl have been used by the industry as replacements with some success. A granular formulation of bifenthrin has been identified but is not registered on ginseng.
2. **Identify effective seed treatments.**
   - Growers have moved to using active ingredients that were shown to be effective against the various pathogens of ginseng. However, getting these products registered needs to continue to be a priority.

3. **Develop management strategies for root rot diseases, including *Phytophthora*, *Cylindrocarpon*, and *Fusarium*, especially during the harvest year.**
   - Forum SC, Cannonball WP, and Fontelis are now labeled on ginseng (including the harvest year) and have been widly adopted by the industry. Topsin M WSB is currently available for use due to a Special Local Needs 24(c) label for non-harvest years. Growers have adopted the addition of rocks to the gutters between beds to reduce splashing of infested water onto the ginseng plants.
4. **Investigate methods (cultural and chemical means) for increasing and stabilizing ginsenoside levels.**
   - Preliminary data is currently being analyzed.

REGULATORY:

1. **Broad spectrum fungicides (i.e., full label for thiophanate-methyl [Topsin, Special Local Need 24(c)], and additional chlorothalonil [Bravo] applications) are needed for use in an alternation program with strobilurin fungicides.**
   - Additional applications of chlorothalonil [Bravo] are now available through a Specal Local Needs 24(c) label. Protectant fungicides fluazinam [Omega] is also now labeled.
2. **Develop improved relations with the plant protection industry to facilitate needed information and product availability.**
   - Multiple new fungicides have been registered in since 2010, often with the direct help of registrants.

EDUCATIONAL:

1. **As new pest management products become available, information is needed regarding their activity and optimal use pattern.**
   - New product registration is highlighted at the winter and summer research meetings. When especially important new regisrations are granted, an email is sent to growers explaining the product and its uses.
2. **Continue educational workshops that highlight effective management programs, establish optimal application techniques, and pest identification.**
   - Research meetings are help twich per year, once in the summer and once in the winter.
3. **Develop fact sheets to identify pests and the resulting crop damage, describe the life stages of the pest, and provide control recommendations.**
   - A fact sheet has been completed and distributed to growers in regards to the following diseases: Fusarium root rot, Cylindrocarpon root rot, Alternaria blight, Botrytis blight, Phytophthora root rot and foliar blight, and Pythium root rot.
4. **Provide information and training on calibration of equipment and application techniques.**
   - Information, including hands on demonstrations, of correct sprayer calibration and setup have been presented at winter and summer research meetings.

The current and previous (archived) Ginseng Pest Management Strategic Plans are available online as pdf files at the North Central IPM Center (http://www.ncipmc.org/pmsp/). and at the national website for the Regional IPM Centers (http://www.ipmcenters.org/pmsp/index.cfm). Anyone wishing a complete copy of the previous PMSP document should contact the Director of the North Central IPM Center.

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TOP PRIORITIES OF THE GINSENG INDUSTRY

RESEARCH:

1. **Continue to test unregistered and experimental seed treatments for disease and insect control. Leverage experimental results into seed treatment labels for ginseng.**
2. **Determine what portion, if any, of the *Alternaria* spp. population are resistant to currently used fungicides. Test new, unregistered and experimental fungicides as possible replacement candidates for blight control.**
3. **Determine pesticide residue levels for the various chemicals based on application timing and/or the number of applications.**
4. **Identify new active ingredients (granular formulations whenever possible) effective against grubs, cutworms and wireworms to replace diazinon.**
5. **Develop management strategies, cultural and chemical, for root rot diseases, including *Phytophthora*, *Cylindrocarpon*, and *Fusarium*, especially during the harvest year.**
6. **Investigate methods (cultural and chemical means) for increasing and stabilizing ginsenoside levels.**
7. Identify effective postemergence and preemergence broad spectrum herbicides that are safe on ginseng.
8. Investigate combining pesticides and fertilizers for efficacy and crop safety.

REGULATORY:

1. **Harvest year applications are needed for (nonfood use labeled) products thiophanate-methyl (Topsin M WSB, Special Local Need 24(c)) and captan (Captan 80WDG, 50W).**
2. **Monitor MRLs (maximum residue limits) of chemicals used on ginseng for export to global trade partners and for import into the United States.**
3. Check on 2010 carrot/beet insecticide cyantraniliprole (HGW86) through IR-4 and whether registrant will allow ginseng on label via crop grouping.
4. Partner with IR-4 to speed registration of needed products for food use. Emphasize products labeled in the same crop grouping as ginseng to establish tolerance levels.
5. Use a nonfood use registration whenever possible to speed availability of needed products to the industry.
6. If the label for slug control product metaldehyde expires, determine necessary steps for continued use.
7. Maintain current protectant fungicide labels (Bravo, Dithane, etc.) for use during harvest year.

EDUCATIONAL:

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, establish optimal application techniques, and pest identification.**
3. Update fact sheets to identify pests and the resulting crop damage, describe the life stages of the pest, and provide control recommendations.

4. Determine if information sharing (pest identification, chemical use efficacy, nutrient programs) from other crops may be applicable to ginseng.
5. Provide information and training on calibration of equipment and application techniques.
6. Refine the optimal nutrient management program, including application methods and impact on disease susceptibility and ginsenoside levels.
7. Educate growers on new fertilization requirements from the State of Wisconsin.
8. Develop cover crop (including biofumigants) fact sheets for growers and/or provide educational seminars on cover crops.

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 early-May, 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 June or 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 125 growers cultivate 1,600 acres of ginseng, producing 500 to 3,000 lb/acre which represents 10% of the world's supply of ginseng root. At an approximate average of $60-$100/lb, ginseng is a high value crop for Wisconsin, totaling approximately $75 to $100 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. Compared to Wisconsin, 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 $100 per green pound and $450 per dry pound. Canada is also a significant producer of ginseng with approximately 8,000 acres grown in 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 is highly conducive to disease, including reduced air movement, increased relative humidity, and increased duration of leaf wetness. 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 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., Roper, Bravo) to delay the development of pathogen resistance. Mancozeb (Roper) 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 had been available to ginseng growers through yearly Specific Exemptions to Section 18 of FIFRA or through a state-issued crisis exemption until recent years, after which these products have gained full use labels. Boscalid (Endura) is now an industry standard for the control of Alternaria blight and is widely used by growers in rotation with protectants. In recent years, fludioxonil + cyprodinil (Switch) and fluazinam (Omega) have gained registration for use on ginseng and are used by some growers, despite their high cost.

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 fruits leads to discoloration, followed by abortion of these plant parts or infection of the developing seeds. Without fungicides to protect against Botrytis blight, growers could lose up to 80 to 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). 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 which 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 resistances 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 would be killed with such a mixture, the remaining fungicide-resistant conidia would not be completely controlled. Surviving resistant conidia would 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) is labeled 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 was available through a Specific Exemption to Section 18 of FIFRA for use on *Alternaria* in Michigan and Wisconsin for 2007-08 and was labeled in 2009. Michigan State University has conducted numerous trials over several years and demonstrated that chlorothalonil is a superior product for *B. cinerea* control. Newly registered fungicides fludioxonil + cyprodinil (Switch) and fluazinam (Omega) have shown to be effective *Botrytis* control products. 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). The powdery mildew pathogen overwinters 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 are caused by *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).

Preemergence damping-off and postemergence seedling root rot, especially of 1- and 2-year-old ginseng plants, are caused by soilborne fungi, *Fusarium* spp. and *R. solani*, and soilborne fungal-like oomycete pathogens, *Pythium* spp. and *P. cactorum* (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 pathogens 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 pathogen attacks at the soil line after the seedling emerges from the soil. Wilting of the seedlings 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 oomycete 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. It 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 *P. cactorum* to build up to high levels rapidly. This pathogen may also be seedborne.

Metalaxyl (Ridomil 2E) or mefenoxam (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 mancozeb (Dithane) are inadequate against this oomycete pathogen when disease pressure is moderate to severe; oomycete pathogens require a pesticide that specifically targets them. A protectant such as mancozeb will provide limited suppression of the foliar phase of disease, but under moderate to heavy disease pressure will not provide commercial control. *Phytophthora* spp., in general, affect a number of crops and

in those situations, pesticides specific for oomycete pathogens have been needed to avert epidemics.

In 2003, Michigan State University received diseased ginseng roots from growers in Michigan and Wisconsin, and over 100 *P. cactorum* isolates were obtained these plants. These isolates have been screened for resistance to the fungicide mefenoxam (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 catastrophic losses. 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, and symptoms often appear later in the season when plants become senescent. Ginseng leaves wilt and droop parallel to the stem, and the plant eventually dies. Roots remain firm, but the vascular tissue is discolored yellow. *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 can infect all underground plant parts causing near total destruction. *Cylindrocarpon destructans* initially infects near the root tip, and progresses upwards until most of the root is diseased. 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, few registered fungicides are 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 to 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 to 72 hours of wetness to infect, and disease can develop rapidly at 20 to 25°C. Mycelium can spread between plant parts that are in contact (Howard, et al., 1994).

Stromatinia black rot is caused by the fungus, *Stromatinia panacis*, which also infects 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), which often results in premature yellowing and death of the above-ground plant parts (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 appearing 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 wilting of the leaves. *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 to 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 to 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 about the size of a small pin head 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). Current cultural and chemical production methods have controlled nemitodes in ginseng.

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 petroleum 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 petroleum 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. They affect seed crops by causing damage to seed clusters. Aphids are not a problem in Michigan.

Organophospate insecticides registered for aphids:

- Diazinon (Diazinon AG500, Diazinon AG600 WBC): Efficacy – unknown. Restricted use pesticide. Highly toxic to bees and other beneficial insects.

Carbamate insecticides registered for aphids:

- None identified.

Other insecticides registered for aphids:

- Azadirachtin (Aza-Direct, AzaSol, Ecozin Plus 1.2%ME, Molt-X, Nemazad 1%EC, Neemix 4.5): Efficacy – potentially fair to poor, feeding repellent. Not tested on ginseng. Classified as a biopesticide. Not used by growers. Not expected to harm nontarget organisms; do not apply when honeybees are foraging.
- Azadirachtin + Pyrethins (Azera): Efficacy unknown. Not tested on ginseng. Classified as a biopesticide. Not used by growers. Not expected to harm nontarget organisms; do not apply when honeybees are foraging.
- *Beauveria bassiana* (BotaniGard ES, Mycotrol O): Efficacy – unknown on ginseng. Classified as a biopesticide. Potential to harm bees; do not apply when bees are foraging.
- Bifenthrin (Brigade WSB, Bifenture 10DF [MI only], Aceto Bifenthrin 2EC, Bifen 2 AG Gold, Bifenture EC, Brigade 2EC, Fanfare 2EC, Sniper, Tailgunner, Z-Bifenthrin 2EC [WI only]): Efficacy – unknown on ginseng. Restricted use pesticide. Toxic to bees.
- Deltamethrin (Battalion 0.2EC, Battalion 1.5EC [MI ONLY], Delta Gold 1.5EC [MI ONLY]): Efficacy – unknown. Classified as an organophosphate alternative. Restricted use pesticide. Highly toxic to bees.
- Flonicamid (Beleaf 50SG): Efficacy -good. Classified as an organophosphate alternative. Do not contaminate or apply to water.
- Imidacloprid (Admire PRO Systemic Protectant, Agri Star Impulse 1.6 FL, Agri Star Macho 2.0 FL, Agrisolutions Advise 2FL, Alias 2F Flowable, Bayer Advanced Fruit Citrus & Vegetable Insect Control Concentrate, Couraze 1.6F, Couraze 2F, Couraze 4F, Imida E-AG 1.6 F, Malice 75 WSP, Midash 2SC AG, Montana 2F, Montana 4F, Nuprid 1.6F, Nuprid 2F, Nuprid 2SC Soil/Foliar, Nuprid 4.6F Pro, Pasada 1.6 F Flowable, Prey 1.6, Provado 1.6 Flowable, Sherpa, Widow): Efficacy – Good. Not tested on ginseng. Classified as an organophosphate alternative. Highly toxic to bees.
- Neem oil (Trilogy): Efficacy – unknown on ginseng. Classified as a biopesticide. Toxic to bees.
- Petroleum oil (Glacial Spray Fluid, Prescription Treatment Ultra-Pure Oil): Efficacy – unknown on ginseng. Do not contaminate or apply to water.
- Pyrethrins (Pyrenone Crop Spray, Evergreen Crop Protection EC 60-6, Prentox Pyronyl Crop Spray, Pres Treat Brand Pyreth-it Formula 2): Efficacy – potentially

good. Not tested on ginseng. Only foliar insecticide used. Do not contaminate or apply to water.

- Pyrethrins/piperonyl butoxide (Bug Buster-O, PyGanic Crop Protection EC 1.4 II, PyGanic Crop Protection EC 5.0 II): Efficacy – unknown on ginseng. Highly toxic to honeybees; suggests there may be nontarget insect concerns.
- Thiamethoxam (Actara, Platinum, Platinum 75SG): Efficacy – good. Classified as an organophosphate alternative. Toxic to wildlife.
- Zeta-cypermethrin (Mustang, Mustang Max, Mustang Max EC, Mustang Max EW, Respect, Respect EC, Steed): Efficacy – unknown on ginseng. Classified as an organophosphate alternative. Restricted use pesticide. Highly toxic to honeybees.
- Zeta-cypermethrin/bifenthrin (Hero, Hero EW): Efficacy – unknown on ginseng. Restricted use pesticide. Highly toxic to honeybees. Zeta-cypermethrin is classified as an organophosphate alternative.
- Zeta-cypermethrin/bifenthrin/imidacloprid (Triple Crown): Efficacy – unknown on ginseng. Restricted use pesticide. Highly toxic to honeybees.

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.
- Sulfloxoflor(Closer) Test efficacy and safety.

"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.
- Wisconsin Department of Agriculture Newsletter publishes state insect scouting.

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 troublesome pest in seedling beds. Cutworms are a problem in Wisconsin in spring.

Organophospate insecticides registered for cutworms:

- Chlorpyrifos (Lorisban 15G) Efficacy – good. Labeled on Wi as a Special Local Need 24c until 2016.

Carbamate insecticides registered for cutworms:

- Carbaryl (Drexel Carbaryl 4L, Sevin Brand 4F, Sevin Brand XLR Plus, Lebanon Sevin 7G): Efficacy – unknown. Very high acute toxicity to honey bees.

Other insecticides registered for cutworms:

- Azadirachtin (Aza-Direct, AzaSol, Ecozin Plus 1.2%ME, Molt-X, Nemazad 1%EC, Neemix 4.5): Efficacy – potentially poor. Not tested on ginseng. Classified as a biopesticide. Not expected to harm nontarget organisms; do not apply when honeybees are foraging.
- Bifenthrin (Bifen 2 AG Gold [MI only], Bifenture EC, Brigade 2EC, Brigade WSB, Fanfare 2EC, Sniper): Efficacy – unknown on ginseng. Restricted use pesticide. Toxic to bees.
- Chloropicrin (Chlor-O-Pic): Efficacy – unknown on ginseng. Restricted use pesticide. Do not contaminate or apply to water.
- Cyfluthrin (Baythroid XL, Renounce 20WP [WI ONLY], Tombstone, Tombstone Helios): Efficacy – unknown on ginseng. Restricted use pesticide. Highly toxic to bees; do not apply when bees are actively foraging. Do not contaminate or apply to water.
- Deltamethrin (Battalion 0.2EC, Battalion 1.5EC [MI ONLY], Delta Gold 1.5EC [MI ONLY]): Efficacy – unknown. Classified as an organophosphate alternative. Restricted use pesticide. Highly toxic to bees.
- Methoxyfenozide (Intrepid 2F): Efficacy – unknown on ginseng. Classified as a reduced-risk pesticide. Do not contaminate or apply to water.
- Pyrethrins (Pyrenone Crop Spray, Evergreen Crop Protection EC 60-6, Prentox Pyronyl Crop Spray, Pres Treat Brand Pyreth-it Formula 2): Efficacy – unknown on ginseng. Do not contaminate or apply to water.
- Zeta-cypermethrin (Mustang, Mustang Max, Mustang Max EC, Mustang Max EW, Respect, Respect EC): Efficacy – unknown on ginseng. Classified as an organophosphate alternative. Restricted use pesticide. Highly toxic to honeybees.
- Zeta-cypermethrin/bifenthrin (Hero, Hero EW, Steed): Efficacy – unknown on ginseng. Restricted use pesticide. Highly toxic to honeybees. Zeta-cypermethrin is classified as an organophosphate alternative.
- Zeta-cypermethrin/bifenthrin/imidacloprid (Triple Crown): Efficacy – unknown on ginseng. Restricted use pesticide. Highly toxic to honeybees.

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 on ginseng. Not tested on ginseng. Classified as a restricted use pesticide. 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.
- Determine if onion (maggot) seed treatments are safe and effective for use on ginseng seeds.
- Test insecticidal baits.
- Determine effects of cover crops on cutworm pressure.

Regulatory needs for cutworms:

- Retain the use of diazinon for ginseng production until cost effective and safe replacements are identified and registered.
- Determine MRL issue for individual pesticides.

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. They are not a significant problem in Wisconsin and Michigan, but become a problem if there is an outbreak. Four-lined plant bugs can possibly be a problem associated with an alfalfa rotation.

Organophospate insecticides registered for four-lined plant bugs:

- Diazinon (Diazinon AG500, Diazinon AG600 WBC): Efficacy – unknown on ginseng. Restricted use pesticide. Highly toxic to bees and other beneficial insects.

Carbamate insecticides registered for four-lined plant bugs:

- Carbaryl (Drexel Carbaryl 4L, Sevin Brand 4F, Sevin Brand XLR Plus): Efficacy – unknown on ginseng. Very high acute toxicity to honey bees.

Other insecticides registered for four-lined plant bugs:

- Azadirachtin (Aza-Direct, AzaSol, Ecozin Plus 1.2%ME, Neemazad 1%EC [MI only], Neemix 4.5): Efficacy – unknown on ginseng. Not tested on ginseng. Classified as a biopesticide. Acts as a feeding repellent. Not expected to harm nontarget organisms; do not apply when honeybees are foraging.
- *Beauveria bassiana* (BotaniGard ES, Mycotrol O): Efficacy – unknown on ginseng. Classified as a biopesticide. Potential to harm bees; do not apply when bees are foraging.
- Deltamethrin (Battalion 0.2EC, Battalion 1.5EC [MI ONLY], Delta Gold 1.5EC [MI ONLY]): Efficacy – unknown. Classified as an organophosphate alternative. Restricted use pesticide. Highly toxic to bees.
- Flonicamid (Beleaf 50SG): Efficacy – unknown on ginseng. Classified as an organophosphate alternative. Do not contaminate or apply to water.
- Pyrethrins (Pyrenone Crop Spray, Evergreen Crop Protection EC 60-6, Prentox Pyronyl Crop Spray, Pres Treat Brand Pyreth-it Formula 2): Efficacy – good. Do not contaminate or apply to water.
- Pyrethrins/piperonyl butoxide (Bug Buster-O, PyGanic Crop Protection EC 1.4 II, PyGanic Crop Protection EC 5.0 II): Efficacy – unknown on ginseng. Highly toxic to honeybees; suggests there may be nontarget insect concerns.
- Zeta-cypermethrin (Mustang, Mustang Max, Mustang Max EC, Mustang Max EW, Respect, Respect EC, Steed): Efficacy – unknown on ginseng. Classified as an organophosphate alternative. Restricted use pesticide. Highly toxic to honeybees.
- Zeta-cypermethrin/bifenthrin (Hero, Hero EW): Efficacy – unknown on ginseng. Restricted use pesticide. Highly toxic to honeybees. Zeta-cypermethrin is classified as an organophosphate alternative.

- Zeta-cypermethrin/bifenthrin/imidacloprid (Triple Crown): Efficacy – unknown on ginseng. Restricted use pesticide. Highly toxic to honeybees.

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*)

Leaf rollers 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 shelter in the rolled leaf at night.

Organophospate insecticides registered for leaf rollers:

- None identified.

Carbamate insecticides registered for leaf rollers:

- None identified.

Other insecticides registered for leaf rollers:

- Azadirachtin (Aza-Direct, AzaSol, Ecozin Plus 1.2%ME, Molt-X, Neemix 4.5): Efficacy – potentially poor. Not tested on ginseng. Classified as a biopesticide. Not expected to harm nontarget organisms; do not apply when honeybees are foraging.
- Pyrethrins (Pyrenone Crop Spray, Evergreen Crop Protection EC 60-6, Prentox Pyronyl Crop Spray, Pres Treat Brand Pyreth-it Formula 2): Efficacy – good. Do not contaminate or apply to water.
- Pyrethrins/piperonyl butoxide (Bug Buster-O, PyGanic Crop Protection EC 1.4 II, PyGanic Crop Protection EC 5.0 II): Efficacy – unknown on ginseng. Highly toxic to honeybees; suggests there may be nontarget insect concerns.

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.
- Add pyrethroids to list of products.

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)

Millipedes are commonly observed in ginseng gardens and are 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. Millipedes are a problem in Wisconsin, especially on seed.

Organophospate insecticides registered for millipedes:

- None identified.

Carbamate insecticides registered for millipedes:

- Carbaryl (Lebanon Sevin 7G): Efficacy – low. Very high acute toxicity to honey bees.

Other insecticides registered for millipedes:

- None identified.

Other pest management aids for millipedes:

- Pyrethrins (Pyrenone Crop Spray, Evergreen Crop Protection EC 60-6, Prentox Pyronyl Crop Spray, Pres Treat Brand Pyreth-it Formula 2): Efficacy – poor to fair. Do not contaminate or apply to water.
- Pyrethrins/piperonyl butoxide (Bug Buster-O, PyGanic Crop Protection EC 1.4 II, PyGanic Crop Protection EC 5.0 II): Efficacy – poor to fair. Highly toxic to honeybees; suggests there may be nontarget insect concerns.

Pipeline pest management tools for millipedes:

- Chlorpyrifos (Empire, Lorsban): Efficacy – unknown on ginseng. MRL issues.
- Diazinon (Diazinon AG500, Diazinon AG600 WBC): Efficacy – unknown on ginseng. Not labeled for use on millipedes. Highly toxic to bees and other beneficial insects.

"To do" list for millipedes:

Research needs for millipedes:

- Pyrethroids test efficacy

Regulatory needs for millipedes:

-

Educational needs for millipedes:

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

6. SPITTLE BUGS (Family Cercopidae)

Spittle bugs can be an occasional problem in Michigan ginseng production in woodlots, but are less of a problem in Wisconsin. These insects can destroy the flower head and damage the seed.

Organophospate insecticides registered for four-lined plant bugs:

- Diazinon (Diazinon AG500, Diazinon AG600 WBC): Efficacy – unknown. Restricted use pesticide. Highly toxic to bees and other beneficial insects.

Carbamate insecticides registered for four-lined plant bugs:

- Carbaryl (Drexel Carbaryl 4L, Sevin Brand 4F, Sevin Brand XLR Plus): Efficacy – unknown on ginseng. Very high acute toxicity to honey bees.

Other insecticides registered for four-lined plant bugs:

- Azadirachtin (Aza-Direct, AzaSol, Ecozin Plus 1.2%ME, Molt-X, Neemazad 1%EC [MI only], Neemix 4.5): Efficacy – unknown. Not tested on ginseng. Classified as a biopesticide. Acts as a feeding repellent. Not expected to harm nontarget organisms; do not apply when honeybees are foraging.
- *Beauveria bassiana* (BotaniGard ES, Mycotrol O): Efficacy – unknown on ginseng. Classified as a biopesticide. Potential to harm bees; do not apply when bees are foraging.
- Deltamethrin (Battalion 0.2EC, Battalion 1.5EC [MI ONLY], Delta Gold 1.5EC [MI ONLY]): Efficacy – unknown. Classified as an organophosphate alternative. Restricted use pesticide. Highly toxic to bees.
- Flonicamid (Beleaf 50SG): Efficacy – unknown on ginseng. Classified as an organophosphate alternative. Do not contaminate or apply to water.
- Pyrethrins (Pyrenone Crop Spray, Evergreen Crop Protection EC 60-6, Prentox Pyronyl Crop Spray, Pres Treat Brand Pyreth-it Formula 2): Efficacy – good. Do not contaminate or apply to water.
- Pyrethrins/piperonyl butoxide (Bug Buster-O, PyGanic Crop Protection EC 1.4 II, PyGanic Crop Protection EC 5.0 II): Efficacy – unknown on ginseng. Highly toxic to honeybees; suggests there may be nontarget insect concerns.
- Zeta-cypermethrin (Mustang, Mustang Max, Mustang Max EC, Mustang Max EW, Respect, Respect EC, Steed): Efficacy – unknown on ginseng. Classified as an organophosphate alternative. Restricted use pesticide. Highly toxic to honeybees.
- Zeta-cypermethrin/bifenthrin (Hero, Hero EW, Steed): Efficacy – unknown on ginseng. Restricted use pesticide. Highly toxic to honeybees. Zeta-cypermethrin is classified as an organophosphate alternative.

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.

7. WHITE GRUBS (Family Scarabidae)

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

Organophospate insecticides registered for white grubs:

- Diazinon (Diazinon AG500, Diazinon AG600 WBC): Efficacy – good. Widely used by growers. Not labeled for white grubs. Restricted use pesticide. Highly toxic to bees and other beneficial insects.

Carbamate insecticides registered for white grubs:

- Carbaryl (Lebanon Sevin 7G): Efficacy – unknown on ginseng. Very high acute toxicity to honey bees. Note: Grubs are on label but not under ginseng pest.

Other insecticides registered for white grubs:

- Chloropicrin (Chlor-O-Pic): Efficacy – unknown on ginseng. Restricted use pesticide. Do not contaminate or apply to water.
- Imidacloprid (Admire, Provado): Efficacy – unknown on ginseng. Classified as an organophosphate alternative. White grubs not on label. Highly toxic to bees.

Other pest management aids for white grubs:

- None identified.

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.
- Test efficacy of granular formulation of imidacloprid (organophosphate alternative).
- Test efficacy of bifenthrin.
- 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.
- Develop pest identification tools.
- Determine residue for products based on year of use.

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.
- Educate growers on life cycle and feeding patterns.

8. WIREWORMS (Family Elateridae)

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

B2 carcinogenic insecticides registered for wireworms:

- 1,3-Dichloropropene (Telone EC [MI only], Telone II): Efficacy – potentially good. Not tested on ginseng. Classified as a partial methyl bromide alternative. Expensive. Restricted use pesticide. Moderate acute toxicity to bees.
- 1,3-Dichloropropene/chloropicrin (In-Line [MI only], Pic-C60, Telone C-17, Telone C-35): Efficacy – potentially good. Not tested on ginseng. Classified as a partial methyl bromide alternative by IR-4. Expensive. Restricted use pesticide. Moderate acute toxicity to bees.

Organophospate insecticides registered for wireworms:

- Diazinon (Diazinon AG500, Diazinon AG600 WBC): Efficacy – good. Used widely by growers. Wireworms not on label. Restricted use pesticide. Highly toxic to bees and other beneficial insects.

Carbamate insecticides registered for wireworms:

- Carbaryl (Lebanon Sevin 7G): Efficacy – unknown on ginseng. Wireworms not on label. Very high acute toxicity to honey bees.

Other insecticides registered for wireworms:

- Chloropicrin (Chlor-O-Pic, Nutrapic [MI only], Pic-C100): Efficacy – unknown on ginseng. Restricted use pesticide. Do not contaminate or apply to water.
- Imidacloprid (Admire, Provado): Efficacy – unknown. Classified as an organophosphate alternative. Wireworms not on label. Highly toxic to bees.

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.

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.
- Determine if previous corn/grass plantings increase wireworm populations.
- Test efficacy of fipronil (organophosphate alternative).
- Research efficacy of cover crops grown in the year prior to planting.

Regulatory needs for wireworms:

- None identified.

Educational needs for wireworms:

- None identified.

9. SLUGS (Order Anaspidea)

Slugs are considered to be one of the top insect/invertebrate problems. Ragged holes in the leaves and mucus trails are characteristic of slug feeding. Most slugs feed at night.

Organophospate insecticides registered for slugs:

- None identified.

Carbamate insecticides registered for slugs:

- None identified.

Other insecticides registered for slugs:

- Metaldehyde (Blue Bombshell Metaldehyde Bait, Deadline Bullets, Deadline M-PS Mini-pellets, Durham Metaldehyde Granules 7.5, Hi-yield Slug & Snail Bait, Metarex 4% Snail and Slug Bait, Ortho Bug-geta Snail & Slug Killer 1): Efficacy – good. Widely used by growers and applied monthly during the growing season. Do not contaminate or apply to water.
- Sodium Ferric EDTA (IronFist Slug, Snail Bait): Efficacy – poor -fair. 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.
- 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. Diatomaceous earth 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.
- Set tolerance of metaldehyde for EPA (IR-4 residue studies).
- Test efficacy of liquid metaldehyde (Slug-Fest)
- Research efficacy of iron phosphate (biopesticide).
- Research efficacy and phytotoxicity issues of copper hydroxide.

Regulatory needs for slugs:

- Another form of metaldehyde (Trail's 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.

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. Alternaria blight is a serious problem yearly in Michigan and Wisconsin.

B2 carcinogenic fungicides registered for Alternaria blight:

- Chlorothalonil (Bravo Weather Stik 6SC, Chloronil 720, Equus 720 SST, Echo 720): Efficacy – good to excellent. Maximum applications used. Extra applications of Bravo Weather Stik SC available for non food use with Special Local Need 24(c) label. Relatively nontoxic to honeybees.
- Iprodione (Iprodione 4L AG, Nevado 4F [MI only], Rovral 4FL, Meteor): Efficacy – fair. Documented pathogen resistance makes this a risky product to use. Two applications used per year. 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. Relatively nontoxic to bees.
- Mancozeb (Dithane F-45 Rainshield, Dithane M-45, ManKocide, Manzate Max Fungicdie, Penncozeb 4FL, Penncozeb 75DF, Penncozeb 80WP, Roper DF Rainshield): Efficacy – fair to good. Maximum applications used. Used in Michigan and Wisconsin. Practically nontoxic to honeybees.

Other fungicides registered for Alternaria blight:

- Aluminum tris (Aliette WDG, Linebacker 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. Practically nontoxic to honeybees.
- Azoxystrobin (Quadris F, Satori): Efficacy – fair -excellent. Classified as a reduced-risk pesticide. Widely used. Maximum applications 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*. Low acute/chronic toxicity to birds, mammals, bees.
- *Bacillus pumilus* (Sonata): Efficacy – poor on other crops. Classified as a biopesticide. No adverse environmental effects to nontarget organisms.
- *Bacillus subtilis* (Serenade ASO, Serenade Max, Cease): Efficacy – poor. Classified as a biopesticide. Not typically used by growers. No adverse environmental effects except bees need more tests; do not apply when bees are actively foraging.
- Boscalid (Endura): Efficacy – excellent. Classified as a reduced-risk pesticide. Expand studies regarding its efficacy and overall crop safety. Maximum applications used. Needs to be used in a program with a rotational partner to delay the development of resistance. Do not contaminate or apply to water.
- Copper ammonium complex (Copper-Count-N): Efficacy – fair to good. Phytotoxicity can be a problem. Label states that it must be tank mixed with product that contains iprodione. Tank mixes with Aliette are a concern. Do not contaminate or apply to water.

- Copper hydroxide (Agri Star Nu-Cop 3L, Agri Star Nu-Cop 50DF, Agri Star Nu-Cop HB, Champ Dry Prill, Champ Formula 2 Flowable**,** Champion WP**,** DuPont Kocide 2000 54DF, DuPont Kocide 3000 46DF): Efficacy – poor to fair. 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. Do not contaminate or apply to water.
- Copper octanoate (Bonide Liquid Copper, Cueva, Natural Guard Copper Soap): Efficacy – fair to poor. Used in early season when disease pressure is not as high. Limited efficacy on significant disease pressure. Do not contaminate or apply to water.
- Copper oxychloride/copper hydroxide (Badge SC, Badge X_2): Efficacy – poor to fair. Do not contaminate or apply to water.
- Copper sulfate (Cuprofix Ultra 40D Disperss): Efficacy – fair. Used in early season when disease pressure is not as high. Do not contaminate or apply to water.
- Cyprodinil/fludioxonil (Switch 62.5WG): Efficacy – good. Maximum applications used. Classified as a reduced-risk pesticide. Expensive when compared to other products highly used within the industry. Do not contaminate or apply to water.
- Fenamidone (Reason 500SC): Efficacy – poor. Labeled for suppression only. Classified as a reduced-risk pesticide. Further research in *Alternaria*-only trial needed. Used primarly for *Phytophthora* control. Do not contaminate or apply to water.
- Fluazinam (Omega 500F): Efficacy – good. Classified as a reduced-risk pesticide. Expensive. Cost prohibited. Max of three apps used. Do not contaminate or apply to water.
- Fludioxonil (Cannonball 50WP): Efficacy – fair. Maximum applications used. Distribution issues have been eased. Classified as a reduced-risk pesticide. *Alternaria* not on label. Do not contaminate or apply to water.
- Fluxapyroxad/pyraclostrobin (Merivon Xemium Brand Fungicide): Efficacy – good. Newly registered and not yet commercially used. Preliminary date from experiments showed good efficacy. Supplimental label expires Sep, 2016.
- Hydrogen dioxide (OxiDate): Efficacy – poor. Classified as a biopesticide. Not used by growers. Highly toxic to bees and other beneficial insects; do not apply when bees are active.
- Neem oil (Gantec GREEN): Efficacy – poor. Classified as a biopesticide. Not typically used by growers. Toxic to bees.
- Penthiopyrad (Fontelis): Efficacy – good to fair. Low rate found to be as efficient as high rate and allows for more applications. Maximum number of application is currently being used by industry. To delay the development of resistance, this fungicide needs to be used in alternation with a fungicide with a different mode of action. Do not contaminate or apply to water.
- Pyrimethanil (Scala): Efficacy - Good. Newly labeled and growers are beginning to adopt into spray program. Three applications on label. Classified as a reduced-risk fungicide.

- Polyoxin D zinc salt (Ph-D WDG, Veranda O, Affirm WDG): Efficacy – good to fair. Classified as a biopesticide. Can serve as a rotational product for the strobilurins. Previous toxicity to crops in subsequent years has prevented use. Not widely available. No toxicity to insects. Needs more research.
- Pyraclostrobin (Cabrio 20EG): Efficacy – good to excellent. 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. Growers rotate this product with Bravo. Do not contaminate or apply to water.
- *Streptomyces lydicus* (Actinovate AG): Efficacy – poor. Classified as a biopesticide. No adverse environmental effects to nontarget organisms.
- Trifloxystrobin (Flint 50WG, Gem 500SC): Efficacy – good to excellent. Classified as a reduced-risk pesticide. 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. Need to test for *Cylindrocarpon*. Low toxicity to honeybees. Do not contaminate or apply to water.

Other pest management aids for Alternaria blight:

- Limit garden size to enhance airflow and movement to reduce the environmental conditions that favor disease development.
- Monitor the environment and treat preventively when environmental conditions favor disease development.
- Using newer and more effective TOM-CAST products.
- Ginseng is never planted again at the same site.

Pipeline pest management tools for Alternaria blight:

- Pyraclostrobin/boscalid (Pristine 38WG): Efficacy – good to excellent. Discuss possible label amendment with registrant on ginseng addition. Boscalid classified as a reduced-risk pesticide.
- Difenoconazole (Inspire): Efficacy – excellent. IR-4 residue field studies are completed. Further research needed on effects on plant and plant derivatives. Difenoconazole is registered with other products as a pre-pack (i.e., Quadris Top, Revus Top).
- Famoxadone/Cymoxanil (Tanos) Efficacy - fair. IR-4 residue field studies are completed.

"To do" list for Alternaria blight:

Research needs for Alternaria blight:

- Test straw types and crop residues as hosts for *Alternaria*. Test straw to determine if they introduce *Alternaria* into gardens. Test various straw types on there ability to aid in the overwintering of *Alternaria*. Straw types most commonly used are wheat and barley.
- Test Bayer (Luna based) products for efficacy and registrants.
- *Alternaria* species and their relation to resistance to fungicides.
- Test safety and efficacy of polyoxin D zinc salt for harvest year.

Regulatory needs for Alternaria blight:

- Extra applications of registered products are needed for the year of harvest. This is a top priority among ginseng growers.
- Special Local Needs 24C label for extra Bravo applications will expire in 2017.
- Emphasis the importance to the industry of protectant fungicides (Dithane, Bravo, Captan).

Educational needs for Alternaria blight:

- Develop web site with disease identification assistance and new information.
- As disease forecasting systems or other management tools are developed, provide workshops and demonstration plots. Increase the use of technology to monitor environmental conditions and disease epidemiology.
- Emphasize the importance of alternating fungicides in a program, especially when using azoxystrobin, pyraclostrobin or trifloxystrobin. Include information on products that have multiple active ingredents.

2. BOTRYTIS BLIGHT (*Botrytis cinerea*)

This 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. Botrytis blight is a big concern for growers.

B2 carcinogenic fungicides registered for Botrytis blight:

- Captan (Drexel Captan 50W, Captan 50WP, Captan 80WDG): Efficacy – good to fair. Available for nonfood use only. Relatively nontoxic to insects.
- Chlorothalonil (Bravo Weather Stik 6SC, Chloronil 720, Echo 720, Equus 720 SST): Efficacy – good to excellent. Classified as a B2 carcinogen. Relatively nontoxic to honeybees. Must be applied preventively and frequently when weather favors disease. Extra applications of Bravo Weather Stik SC available for non-food use with Special Local Need 24(c) label.
- Iprodione (Iprodione 4L AG, Nevado 4F [MI only], Rovral 4FL, Meteor): 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. *Botrytis* not on label. Relatively nontoxic to bees.
- Mancozeb (Dithane F-45 Rainshield, Dithane M-45, ManKocide, Manzate Max Fungicdie, Penncozeb 4FL, Penncozeb 75DF, Penncozeb 80WP, Roper DF Rainshield): Efficacy – fair. *Botrytis* not on label. Most often used for *Alternaria* control. Practically nontoxic to honeybees.

Other fungicides registered for Botrytis blight:

- Azoxystrobin (Quadris F): Efficacy – fair. Classified as a reduced-risk pesticide. *Botrytis* not on label. 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. Low acute/chronic toxicity to birds, mammals, bees.
- *Bacillus amyloliquefaciens* (Double Nickle 55, Double Nickle LC [WI Only]): Efficacy – unknown. Classified as a biopesticide. Not used by growers. No adverse

environmental effects except bees need more tests; do not apply when bees are actively foraging.

- *Bacillus subtilis* (Serenade ASO, Serenade Max WP): Efficacy – poor. Classified as a biopesticide. Not used by growers. No adverse environmental effects except bees need more tests; do not apply when bees are actively foraging.
- Boscalid (Endura): Efficacy – good. *Botrytis* not on label. Classified as a reduced-risk pesticide. Needs to be used in a program with a rotational partner to delay the development of resistance. Do not contaminate or apply to water.
- Copper hydroxide (Agri Star Nu-Cop 3L, Agri Star Nu-Cop 50DF, Agri Star Nu-Cop HB, Champ Dry Prill, Champ Formula 2 Flowable**,** Champion WP**,** DuPont Kocide 2000 54DF, DuPont Kocide 3000 46DF): Efficacy – fair. *Botrytis* not on label. Not used for *Botrytis* control. Do not contaminate or apply to water.
- Copper octanoate (Bonide Liquid Copper, Cueva, Natural Guard Copper Soap: Efficacy – fair (Michigan). Not used in Wisconsin. Do not contaminate or apply to water.
- Cyprodinil/fludioxonil (Switch 62.5WG): Efficacy – fair. Classified as a reduced-risk pesticide. *Botrytis* not on label. Do not contaminate or apply to water.
- 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. Practically nontoxic to honeybees.
- Fluazinam (Omega 500F): Efficacy – good. Classified as a reduced-risk pesticide. Do not contaminate or apply to water. Cost prohibited.
- Fludioxonil (Cannonball 50WP): Efficacy – fair. Classified as a reduced-risk pesticide. *Botrytis* not on label. Do not contaminate or apply to water.
- Neem oil (Trilogy): Efficacy – poor. Classified as a biopesticide. Toxic to bees.
- Penthiopyrad (Fontelis): Efficacy – poor in greenhouse studies. Classified as reduced-risk.
- Polyoxin D zinc salt (Ph-D WDG, Veranda O, Affirm WDG): 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. No toxicity to insects. Concerns about phytotoxicity. Not widely available and not used.
- Pyraclostrobin (Cabrio): Efficacy – fair. *Botrytis* not on label. Do not contaminate or apply to water.
- Pyrimehtanil (Scala): Efficacy – unknown. Newly labeled and growers are beginning to adopt into spray program. Classified as reduced-risk fungicide.
- Reynoutria sachalinensis (Regalia Biofungicide): Efficacy – unknown. Not used by growers. Classified as a biopesticide. Not shown to be effective when tested against *Botryis* on other crops.
- *Streptomyces lydicus* (Actinovate AG): Efficacy – unknown/poor on other crops. Classified as a biopesticide. No adverse environmental effects to nontarget organisms.

- Trifloxystrobin (Flint 50WG, Gem 500SC): Efficacy – fair. Classified as a reduced-risk pesticide. *Botrytis* not on label. Low toxicity to honeybees. Do not contaminate or apply to water.
- Thiophanate-methyl (Topsin M WSB): Efficacy – good. Classified as a B2 carcinogen. Available as a Special Local Need Label under Section 24(c) of FIFRA for use on *Cylindrocarpon*, *Rhizoctonia*, and *Sclerotinia* in Michigan and Wisconsin (expires 2017). 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.

Other pest management aids for Botrytis blight:

- Growers currently limit garden size to enhance airflow 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.

Pipeline pest management tools for Botrytis blight:

- Pyraclostrobin/boscalid (Pristine 38WG): Efficacy – good. Boscalid classified as a reduced-risk pesticide. Needs to be used in a program with a rotational partner to delay the development of resistance. Discuss possible label amendment with registrant on ginseng addition.
- Thiophanate-methyl (Topsin M WSB): Efficacy – good. Classified as a B2 carcinogen. Available as a Special Local Need Label under Section 24(c) of FIFRA for use on *Cylindrocarpon*, *Rhizoctonia*, and *Sclerotinia* in Michigan and Wisconsin for 2011. 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:

- Pyraclostrobin/boscalid (Pristine 38WG): 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:

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

Educational needs for Botrytis blight:

- Assist growers in correctly distinguishing Botrytis blight from Alternaria blight and make this information available on a website.
- 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 pathogens. This disease is a major problem for growers.

B2 carcinogenic fungicides registered for damping-off:

- 1,3-Dichloropropene (Telone EC [MI only], Telone II): Efficacy – poor-fair. Not tested on ginseng. Classified as a partial methyl bromide alternative. Restricted use pesticide. Moderate acute toxicity to bees.
- 1,3-Dichloropropene/chloropicrin (In-Line [MI only], Pic-C60, Telone C-17, Telone C-35): Efficacy – potentially good. Not tested on ginseng. Classified as a partial methyl bromide alternative. Restricted use pesticide. Moderate acute toxicity to bees.
- Captan (Drexel Captan 50W, Captan 80WDG, Captan 50WP): Efficacy – good on *Pythium* and *Cylindrocarpon*. Effective against *Phytophthora* and appears to suppress *Rhizoctonia*. Available for nonfood use only. *Cylindrocarpon*, *Pythium*, *Rhizoctonia* on label. Need efficacy data for *Fusarium*. Relatively nontoxic to insects.
- Dazomet (Basamid Granular Soil Fumigant): Efficacy – fair. Restricted use pesticide. Toxic to algae, fish. Do not contaminate or apply to water.

Carbamate fungicides registered for damping-off:

- Metam potassium (K-Pam HL, Metam KLR 54%, Sectagon K-54): Efficacy – unknown. *Rhizoctonia*, *Pythium* on label. Restricted use pesticide. Toxic to fish. Do not contaminate or apply to water.
- Metam sodium (Metam CLR 42%, Sectagon 42, Vapam HL [used by WI growers]): Efficacy – good. *Rhizoctonia*, *Pythium* on label. Should be applied at lower temperatures. Restricted use pesticide. Toxic to fish. Do not contaminate or apply to water.

Other fungicides registered for damping-off:

- Aluminum tris (Aliette WDG, Linebacker 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. Not labeled for damping off. Practically nontoxic to honeybees.
- Azoxystrobin (Quadris F, Dynasty): Efficacy – good on *Cylindrocarpon*. Not tested for damping-off on ginseng. Classified as a reduced-risk pesticide. *Rhizoctonia*, *Pythium* on label. May have limited activity, but efficacy data are not available. Low acute/chronic toxicity to birds, mammals, bees. Dynasty registered for seed treatment only.
- *Bacillus subtilis* (Serenade Soil): Efficacy – unknown. *Fusarium* spp., *Pythium* spp., *Rhizoctonia solani* on label. Classified as a biopesticide. No adverse environmental effects except bees need more tests; do not apply when bees are actively foraging.
- *Bacillus amyloliquefaciens* (Double Nickle 55, Double Nickle LC [WI Only]): Efficacy – unknown. Classified as a biopesticide. Not used by growers. No adverse environmental effects except bees need more tests; do not apply when bees are actively foraging.

- Chloropicrin (Chlor-O-Pic, Nutrapic [MI only], Pic-C100): Efficacy – good. *Fusarium*, *Pythium* on label. *Rhizoctonia* also on label of Chlor-O-Pic. Restricted use pesticide. Do not contaminate or apply to water.
- Copper hydroxide (Agri Star Nu-Cop 3L, Agri Star Nu-Cop 50DF, Agri Star Nu-Cop HB, Champ Dry Prill, Champ Formula 2 Flowable**,** Champion WP**,** DuPont Kocide 2000 54DF, DuPont Kocide 3000 46DF): Efficacy – fair. Damping-off pathogens not on label. Do not contaminate or apply to water.
- Fenamidone (Reason 500SC): Efficacy – good. Classified as a reduced-risk pesticide. *Pythium* on label. Do not contaminate or apply to water.
- Fluazinam (Omega 500SC): Efficacy – good for *Rhizoctonia*. May suppress *Fusarium*. Classified as a reduced-risk pesticide. *Rhizoctonia solani* on label. Do not contaminate or apply to water.
- Fludioxonil (Cannonball 50WP, Maxim 4FS): Efficacy – good to fair. Classified as a reduced-risk pesticide. Nonfood use label. *Cylindrocarpon* on label. May suppress *Rhizoctonia* and *Fusarium*. Maxim registered for seed treatment only. Do not contaminate or apply to water.
- Fluopicolide (Presidio): Efficacy – fair. *Pythium* on label. Do not contaminate or apply to water.
- Ipconazole (Rancona 3.8FS): Efficacy – unknown. Seed/propagating root treatment. Do not contaminate or apply to water.
- Iprodione (Iprodione 4L AG, Nevado 4F [MI only], Rovral 4FL, Meteor): Efficacy – unknown. Classified as a B2 carcinogen. May suppress *Rhizoctonia*. Damping-off not on label. Relatively nontoxic to bees.
- Mefenoxam (Apron XL, Axle 2E, Ridomil Gold GR, Ridomil Gold EC, Ridomil Gold SL, Ultra Flourish): Efficacy – good. Pathogen resistance has been documented and is prevalent in Wisconsin. Classified as a reduced-risk pesticide. *Pythium* on Apron label. *Phytophthora cactorum* on Ridomil Gold and Ultra Flourish labels. Do not contaminate or apply to water.
- Metalaxyl (MetaStar 2E AG): Efficacy – good. Agri Star Metalaxyl, Allegiance-FL, Belmont labeled as seed treatments for *Pythium*. *Phytophthora cactorum* on MetaStar label. Practically nontoxic to honeybees.
- Neem oil (Trilogy): Efficacy – unknown. Classified as a biopesticide. Toxic to bees.
- Phosphorous acid salts (Agrisolutions Topaz [MI only], Fosphite, K-Phite 7LP, Resist 57, Rampart): Efficacy – fair. *Pythium*, *Fusarium*, *Rhizoctonia* on label of Agrisolutions Topaz, Fosphite, Kphite 7LP, Rampart. *Pythium* on label of Phorcephite. Classified as a biopesticide. No adverse environmental effects to nontarget organisms.
- Polyoxin D zinc salt (Ph-D WDG, Veranda O, Affirm WDG): Efficacy – excellent for *Rhizoctonia*, poor for *Fusarium*, no control of *Pythium*. Classified as a biopesticide. *Cylindrocarpon*, *Rhizoctonia* on label. No toxicity to insects.
- Reynoutria sachalinensis (Regalia Biofungicide): Efficacy – unknown. Not used by growers. Classified as a biopesticides.
- *Streptomyces lydicus* (Actinovate AG): Efficacy – unknown/poor on other crops. Classified as a biopesticide. *Fusarium*, *Rhizoctonia*, *Pythium* on label. No adverse environmental effects to nontarget organisms.

- Thiophanate-methyl (Topsin M WSB): Efficacy – poor for *Rhizoctonia*, good on *Cylindrocarpon*. Classified as a B2 carcinogen. Available as a Special Local Need Label under Section 24(c) of FIFRA for use on *Cylindrocarpon*, *Rhizoctonia*, and *Sclerotinia* in Michigan and Wisconsin (expires 2017). 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. Do not contaminate or apply to water.
- *Trichoderma asperellum/T. gamsii* (Bio-Tam, Tenet WP): Efficacy – unknown. Classified as a biopesticide. *Fusarium*, *Rhizoctonia*, *Pythium* on label. May pose a risk to beneficial beetle species.

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*. Classified as a reduced-risk pesticide.
- Mancozeb/zoxamide (Gavel 75DF): Efficacy – good to fair.
- Thiophanate-methyl (Topsin M WSB): Efficacy – poor for *Rhizoctonia*, good on *Cylindrocarpon*. Classified as a B2 carcinogen. Available as a Special Local Need Label under Section 24(c) of FIFRA for use on *Cylindrocarpon*, *Rhizoctonia*, and *Sclerotinia* in Michigan and Wisconsin (expires 2017). 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. Do not contaminate or apply to water.
- V-10208 (experimental): Efficacy – excellent on *Pythium*. IR-4 residue studies conducted in 2011.

"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 4L AG, Nevado 4F [MI only], Rovral 4FL): Data needed on effectiveness when sprayed on seedlings following emergence.
- 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:

- Transition 24(c) label of thiophanate-methyl (Topsin M WSB) to a full, permanent label.
- Speed registration of effective products using crop groupings whenever possible.
- Obtain new products through a nonfood 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.
- Emphasize preventive applications.
- Pre-emergence treatment.

4. DISAPPEARING ROOT ROT (*Cylindrocarpon destructans*)

This is a major pathogen of cultivated ginseng and occurs yearly. The pathogen infects the roots as well as the seeds. 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. *Cylindrocarpon* is emerging as a leading cause of root rot. Infected roots can be a phyto-sanitary issue when exporting to China.

B2 carcinogenic fungicides registered for disappearing root rot:

- 1,3-Dichloropropene/chloropicrin (Telone C-17, Telone 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. Restricted use pesticide. Moderate acute toxicity to bees.
- Captan (Drexel Captan 50W, Captan 50WP, Captan 80WDG): Efficacy –fair - good. Available for nonfood use only. Relatively nontoxic to insects. Maximum applications used.
- Dazomet (Basamid Granular Soil Fumigant): Efficacy – fair. Restricted use pesticide. Toxic to algae, fish. Do not contaminate or apply to water.

Carbamate fungicides registered for disappearing root rot:

- Metam potassium (K-Pam HL, Metam KLR 54%, Sectagon K-54): Efficacy – potentially fair. Restricted use pesticide. Toxic to fish. Do not contaminate or apply to water.
- Metam sodium (Metam CLR 42%, Sectagon 42, Vapam HL [used by WI growers]): Efficacy –potentially good. Should be applied at lower temperatures. Restricted use pesticide. Toxic to fish. Do not contaminate or apply to water.

Other fungicides registered for disappearing root rot:

- Azoxystrobin (Quadris 2.08SC): Efficacy – fair to good. Classified as a reduced-risk pesticide. 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. Low acute/chronic toxicity to birds, mammals, bees.
- Fludioxonil (Cannonball 50WP): Efficacy – good. Classified as a reduced-risk pesticide. Do not contaminate or apply to water.
- Penthiopyrad (Fontelis): Efficacy – good. Classified as reduced-risk. *Cylindrocarpon* not on label.
- Polyoxin D zinc salt (Ph-D WDG): Efficacy – poor. Classified as a biopesticide. No toxicity to insects.
- Thiophanate-methyl (Topsin M WSB): Efficacy – good. Classified as a B2 carcinogen. Available as a nonfood use Special Local Need Label under Section 24(c) of FIFRA for use on *Cylindrocarpon*, *Rhizoctonia*, and *Sclerotinia* in Michigan and Wisconsin for (expires 2017). 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.

Other pest management aids for disappearing root rot:

- Rotate crops to avoid pathogen buildup.

Pipeline pest management tools for disappearing root rot:

"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.
- Test registered and unregistered products for efficacy.
- Determine efficient and effective methods of applying fungicides (drench, seed treatments) to the root zone.
- Investigate different types of mulches and determine whether they impact disease development.
- Seasonal temperature effects on the pathogen.
- Test new seed treatments for safety and efficacy.

Regulatory needs for disappearing root rot:

- Transition 24(c) label of thiophanate-methyl (Topsin M WSB) to a full, permanent label.
- Several fungicides are needed to ensure protection throughout the growing season. Speed registration of products determined to be effective against this pathogen.
- Continue Section 18s for disease control.
- New products are needed that are not in same FRAC class as azoxystrobin (Quadris, reduced-risk).
- Keep fumigants available.

Educational needs for disappearing root rot:

- Work closely with growers to implement new management tools as soon as they are developed.
- Establish demonstration plots with grower cooperators to highlight effective products and management strategies.
- Update for growers on pathogen identification.
- How to use seed treatments including managing rates for small seed lots.
- Investigate possible seed treatment facility in Wisconsin.

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 registered for Phytophthora foliar blight and root rot:

- 1,3-Dichloropropene/chloropicrin (In-Line [MI only], Pic-C60, Telone C-17, Telone C-35): Efficacy – unknown. Classified as a partial methyl bromide alternative. Restricted use pesticide. Moderate acute toxicity to bees.

- Captan (Drexel Captan 50W, Captan 50WP, Captan 80WDG): Efficacy – good. Available for nonfood use only. Relatively nontoxic to insects.
- Dazomet (Basamid Granular Soil Fumigant): Efficacy – fair. Restricted use pesticide. Toxic to algae, fish. Do not contaminate or apply to water.
- Mancozeb (Dithane F-45 Rainshield, Dithane M-45, ManKocide, Manzate Max Fungicdie, Penncozeb 4FL, Penncozeb 75DF, Penncozeb 80WP, Roper DF Rainshield): Efficacy – fair for folier blight only. Practically nontoxic to honeybees.

Carbamate fungicides registered for Phytophthora foliar blight and root rot:

- Metam potassium (K-Pam HL, Metam KLR 54%, Sectagon K-54): Efficacy – unknown. Restricted use pesticide. Toxic to fish. Do not contaminate or apply to water.
- Metam sodium (Metam CLR 42%, Sectagon 42, Vapam HL [used by WI growers]): Efficacy – good. Should be applied at lower temperatures. Restricted use pesticide. Toxic to fish. Do not contaminate or apply to water.

Other fungicides registered for Phytophthora foliar blight and root rot:

- Aluminum tris (Aliette WDG, Linebacker WDG): Efficacy – fair. Specific to oomycetes and does not have broad-spectrum activity. Should be alternated with products with a different mode of action. Practically nontoxic to honeybees. Four applications used.
- *Bacillus subtilis* (Serenade Soil): Efficacy – unknown. *Fusarium* spp., *Pythium* spp., *Rhizoctonia solani* on label. Classified as a biopesticide. No adverse environmental effects except bees need more tests; do not apply when bees are actively foraging.
- Chloropicrin (Chlor-O-Pic, Nutrapic [MI only], Pic-C100): Efficacy – good. Restricted use pesticide. Do not contaminate or apply to water.
- Copper hydroxide (Agri Star Nu-Cop 3L, Agri Star Nu-Cop 50DF, Agri Star Nu-Cop HB, Champ Dry Prill, Champ Formula 2 Flowable**,** Champion WP**,** DuPont Kocide 2000 54DF, DuPont Kocide 3000 46DF): Efficacy – fair. *Phytophthora* not on label. Do not contaminate or apply to water.
- Copper octanoate (Bonide Liquid Copper, Cueva, Natural Guard Copper Soap): Efficacy – unknown. Do not contaminate or apply to water.
- Dimethomorph (Forum SC): Efficacy – good. Do not contaminate or apply to water. Maximum applications used.
- Fenamidone (Reason 500SC): Efficacy – fair-good. Classified as a reduced-risk pesticide. Do not contaminate or apply to water. Maximum applications are being used.
- Fluopicolide (Presidio SC): Efficacy – good. Classified as a reduced-risk pesticide. Do not contaminate or apply to water. Maximum applications are used. Resistance a concern.
- Mandipropamid (Revus SC): Efficacy – good. Classified as a reduced-risk pesticide. Do not contaminate or apply to water. Newly labeled and quickly being incorporated into growers spray programs. Maximum applications used.
- Mefenoxam (Ridomil Gold GR, Ridomil Gold SL, Ultra Flourish): Efficacy – good. Pathogen resistance has been documented and is prevalent in Wisconsin. Classified as a reduced-risk pesticide. Do not contaminate or apply to water.

- Metalaxyl (MetaStar 2E AG): Efficacy – good. Practically nontoxic to honeybees.
- Neem oil (Trilogy): Efficacy – poor. Classified as a biopesticide. Not used. Toxic to bees.
- Phosphorous acid salts (Agri-fos, Agrisolutions Topaz [MI only], Alude, Drexel Phiticide, Exel LG, Fosphite, Kphite 7LP, Phorcephite, Phostrol, Rampart): Efficacy – fair. Specific to oomycetes and does not have broad-spectrum activity. Classified as a biopesticide. No adverse environmental effects to nontarget organisms. 4-5 applications are currently being used in tank mix.
- Reynoutria sachalinensis (Regalia Biofungicide): Efficacy – unknown. Not used by growers. Classified as a biopesticides.
- *Streptomyces lydicus* (Actinovate AG): Efficacy – unknown/poor on other crops. Classified as a biopesticide. No adverse environmental effects to nontarget organisms.
- *Trichoderma asperellum/T. gamsii* (Tenet WP, Bio-Tam): Efficacy – unknown. Classified as a biopesticide. May pose a risk to beneficial beetle species.

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

- Use of 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:

- Mancozeb/zoxamide (Gavel 75DF): Efficacy – good. Especially helpful for the foliar blight phase of this disease. Also helpful in suppressing root rot when applied as a drench. Considered a priority for registration through IR-4. Mancozeb is a B2 carcinogen; practically nontoxic to honeybees. Zoxamide is reduced-risk; practically nontoxic to nontarget insects.
- V-10208: Efficacy – good. Continued research needed. IR-4 residue studies completed in 2011. Submitted label for 2013.
- OXTP-MFX: Efficacy – excellent. Continued research needed to determine most effective rate. IR-4 residue studies completed in 2011.

"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. Focus on materials for year of harvest.
- Seed treatment for *Phytophthora*.
- Determine if *Phytophthora* populations have fungicide resistance.
- Determine soil tempuratures 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.
- Determine status of mancozeb/zoxamide (Gavel 75DF) registration, Gavel has been submitted and has been in the pipeline.
- 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).
- Reliance on nonfood use materials challenges growers with difficult decisions regarding when to harvest ginseng gardens.

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.
- Provide an in-depth workshop regarding the biology of the pathogen so control measures can be understood and better implemented.
- Seed treatment research.
- Continue to research new products.

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 registered for powdery mildew:

- Chlorothalonil (Bravo Weather Stik 6SC, Chloronil 720, Equus 720 SST, Echo 720): Efficacy – good to excellent. Also has good activity against Alternaria and Botrytis blights. Relatively nontoxic to honeybees. Must be applied preventively and frequently when weather favors disease. A maximum of six applications is allowed.
- Mancozeb (Dithane F-45 Rainshield, Dithane M-45, ManKocide, Manzate Max Fungicdie, Penncozeb 4FL, Penncozeb 75DF, Penncozeb 80WP, Roper DF Rainshield): Efficacy – poor. Practically nontoxic to honeybees.

Other fungicides registered for powdery mildew:

- Azoxystrobin (Quadris F): Efficacy – good. Classified as a reduced-risk pesticide. 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. Low acute/chronic toxicity to birds, mammals, bees.

- *Bacillus pumilus* (Sonata): Efficacy – unknown. Classified as a biopesticide. No adverse environmental effects to nontarget organisms.
- *Bacillus subtilis* (Serenade ASO, Serenade Max): Efficacy – unknown. Classified as a biopesticide. No adverse environmental effects except bees need more tests; do not apply when bees are actively foraging.
- Borax (Prev-Am Ultra): Efficacy – unknown. Not used by growers. Do not contaminate or apply to water.
- Boscalid (Endura): Efficacy – excellent. Classified as a reduced-risk pesticide. Needs to be used in a program with a rotational partner to delay the development of resistance. Do not contaminate or apply to water.
- Copper octanoate (Bonide Liquid Copper, Cueva, Natural Guard Copper Soap): Efficacy – unknown. Do not contaminate or apply to water.
- Cyprodinil/fludioxonil (Switch 62.5WG): Efficacy – unknown. Classified as a reduced-risk pesticide. Do not contaminate or apply to water. Do not contaminate or apply to water.
- Fluazinam (Omega): Efficacy – good to excellent. Classified as a reduced-risk pesticide. Do not contaminate or apply to water.
- Fluxapyroxad/pyraclostrobin (Merivon Xemium Brand Fungicide): Efficacy – unknown. Newly registered and not yet commercially used. Supplimental label expires September, 2016.
- Neem oil (Trilogy): Efficacy – potentially fair to poor. Not tested on ginseng. Classified as a biopesticide. Not used by growers. Toxic to bees.
- Phosphorous acid salts (Agrisolutions Topaz [MI only], Fosphite, Kphite 7LP, Rampart): Efficacy – unknown. Classified as a biopesticide. No adverse environmental effects to nontarget organisms.
- Penthiopyrad (Fontelis): Efficacy – unknown. Classified as reduced-risk.
- Pyraclostrobin (Cabrio 20EG): Efficacy – good. Widely used to control 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. Do not contaminate or apply to water.
- Reynoutria sachalinensis (Regalia Biofungicide): Efficacy – unknown. Not used by growers. Classified as a biopesticides.
- *Streptomyces lydicus* (Actinovate AG): Efficacy – unknown. Classified as a biopesticide. No adverse environmental effects to nontarget organisms.
- Trifloxystrobin (Flint 50WG, Gem 500SC): Efficacy – unknown. Classified as a reduced-risk pesticide. Low toxicity to honeybees. Do not contaminate or apply to water.
- Thiophanate-methyl (Topsin M WSB): Efficacy – good. Classified as a B2 carcinogen. Available as a Special Local Need Label under Section 24(c) of FIFRA for use on *Cylindrocarpon*, *Rhizoctonia*, and *Sclerotinia* in Michigan and Wisconsin (expires 2017). 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.

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 airflow 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:

- Pyraclostrobin/boscalid (Pristine WG): Efficacy – good. Boscalid classified as a reduced-risk pesticide. Discuss possible label amendment with registrant on ginseng addition.
- Thiophanate-methyl (Topsin M WSB): Efficacy – good. Classified as a B2 carcinogen. Available as a Special Local Need Label under Section 24(c) of FIFRA for use on *Cylindrocarpon*, *Rhizoctonia*, and *Sclerotinia* in Michigan and Wisconsin (expires 2017). 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:

- 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.)

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

B2 carcinogenic fungicides registered for rusty root:

- 1,3-Dichloropropene/chloropicrin (In-Line [MI only], Pic-C60, Telone C-17, Telone C-35): Efficacy – potentially good. Not tested on ginseng. Classified as a partial methyl bromide alternative by IR-4. Expensive. Restricted use pesticide. Moderate acute toxicity to bees.
- Captan (Drexel Captan 50W, Captan 50WP, Captan 80WDG): Efficacy – good on *Cylindrocarpon*. *Fusarium*, *Rhexocercosporidium* not on label. Available for nonfood use only. Relatively nontoxic to insects.

Other fungicides registered for rusty root:

- Azoxystrobin (Quadris F): Efficacy – good. Classified as a reduced-risk pesticide. Widely used for control of Alternaria blight; *Cylindrocarpon*, *Fusarium*, *Rhexocercosporidium* not on label. 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. Low acute/chronic toxicity to birds, mammals, bees.
- Chloropicrin (Chlor-O-Pic, Nutrapic [MI only], Pic-C100): Efficacy – good. Restricted use pesticide. Do not contaminate or apply to water.

- Fludioxonil (Cannonball 50WP): Efficacy – good on *Cylindrocarpon*. Classified as a reduced-risk pesticide. *Cylindrocarpon* on label. Do not contaminate or apply to water.
- Penthiopyrad (Fontelis): Efficacy – Good against *Cylindrocarpon*. Unknown against *Fusarium* and *Rhexocercosporidium*. Classified as reduced-risk.
- Polyoxin D zinc salt (Afirm WDG, Ph-D WDG, Veranda O): Efficacy – good. *Cylindrocarpon* on label. Classified as a biopesticide. No toxicity to insects.
- *Streptomyces lydicus* (Actinovate AG): Efficacy – unknown. Classified as a biopesticide. *Fusarium* on label. No adverse environmental effects to nontarget organisms.
- Thiophanate-methyl (Topsin M WSB): Efficacy – Fair. Classified as a B2 carcinogen. Available as a Special Local Need Label under Section 24(c) of FIFRA for use on *Cylindrocarpon*, *Rhizoctonia*, and *Sclerotinia* in Michigan and Wisconsin (expires 2017). 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.
- *Trichoderma asperellum/T. gamsii* (Tenet WP, Bio-Tam): Efficacy – unknown. Classified as a biopesticide. *Fusarium* on label. May pose a risk to beneficial beetle species.

Other pest management aids for rusty root:

- None identified.

Pipeline pest management tools for rusty root:

- Thiophanate-methyl (Topsin M WSB): Efficacy – Fair. Classified as a B2 carcinogen. Available as a Special Local Need Label under Section 24(c) of FIFRA for use on *Cylindrocarpon*, *Rhizoctonia*, and *Sclerotinia* in Michigan and Wisconsin (expires 2017). 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 effectiveness of fungicides captan, thiophanate-methyl, fluazinam, fluidioxonil, etc.
- Isolate and complete epidemiological studies.
- Determine economic losses due to this disease.
- Determine the virulence of and symptoms associated with each pathogen (*Fusarium* and/or *Rhexocercosporidium*) in root rusting.

Regulatory needs for rusty root:

- Transition 24(c) label of thiophanate-methyl (Topsin M WSB) to a full, permanent label.
- Work with EPA on getting products labeled or get 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. White mold is not a constant problem, but when present, can be devastating. Control in soybean gardens has resulted in this pathogen being detected with less regularity in ginseng gardens.

B2 carcinogenic fungicides registered for Sclerotinia white mold:

- 1,3-Dichloropropene/chloropicrin (In-Line [MI only], Pic-C60, Telone C-17, Telone C-35): Efficacy – unknown. Not tested on ginseng. Classified as a partial methyl bromide alternative. Restricted use pesticide. Moderate acute toxicity to bees.

Carbamate fungicides registered for Sclerotinia white mold:

- Metam potassium (K-Pam HL, Metam KLR 54%, Sectagon K-54): Efficacy – unknown. Restricted use pesticide. Toxic to fish. Do not contaminate or apply to water.
- Metam sodium (Metam CLR 42%, Sectagon 42, Vapam HL [used by WI growers]): Efficacy – good. Should be applied at lower temperatures. Restricted use pesticide. Toxic to fish. Do not contaminate or apply to water.

Other fungicides registered for Sclerotinia white mold:

- *Bacillus pumilus* (Sonata): Efficacy – unknown. Classified as a biopesticide. No adverse environmental effects to nontarget organisms.
- *Bacillus amyloliquefaciens* (Double Nickle 55, Double Nickle LC [WI Only]): Efficacy – unknown. Classified as a biopesticide. Not used by growers. No adverse environmental effects except bees need more tests; do not apply when bees are actively foraging.
- *Bacillus subtilis* (Serenade ASO, Serenade Max): Efficacy – unknown. Classified as a biopesticide. No adverse environmental effects except bees need more tests; do not apply when bees are actively foraging.
- Chloropicrin (Chlor-O-Pic, Nutrapic [MI only], Pic-C100): Efficacy – unknown. Restricted use pesticide. Do not contaminate or apply to water.
- Fluazinam (Omega 500F): Efficacy – good on other crops. Classified as a reduced-risk pesticide. Do not contaminate or apply to water.
- Fludioxonil (Cannonball 50WP): Efficacy – unknown. Classified as a reduced-risk pesticide. Do not contaminate or apply to water.
- Reynoutria sachalinensis (Regalia Biofungicide): Efficacy – unknown. Not used by growers. Classified as a biopesticides.
- *Streptomyces lydicus* (Actinovate AG): Efficacy – unknown. Classified as a biopesticide. No adverse environmental effects to nontarget organisms.
- Thiophanate-methyl (Topsin M WSB): Efficacy – good. Classified as a B2 carcinogen. Available as a Special Local Need Label under Section 24(c) of FIFRA for use on *Cylindrocarpon*, *Rhizoctonia*, and *Sclerotinia* in Michigan and Wisconsin (expires 2017). 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.

- *Trichoderma asperellum/T. gamsii* (Bio-Tam, Tenet WP): Efficacy – unknown. Classified as a biopesticide. May pose a risk to beneficial beetle species.

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:

- Thiophanate-methyl (Topsin M WSB): Efficacy – good. Classified as a B2 carcinogen. Available as a Special Local Need Label under Section 24(c) of FIFRA for use on *Cylindrocarpon*, *Rhizoctonia*, and *Sclerotinia* in Michigan and Wisconsin (expires 2017). 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:

- Transition 24(c) label of thiophanate-methyl (Topsin M WSB) to a full, permanent label.
- 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 registered for Septonema disease:

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

Other fungicides 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*)

Stromatinia black rot is a serious problem in Michigan woodlots. This pathogen also infects false solomon's seal, a woodland plant. Black rot is a minor problem in Wisconsin.

B2 carcinogenic fungicides registered for Stromatinia black rot:

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

Other fungicides registered for Stromatinia black rot:

- Azoxystrobin (Quadris F): Efficacy – good in laboratory studies. Classified as a reduced-risk pesticide. Widely used for control of Alternaria blight. Low acute/chronic toxicity to birds, mammals, bees.
- Fluazinam (Omega 500F): Efficacy – good in laboratory studies. Classified as a reduced-risk pesticide. Do not contaminate or apply to water.
- Fludioxonil (Cannonball 50WP): Efficacy – good in laboratory studies. Classified as a reduced-risk pesticide. Do not contaminate or apply to water.

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 registered for Verticillium wilt:

- 1,3-Dichloropropene/chloropicrin (In-Line [MI only], Pic-C60, Telone C-17, Telone C-35): Efficacy – unknown. Not tested on ginseng. Classified as a partial methyl bromide alternative. Restricted use pesticide. Moderate acute toxicity to bees.

Carbamate fungicides registered for Verticillium wilt:

- Metam potassium (K-Pam HL, Metam KLR 54%, Sectagon K-54): Efficacy – unknown. Restricted use pesticide. Toxic to fish. Do not contaminate or apply to water.
- Metam sodium (Metam CLR 42%, Sectagon 42, Vapam HL [used by WI growers]): Efficacy – good. Should be applied at lower temperatures. Restricted use pesticide. Toxic to fish. Do not contaminate or apply to water.

Other fungicides registered for Verticillium wilt:

- *Streptomyces lydicus* (Actinovate AG): Efficacy – unknown. Classified as a biopesticide. No adverse environmental effects to nontarget organisms.
- *Trichoderma asperellum/T. gamsii* (Bio-Tam, Tenet WP): Efficacy – unknown. Classified as a biopesticide. *Fusarium*, *Rhizoctonia*, *Pythium* on label. May pose a risk to beneficial beetle species.

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.

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

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

Organophospate nematicides registered:

- None identified.

Carbamate nematicides registered:

- Metam potassium (K-Pam HL, Metam KLR 54%, Sectagon K-54): Efficacy – good. Restricted use pesticide. Toxic to fish. Do not contaminate or apply to water.
- Metam sodium (Metam CLR 42%, Sectagon 42, Vapam HL [used by WI growers]): Efficacy – good. Should be applied at lower temperatures. Restricted use pesticide. Toxic to fish. Do not contaminate or apply to water.

B2 carcinogenic nematicides registered:

- 1,3-Dichloropropene (Telone EC [MI only], Telone II): Efficacy – good. Classified as a partial methyl bromide alternative. Restricted use pesticide. Moderate acute toxicity to bees.

- 1,3-Dichloropropene/chloropicrin (In-Line, Pic-C60, Telone C-17, Telone C-35): Efficacy – good to fair. Classified as a partial methyl bromide alternative. Restricted use pesticide. Moderate acute toxicity to bees.
- Dazomet (Basamid Granular Soil Fumigant): Efficacy – fair. Restricted use pesticide. Toxic to algae, fish. Do not contaminate or apply to water.

Other nematicides registered:

- Azadirachtin (Ecozin 1.2%ME, Molt-X): Efficacy – not being used. Classified as a biopesticide. Not expected to harm nontarget organisms; do not apply when honeybees are foraging.
- Chloropicrin (Chlor-O-Pic, Nutrapic [MI only], Pic-C100): Efficacy – poor to fair. Restricted use pesticide. Do not contaminate or apply to water.

Other pest management aids for nematodes:

- Crop rotation. Do not follow an alfalfa crop. Most grasses are not hosts.

Pipeline pest management tools for nematodes:

- Use of cover crops/biofumigation prior to planting ginseng.

Research needs for nematodes:

- Conduct a survey to identify and determine the nematodes present in Wisconsin and Michigan ginseng production. Examine potato nematode data for possible application to ginseng.
- For exported ginseng, need to document that certain nematodes are not present.
- Characterize nematode biodiversity.
- Test seed treatments: abamectin/thiamethoxam (Avicta Duo Corn) from Syngenta; clothianidin/*Bacillus firmus* (Poncho/VOTiVO) from Bayer, and Pasteuria (biological seed treatment).
- Biofumigation.
- Develop pocket guides for nematodes and fumigants.
- Test fumigants and fumigant alternatives for their ability to limit parasitic nematode populations.
- Determine a cover crop for preplant use (1 year). Grasses are nonhosts (Sudan grass). Vetches and alfalfa are nematode hosts. Do not use radish type crops. Research buckwheat as a cover crop.

Regulatory needs for nematodes:

- Survey of nematodes for USDA-APHIS export.

Educational needs for nematodes:

- Growers are interested in learning which nematodes negatively or positively impact ginseng production.
- Provide information and training for new regulations for applying fumigants. Develop fumigant management plans.

WILDLIFE PESTS

1. DEER, RACCOONS, 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, yellow woodsorrel, broadleaf weeds, sedges, pigweed, thistles, and raspberry (Michigan only). Grasses are easy to control. Weeds are very expensive to control by hand ($1,000-$2,000/acre/year).

1. PRE-PLANT HERBICIDES

- Dazomet (Basamid Granular Soil Fumigant): Efficacy – fair. Restricted use pesticide. Toxic to algae, fish. Do not contaminate or apply to water.
- Diquat dibromide (Aceto Diquat 2L AG, Reglone Dessicant, Rowrunner AG): Efficacy – unknown. Practically nontoxic to bees.
- Glyphosate (Agrisolutions Cornerstone [WI only], Agrisolutions Cornerstone 5 Plus, Agrisolutions Cornerstone Plus, Alligare Glyphosate 4 Plus, Buccaneer Glyphosate, Buccaneer Plus Glyphosate, CropSmart Glyphosate 41 Plus, Czar, Duramax, Durango DMA, Four Power Plus, Gly Star Gold, Gly Star Plus, Gly-4 Plus, Gly-4 Plus, Glyfine Plus, Glyfos, Glyfos X-Tra, Glyphogan, Glyphogan Plus, GlySupreme Plus, Gordon's Pronto Big N' Tuf 2 Nonselective Agricultural, Hi-Yield Super Concentrate Kill-Zall II, Honcho, Honcho Plus, Hoss Ultra, Mad Dog Plus, Mirage [MI only], Mirage Plus [MI only], Rapidfire, Rascal Plus, Rattler [MI only], Rattler Plus, Roundup Original Max, Roundup Powermax, Touchdown Hitech, Touchdown Total, Traxion, Z-glyphosate 41% Max): Efficacy – good to excellent. Kills emerged weeds, very effective against most green plants. Cannot be applied during the harvest year. Practically nontoxic to honeybees. Classified as a reduced-risk pesticide.
- Pelargonic acid (Scythe): Efficacy – not being used. No adverse environmental effects to nontarget organisms. Classified as a biopesticide.
- Metam potassium (K-Pam HL, Metam KLR 54%, Sectagon K-54): Efficacy – unknown. Classified as a carbamate. Restricted use pesticide. Toxic to fish. Do not contaminate or apply to water.
- Metam sodium (Metam CLR 42%, Sectagon 42, Vapam HL): Efficacy – good. Classified as a carbamate. Restricted use pesticide. Toxic to fish. Do not contaminate or apply to water.

2. POST-EMERGENCE HERBICIDES – BEFORE PLANTING

- Glyphosate (Agrisolutions Cornerstone [WI only], Agrisolutions Cornerstone 5 Plus, Agrisolutions Cornerstone Plus, Alligare Glyphosate 4 Plus, Buccaneer Glyphosate, Buccaneer Plus Glyphosate, CropSmart Glyphosate 41 Plus, Czar, Duramax, Durango DMA, Four Power Plus, Gly Star Gold, Gly Star Plus, Gly-4 Plus, Gly-4 Plus, Glyfine Plus, Glyfos, Glyfos X-Tra, Glyphogan, Glyphogan Plus, GlySupreme Plus, Gordon's Pronto Big N' Tuf 2 Nonselective Agricultural, Hi-Yield Super Concentrate Kill-Zall II, Honcho, Honcho Plus, Hoss Ultra, Mad Dog Plus, Mirage [MI only], Mirage Plus [MI only], Rapidfire, Rascal Plus, Rattler [MI only], Rattler Plus, Roundup Original Max, Roundup Powermax, Touchdown Hitech, Touchdown Total, Traxion, Z-glyphosate 41% Max): Efficacy – excellent. Kills emerged weeds, very effective against most green plants. No pre-activity. Cannot be applied during the harvest year. Practically nontoxic to honeybees. Classified as a reduced-risk pesticide.

3. PRE- AND POST-EMERGENCE HERBICIDES

- None identified.

4. POST-EMERGENCE HERBICIDES

- Clethodim (Agrisolutions Section 2EC, Agrisolutions Select 2EC, Arrow 2EC, Cleo 26.4 [MI only], CropSmart Clethodim [MI only], Intensity Post-emergence Grass Herbicide, Select 2EC, Shadow, Volunteer): Efficacy – unknown. Nontoxic to adult worker bees.
- Fluazifop (Fusilade DX): Efficacy – good. Kills most annual and perennial grasses. No pre-activity. Cannot be applied during the harvest year.

Other weed management aids:

- Straw mulch efficacy depends on quality of straw.
- Hand weeding – currently the main weed control tool, very expensive (thousands ($)/acre/year).

Pipeline weed management tools:

- None identified.

"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.
- Continue research on pre-emergent herbicide dimethenamid-P (Outlook, generics)
- More work with dicamba (Rifle), 2,4-D and mesotrione (Callisto, reduced-risk) needed.
- Test new chemistries for efficacy and crop safety, including 2,4-DB, MCPA, MCPB, MCPP and related products; sulfentrazone (Spartan, FMC); indaziflam (Alion, Bayer CropScience); saflufenacil (Kixor, BASF, reduced-risk, a PPO inhibitor, for woodsorrel control); carfentrazone (Aim, FMC, reduced-risk); pelargonic acid (Scythe, biopesticide); glufosinate (Ignite, reduced-risk), [glufosinate + carfentrazone]; other preemergance class herbicides s-metolachlor (Dual Magnum) and pendimethalin (Prowl); flumioxazin (Chateau, Broadstar); dichlobenil (Casoron); pronamide (Kerb); ethalfluralin (Curbit EC).
- Test new techniques for applying fumigants.

- Test new fumigants for efficacy and crop safety.
- Research herbicides to control yellow woodsorrel.
- Determine favorable carriers for penetrating the straw mulch.
- Safety and efficacy trials for Zidua product.

Regulatory needs for weeds:

- Explore nonfood use registrations as soon as safe and effective products are identified.
- Work with registrant and state agencies for label of DCPA (Dacthal).
- Continue discussion with UPI regarding napropamide (Devrinol) and IR-4 residue studies.

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 noncarcinogenicity in humans.

TABLE 2. REGISTERED PESTICIDES FOR GINSENG

Active ingredient	Trade name	Company
PESTICIDES for INSECTS and other invertebrates		
1,3-dichloropropene (*fumigant*)	Telone II, Telone EC [MI only]	Dow AgroSciences
1,3-dichloropropene/ chloropicrin (*fumigant*)	In-Line [MI only], Telone C-17, Telone C-35	Dow AgroSciences
	Pic-C60	Reddick Fumigants of NC LLC
azadirachtin	Agroneem Plus EC [MI only]	Agro Logistic Systems Inc
	Aza-Direct	Gowan Company
	AzaSol	Arborjet Inc
	Ecozin Plus 1.2%ME	Amvac Chemical Corp
	Molt-X	BioWorks, Inc.
	Neemazad 1%EC [MI only], Neemix 4.5	Certis USA LLC
Beauveria bassiana	BotaniGard ES, Mycotrol O	Laverlam International Corp
bifenthrin	Bifen 2 AG Gold [MI only]	J Oliver Products
	Bifenture EC	United Phosphorus Inc
	Brigade 2EC, Brigade WSB	FMC Corp
	Fanfare 2EC	Makhteshim Agan of N. America
	Sniper	Loveland Produts Inc
carbaryl	Lebanon Sevin 7G	LebanonTurf
	Drexel Carbaryl 4L	Drexel Chemical Co
	Sevin Brand 4F Carbaryl, Sevin Brand XLR Plus Carbaryl	Bayer CropScience LP
chloropicrin (*fumigant*)	Chlor-O-Pic	Great Lakes Chemical Corp
	Nutrapic [MI only]	Arysta LifeScience N. Amer. LLC
	Pic-C100	Reddick Fumigants of NC LLC
cyfluthrin	Baythroid XL	Bayer CropScience
	Tombstone Helios, Tombstone	Loveland Products Inc
	Renounce 20WP [WI only]	Bayer CropScience
deltamethrin	Battalion 0.2EC, Battalion 1.5EC	Arysta LifeScience N. Amer. Corp
	Delta Gold 1.5EC	Winfield Solutions LLC
diazinon	Diazinon AG500	Helena Chemical Co
	Diazinon AG500	Makhteshim Agan of N. Amer. Inc
	Diazinon AG600 WBC	Loveland Products Inc
flonicamid	Beleaf 50SG	FMC Corp
imidacloprid	Admire PRO, Provado 1.6 F	Bayer CropScience
	Agri Star Macho 2.0 FL	Albaugh Inc
	Agrisolutions Advise 2FL	Agriliance LLC
	Alias 2F Flowable, Pasada 1.6 F Flowable	Makhteshim Agan of N. Amer. Inc
	Bayer Advanced Fruit Citrus & Vegetable Insect Control Concentrate	Bayer Advanced/Bayer CropScience LP
	Couraze 2F, Couraze 4F	Cheminova Inc

TABLE 2. REGISTERED PESTICIDES FOR GINSENG

Active ingredient	Trade name	Company
PESTICIDES for INSECTS and other invertebrates *continued*		
imidacloprid *continued*	Malice 75WSP, Prey 1.6, Sherpa, Widow	Loveland Products Inc
	Midash 2SC AG	Sharda USA LLC
	Montana 2F, Montana 4F	Rotam N. Amer. Inc
	Nuprid 1.6F, Nuprid 2F, Nuprid 2SC Soil/Foliar	Nufarm Americas Inc
metaldehyde	Lock Out	Wilbur-Ellis
	Deadline Bullets, Deadline M-Ps, Durham Metaldehyde Granules 7.5	Amvac Chemical Corp
	Hi-yield Slug & Snail Bait	Voluntary Purchasing Groups Inc
	Metarex 4% Snail and Slug Bait	Liphatech Inc
	Ortho Bug-geta Snail & Slug Killer 1	The Ortho Group
methoxyfenozide	Intrepid 2F	Dow AgroSciences
neem oil	Trilogy	Certis USA LLC
petroleum oil	Glacial Spray Fluid	Loveland Products Inc
	Prescription Treatment Ultra-Pure Oil	Whitmire Micro-Gen Research Laboratories Inc
pyrethrins	Pyrenone Crop Spray	Bayer Environmental Science
	Evergreen Crop Protection EC 60-6	McLaughlin Gormley King Co
	Prentox Pyronyl Crop Spray	Prentiss Inc
	Pres Treat Brand Pyreth-it Formula 2	Whitmire Micro-Gen Research Labs Inc
pyrethrins/piperonyl butoxide	Bug Buster-O	Lawn & Garden Products Inc
	PyGanic Crop Protection EC 1.4 II, PyGanic Crop Protection EC 5.0 II	McLaughlin Gormley King Co
sodium ferric EDTA	IronFist Slug and Snail Bait	Engage Agro USA, LLC
spinetoram	Radiant SC	Dow AgroSciences
spinosad	Conserve SC	Dow AgroSciences
	Blackhawk Naturalyte Insenct Control, Entrust Naturalyte Insect Control, SpinTor 2SC	
thiamethoxam	Actara, Platinum, Platinum 75SG	Syngenta Crop Protection Inc
zeta-cypermethrin	Mustang, Mustang Max, Mustang Max EC, Mustang Max EW, Steed	FMC Corp
	Respect, Respect EC	BASF Corp
zeta-cypermethrin/bifenthrin	Hero, Hero EW, Triple Crown Insecticide`	FMC Corp
NEMATICIDES		

TABLE 2. REGISTERED PESTICIDES FOR GINSENG

Active ingredient	Trade name	Company
1,3-dichloropropene (*fumigant*)	Telone II, Telone EC [MI only]	Dow AgroSciences
NEMATICIDES *continued*		
1,3-dichloropropene/ chloropicrin (*fumigant*)	In-Line [MI only], Telone C-17, Telone C-35 Pic-C60	Dow AgroSciences Reddick Fumigants of NC LLC
azadirachtin	Molt-X, Neemix 4.5 IGR	BioWorks, Inc. Certis USA, L.L.C.
chloropicrin (*fumigant*)	Chlor-O-Pic Nutrapic [MI only] Pic-C100	Great Lakes Chemical Corp Arysta LifeScience N. Amer. LLC Reddick Fumigants of NC LLC
dazomet (*fumigant*)	Basamid Granular Soil Fumigant	BASF Corp
metam potassium (*fumigant*)	K-Pam HL Metam KLR 54% Sectagon K-54	Amvac Chemical Corp Taminco Inc Tessenderlo Kerley
metam sodium (*fumigant*)	Metam CLR 42% Sectagon 42 Vapam HL	Taminco Inc Tessenderlo Kerley Amvac Chemical Corp
FUNGICIDES		
1,3-dichloropropene (*fumigant*)	Telone II, Telone EC [MI only]	Dow AgroSciences
1,3-dichloropropene/ chloropicrin (*fumigant*)	In-Line [MI only], Telone C-17, Telone C-35 Pic-C60	Dow AgroSciences Reddick Fumigants of NC LLC
aluminum tris	Aliette WDG Linebacker WDG	Bayer CropScience Tessenderlo Kerley Inc
azoxystrobin	Quadris F Satori Fungicide	Syngenta Crop Protection Inc Loveland Products, Inc.
Bacillus pumilus	Sonata	AgraQuest Inc
Bacillus subtilis	Serenade ASO, Serenade Max, Serenade Soil	AgraQuest Inc
boscalid	Endura 70WG	BASF Corp
captan	Drexel Captan 50W Captan 50WP Agri Star Captan 80WDG	Drexel Chemical Co Albaugh, LLC/Agri Star
chloropicrin (*fumigant*)	Chlor-O-Pic Nutrapic [MI only] Pic-C100	Great Lakes Chemical Corp Arysta LifeScience N. Amer. LLC Reddick Fumigants of NC LLC
chlorothalonil	Bravo Weather Stik SC, Chloronil 720 Echo 720 Agriculture Fungicide Equus 720 SST	Syngenta Crop Protection Inc SipcamAdvan MANA – Makhteshim Agan
copper ammonium complex	Copper-Count-N	Mineral Research & Development

TABLE 2. REGISTERED PESTICIDES FOR GINSENG

Active ingredient	Trade name	Company
copper hydroxide	Agri Star Nu-Cop 3L, Agri Star Nu-Cop 50WP, Agri Star Nu-Cop HB	Albaugh Inc
	Champ DP Dry Prill, Champ Formula 2 Flowable,	Nufarm Americas Inc
	FUNGICIDES continued	
copper hydroxide continued	DuPont Kocide 2000 54DF, DuPont Kocide 3000 46DF	du Pont de Nemours & Co
copper octanoate	Bonide Liquid Copper	Bonide Products Inc
	Cueva	Certis USA LLC
	Natural Guard Copper Soap	Voluntary Purchasing Groups Inc
copper oxychloride/copper hydroxide	Badge SC	Isagro USA Inc
	Badge X_2	
copper sulfate	Cuprofix Ultra 40 Disperss	United Phosphorous Inc
cyprodinil/fludioxonil	Switch 62.5WG	Syngenta Crop Protection Inc
dazomet (*fumigant*)	Basamid Granular Soil Fumigant	BASF Ag Products
dimethomorph	Forum Fungicide	BASF Ag Products
fenamidone	Reason 500SC	Bayer CropScience
fenhexamid	Elevate 50WDG	Arysta LifeScience N. Amer. Corp
fluazinam	Omega 500F	Syngenta Crop Protection Inc
fludioxonil	Cannonball WP, Maxim 4FS	Syngenta Crop Protection Inc
fluopicolide	Presidio	Valent USA Corp
fluxapyroxad/pyraclostrobin	Merivon Xemium Brand Fungicide	BASF Ag Products
hydrogen dioxide	OxiDate 2.0	BioSafe Systems LLC
iprodione	Iprodione 4L AG	Arysta LifeScience N. Amer. LLC
	Meteor Fungicide	United Phosphorus, Inc.
	Nevado 4F	Makhteshim Agan of N. Amer. Inc
	Rovral 4FL	Bayer CropScience
mancozeb	Dithane M45 Fungicide, Dithane F45 Fungicide,	Dow AgroSciences
	Koverall Fungicide,	Cheminova, Inc.
	Manzate Max,	United Phosphorous Inc
	Penncozeb 4FL, Penncozeb75DF, Penncozeb 80WP,	Loveland Products, Inc.
	Roper DF Rainshield	
mandipropamid	Revus	Syngenta Crop Protection Inc
mefenoxam	Apron XL, Ridomil Gold GR, Ridomil Gold SL	Syngenta Crop Protection Inc
	Ultra Flourish	Nufarm Americas Inc
metalaxyl	Agri Star Metalaxyl 265 ST	Albaugh Inc
	Allegiance-FL	Bayer CropScience
	Belmont 2.7 FS	Chemtura Corp
	MetaStar 2E AG	Arysta LifeScience N. Amer. Corp

TABLE 2. REGISTERED PESTICIDES FOR GINSENG

Active ingredient	Trade name	Company
metam potassium (*fumigant*)	K-Pam HL	Amvac Chemical Corp
	Metam KLR 54%	Taminco Inc
	Sectagon K-54	Tessenderlo Kerley
metam sodium (*fumigant*)	Metam CLR 42%	Taminco Inc
	Sectagon 42	Tessenderlo Kerley
	Vapam HL	Amvac Chemical Corp
neem oil	Trilogy	Certis USA LLC
penthiopyrad	DuPont Fontelis	DuPont Crop Protection
phosphorous acid salts	Agri-fos	Lawn & Garden Products Inc
	Agrisolutions Topaz [MI only]	Agriliance LLC
	Alude	Cleary Chemical Corp
	Drexel Phiticide	Drexel Chemical Co
	Fosphite	JH Biotech Inc
	Kphite 7LP	Plant Food Systems Inc
	Phorcephite, Rampart	Loveland Products Inc
FUNGICIDES continued		
phosphorous acid salts *continued*	Phostrol	Nufarm Americas Inc
polyoxin D zinc salt	Ph-D WDG	Arysta LifeScience N. Amer. Corp
pyraclostrobin	Cabrio 20EG	BASF Inc
pyrimethanil	Scala SC	Bayer CropScience
Streptomyces lydicus	Actinovate AG	Natural Industries Inc
thiophanate-methyl	Topsin M WSB	United Phosphorus Inc
Trichoderma asperellum/*T. gamsii*	Tenet WP	Isagro USA Inc
trifloxystrobin	Flint 50WG, Gem 500SC	Bayer CropScience
HERBICIDES		
clethodim	Agrisolutions Section 2EC, Agrisolutions Select 2EC	Winfield Solutions LLC
	Arrow 2EC	Makhteshim Agan of N. Amer. Inc
	Cleo 26.4 [MI only]	Ritter Chemical LLC
	CropSmart Clethodim [MI only]	CropSmart LLC
	Intensity Post-emergence Grass Herbicide	Loveland Products Inc
	Select 2EC, Select Max Herbicide With Inside Technology	Valent USA Corp
	Shadow	Arysta Life Science N. Amer. Corp
	Tapout Selective Grass Herbicide	Helena Chemical Co
	Volunteer	Tenkoz Inc
dazomet (*fumigant*)	Basamid Granular Soil Fumigant	BASF Corp
diquat dibromide	Aceto Diquat 2L AG	Aceto Agricultural Chemicals Corp
	Reglone Dessicant	Syngenta Crop Protection Inc
	Rowrunner AG	Rotam N. Amer. Inc
fluazifop-p-butyl	Fusilade DX	Syngenta Crop Protection Inc

TABLE 2. REGISTERED PESTICIDES FOR GINSENG

Active ingredient	Trade name	Company
glyphosate	Agrisolutions Cornerstone [WI only], Agrisolutions Cornerstone 5 Plus, Agrisolutions Cornerstone Plus, Rascal, Rascal Plus	Winfield Solutions LLC
	Alligare Glyphosate 4 Plus	Alligare LLC
	Buccaneer Glyphosate, Buccaneer Plus Glyphosate	Tenkoz Inc
	CropSmart Glyphosate 41 Plus	CropSmart LLC
	Czar	Fuzion Technologies LLC
	Duramax, Durango DMA, Rapidfire	Dow AgroSciences LLC
	Four Power Plus, Mad Dog Plus, Makaze, Mirage Plus [MI only]	Loveland Products Inc
	Gly-4 Plus, Gly-4 Plus	Universal Crop Protection Alliance LLC

HERBICIDES continued

glyphosate continued	Glyfos, Glyfos X-Tra	Cheminova Inc
	Glyphogan, Glyphogan Plus, Quali-pro Glyphosate Plus	Makhteshim Agan of N. Amer. Inc
	GlySupreme Plus,	Mey Corp
	Gordon's Pronto Big N' Tuf 2 Nonselective Agricultural Herbicide	PBI/Gordon Corp
	Hi-Yield Super Concentrate Kill-Zall II	Voluntary Purchasing Groups Inc
	Honcho, Honcho Plus, Roundup Original Max, Roundup Powermax	Monsanto Co
	Hoss Ultra, Rattler [MI only], Rattler Plus	Helena Chemical Co
	Touchdown Hitech, Touchdown Total, Traxion	Syngenta Crop Protection Inc
metam potassium (*fumigant*)	K-Pam HL	Amvac Chemical Corp
	Metam KLR 54%	Taminco Inc
	Sectagon K-54	Tessenderlo Kerley
metam sodium (*fumigant*)	Metam CLR 42%	Taminco Inc
	Sectagon 42	Tessenderlo Kerley
	Vapam HL	Amvac Chemical 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*
cyazofamid (Ranman 400SC)	–	–	–	–	F-P	–	–
cymoxanil (Curzate 60DF)	–	–	–	–	F	–	–
difenoconazole (Inspire SC)	E	P-F	–	–	–	–	–
famoxadone/cymoxanil (Tanos 50DF)	G-F	F	–	–	G	–	–
flutolanil (Moncut 70DF)	-	-	P	–	–	G	?
mancozeb/zoxamide (Gavel 75DF)	G	F	–	–	G	–	–
propamocarb (Previcur Flex 6F)	–	–	–	–	P	–	–
propiconazole (Tilt EC)	G	P-F	–	–	–	–	–
pyraclostrobin/boscalid (Pristine 38WG)	E	E	–	–	P	G	–
Experimental 1 (Experimental)	–	–	–	–	E	–	–
thiophanate-methyl (Topsin)	P	G-F	G	?	P	P	?
triflumizole (Terraguard 50W)	–	?	P	?	–	F	?
V-10208 (Experimental)	–	–	–	–	G	–	–
zoxamide (Zoxium 80WP)	–	–	–	–	F-P	–	–

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

[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 ARTHOPODS	
Aphids Family Aphididae	Aphids pierce foliage and suck out the plant sap, and may cause twisting and distortion of new growth.
Cutworms Family Noctuidae	Minor pest of ginseng. Cutworms feed on stems, girdling young plants and chewing ginseng tops.
Four-lined plant bugs *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 *Archips purpurana*	Larvae partially chew the petiole to wilt the leaf, then fold the leaf around themselves. Larvae feed on ginseng during the day and shelter in the rolled leaf at night.
Millipedes Class Diplopoda	An innocuous feeder of composting vegetation.
Slugs Order Anaspidea	Ragged holes in the leaves and slime trails are symptoms of slug feeding.
Spittle bugs Family Cercopidae	Spittle bugs suck plant sap. Larvae of spittle bugs hatch out and shelter in frothy “spittle” on plant stems.
Thrips Order Thysanoptera	Minor pest of ginseng. Most damage occurs to flower heads.
White grubs Family Scarabidae	Grubs feed below the surface on plant roots.
Wireworms Family Elateridae	Wireworms feed below the surface on plant roots.
DISEASE PATHOGENS	
Alternaria blight *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 *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 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 foliar blight and 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*	White mold 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, which can eventually kill the plants. 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.
Raccoons, 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, yellow woodsorrel.

TABLE 5. ADVANTAGES AND DISADVANTAGES OF PESTICIDES FOR GINSENG

Active ingredient	Pest	Advantages/Disadvantages
INSECTICIDES		
1,3-dichloropropene	wireworms	• B2 carcinogen/ under re-registration • restricted use pesticide • cannot use on heavy soil • worker personal protective equipment required • water setbacks • fumigant • expensive, requires costly equipment • specific temperature requirements limit its use • also used for soilborne diseases and nematodes • moderate acute toxicity to bees • do not contaminate or apply to water
1,3-dichloropropene/ chloropicrin	wireworms	• B2 carcinogen • restricted use pesticide • worker personal protective equipment required • water setbacks • fumigant • expensive, requires costly equipment • restricted use pesticide • specific temperature requirements limit its use • also used for soilborne diseases and nematodes • moderate acute toxicity to bees • do not contaminate or apply to water
alpha-cypermethrin	aphids, armyworms, cutworms, fleabeetles, wireworms	• restricted use pesticide • highly toxic to fish and aquatic organisms • product is highly toxic to bees • do not contaminate or apply to water
azadirachtin	aphids, cutworms, 4-lined plant bugs, leaf rollers, millipedes, spittle bugs, thrips, white grubs, wireworms	• biopesticide • disrupts insect molting • do not apply when honeybees are actively foraging • toxic to fish and aquatic invertebrates • do not contaminate or apply to water • not expected to harm nontarget organisms
Beauveria bassiana	aphids, 4-lined plant bugs, spittle bugs, thrips	• biopesticide • nontoxic to mammals, birds and plants • potential to harm bees • do not apply when bees are foraging; do not apply near hives • do not contaminate or apply to water

TABLE 5. ADVANTAGES AND DISADVANTAGES OF PESTICIDES FOR GINSENG

Active ingredient	Pest	Advantages/Disadvantages
bifenthrin	aphids, 4-lined plant bugs, cutworms, spittle bugs	• restricted use pesticide • highly toxic to bees • extremely toxic to fish and aquatic invertebrates • do not contaminate or apply to water • use prohibited where endangered species may be exposed
carbaryl	cutworms, 4-lined plant bugs, millipedes, spittle bugs	• highly toxic to honeybees and other bees • notify beekeepers within 1 mile at least 48 hours before treatment • apply when bees are not active • extremely toxic to aquatic invertebrates • do not contaminate or apply to water
chloropicrin	cutworms, white grubs, wireworms	• restricted use pesticide • toxic to fish and aquatic invertebrates • do not contaminate or apply to water
chlorantraniliprole	armyworms	• organophosphate alternative • reduced risk insecticide • good efficacy
cyfluthrin	cutworms	• restricted use pesticide • pyrethroid • highly toxic to bees; do not apply when bees are foraging • extremely toxic to fish and aquatic invertebrates • do not contaminate or apply to water
deltamethrin	aphids, 4-lined plant bugs, cutworms, spittle bugs	• organophosphate alternative • restricted use pesticide • highly toxic to bees; do not apply when bees are foraging • extremely toxic to fish and aquatic invertebrates • do not contaminate or apply to water
diazinon	aphids, 4-lined plant bugs, cutworm, spittle bugs, white grubs, wireworms,	• organophosphate • highly toxic to bees and other beneficial insects; do not apply when bees are foraging • highly toxic to birds, fish and other wildlife • do not exceed maximum permitted label rates; rates above those recommended significantly increase potential hazards to birds, especially waterfowl • shrimp, crab may be killed at recommended rates; do not apply where they are important resources • long residual time, good efficacy • do not contaminate or apply to water
flonicamid	aphids, 4-lined plant bugs, spittle bugs	• organophosphate alternative • do not contaminate or apply to water

TABLE 5. ADVANTAGES AND DISADVANTAGES OF PESTICIDES FOR GINSENG

Active ingredient	Pest	Advantages/Disadvantages
imidacloprid	aphids, thrips	• organophosphate alternative • systemic soil treatment • expensive • highly toxic to bees; do not apply if bees are foraging • do not contaminate or apply to water
metaldehyde	slugs	• avoid contact with plants • used between rows • do not contaminate or apply to water
methoxyfenozide	cutworms	• reduced-risk pesticide • do not contaminate or apply to water
neem oil	aphids, thrips	• biopesticide • no adverse environmental effects to nontarget organisms • toxic to bees; do not apply when bees are foraging • hazardous to fish and aquatic invertebrates • do not contaminate or apply to water
petroleum oil	aphids, thrips	• potential for phytotoxicity especially under high temperatures • do not contaminate or apply to water
pyrethrins	aphids, 4-lined plant bugs, cutworms, millipedes, leafrollers, spittle bugs, thrips	• limited efficacy • highly toxic to fish • do not contaminate or apply to water
pyrethrins/ piperonyl butoxide	aphids, 4-lined plant bugs, millipedes, spittle bugs, thrips	• highly toxic to honeybees do not apply when honeybees are foraging • honeybee toxicity suggest there may be nontarget insect concerns • toxic to fish and aquatic invertebrates • do not contaminate or apply to water
spinetoram	thrips	• reduced-risk pesticide • highly toxic to honeybees; do not apply when honeybees are foraging • potential concern for insects • highly toxic to aquatic invertebrates • do not contaminate or apply to water

TABLE 5. ADVANTAGES AND DISADVANTAGES OF PESTICIDES FOR GINSENG

Active ingredient	Pest	Advantages/Disadvantages
spinosad	thrips	• reduced-risk pesticide • new product • used in resistance management programs • expensive • short preharvest interval (1 day) • adverse effects to nontarget organisms and endangered species unlikely • toxic to bees; do not apply when bees are foraging • toxic to aquatic invertebrates • do not contaminate or apply to water
thiamethoxam	aphids	• organophosphate alternative • broad-spectrum • organophosphate alternative • highly toxic to bees; do not apply when bees are foraging • toxic to wildlife • highly toxic to aquatic invertebrates • do not contaminate or apply to water
zeta-cypermethrin	aphids, 4-lined plant bugs, cutworms, leafrollers, spittle bugs	• organophosphate alternative • restricted use pesticide • highly toxic to bees; do not apply when bees are foraging • extremely toxic to fish, aquatic invertebrates, shrimp, oysters • do not contaminate or apply to water
zeta-cypermethrin/ bifenthrin	aphids, 4-lined plant bugs, cutworms, leafrollers, spittle bugs	• restricted use pesticide • highly toxic to bees; do not apply when bees are foraging • extremely toxic to fish, aquatic invertebrates, shrimp, oysters • do not contaminate or apply to water
FUNGICIDES		
1,3-dichloropropene	damping-off, disappearing root rot, rusty root	• B2 carcinogen • restricted use pesticide • cannot use on heavy soil • worker personal protective equipment required • water setbacks • fumigant • expensive, requires costly equipment • specific temperature requirements limit its use • also used to control insects and nematodes • moderate acute toxicity to bees • do not contaminate or apply to water

TABLE 5. ADVANTAGES AND DISADVANTAGES OF PESTICIDES FOR GINSENG

Active ingredient	Pest	Advantages/Disadvantages
1,3-dichloropropene/ chloropicrin	damping-off, disappearing root rot, rusty root, Phytophthora foliar blight and root rot, Sclerotinia white rot, Septonema disease, Stromatinia disease, Verticillium wilt	• B2 carcinogen • restricted use pesticide • worker personal protective equipment required • water setbacks • fumigant • expensive, requires costly equipment • restricted use pesticide • specific temperature requirements limit its use • also used to control insects and nematodes • moderate acute toxicity to bees • do not contaminate or apply to water
aluminum tris	Alternaria blight, damping-off, Phytophthora foliar blight and root rot	• limited efficacy • not effective against *Alternaria* • practically nontoxic to honeybees • toxic to aquatic/estuarine invertebrates • do not contaminate or apply to water
azoxystrobin	Alternaria blight, Botrytis blight, damping-off (*Pythium*, *Rhizoctonia*), disappearing root rot, powdery mildew, rusty root, Sclerotinia white mold	• reduced-risk pesticide • potential resistance issues • known control against *Alternaria* • low acute/chronic toxicity to birds, mammals, bees • toxic to freshwater and estuarine/marine fish and aquatic invertebrates • do not contaminate or apply to water • may leach through permeable soils to ground water
Bacillus pumilus	Alternaria blight, powdery mildew, Sclerotinia white mold	• biopesticide • no adverse environmental effects • do not contaminate or apply to water
Bacillus subtilis	Alternaria blight, Botrytis blight, damping-off, powdery mildew, Sclerotinia white mold	• biopesticide • no adverse environmental effects except bees need more tests • do not apply when bees are actively foraging • do not contaminate or apply to water
boscalid	Alternaria blight, Botrytis blight, disappearing root rot, powdery mildew, Sclerotinia white mold	• reduced-risk pesticide • potential resistance issues • do not contaminate or apply to water
captan	Alternaria blight, Botrytis blight, damping-off, disappearing root rot, Phytophthora foliar blight and root rot, Pythium root rot, Rhizoctonia root and crown rot, rusty root	• B2 carcinogen • nonfood use only • relatively nontoxic to insects • toxic to fish • do not contaminate or apply to water

TABLE 5. ADVANTAGES AND DISADVANTAGES OF PESTICIDES FOR GINSENG

Active ingredient	Pest	Advantages/Disadvantages
chloropicrin	damping-off, Phytophthora foliar blight and root rot, rusty root, Sclerotinia white mold	• restricted use pesticide • toxic to fish and aquatic invertebrates • do not contaminate or apply to water
chlorothalonil	Alternaria blight, Botrytis blight	• B2 carcinogen • toxic to aquatic invertebrates and wildlife • relatively nontoxic to honeybees • do not contaminate or apply to water • may leach through permeable soils to ground water
copper ammonium complex	Alternaria blight	• limited efficacy • potential for phytotoxicity especially under high temperatures • toxic to fish and aquatic organisms • do not contaminate or apply to water
copper hydroxide	Alternaria blight, Botrytis blight, damping-off, Phytophthora foliar blight and root rot	• potential phytotoxicity • limited control of *Alternaria* • toxic to fish and aquatic invertebrates • do not contaminate or apply to water
copper octanoate	Alternaria blight, Botrytis blight, Phytophthora foliar blight and root rot, powdery mildew	• limited efficacy • potential for phytotoxicity especially under high temperatures • toxic to fish and aquatic invertebrates • do not contaminate or apply to water
copper oxychloride/ copper hydroxide	Alternaria blight	• toxic to fish and aquatic invertebrates • do not contaminate or apply to water
copper sulfate	Alternaria blight	• limited efficacy • potential for phytotoxicity especially under high temperatures • toxic to most fish and aquatic invertebrates • do not contaminate or apply to water
cyprodinil/ fludioxonil	Alternaria blight, Botrytis blight, powdery mildew	• reduced-risk pesticide • toxic to fish, aquatic invertebrates, shrimp, oysters • do not contaminate or apply to water
dazomet	damping-off, disappearing root rot, Phytophthora foliar blight and root rot	• restricted use pesticide • toxic to algae, fish • do not contaminate or apply to water
dimethomorph	Phytophthora foliar blight and root rot	• excellent efficacy • do not contaminate or apply to water
fenamidone	Alternaria blight, damping-off, Phytophthora foliar blight and root rot	• reduced-risk pesticide • toxic to fish, aquatic invertebrates, shrimp, oysters • do not contaminate or apply to water

TABLE 5. ADVANTAGES AND DISADVANTAGES OF PESTICIDES FOR GINSENG

Active ingredient	Pest	Advantages/Disadvantages
fenhexamid	Botrytis leaf blight	• reduced-risk pesticide • nonfood use only • cannot be used on crop to be harvested • limited range of pathogens controlled • only 4 applications allowed per season • practically nontoxic to honeybees • toxic to fish and aquatic organisms • do not contaminate or apply to water
fluazinam	Alternaria blight, Botrytis blight, damping-off, Sclerotinia white mold	• reduced-risk pesticide • toxic to fish and aquatic invertebrates • do not contaminate or apply to water
fludioxonil	damping-off	• reduced-risk pesticide • toxic to fish and aquatic invertebrates • do not contaminate or apply to water
fluopicolide	damping-off	• toxic to fish and aquatic invertebrates • do not contaminate or apply to water
fluxapyroxad/ pyraclostrobin	Alternaria blight and botrytis blight	• supplemental label; expires Sep 30, 2016 • good efficacy • toxic to fish and aquatic organisms • do not contaminate water supply
hydrogen dioxide	Alternaria blight	• biopesticide • not tested on ginseng • not used by growers • limited efficacy when tested on other crops • no risks to the environment are expected • highly toxic to bees and other beneficial insects; do not apply when bees are foraging • toxic to birds and fish • do not contaminate or apply to water
ipconazole	damping-off	• do not contaminate or apply to water
iprodione	Alternaria blight, Botrytis blight	• B2 carcinogen • resistance issues • effective against sensitive pathogen populations • relatively nontoxic to bees • toxic to invertebrates • do not contaminate or apply to water
mancozeb	Alternaria blight, damping-off	• B2 carcinogen • practically nontoxic to honeybees • toxic to aquatic organisms • do not contaminate or apply to water
mandipropamid	Phytophthora foliar blight and root rot	• good efficacy • reduced-risk pesticide • do not contaminate or apply to water • surfactant recommended

TABLE 5. ADVANTAGES AND DISADVANTAGES OF PESTICIDES FOR GINSENG

Active ingredient	Pest	Advantages/Disadvantages
mefenoxam	damping-off, Phytophthora foliar blight and root rot	• reduced-risk pesticide • resistance documented and widespread • do not contaminate or apply to water
metalaxyl	damping-off, Phytophthora foliar blight and root rot	• practically nontoxic to honeybees • do not contaminate or apply to water
metam potassium	damping-off, disappearing root rot, damping-off, Phytophthora foliar blight and root rot, Sclerotinia white mild, Verticillium root rot	• restricted use pesticide • toxic to fish • do not contaminate or apply to water
metam sodium	damping-off, disappearing root rot, damping-off, Phytophthora foliar blight and root rot, Sclerotinia white mild, Verticillium root rot	• restricted use pesticide • toxic to fish • do not contaminate or apply to water
neem oil	Alternaria blight, Botrytis blight, damping-off, damping-off, disappearing root rot, damping-off, Phytophthora foliar blight and root rot, powdery mildew	• biopesticide • efficacy data and use pattern lacking for ginseng • very limited efficacy demonstrated for the same pathogens on other crops • no adverse environmental effects to nontarget organisms • toxic to bees; do not apply when bees are foraging • hazardous to fish and aquatic invertebrates • do not contaminate or apply to water
phosphorous acid salts	damping-off, Phytophthora foliar blight and root rot, powdery mildew	• biopesticide • limited efficacy • pathogen-specific • no adverse environmental effects to nontarget organisms • toxic to fish and aquatic organisms • do not contaminate or apply to water
polyoxin D zinc salt	Alternaria blight, Botrytis blight, damping-off, disappearing root rot, rusty root	• biopesticide • no toxicity to insects • moderately toxic to fish and aquatic invertebrates • do not contaminate or apply to water
pyraclostrobin	Alternaria blight, Botrytis blight, disappearing root rot, powdery mildew	• broad-spectrum activity • excellent efficacy • potential for resistance • toxic to fish and aquatic invertebrates • do not contaminate or apply to water

TABLE 5. ADVANTAGES AND DISADVANTAGES OF PESTICIDES FOR GINSENG

Active ingredient	Pest	Advantages/Disadvantages
pyrimethanil	Alternaria blight, botrytis blight	• good efficacy • no known cross resistance issues with other chemistries • do not contaminate water supply with product
Streptomyces lydicus	Alternaria blight, Botrytis blight, damping-off, Phytophthora foliar blight and root rot, powdery mildew, rusty root, Sclerotinia white mold, Verticillium root rot	• biopesticide • no adverse environmental effects to nontarget organisms • do not contaminate or apply to water
Trichoderma asperellum/T. gamsii	damping-off, Phytophthora foliar blight and root rot, rusty root, Sclerotinia white mold, Verticillium root rot	• biopesticide • may pose a risk to beneficial beetle species • do not contaminate or apply to water
trifloxystrobin	Alternaria blight, Botrytis blight, powdery mildew	• reduced-risk pesticide • excellent efficacy • potential for resistance • low toxicity to honeybees • toxic to fish and aquatic invertebrates • do not contaminate or apply to water
NEMATICIDES		
1,3-dichloropropene	nematodes	• B2 carcinogen • restricted use pesticide • cannot use on heavy soil • worker personal protective equipment required • water setbacks • fumigant • expensive, requires costly equipment • specific temperature requirements limit its use • also used for soilborne diseases and insects • moderate acute toxicity to bees • do not contaminate or apply to water

TABLE 5. ADVANTAGES AND DISADVANTAGES OF PESTICIDES FOR GINSENG

Active ingredient	Pest	Advantages/Disadvantages
1,3-dichloropropene/ chloropicrin	nematodes	• B2 carcinogen • restricted use pesticide • worker personal protective equipment required • water setbacks • fumigant • expensive, requires costly equipment • restricted use pesticide • specific temperature requirements limit its use • also used for soilborne diseases and insects • moderate acute toxicity to bees • do not contaminate or apply to waterr
azadirachtin	nematodes	• biopesticide • disrupts insect molting • do not apply when honeybees are actively foraging • toxic to fish and aquatic invertebrates • do not contaminate or apply to water • not expected to harm nontarget organisms
chloropicrin	nematodes	• restricted use pesticide • toxic to fish and aquatic invertebrates • do not contaminate or apply to water
dazomet	nematodes	• restricted use pesticide • toxic to algae, fish • do not contaminate or apply to water
iodomethane/ chloropicrin	nematodes	• restricted use pesticide • expensive • special training needed • toxic to mammals, birds • do not contaminate or apply to water
metam potassium	nematodes	• restricted use pesticide • toxic to fish • do not contaminate or apply to water
metam sodium	nematodes	• restricted use pesticide • carbamate • highly efficient • very expensive • controls bacteria, fungi, weeds, soil insects • fumigant or chemigant • toxic to fish • do not contaminate or apply to water
HERBICIDES		
ammonium salts of fatty acids	postemergence grasses and broadleaves	• biopesticide • broad spectrum • nonselective

TABLE 5. ADVANTAGES AND DISADVANTAGES OF PESTICIDES FOR GINSENG

Active ingredient	Pest	Advantages/Disadvantages
clethodim	postemergence grasses	• only targets grasses • nontoxic to adult worker bees • do not contaminate or apply to water
dazomet	preplant	• restricted use pesticide • toxic to algae, fish • do not contaminate or apply to water
diquat dibromide	postemergent contact	• practically nontoxic to bees • toxic to aquatic invertebrates • do not contaminate or apply to water
fluazifop	postemergence grasses	• toxic to grasses and other monocot plants • limits grasses for only 1 year • limit 6 pt/A/year • broadleaf crops are tolerant, but higher rate needed for quackgrass • cannot apply during the harvest year • toxic to fish and aquatic invertebrates • do not contaminate or apply to water
glyphosate	postemergence grasses and broadleaves	• reduced-risk pesticide • limits weeds for only 2 weeks • excellent efficacy, nonresidual • broad spectrum, excellent on perennials • slightly toxic to birds • practically nontoxic to fish, aquatics, honeybees • apply before planting only • do not contaminate or apply to water
pelargonic acid	preplant	• biopesticide • no adverse environmental effects to nontarget organisms • do not contaminate or apply to water

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]									
	Aph	CW	4LB	LR	Mil	Slu	SB	Thr	WG	WW
REGISTERED B2 CARCINOGENIC INSECTICIDES/MOLLUSCICIDES										
dichloropropene (Telone II)	–[2]	–	–	–	–	–	–	–	–	G
dichloropropene/chloropicrin (Telone C-17, C-35)	–	–	–	–	–	–	–	–	–	G
REGISTERED CARBAMATE INSECTICIDES/MOLLUSCICIDES										
carbaryl (Sevin)	U	U	U	U	U	–	U	U	U	U
REGISTERED ORGANOPHOSPHATE INSECTICIDES/MOLLUSCICIDES										
diazinon (Diazinon)	–	E-G	–	–	U	–	–	–	G	–
OTHER REGISTERED INSECTICIDES/MOLLUSCICIDES										
azadirachtin (Neemix 4.5)	F-P	P	U	P	P	–	F-P	U	P	P
Beauveria bassiana (Mycotrol)	U	U	U	U	U	–	U	U	U	U
bifenthrin (Brigade)	U	U	U	U	U	–	U	U	U	U
chlorantraniliprole (Coragen)	P	G	P	P	U	–	P	P	G	U
chloropicrin (Chlor-O-Pic)	U	U	U	U	U	–	U	U	U	U
cyfluthrin (Baythroid XL)	U	U	U	U	U	–	U	U	U	U
deltamethrin (Delta Gold)	U	U	U	U	U	–	U	U	U	U
flonicamid (Beleaf)	U	U	U	U	U	–	U	U	U	U
imidacloprid (Admire, Provado)	G	P	U	P	P	–	G	U	G	F
metaldehyde MOLLUSCICIDE (Deadline)	–	–	–	–	–	G	–	–	–	–
methoxyfenozide (Intrepid)	U	U	U	U	U	–	U	U	U	U
neem oil (Trilogy)	U	U	U	U	U	–	U	U	U	U
petroleum oil (Glacial Spray)	U	U	U	U	U	–	U	U	U	U
pyrethrins/piperonyl butoxide (Pyrenone)	G	–	–	–	–	–	F-P	–	P	P
sodium ferric EDTA (IronFist)						F				
spinetoram (Radiant SC)	U	U	U	U	U	–	U	U	U	U
spinosad (SpinTor)	U	G	U	G	P	–	G	–	P	P
thiamethoxam (Actara,)	?	?	?	?	–	–	?	–	–	–
zeta-cypermethrin (Mustang)	U	U	U	U	U	–		U	U	U
zeta-cypermethrin/bifenthrin (Hero)	U	U	U	U	U	–	U	U	U	U
PIPELINE PEST MANAGEMENT TOOLS										
chlorpyrifos (Lorsban)	U	U	U	U	U	–	U	U	U	U
lambda-cyhalothrin (Warrior)	?	?	?	?	–	–	?	?	–	–

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]									
	Aph	CW	4LB	LR	Mil	Slu	SB	Thr	WG	WW
pymetrozine (Fulfill)	?	–	–	–	–	–	–	–	–	–
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: Aph = aphids, CW = cutworms, 4LB = four-lined plant bugs, LR = leaf rollers, Mil = millipedes, Slu = slugs, SB = spittle bugs, Thr = thrips, 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	Ver
REGISTERED B2 CARCINOGENIC FUNGICIDES										
chlorothalonil (Bravo)	G-E	G-E	–	–	P	E	–	–	–	–
captan (Captan 50W)	G-F	F-G	G	G	E	–	?	–	–	–
dazomet (Basamid)	–	–	?	?	?	–	?	?	?	?
dichloropropene (Telone II)	–[1]	–	?	?	?	–	?	?	?	?
dichloropropene/chloropicrin (Telone C-17/C-35)	–	–	?	?	?	–	?	?	?	?
iprodione (Rovral)	F	F-P	–	–	–	–	–	–	–	–
mancozeb (Dithane)	F-G	F	–	–	F-P	E	–	–	–	–
REGISTERED CARBAMATE FUNGICIDES										
metam potassium (Sectagon)	–	–	?	?	?	–	?	?	?	?
metam sodium (Vapam)	–	–	?	?	?	–	?	?	?	?
OTHER REGISTERED FUNGICIDES										
aluminum tris (Aliette)	P	–	P	–	F	–	–	–	–	–
azoxystrobin (Quadris)	G	F	F	G	–	E	F	?	–	–
Bacillus pumilus (Sonata)	P	?	–	–	–	?	–	?	?	–
Bacillus subtilis (Serenade)	P	P	–	–	–	–	–	–	–	–
boscalid (Endura)	E	G	–	–	–	E	–	E	–	–
chloropicrin (Chlor-O-Pic)	–	–	F-G	?	G	–	G	G	?	–
copper hydroxide (Champ, Kocide, Nu-Cop)	P-F	F	F	–	–	G	–	–	–	–
cyprodinil/fludioxonil (Switch 62.5WG)	F-G	F	–	–	–	?	–	?	–	–
dimethomorph (Forum)	–	–	P	–	G	–	–	–	–	–
fenamidone (Reason 500SC)	P	–	G	–	G	–	–	–	–	–
fenhexamid (Elevate)	P	E	–	–	–	–	–	–	–	–
fluazinam (Omega)	F-G	E	–	–	P	E	–	G	–	–
fludioxonil (Cannonball)	F	F	F-G	G	–	–	G	–	–	–
fludioxonil (Maxim) seed treatment	–	–	F	–	–	–	?	–	–	–
fluopicolide (Presidio)	–	–	G	–	G	–	–	–	–	–
fluxapyroxad/pyraclostrobin (Merivon)	G	F-G	–	–	–	?	?	?	–	–
hydrogen dioxide (OxiDate)	P	–	P	P	–	–	–	–	–	–
ipconazole (Rancona 3.8FS)	?	?	?	?	?	?	?	?	?	?
mandipropamid (Revus)	–	–	–	–	G	–	–	–	–	–
mefenoxam (Ridomil)	–	–	E-P	–	E-P	–	–	–	–	–
metalaxyl (Allegiance-FL)	–	–	E-P	–	E-P	–	–	–	–	–
neem oil (Trilogy)	P	P	–	–	–	P-F	–	–	–	–
polyoxin D zinc salt (Ph-D)	F-G	G	P-E	P	–	P	?	–	–	–
pyraclostrobin (Cabrio WG)	G-E	F	P	–	–	G	–	–	–	–
pyrimethanil (Scala)	G	G	–	–	–	?	–	–	–	–
phosphorous acid salts (Agri-Fos, Phostrol)	–	–	–	–	P-F	–	–	–	–	–
Streptomyces lydicus (Actinovate)	P	P	P	–	P	P	?	?	–	?

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	Ver
Trichoderma asperellum/T. gamsii (Tenet)	P	P	P	–	–	?	?	?	–	?
trifloxystrobin (Flint, Gem)	G-E	F	?	–	–	?	?	–	–	–
PIPELINE PEST MANAGEMENT TOOLS										
cyazofamid (Ranman 400SC)	–	–	F	–	F	–	–	–	–	–
difenoconazole (Inspire)	E	–	–	–	–	?	–	–	–	–
mancozeb/zoxamide (Gavel 75DF)	G	F-P	G	–	G	E		–	–	–
pyraclostrobin/boscalid (Pristine)	E	G	–	–	–	G	–	–	–	–
Experimental 1 (Experimental)	–	–	P	–	E	–	–	–	–	–
thiophanate-methyl (Topsin)	F-P	G	F-G	G	–	E	F	G	?	?
V-10208 (Experimental)	–	–	P-E	–	G	–	–	–	–	–
OTHER PEST MANAGEMENT AIDS										
good ventilation	F	F	–	–	F	F	–	F	–	–
increased drainage	F	F	F	F	F	–	F	F	–	–
limit garden size	F	F	–	–	F	F	F	–	–	–
sanitation	–	–	F	F	F	–	F	F	–	F
scouting	F	F	–	–	F	F	–	–	–	–
seed treatments	F	–	F	F	F	–	F	P	?	?
time sprays to initial disease occurrence	P	P	P	P	P	F	P	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; Ver=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	
dazomet (Basamid)	U[1]
dichloropropene (Telone II)	G-F
dichloropropene/chloropicrin (Telone C-17/C-35)	G-F
REGISTERED CARBAMATE NEMATICIDES	
metam potassium (Sectagon)	U
metam sodium (Vapam)	G-F
OTHER REGISTERED NEMATICIDES	
azadirachtin (Ecozin)	U

chloropicrin (Chlor-O-Pic)	F
iodomethane/chloropicrin (Midas)	F

[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				
dazomet (Basamid)	?	?	?	?
diquat dibromide (Reglone Dessicant)	G	G	G	G
glyphosate (Roundup, etc)	G[1]	G	G	G
metam potassium (Sectagon)	?	?	?	?
metam sodium (Vapam HL)	G	G	G	G
pelargonic acid (Scythe)	?	?	?	?
REGISTERED POST-EMERGENCE HERBICIDES – Before Planting				
glyphosate (Roundup, etc)	G	G	G	G
REGISTERED POST-EMERGENCE HERBICIDES				
clethodim (Section, Select)	none	?	none	?
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)							■	■	■	■	■							
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)							■	■	■	■								
Hand weeding								■	■	■	■	■						
Roundup			■													■	■	
Shade removed														■	■			
Fertilization (soil sampling)															■	■	■	■
Bloom period								■	■	■								
Seed harvested (3 year olds)													■	■				

TABLE 10. GENERAL TIMELINE FOR CROP STAGES AND WORKER ACTIVITIES

Years 2-3 (2-3 year old plants)	Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov	
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)																		
Hand weeding																		
Roundup																		
Shade removed																		
Fertilization (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		■	■	■	■	■	■	■	■	■	■	■		