PEST MANAGEMENT IN THE FUTURE

A Strategic Plan for the Michigan Asparagus Industry

Workshop Summary
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TABLE OF CONTENTS

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ABOUT THE WORKSHOP

A group of growers, processors and technical experts met in Muskegon, Michigan for one and a half days to determine and summarize the critical needs of the Michigan asparagus industry in terms of the efficacy of current pest management practices and tools and the feasibility of identified alternatives. The participants discussed current insect pest, disease, and weed management practices and determined the top research, regulatory and education needs of the industry.

TOP PRIORITIES OF MICHIGAN ASPARAGUS PRODUCTION

Research:

1. Identify effective reduced-risk pesticides and/or biocontrol alternatives to pest management products critical to asparagus production (i.e. chlorpyrifos (Lorsban), carbaryl (Sevin), and chlorothalonil (Bravo)).
2. Develop management strategies for *Fusarium* crown and root rot based on the biology of the pathogen, influence of the environment and interaction with insect vectors.
3. Determine economic thresholds for the foliar diseases rust and purple spot and develop disease management strategies including disease forecasting systems.
4. Identify and develop new marketing strategies and value-added products.
5. Determine economic thresholds for fern damage caused by onion thrips, asparagus miner, and beetles.
6. Identify effective reduced-risk herbicides and develop alternative weed control methods including management of weeds in nursery beds.
7. Identify asparagus varieties suitable for Michigan that are resistant to plant diseases and insects.

Regulatory:

1. Chlorpyrifos (Lorsban), carbaryl (Sevin), and chlorothalonil (Bravo) are critical for pest management and their use must be retained until safe, cost-effective alternatives become available.
2. Expedite registration of new pest control alternatives once they are shown to be safe and effective.

Education:

1. Continue Integrated Pest Management (IPM) education and on-farm demonstration plots.
2. Educate and provide technical support to growers and consultants as new materials and management strategies are developed.
3. As information becomes available, educate growers on economic thresholds for foliar diseases and insect damage.
4. Educate consumers on recent strides in integrated pest management and production practices.

BACKGROUND

Michigan is ranked third nationally (after California and Washington) in asparagus production. With an average of 18,300 acres planted and 17,800 acres harvested, Michigan produces approximately 27,700,000 lbs. of asparagus at a value of almost $18 million annually. In 1998, fresh market asparagus accounted for 4,000,000 lbs. at $2.6 million, while processing asparagus accounted for 24,000,000 lbs. at $14.9 million. Major asparagus producing counties in lower Michigan include Mason and Oceana in the northwest and Cass and Van Buren in the southwest.

Asparagus is a perennial crop that under ideal conditions should have a production life of 20 or more years. Establishment costs are $9,500 per acre for crown nurseries and $2,100 per acre for production fields. Seeds are planted in nursery fields in early spring and grown until the following spring, when the young crowns are transplanted into production fields. The young stand is allowed to grow for one to two years, also known as the "non-bearing" stage of production, before harvesting begins. Harvesting is accomplished by hand every one to five days for two to eight weeks depending on the maturity of the stand. "Layby" is the process of ending harvest and applying fertilizer and herbicide prior to the fern stage. The fern stage provides necessary photosynthetic energy for the following year's harvest.

The most economically devastating insect pests are asparagus beetles (*Crioceris asparagi* and *C. duodecimpunctata*) and cutworms (Noctuidae). Adults of the common and spotted asparagus beetles overwinter in crop residue and emerge in early spring to feed and lay eggs on growing spears, producing two or three generations per year. Eggs are extremely difficult to remove from the harvested spears and currently there is zero tolerance for egg-infested spears. In addition, larvae and summer-generation adults feed on growing fern and can cause severe defoliation, reducing plant vigor. Several cutworm species are pests of asparagus, damaging spears in the spring by their feeding. Some cutworms, such as the white cutworm and spotted cutworm, feed on the tips of spears. Dark-sided cutworms feed on the sides of emerging asparagus spears, causing crooked growth. Damage can be more common in no-till fields, and more severe early in the season when spear growth is slow. There is zero tolerance for cutworm feeding with damaged spears rejected as unmarketable by both fresh and processing markets.

Sporadic insect pests include onion thrips (*Thrips tabaci*), tarnished (*Lygus lineolaris*)

and alfalfa (*Adelphocoris lineolatus*) plant bugs, and asparagus aphids (*Brachycorynella asparagi*). Infestations of asparagus spears by onion thrips is a problem for the fresh market industry rendering spears unsaleable. Onion thrips sometimes injure new fern growth. Populations are usually controlled by natural predators and hard rains. In hot, dry weather, thrips can be a problem because populations can build up quickly. The tarnished and alfalfa plant bugs overwinter as adults and emerge in April to May with several generations occurring over the growing season. Both species feed on a wide variety of crops and weeds, however, the first generation often occurs on alfalfa and migrates to asparagus when hay is cut. Adults and nymphs cause tip dieback with damage most common during the summer flush of new fern growth. Asparagus aphids overwinter as eggs on asparagus foliage or on the soil surface. The aphids feed on asparagus fern, resulting in bushy, "witches' broom" growth and bluish-green coloration. Heavily infested plants are weak, have reduced yields, and may die in two years. Aphids are usually controlled by natural predators.

Another insect commonly found on asparagus is the asparagus miner, *Ophiomyia simplex*. During the fern stage it lays its eggs at the base of asparagus stems, where larvae mine stems and pupate within them. Larvae are small (5 mm) and mining is confined to the cortex. Damage by asparagus miner has been considered insignificant, thus growers have not monitored or tried to control this insect. However, research suggests that the asparagus miner may harbor *Fusarium* and passively vector it with infected pupae serving as an overwintering source of inoculum.

There are several major diseases which adversely affect asparagus in Michigan: crown and root rot (*Fusarium oxysporum* f.sp. *asparagi* and *F. proliferatum*), rust (*Puccinia asparagi*), and purple spot (*Stemphylium vesicarium*). *Fusarium* crown and root rot results in damping-off of seedlings in crown nurseries, poor stand establishment in young asparagus fields, and a slow decline in productivity of mature fields. Symptoms include weak, spindly spears in the spring followed later in the season by bright yellow shoots, discolored vascular tissue and rotting roots. Losses resulting from *Fusarium* crown and root rot can be staggering due to years of lost productivity when declining fields are abandoned prematurely. Although the pathogens can be seed-borne, they are ubiquitous in Michigan and may be found in soil with no history of asparagus culture. Genetic resistance to this disease is unavailable in commercial cultivars and fungicides and fumigation have not been shown to provide consistent control. Cultural strategies

to reduce this disease include reduced or no tillage to prevent wounding of the crown.

Adoption of no tillage to minimize incidence of *Fusarium* crown and root rot and to reduce wind and water erosion, has exacerbated the foliar diseases, rust and purple spot. Since the previous year's fern is chopped and left on the soil surface, the rust and purple spot pathogens overwinter on the debris. When foliar diseases are left unchecked, premature defoliation occurs, which negatively impacts subsequent yields and weakens the crown predisposing the plant to *Fusarium* infection.

Rust occurs on the fern following spear harvest with symptoms including red or brown pustules within which spores are produced. Severe infections can defoliate plants. When a rust epidemic was left uncontrolled for two subsequent years, total spear weight was decreased 54% and the number of spears reduced by 46%. Translated into revenue, approximately $1,617,000 to $7,938,000 could be lost yearly by the Michigan asparagus industry following consecutive years of a rust epidemic. Ethylenebisdithiocarbamate fungicides (i.e. mancozeb) are registered to control rust but are not allowed by some processors. Therefore, Michigan obtains a Section 18 Specific Exemption for the use of myclobutanil (Nova 40W) for rust control.

Purple spot is characterized by small, elliptical purple lesions with brown centers occurring on both spears and fern. Lesions may occur on 60 to 90% of the spears, which is especially of concern to fresh market producers as spotted spears may not be marketable. Severe purple spot infections on ferns can result in defoliation and dieback of plants, as well as cause reductions in yield. Purple spot is managed with the application of fungicides to the fern; fungicides are not applied to the spears. Michigan has pursued and obtained a yearly Section 18 Specific Exemption for the use of chlorothalonil (Bravo) to control purple spot because some processors do not allow the use of mancozeb. Tom-Cast is a disease forecaster that uses weather data to determine spray timing, which minimizes the number of sprays used while maintaining maximum disease control. Over a two-year period, chlorothalonil (Bravo) was applied according to Tom-Cast to newly established commercial asparagus fields. This treatment enhanced yields compared to untreated fields resulting in a benefit per acre of up to $2,057.69.

Currently, *Phytophthora* spear and crown rot, caused by *Phytophthora megasperma* and *P. cryptogea*, is not a problem in Michigan. However, given the devastating, long-term nature of this disease in other regions, cultural techniques and rotation programs that insure continued

exclusion of this problem are critical. This disease causes gray-beige to brown lesions on the spear, resulting in establishment failure of new stands or reduction in yield of mature stands.

Annual and perennial broadleaf and grass weeds compete with asparagus for nutrients, water and light. Weeds also serve as hosts for asparagus insect pests, and interfere with harvesting and efficient pesticide application. Because heavy infestations of perennial weeds can be difficult to manage without damaging the asparagus, production fields are carefully cleared of weeds prior to planting. Cover crops such as rye are often planted in late summer to decrease soil erosion, but need to be killed and mowed in the spring prior to harvest. Cover crops as well as weeds are controlled primarily with herbicides. Tilling as a method of weed control is used infrequently because of soil erosion problems on sandy soils and potential damage to crowns, which may result in greater incidence of *Fusarium* crown and root rot.

Michigan asparagus growers use integrated pest management strategies to minimize cost and maximize yields and are continuously looking for improvements in safety and effectiveness. However, without replacement pesticides or management strategies to offset the loss of one or more pesticides at risk due to implementation of the Food Quality Protection Act (FQPA), growing asparagus in Michigan will not be profitable. Pro-actively identifying research and regulatory needs for replacing those products scheduled for review by the FQPA is vital to the future of the Michigan asparagus industry.

OUTLINE OF PLAN

The remainder of this document is a pest by pest analysis of the current role of pesticides classified as organophosphates, carbamates and B2 carcinogens, the use of other pest management aids (chemical, cultural and otherwise) that offer some control but are not "stand alone" tools, pipeline pest management tools (identified as effective but not yet available), and "to do" lists for research, regulatory, and education needs. Pests are presented in alphabetical order.

INSECTS

1. Asparagus aphid (*Brachycorynella asparagi*)

Currently not a problem in Michigan and insecticides are typically not used. However, a prolonged drought or change in standard insecticides currently used for other insect pests may increase populations. Natural predators, parasites and insect pathogens may be keeping pest populations low.

Organophosphate insecticides currently registered:

- Chlorpyrifos (Lorsban)
- Malathion
  - Currently not used for this pest.

Carbamate insecticides currently registered:

- None

Other insecticides currently registered:

- Permethrin (Ambush, Pounce)
  - Only used in problem areas; could be harmful to natural predators.
  - Less effective in hot weather.

Other pest management aids:

- Scouting.
- Removing and/or destroying crop debris.
  - not practical.

Pipeline pest management tools:

- None identified.

"To do" list for asparagus aphid:

Research needs:

- Determine ability of the naturally occurring soil-borne parasite *Beauvaria bassiana* to limit aphids.
- Determine and use patterns of reduced risk insecticides and biocontrol agents including *Beauvaria bassiana*.
- Develop selective insecticides and pest monitoring programs to enhance the effectiveness of biocontrol agents.

Regulatory needs:

- Expedite registration for safe and effective alternatives.

Education needs:

- As new management tools become available, provide training on proper use.

2. Asparagus beetle (common asparagus beetle, *Crioceris asparagi*; spotted asparagus beetle, *C. duodecimpunctata*)

Most important pest since there is zero tolerance for beetle eggs on fresh and processing asparagus, and eggs cannot be physically removed without damaging the spears. During the harvest season, adults must be controlled before they lay eggs. Later in the season, adults feeding on fern can cause defoliation.

Organophosphate insecticides currently registered:

- Chlorpyrifos (Lorsban)
  - Applied before harvest or during fern stage (generally not used during harvest season).
  - Limited to one pre-harvest application and two post-harvest applications.
  - Short pre-harvest interval (1 day).
- Malathion
  - Not effective.

Carbamate insecticides currently registered:

- Carbaryl (Sevin)

  - Critical pest management tool relied on by the industry to prevent contamination of spears by beetle eggs.
  - Works swiftly to knock down adult beetles before they can lay eggs on spears.
  - Short re-entry time (12 hours) and pre-harvest interval (1 day).
  - Effective when applied at lower than labeled rates, cost effective.
- Methomyl (Lannate)
  - Cost is twice that of pyrethroids.
  - Long re-entry interval (48 hours) limits use and therefore is not widely used.
  - Handler and applicator concerns.
  - Short residual.

Other insecticides currently registered:

- Methoxychlor
  - Good control during fern stage and not used during harvest.
  - Not widely used, costly and slow acting.
  - Short re-entry interval (12 hours), but long pre-harvest interval (3 days).
- Permethrin (Ambush, Pounce)
  - Used during fern stage.
  - Inexpensive.
  - Short re-entry (12 hour) and pre-harvest (1 day) intervals.
  - Not effective on adult beetles.
  - Not effective in hot weather.

Other pest management aids:

- Scouting.
- Parasitic wasp (*Tetrastichus asparagi*).
  - Attacks eggs of common asparagus beetles.
  - Can help reduce populations during fern stage, but not commonly found in commercial fields due to insecticide use.
- Lacewings and stinkbugs.
  - Can provide a low level of control when present.

Pipeline pest management tools:

- None identified.

"To do" list for asparagus beetles:

Research needs:

- Determine efficacy and use patterns of reduced risk insecticides (imidacloprid (Admire, Provado) and spinosad (SpinTor)) and biocontrol agents.
- Integrate biological control into pest management system to protect parasitic wasps (*T. asparagi*).
- Develop economic thresholds for asparagus beetles in fern stage.
- Develop processes to remove beetle eggs from spears without damaging spears.

Regulatory needs:

- Must retain carbaryl (Sevin) registration until safe and effective alternatives are identified and registered.
- If proven safe and effective, expedite registration of imidacloprid (Admire, Provado) and spinosad (SpinTor) and other alternatives.

Education needs:

- As new management tools become available, provide training on proper use.

3. Asparagus miner (*Ophiomyia simplex*)

Although this insect causes very little physical damage, it may be a vector and source of overwintering inoculum for *Fusarium*.

Organophosphate insecticides currently registered:

- None.

Carbamate insecticides currently registered:

- None.

Other insecticides currently registered:

- None.

Other pest management aids:

- Scouting.

Pipeline pest management tools:

- None identified.

"To do" list for asparagus miner:

Research needs:

- Determine if asparagus miner is a vector for *Fusarium*.
- Investigate life history of asparagus miner in Michigan.
- Develop efficient scouting techniques.
- Determine which insecticides or cultural practices effectively manage the miner.

Regulatory needs:

- None identified.

Education needs:

- As new management tools become available, provide training on proper use.

4. Cutworms (Noctuidae)

Cutworms are the second most devastating insect pest. Feeding damage on spears can significantly reduce marketable yield since there is zero tolerance in both fresh and processing markets for damaged spears. Without chlorpyrifos (Lorsban), the asparagus industry would be jeopardized unless an effective alternative is identified and registered.

Organophosphate insecticides currently registered:

- Chlorpyrifos (Lorsban)
  - Critical tool, widely used and very effective.
  - Limited to one pre-harvest application typically used mostly 7 to 14 days prior to first harvest.
  - Used primarily for cutworm, but also controls beetles on asparagus fern.

Carbamate insecticides currently registered:

- Carbaryl (Sevin)
  - Not effective, not used.
  - Short pre-harvest interval (1 day).
- Methomyl (Lannate)
  - Long re-entry interval (48 hours) limits use and therefore is not widely used.
  - Short pre-harvest interval (1 day).

- Handler and applicator concerns.
- Short residual.

Other insecticides currently registered:

- Permethrins (Ambush, Pounce)
  - Only product labeled for use during harvest.
  - One species of cutworm feeds at or below ground level where this product is ineffective.
  - Not effective in hot weather.
  - Reliance on permethrin (Ambush, Pounce) may result in insect resistance problems.
  - Short re-entry (12 hours) and pre-harvest (1day) intervals.

Other pest management aids:

- Scouting.
- Remove weeds to reduce area for adult moths to lay eggs.

Pipeline pest management tools:

- None identified.

"To do" list for cutworms:

Research needs:

- Develop and determine efficacy and use patterns of reduced risk insecticides and biocontrol agents including spinosad (SpinTor).

Regulatory needs:

- Must retain chlorpyrifos (Lorsban) registration until safe, effective alternative is identified and registered.
- Expedite registration for safe and effective alternatives.

Education needs:

- As new management tools become available, provide training on proper use.

5. **Plant bugs (Tarnished plant bug, *Lygus lineolaris*; alfalfa plant bug, *Adelphocoris lineolatus*)**

   A sporadic pest, but can be a problem in young, actively growing asparagus.

   Organophosphate insecticides currently registered:

- None.

Carbamate insecticides currently registered:

- None.

Other insecticides currently registered:

- Permethrin (Ambush, Pounce)
  - Only registered insecticide for tarnished plant bug in asparagus.

Other pest management aids:

- Scouting.

Pipeline pest management tools:

- None identified.

"To do" list for plant bugs:

Research needs:

- Develop cultural control alternatives.
- Determine efficacy and use patterns of reduced risk insecticides and biocontrol agents including imidacloprid (Admire, Provado).
- Determine if plant bugs cause plant dieback.

Regulatory needs:

- If proven safe and effective, expedite registration of imidacloprid (Admire, Provado) and other alternatives.

Education needs:

- As new management tools become available, provide training on proper use.

6. Onion thrips (*Thrips tabaci*)

Primarily a problem in nursery (seedbeds) and young fields (new stands) with population sizes dependent on weather. Insecticide resistance is an issue. Damage from feeding limits marketing of asparagus spears and decreases plant vigor.

Organophosphate insecticides currently registered:

- Malathion
  - Not widely used.

Carbamate insecticides currently registered:

- Carbaryl (Sevin)
- Methomyl (Lannate)
  - More effective than carbaryl (Sevin), but more expensive.

Other insecticides currently registered:

- None.

Other pest management aids:

- Scouting.

Pipeline pest management tools:

- None identified.

"To do" list for thrips:

Research needs:

- Determine if thrips cause plant dieback.
- Determine economic thresholds.
- Determine efficacy and use patterns of reduced risk insecticides, spinosad (SpinTor), and biocontrol agents.
- Develop cultural control alternatives.

Regulatory needs:

- If proven safe and effective, expedite registration of spinosad (SpinTor) and other alternatives.

Education needs:

- As new management tools become available, provide training on proper use.

FUNGAL PATHOGENS

1. ***Fusarium*** **Crown and Root Rot (*Fusarium oxysporum* f.sp. *asparagi*, *F. proliferatum*)**

   Serious disease with no known chemical control caused by an extremely long-lived soil-borne pathogen.

   B2 carcinogenic fungicides currently registered:

   - None.

   Other fungicides currently registered:

- None.

Other pest management aids:

- Avoid rotations to corn and planting on previous asparagus fields for a minimum of four years.
- Maximize plant vigor.
  - Select vigorous varieties, avoid over harvesting, control pests (weed, disease, insects), and avoid soil compaction; maintain moderate soil fertility and pH between 6.5 and 7.5.
- Avoid tillage that may damage roots and crown.

Pipeline pest management tools:

- None identified.

"To do" list for *Fusarium* crown and root rot:

Research needs:

- Investigate ability of commercially available biological control organisms and mycorrhizae to suppress disease.
- Investigate use of soil amendments to suppress disease and enhance fern vigor to aid in disease resistance and/or tolerance.
- Investigate the role of airborne *Fusarium* spores in disease development.
- Investigate the role of asparagus miner in disease incidence and spread.
- Screen new fumigants, reduced risk fungicides, and plant inducers for efficacy and safety.
- Screen and breed disease resistant asparagus varieties suitable for Michigan.
- Determine an effective crop rotation prior to bed establishment that reduces initial *Fusarium* inoculum.
- Investigate sources and spread of *Fusarium* inoculum.
- Test the effects of foliar fertilizer on fern vigor and disease resistance.

Regulatory needs:

- None identified.

Education needs:

- Continue grower education on cultural practices that reduce disease incidence and severity.

- As new management tools become available, provide training on proper use.

2. *Phytophthora* Spear and Crown Rot (*Phytophthora megasperma, P. cryptogea*)

Not currently a problem in Michigan, but it is seen in other production regions.

B2 carcinogenic fungicides currently registered:

- None

Other fungicides currently registered:

- Fosetyl-al (Aliette)
- Mefenoxam (Ridomil Gold)

Other pest management aids:

- None identified.

Pipeline pest management tools:

- None identified.

"To do" list for Phytophthora spear and crown rot:

Research needs:

- Develop soil test to detect pathogen presence.
- Determine pathogen host range.

Regulatory needs:

- None identified.

Education needs:

- Emphasize cultural and rotational strategies to exclude the pathogen from production areas.

3. Purple Spot (*Stemphylium vesicarium*)

To control purple spot on the ferns, fungicides are applied during June to September, 9 to 10 months before harvest the subsequent spring (pre-harvest interval is approximately 250 days). No fungicides are applied to the spears. A disease forecaster (Tom-Cast) is used to predict when to apply chlorothalonil (Bravo) fungicide. Controlling purple spot enhances fern vigor and may thereby aid in managing *Fusarium* crown and root rot.

B2 carcinogenic fungicides currently registered:

- Chlorothalonil (Bravo), Section 18 Specific Exemption for use in Michigan
  - High importance, commonly used, cost effective.
  - Part of an IPM program used with disease forecaster, loss of this product would disrupt current IPM system.
- Mancozeb (Dithane, Manzate, Penncozeb)
  - Some processors restrict use.

Other fungicides currently registered:

- None.

Other pest management aids:

- Scouting.
- Burning crop debris in late fall or winter.
  - Not feasible in large acreage due to human and environmental safety concerns.
- Tilling to bury crop debris.
  - Leads to wind erosion, reduced spear quality and marketability, and damaged crown and roots.

Pipeline pest management tools:

- Reduced risk fungicides azoxystrobin (Quadris) and trifloxystrobin (Flint) are effective.

"To do" list for purple spot:

Research needs:

- Determine efficacy and use patterns of reduced-risk fungicides, biocontrol agents and plant inducers.
- Develop resistance management programs for new products including azoxystrobin (Quadris) and trifloxystrobin (Flint).
- Determine suitability of using Tom Cast with azoxystrobin (Quadris) and trifloxystrobin (Flint).
- Identify effective broad-spectrum fungicides to use in rotation with azoxystrobin (Quadris) and trifloxystrobin (Flint).
- Screen and breed disease resistant asparagus varieties suitable for Michigan.

Regulatory needs:

- Expedite registration of azoxystrobin (Quadris) and trifloxystrobin (Flint) and other safe

and effective alternatives.

- Need full registration for chlorothalonil (Bravo).

Education needs:

- As new management tools become available, provide training on proper use.

4. Rust (*Puccinia asparagi*)

To control rust on the ferns, fungicides are applied 9 to 10 months before harvest the subsequent spring (pre-harvest interval is approximately 250 days). Rust is not a problem on the spears. Controlling rust enhances fern vigor and may aid in managing *Fusarium* crown and root rot.

B2 carcinogenic fungicides currently registered:

- Mancozeb (Dithane, Manzate, Penncozeb)
  - Some processor restrict use.
  - Must be applied frequently to be effective.

Other fungicides currently registered:

- Myclobutanil (Nova [Section 18 Specific Exemption for use in Michigan])
  - Systemic, provides a longer period of control than mancozeb.
  - Should be used in rotation with other products because of possible resistance development.
  - Moderate to high expense.
- Sulfur (Kumulus, Thiolux)
  - Not effective and not currently used.

Other pest management aids:

- Scouting.
- Planting moderately disease resistant or tolerant asparagus varieties.
- Eliminating asparagus seedlings and volunteers.
- Burning crop debris in late fall or winter.
  - Not feasible in large acreages due to human and environmental safety concerns.
- Tilling to bury crop debris.
  - Leads to wind erosion, reduced spear quality and marketability, and damaged crown

and roots.

Pipeline pest management tools:

- Reduced risk fungicides azoxystrobin (Quadris) and trifloxystrobin (Flint) are effective.

"To do" list for Rust:

Research needs:

- Develop a disease forecasting system to time fungicide sprays.
- Determine efficacy and use patterns of biocontrol agents and plant inducers.
- Screen and breed disease resistant asparagus varieties suitable for Michigan.
- Develop fungicide spray programs to avoid fungicide resistance.

Regulatory needs:

- Need full registration for myclobutanil (Nova).
- Expedite registration of azoxystrobin (Quadris) and trifloxystrobin (Flint) and other safe and effective alternatives.

Education needs:

- As new management tools become available, provide training on proper use.

WEEDS

Annual/perennial grasses and broadleaf weeds:

Weed management is handled differently according to the maturity of the asparagus stand. This section is divided between herbicides registered for use on non-bearing (crown nurseries to first year plantings) and bearing (two years and older) stands. Most growers use a no-till system to prevent wind and water erosion and damage to crowns and roots.

1. **Young or "non-bearing" (not harvested) asparagus:**

   B2 carcinogenic herbicides currently registered:

   - Metam-sodium (Vapam) (fumigant)
     - Expensive and not very effective.

   Other herbicides currently registered:

   - Fluazifop-P-butyl (Fusilade)
     - Used for annual grass control; works well on sandburs, crabgrass, volunteer grains;

not very effective on quackgrass.

  - Cost effective.
  - Safe to use on asparagus; can be used post-emergence to the crop.
  - Versatile, long period of time that applications can be made safely.
  - Potential annual grass resistance problems have been seen in other crops.

- Glyphosate (Roundup)
  - Good for perennial weed control (systemic).
  - Necessary for cover crops management.
  - Very cost effective.
  - Spot treatment as well as broadcast applications are effective.
  - Weak on field bindweed.
  - Not effective on hemp dogbane, milkweed, clovers or alfalfa.
  - Cannot be sprayed over the fern.
- Linuron (Lorox, Linex)
  - Primary pre-emergence broadleaf herbicide labeled for seedbeds or first year crowns.
  - Controls annual broadleaves and grasses.
  - Cost effective.
  - Effective tool for post-emergent weed control.
  - Relatively short residual (3 to 4 weeks).
  - Asparagus becomes sensitive to the product under hot conditions.
- Paraquat (Gramoxone)
  - Effective on annual broadleaves and grasses; no control of perennials.
  - Cost effective.
  - Contact herbicide.
  - Necessary for cover crop management.
  - Used only pre-emergence to asparagus because of phytotoxicity to asparagus.
  - Volatilization is a potential problem and therefore limits its use in some situations.
- Sethoxydim (Poast)
  - Excellent annual grass control; works well on sandburs, crabgrass, volunteer grains;

not very effective on quack grass.

- Cost effective.
- Safe to use on asparagus, can be used post-emergence to the crop.
- Versatile; labeled for application throughout growing season.
- Potential weed resistance problem has been seen in other crops.

- Terbacil (Sinbar)
  - Primarily used for annual broadleaves and grasses.
  - Cost effective.
  - Not commonly used on seed beds.
  - Crop injury concerns on sandy soils.
  - Activated charcoal must be used on seed bed.
  - Very soluble, leaching may occur.
  - Long term carryover concerns, rotation problems.

Other pest management aids:

- Avoid fields known to be infested with perennial weeds
  - Not possible because suitable virgin asparagus ground is limited.
  - A perennial-free field is usually the result of aggressive chemical control.
- Hand weeding
  - More effective on annuals, may be the only control for certain weeds (i.e. velvetleaf).
  - Labor intensive and very expensive.
  - Not used, except as part of a herbicide program and only as a last resort to control weeds that have escaped herbicide application.
  - Potentially destructive to asparagus plants.
- Tillage
  - Used as a last resort for difficult weed infestations to control weeds that escaped herbicide program; more effective on annuals.
  - Not used due to potential damage to asparagus crowns.

2. Mature or "bearing" (harvested) asparagus

B2 carcinogenic herbicides currently registered:

- None

Other herbicides currently registered:

- 2,4-D dimethylamine (Formula 40)
  - Effective on annual broadleaves and in combination with glyphosate (Roundup), effective on some perennial broadleaves (e.g. milkweed).
  - Cost effective.
  - Used widely after harvest.
  - Does not control bindweed.
  - Off-target movement is a potential concern, has offensive odor.
  - Long pre-harvest interval (3 days), so normally not used during harvest.
- Clopyralid monothanolamine (Stinger)
  - Very effective on plants from the *Compositae* family (e.g. Canada thistle, marestail), *Polygonaceae* (e.g. smartweeds), plantains (e.g. buckthorn, broadleaf).
  - Very expensive.
  - Limited control spectrum.
- Dicamba (Clarity, Banvel)
  - Effective on annual and perennial broad-leaves.
  - Can be tank mixed with 2, 4-D or glyphosate for control on Canada thistle and field bindweed.
  - Apply to actively growing weeds immediately after harvest.
  - Use high rate to control perennial weeds.
  - Limited to 1 pint per acre per year.
- Diuron (Karmex, Direx)
  - Effective on annual broadleaves and grasses; no control of perennials.
  - Cost effective and reasonably priced; most widely used pre-emergence herbicide.
  - Low human toxicity.
  - Compatible with other herbicides (tank mixes).
  - Minimal carryover problems when rotating out of asparagus or in cover crops.
  - Should be used in combination with other herbicides to minimize resistance (some resistance has been seen in pigweed and lambsquarter).

- Glyphosate (Roundup)
  - Necessary for cover crop management.
  - Good for perennial weed control (systemic).
  - Weak on field bindweed.
  - Not effective on hemp dogbane, milkweed, clovers or alfalfa.
  - Very cost effective.
  - Spot treatment as well as broadcast applications.
  - Cannot be sprayed over the fern.
- Linuron (Lorox, Linex)
  - Controls annual broadleaves and grasses.
  - Cost effective.
  - Can be used pre- or post-emergence and during harvest (pre-harvest interval is 1 day).
  - Asparagus becomes sensitive to product under hot conditions.
  - Relatively short residual (3 to 4 weeks).
- Metribuzin (Sencor)
  - Good alternative for pre-emergence control of broadleaves and grasses.
  - Cost effective; used at low rates; safe for asparagus.
  - Mostly used in tank mix with diuron (Karmex).
- Napropamide (Devrinol)
  - Expensive and ineffective.
  - Not used in Michigan.
- Norflurazon (Solicam)
  - Good nutsedge control (no alternatives), good annual grass, crabgrass and sandbur control.
  - Can be applied in the fall or spring.
  - Very effective on first or second year of harvest due to season-long control.
  - Does not leach, very low solubility.
  - Expensive.
  - Interferes in cover crop establishment.

- Paraquat (Gramoxone)
  - Necessary for cover crop management.
  - Effective on annual broadleaves, grasses, and cover crops.
  - Cost effective.
  - Not effective on perennials.
  - Contact herbicide.
  - Volatilization is a potential problem and therefore limits its use in some situations.
- Sethoxydim (Poast)
  - Excellent annual grass control; works well on sandburs, crabgrass, volunteer grains; not very effective on quack grass.
  - Cost effective.
  - Safe to asparagus, can be used post-emergence to the crop.
  - Versatile; labeled for application throughout growing season.
  - Potential weed resistance problem has been seen in other crops.
- Terbacil (Sinbar)
  - Primarily used for annual broadleaves and grasses.
  - Cost effective.
  - Crop injury concerns on sandy soils.
  - Very soluble, leaching may occur.
  - Long term carryover concerns, rotation problems.
- Trifluralin (Treflan, Trilin)
  - Not used in Michigan.

Other pest management aids:

- Tillage
  - Causes erosion and mechanical injury to asparagus.
  - Can increase weed problems.
  - Cannot cultivate bearing fields after harvest.

Pipeline pest management tools:

- Alpha-metolachlor (Dual Magnum)

  - Good grass and nutsedge suppression.
  - Different mode of action from herbicides currently registered.
- Azafenidin (Milestone)
  - Different mode of action from herbicides currently registered.
  - Low rates of application.
- Clethodim (Select)
  - Post-emergence grass control, including annual bluegrass.
- Halosulfuron (Permit)
  - Good nutsedge control, some resistance seen in pigweed.
  - Different mode of action from herbicides currently registered.
  - Compatible with cover crop system.

"To do" list for weeds:

Research needs:

- Develop resistance management strategies using pipeline chemistries.
- Develop herbicides safe for use in crown nurseries and first-year stands.
- Develop herbicides to control velvetleaf, horsenettle, bindweed, clammy groundcherry, puncturevine, swamp smartweed, bramble, sumac, bermudagrass, milkweed, hemp dogbane, resistant redroot pigweed, white campion, and redstem filaree.

Regulatory needs:

- Expedite registration of pipeline chemistries once they are shown to be safe and effective.

Education needs:

- Production industry should be kept informed of potential changes in pesticide registration.
- As new management tools become available, provide training on proper use.
- Emphasize sanitation practices and management of cover crops.
- Educate growers regarding water pH and its effects on herbicide performance.
- Educate growers regarding tank mix compatibility of current and future products.
- Educate regulators regarding the actual rate at which herbicides are used.

Table 1. Classification of Pesticides

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

Table 2. Registered Pesticides for Asparagus in Michigan

Active ingredient	Trade name	Company
	INSECTICIDES	
carbaryl	Sevin	Multiple manufacturers
chlorpyrifos	Lorsban 4E	Dow Agrosciences
malathion	Malathion 57EC	United Agri Products
methomyl	Lannate SP	DuPont Agricultural Products
methoxychlor	Methoxychlor 2EC	Platte Chemical Company
permethrin	Ambush Pounce 3.2EC	Zeneca Ag Products FMC Corporation
	SECTION 18 FUNGICIDES	
chlorothalonil	Bravo	Zeneca Ag Products
myclobutanil	Nova	Rohm and Haas Company
	FUNGICIDES	
fosetyl-al	Aliette	Rhone-Poulenc Ag Company
mancozeb	Dithane Manzate Penncozeb	Rohm and Haas Company Griffin L.L.C. Elf Atochem North American, Inc.
mefenoxam	Ridomil Gold	Novartis Crop Protection, Inc.
sulfur	Kumulus DF Thiolux DF	BASF Corporation Sandoz
	HERBICIDES	
2,4-D dimethylamine	Weedar Hi Dep	Rhône-Poulenc Ag Company
clopyralid monoethanolamine	Stinger	Dow Agrosciences
dicamba	Clarity	BASF Corporation
diuron	Karmex	Griffin L.L.C.
fluazifop-p-butyl	Fusilade	Zeneca Ag Products
glyphosate	Roundup	Monsanto Company
linuron	Lorox	Griffin L.L.C.

Table 2. Registered Pesticides for Asparagus in Michigan

Active ingredient	Trade name	Company
metam-sodium	Vapam	Zeneca Ag Products
metribuzin	Lexone Sencor	DuPont Agricultural Products Bayer Corporation
napropamide	Devrinol	United Phosphorus
norflurazon	Solicam	Novartis Crop Protection, Inc.
paraquat	Gramoxone	Zeneca Ag Products
sethoxydim	Poast	BASF Corporation
terbacil	Sinbar	DuPont Agricultural Products
trifluralin	Treflan Trilin	Dow AgroSciences Griffin L.L.C.

Table 3. Unregistered Fungicides Tested on Asparagus in Michigan

Active ingredient	Trade name	Company
azoxystrobin	Quadris	Zeneca Ag Products
kresoxim-methyl	Sovran	BASF Corporation Ag Products
propiconazole	Tilt	Novartis Crop Protection, Inc.
tebuconazole	Folicur	Bayer Corporation
trifloxystrobin	Flint	Novartis Crop Protection, Inc.
triflumizole	Procure	Uniroyal Chemical Company, Inc.

Table 4. Description of Pests and Pathogens of Asparagus

Pest/Pathogen	Symptoms
INSECTS	
Asparagus aphid . . . . . (*Brachycorynella asparagi*)	Feeding causes stunting of the cladophylls and shortening of the internodes near the feeding site. Heavy infestation results in marked reduction in yield, and plants can die in two years.
Asparagus beetles . . . . . (common asparagus beetle, *Crioceris asparagi*; spotted asparagus beetle, *C. duodecimpunctata*)	Most important insect pest since there is zero tolerance for beetle eggs on asparagus spears. Adults of both species and larvae of *C. asparagi* feed on the fern and cause defoliation. Larvae of *C. duodecimpunctata* feed almost exclusively inside the berries and affect seed production.
Asparagus miner . . . . . (*Ophiomyia simplex*)	Lay eggs in the lower stem of asparagus in the fern stage. Larvae mine the cortex of stems (not affecting the vascular system) and pupate within them. Eggs, larvae, pupae and adults may harbor *Fusarium* spp. and passively vector the pathogen. Infected pupae can serve as an overwintering source of inoculum.
Cutworms . . . . . (*Noctuidae*)	Second most damaging insect pest. Feeding on the succulent tips of emerging asparagus spears stops spear growth, and feeding on the side causes crooked spears. Feeding damage on spears can significantly reduce marketable yield since there is zero tolerance for damaged spears.
Plant bugs . . . . . (tarnished plant bug, *Lygus lineolaris*; alfalfa plant bug, *Adelphocoris lineolatus*)	Adults and nymphs feed by inserting sucking mouthparts into the plant, injecting salivary enzymes and causing tip dieback (collapse and death of conductive tissue above injury).
Onion thrips . . . . . (*Thrips tabaci*)	Injure new fern growth. Damage from feeding limits marketing of asparagus spears and decreases plant vigor. Populations can build up quickly in hot, dry weather. General predators and hard rains can control populations.
FUNGI	
Fusarium crown and root rot . . . . (*Fusarium oxysporum* f.sp. *asparagi*, *F. proliferatum*)	Results in damping-off of seedlings in crown nurseries, poor stand establishment in young asparagus fields, and a decline in productivity of mature fields. Weak spindly spears followed by shoots with a bright yellow coloration and sporadic vascular discoloration. Feeder roots can be discolored and rotted and crowns may show internal discoloration. These fungi inhibit water uptake and carbohydrate transport within the plant.

Table 4. Description of Pests and Pathogens of Asparagus

Pest/Pathogen	Symptoms
Phytophthora spear and crown rot (*Phytophthora* spp.)	Gray-beige to brown lesions occur on the spear slightly above or below soil level. As the spear rots, secondary infection may occur, or during dry conditions, the spear may shrivel up. May become a problem after heavy and prolonged rainfall. Losses are due to failure of new stands to become established and from reduced yields in mature stands.
Purple spot . . . . . (*Stemphylium vesicarium*)	Small, elliptical, purple lesions with brown centers occur on all above-ground plant parts. Severe disease results in defoliation and dieback. Repeated defoliation can lead to reduced yields.
Rust . . . . . (*Puccinia asparagi*)	Red or brown elongated spots which are typically confined to the ferns produced after the cutting period. Fungal spores are produced in pustules with a reddish color predominating at first and becoming black later in the season. Severe infections stunt or kill young shoots, and can defoliate plants. Repeated defoliation can lead to reduced yields.

Table 5. Advantages and Disadvantages of Pesticides for Asparagus

Active ingredient	Disease/Pest	Advantages/Disadvantages
INSECTICIDES		
carbaryl	Asparagus beetles Cutworms Onion thrips	ž Currently relied on for beetle control. ž Most effective and inexpensive, registered on many crops, low mammalian toxicity. ž Non-specific insecticide, drifts, toxic to bees. ž Insecticidal properties on crop for 3 to 10 days. ž Half-life in aerobic soil 7 days, 28 days in anaerobic soil. ž Carbamate insecticide.
chlorpyrifos	Asparagus aphids Asparagus beetles Cutworms	ž Currently relied on for cutworm control. ž More expensive than some products. ž Residues can remain on foliage for 10 to 14 days, soil half-life of 11 to 14 days. ž Organophosphate insecticide.
malathion	Asparagus aphids Onion thrips	ž High efficacy, excellent aphid control, less toxicity to bees than some products, non-toxic to humans, more expensive than other products. ž Organophosphate insecticide.
methomyl	Asparagus beetles Onion thrips	ž Restricted use insecticide. ž More expensive than other products, toxicity to beneficial insects is a concern, higher dermal and oral toxicity than some products. ž Carbamate insecticide.
methoxychlor	Asparagus beetles	ž Organochlorine insecticide.
permethrin	Asparagus aphid Asparagus beetles Cutworms Plant bugs	ž Restricted use insecticide. ž More expensive than other products. ž Less effective in hot weather. ž Toxic to bees.
SECTION 18 FUNGICIDES		
chlorothalonil	Purple spot	ž Broad spectrum foliar protectant fungicide. ž Fairly persistent on crop surfaces, half-life in aerobic soils 1 to 3 months. ž B2 carcinogen.
myclobutanil	Rust	ž Systemic fungicide with limited pathogen range. ž Resistance is a concern.

Table 5. Advantages and Disadvantages of Pesticides for Asparagus

Active ingredient	Disease/Pest	Advantages/Disadvantages
FUNGICIDES		
fosetyl-al	*Phytophthora*	ž Moderate effectiveness
mancozeb	Purple spot Rust	ž Moderately effective on purple spot and rust when applied preventively and frequently. ž It is not allowed by some processors. ž Inexpensive. ž Non to moderately persistent (up to 18 months) in the environment. ž B2 carcinogen.
mefenoxam	*Phytophthora*	ž Group E chemical, resistance concerns, corrosive. ž Long lasting activity.
sulfur	Rust	ž Very safe chemical. ž Does not provide a commercial level of control. ž Effectiveness is related to the fineness of the particles.
UNREGISTERED FUNGICIDES		
azoxystrobin	Rust Purple spot	ž Broad control spectrum, low application rates and intervals comparable to or longer than most alternatives. ž Practically nontoxic to birds, mammals, honeybees. ž Highly toxic to freshwater fish and invertebrates. ž Resistance is a concern.
kresoxim-methyl	Rust Purple spot	ž Broad control spectrum. ž Data suggests it will have a tendency to accumulate in fish. ž Resistance is a concern.
propiconazole	Rust	ž Resistance is a concern. ž Broad control spectrum. ž Toxic to fish.
tebuconazole	Rust	ž Toxic to estuarine and marine invertebrates.
trifloxystrobin	Rust Purple spot	ž Not considered a risk to birds, mammals and honeybees because of low toxicity. ž Highly toxic to fish and aquatic invertebrates but not expected to occur in concentrations high enough to be risky.
triflumizole	Rust	ž Toxic to fish.

Table 5. Advantages and Disadvantages of Pesticides for Asparagus

Active ingredient	Disease/Pest	Advantages/Disadvantages
HERBICIDES (NON-BEARING ASPARAGUS)		
fluazifop-p-butyl	Grasses	ž Broadleaf crops are tolerant, higher rate needed on quackgrass. ž Limit 6 pt/A/year.
glyphosate	Annual grasses Broadleaf weeds	ž Post-emergence. ž Excellent efficacy, non-residual. ž Can control dense stands of perennials other herbicides cannot. ž Slightly toxic to birds, practically nontoxic to fish, aquatics, honeybees. ž Group E chemical.
linuron	Annual grasses broadleaf weeds	ž Pre- and post emergence ž Not effective on perennial weeds, can harm young seedlings, cannot apply at temperatures $85°F and pressures $40 psi, weeds of *Amaranthaceae* and *Compositae* families beginning to show resistance. ž Minimal risk to honeybees, chronic risk to birds, chronic effects in wild mammals likely. ž Group C carcinogen.
metam-sodium	All weeds	ž Fumigant. ž Very expensive, toxic to fish. ž B2 carcinogen.
paraquat	All weeds	ž Pre-emergence. ž Can't be used in crop, kills asparagus post emergence. ž Restricted use herbicide. ž Kills all emerged green foliage, inexpensive, effective rapid knockdown. ž No control of perennials, no residual control, no soil action. ž Group E chemical.
sethoxydim	Grasses	ž Post-emergence. ž Selective for emerged grasses. ž Not effective at temperatures <60°F, established grasses may need two applications.

Table 5. Advantages and Disadvantages of Pesticides for Asparagus

Active ingredient	Disease/Pest	Advantages/Disadvantages
terbacil	Pre-emergence annuals	ž Used on charcoal-protected seed rows. ž Controls many hard to kill perennials, controls for 2 to 4 months. ž Potential phytotoxicity on sandy soils, cannot use on soils with <1% organic matter. ž Group E chemical.
HERBICIDES (BEARING ASPARAGUS)		
2,4-D dimethylamine	Annual broadleaf weeds Some perennial broadleaf weeds	ž Post-emergence. ž May be combined with other herbicides.
clopyralid monoethanolamine	Specific broadleaf weeds	ž Post-emergence. ž Will control larger (4 inch) ragweed and clovers. ž Kills Canada thistle and sow thistle. ž Most weed species must be ½ inch or less at time of application. ž Very expensive.
dicamba	Annual and perennial broadleaf weeds	ž Post-emergence. ž Very effective on annual broadleaf weeds. ž May be combined with glyphosate to control Canada thistle and bindweed. ž Apply to actively growing weeds immediately after harvest.
diuron	Annual grasses Broadleaf weeds	ž Pre-emergence. ž Very effective, at higher rate can suppress quackgrass.
glyphosate	Annual and perennial grasses Broadleaf weeds	ž Post-emergence. ž Excellent efficacy, non-residual. ž Controls perennials. ž Slightly toxic to birds, practically nontoxic to fish, aquatics, honeybees. ž Can injure asparagus. ž Group E chemical.
linuron	Annual grasses Broadleaf weeds	ž Pre- and post emergence. ž Not effective on perennial weeds. ž Minimal risk to honeybees, chronic risk to birds, chronic effects in wild mammals likely. ž Group C carcinogen.

Table 5. Advantages and Disadvantages of Pesticides for Asparagus

Active ingredient	Disease/Pest	Advantages/Disadvantages
metribuzin	Annual and broadleaf weeds Grasses	ž Good efficacy, control lasts 3 to 4 months. ž Higher rates needed on soils with high organic matter. ž Do not apply during cloudy weather or when temperature >85°F. ž Relative inexpensive, can cause phytotoxicity. ž Group D carcinogen.
napropamide	Germinating grasses Broadleaf weeds	ž Not used in Michigan.
norflurazon	Annual weeds	ž Pre-emergence. ž Irrigation or rain helpful after application, fall application generally more effective than spring application, use lower rates on coarser soils. ž Does not control established weeds. ž Group C carcinogen.
paraquat	All weeds	ž Use before asparagus emergence only. ž Restricted use herbicide. ž Kills all emerged green foliage, cheap, effective rapid knockdown. ž No control of perennials, no residual control, no soil action. ž Group E chemical.
sethoxydim	Grasses	ž Post-emergence. ž Selective for emerged grasses. ž Not effective at temperatures <60°F, established grasses may need two applications.
terbacil	Annual broadleaf grasses	ž Cost effective. ž Crop injury concerns. ž Long term carry over concerns, rotation problems.
trifluralin	Annual grasses Broadleaf weeds	ž Currently not used in Michigan. ž Needs to be incorporated.

Table 6. Efficacy Ratings of Pest Management Tools for Control of Insect Pests on Asparagus in Michigan

Management tool	Insects of Asparagus[1]					
	AA	AB	AM	CW	PB	OT
Carbamate insecticides registered in MI						
carbaryl (Sevin)	–[2]	E	?	P	?	P-F
methomyl (Lannate)	–	P-F	?	F	F-G	G
Organophosphate insecticides registered in MI						
chlorpyrifos (Lorsban)	G	G	?	E	?	?
malathion	F-G	P-F	?	P	?	?
Other insecticides registered in MI						
methoxychlor [organochlorine]	–	G-E	?	P	?	?
permethrin (Ambush, Pounce)	P	P	?	F-E	G-E	P
Other pest management aids						
Beauvaria bassiana (natural in soil)	G-E	–	?	–	–	–
Burn/bury crop debris	F	–	F	–	–	–
Eliminate weeds	–	–	–	P-F	?	–
Isolate from alfalfa fields	–	–	–	–	–	–
Parasitic wasp *Tetrastichus asparagi*	–	?	–	–	–	–
Predators/parasitoids	G	P-F	?	?	?	?
Male asparagus cultivars	–	–	–	–	–	–
Pipeline pest management tools						
imidacloprid (Amire, Provado) *data from 1 year of research*	G?	G?	–	–	?	–
spinosad (SpinTor) *data from 1 year of research*	–	?	?	F-G	–	G?

[1]Insect abbreviations: AA = asparagus aphids, AB = asparagus beetles, AM = asparagus miners, CW = cutworms, PB = plant bugs, OT = onion thrips.

[2]Efficacy rating symbols: E = excellent (90-100% control), G = good (80-90% control), F = fair (70-80% control), P = poor (<70% control), ? = no data but suspected of being efficacious, – = not applicable, not used and/or not suspected of being efficacious.

Table 7. Efficacy Ratings of Pest Management Tools for Control of Diseases on Asparagus in Michigan

Management tool	Diseases of Asparagus[1]			
	Fus	PS	Rust	Phy
B2 carcinogen fungicides registered in MI				
chlorothalonil (Bravo)[2]	–[3]	G-E	F-G	–
mancozeb (Dithane, Manzate, Penncozeb)	–	F-G	F-G	–
mefenoxam (Ridomil Gold)	–	–	–	F?
Other fungicides registered in MI				
fosetyl-al (Aliette)	–	–	–	?
myclobutanil [C carcinogen](Nova)[2]	–	–	G-E	–
sulfur (Kumulus, Thiolux)	–	ND	P	–
Biocontrol agents				
BioTerra Plus (Bio Organics, Inc.)	ND	–	–	ND
General bio-controls	ND	ND	ND	ND
RootShield	ND	–	–	–
Other pest management aids				
Avoid planting on previous asparagus fields for four years	P-F	P-F	P-F	P-F
Avoid rotations to corn and/or sorghum	?	–	–	–
Plant vigorous cultivars	?	P	P	–
Minimize plant stress	?	P	P	–
Avoid mechanical damage to roots/crowns	P-F?	–	–	ND
Burn/bury crop debris in the fall/winter	–	F-G?	F-G?	–
Resistant/moderately resistant cultivars	?	F-G	G	ND
Eliminate asparagus seedlings/volunteers	–	–	F	–
Isolate nurseries from production fields	P	P	P	–
Maintain air movement/avoid windbreaks/ orient rows with prevailing winds	–	P-F	P-F	–
Cut all beds $3 years old until July 1 *	P	P	P	–

Table 7. Efficacy Ratings of Pest Management Tools for Control of Diseases on Asparagus in Michigan

Management tool	Diseases of Asparagus[1]			
	Fus	PS	Rust	Phy
Cut spears below ground level	P	P	P	–
Cultural controls/pH management	?	P	P	–
Sodium chloride amendment	?	–	–	–
Pipeline pest management tools				
azoxystrobin (Quadris)	–	G	G	–
propiconazole [C carcinogen](Tilt)	–	–	G?	–
tebuconazole [C carcinogen](Folicur)	–	–	G?	–
trifloxystrobin (Flint)	–	G	G	–
triflumizole [C carcinogen](Procure)	–	–	G?	–

[1]Disease abbreviations: Fus = *Fusarium* crown and root rot, PS = purple spot, Phy = *Phytophthora* spear and crown rot.
[2]Section 18 registration.
[3] Efficacy rating symbols: E = excellent (90-100% control), G = good (80-90% control), F = fair (70-80% control), P = poor (<70% control), ? = no data but suspected of being efficacious, – = not used and not suspected of being efficacious, ND = no data.
*Jeopardizes the health and longevity of the plants.

Table 8. Efficacy Ratings of Pest Management Tools for Control of Weeds in Asparagus Production in Michigan

Management tool	Annual weeds		Perennial weeds	
	Broadleaf	Grasses	Broadleaf	Grasses
NON-BEARING ASPARAGUS				
B-2 carcinogenic herbicide registered in MI				
metam-sodium (Vapam)	– [1]	–	–	–
Other herbicides registered in MI				
fluazifop-P-butyl (Fusilade)	–	E	–	F-G
glyphosate [E chemical](Roundup)	E	E	E	E
linuron [C carcinogen](Lorox)	G	F-G	P	P
paraquat (Gramoxone)	G-E	E	P	P
sethoxydim (Poast)	–	E	–	F
terbacil (Sinbar)	E	E	F	F
Other pest management aids				
Avoid fields with perennial weeds	–	–	F-E	F-E
Hand weeding	F-G	P-F	P	P
Tillage	F-G	P-F	P	P
BEARING ASPARAGUS				
Herbicides registered in MI				
2,4-D dimethylamine (Formula 40)	G-E	–	F-G	–
clopyralid monothanolamine (Stinger)	F-E	–	F-E	–
dicamba (Clarity, Banvel)	E	–	G	–
diuron (Karmex)	G	F-G	P	P-F
glyphosate (Roundup)	E	E	E	E
linuron (Lorox, Linex)	G-E	F-G	P-F	P
metribuzin [D carcinogen](Sencor)	E	F-G	P	P
norflurazon (Solicam) (nutsedge - E)	F-G	E	P	F-G
paraquat (Gramoxone)	E	F	P	P
sethoxydim (Poast)	–	E	–	F-G

Table 8. Efficacy Ratings of Pest Management Tools for Control of Weeds in Asparagus Production in Michigan

Management tool	Annual weeds		Perennial weeds	
	Broadleaf	Grasses	Broadleaf	Grasses
terbacil (Sinbar)	E	E	F	F
Other pest management aids				
Tillage (exacerbates *Fusarium* crown & root rot)	P-F	P-F	P	P
Pipeline pest management tools				
alpha-metolachlor (Dual Magnum)	F-G	G-E	–	P
azafenidin (Milestone)	G	G	F-G	F-G
clethodim (Select)	–	E	–	F-G
halosulfuron (Permit)	E	F-G	G-E	F
sulfentrazone (Authority)	E	G	F	F

[1]Efficacy rating symbols: E = excellent (90-100% control), G = good (80-90% control), F = fair (70-80% control), P = poor (<70% control), ? = no data but suspected of being efficacious, – = not applicable, not used and/or not suspected of being efficacious.