

**A PEST MANAGEMENT STRATEGIC PLAN FOR THE INDIANA,
WISCONSIN, AND MICHIGAN MINT INDUSTRIES**

Compiled at a workshop conducted
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Executive Summary

Peppermint and spearmint (“mint”) are produced in Indiana, Wisconsin, and Michigan as high value horticultural crops which are intensively managed. Midwest mint is grown almost exclusively for distillation into mint oil and used as a flavoring. Any stress on the crop or contamination of mint hay during the distillation process, whether from weeds, insects or disease, must be prevented in order to maintain mint oil quality as well as yield. Because of this, mint requires highly specialized pest management plans which integrate many strategies including pesticide use, crop rotation, intensive scouting, and non-chemical pest control measures.

In order to set the research priorities to ensure that future pest management concerns for Midwest mint production will be addressed, a group of mint producers, mint oil purchasers, and university researchers met in December 2002, to develop this Pest Management Strategic Plan.

In reality, loss of any pest management control option will greatly reduce the ability of growers to maintain mint oil yields and quality. However, when it became necessary to prioritize pest control needs, it was determined that continuation of the registration and production of key herbicides, particularly pyridate, was of most concern to Midwest mint producers as weed management is the most critical pest control concern. This research priority was closely followed by the need to develop better management strategies to control Verticillium Wilt and to manage infestations of Mint Bud Mite.

This document specifically reflects the pest management needs of Midwest mint production. In addition to this pest management plan, a strategic plan for pest management for mint production in the Pacific Northwest is being developed. Although some aspects of mint production are similar between these two regions, many pest management strategies must be altered to suit local environmental conditions and production practices. Some practices effective in the Midwest are ineffective in the Pacific Northwest and vice versa. It is important that national agencies addressing registration of pest management products take these regional differences into account.

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TOP PRIORITIES OF MIDWEST MINT PRODUCTION

In this document all references to “mint” refer to both peppermint (*Mentha piperita* L.) and the spearmints (*M. spicata* L. and *M. cardiaca* Baker).

Research priorities are listed in order of importance within each section.

All pesticide trade names are listed for clarification purposes only and are not intended as endorsement of a specific product.

Weed Control Priorities

- Continuance of pyridate (Tough) registration and production.
- Continuance of registration and production of other major mint herbicides, especially terbacil (Sinbar), bentazon (Basagran), sethoxydim (Poast), quizalofop–P-ethyl (Assure), and clethodim (Select).
- Development of effective control strategies for *Amaranthus* spp. (waterhemp, redroot pigweed, and other pigweeds). These include development of new herbicides, research into biology of the species (particularly with respect to herbicide resistance and interspecific hybridization), and research into biological control strategies.
- Development of effective control strategies for perennial weeds (common pokeweed, field bindweed, white cockle (sometimes considered a short lived perennial or a biennial), Canada thistle, swamp smartweed, quackgrass).
- Development of effective control strategies for existing and new annual weeds (lambs quarters, velvetleaf, giant and common ragweed, annual grasses, burcucumber).
- Development of effective control strategies for emerging weed problems in Midwest mint production (yellow toadflax, field pansy).
- Increased research on herbicide resistance in weeds to existing and new products, as well as investigation of shifts in weed species populations due to production practices so effective control strategies can be developed

Insect Control Priorities

- Development of mint bud mite control strategies. Due to the limited effectiveness of chemical control strategies, increased research is needed regarding improved methods of field surveys, economic threshold levels, predictive models for potential damage, and timing of pesticide applications.
- Development of Mint Flea Beetle control strategies in order to reduce the effects of flea beetle infestations in both fall-tilled and no-till mint.
- Development of replacement products for currently registered miticides with efficacy on tarsenomid mites. This includes investigation of products with systemic activity and labeling of products with preharvest intervals which will not interfere with timely distillation.
- Continuance of malathion registration and production for use in control of mint flea beetle.

Disease Control Priorities

- Development of improved control strategies for verticillium wilt (*Verticillium dahliae*). This includes: recognition of differences in disease development and impact between the Midwest and Pacific Northwest mint growing regions, genotype development and breeding programs for varietal resistance, local evaluations of new genotypes, cultural approaches, and research into any other chemical or biological control measures available.
- Development of mint rust (*Puccinia menthae* L.) control strategies for Midwest spearmint production, including Integrated Pest Management strategies and resistance management strategies.

Regulatory Priorities

- New pest control products need to be moved through the regulatory process at a faster pace.
- Increase the awareness of regulatory entities to the impact of changing or lengthening the PHIs or REIs of pesticides used in mint.

Education Priorities

- Make education and training available to mint growers as new cultural and pest management techniques become available. Training should include use, costs, effectiveness, and adaptability to mint and other crops on the farm. These new technologies include GPS, remote sensing and other new technologies.
- Extension materials developed for mint pest management directed to members of the Indiana, Wisconsin, and Michigan Mint growers associations. The goal of this research and publications is to make mint growers more efficient and profitable.
- Increase organized marketing efforts to promote use of United States, particularly Midwest-grown, mint oil both statewide and nationally.

General Priorities

- Increase the utility and profitability of precision pest management tactics such as GPS/GIS, smart sprayers, etc.
- Investigate crop management and soil quality issues that impact pest complexes and plant health.
- Increased research in biotechnology and genetic engineering of mint to determine if this is a viable option to develop traits such as resistance to herbicides, diseases, insects, and nematodes, as well as drought tolerance and winter hardiness.
- Acknowledgement by mint oil buyers and end users of the adoption of a strategic management plan for pest control by Midwest mint growers and resulting safety and quality of Midwest grown peppermint and spearmint oil.

BACKGROUND

Peppermint and the spearmints have been grown in Indiana since the late 1800s. The soils and climate of northern Indiana are well suited for mint production. For many years this area, southern Michigan, and southern Wisconsin was the major production area of the U.S. After the 1950s, mint acreage increased rapidly in Oregon and Washington, and that area is now the major mint-producing region of the country. However, Indiana and Wisconsin continue to be important mint-producing states.

The mints are grown for the essential oils that they produce in specialized glands on the leaves and stems. This oil is readily recovered by steam distillation of the harvested hay. Peppermint and spearmint oils are widely used to flavor chewing gum, candy, pharmaceuticals, toothpaste and other oral hygiene products. More than 30% of the mint oil produced in the U.S. is exported to Europe and other countries around the world.

There are two types of mint grown for their essential oils. These are peppermint (*Mentha piperita*) and two species of spearmint: native or American spearmint (*Mentha spicata*), and Scotch spearmint (*Mentha cardiaca*). All of these came originally as selections from native plants, and until the 1970s there were no commercially developed varieties of any of these species.

Presently, there are four varieties of peppermint: Black Mitcham (the original selection from the wild), Todd's Mitcham, Murray Mitcham, and Robert's Mitcham. The last three varieties were developed to reduce losses from the highly destructive disease Verticillium wilt.

The oils from Native and Scotch spearmints are very similar, but have different commercial uses. Native spearmint is used most often to flavor toothpaste and dental hygiene products. Scotch spearmint has a milder, more pleasant taste and is used in chewing gum and confections. At present, no new varieties of either type of spearmint are widely grown. Breeding and selection work continue in the development of new varieties.

Midwest Mint Production

Mint is grown as a short-term perennial, the first year as a row crop and the next three to four years as a solid stand or meadow crop. All phases of crop production have been mechanized, so farm acreage is relatively large. Mint production requires an initial

high capital investment in specialized planting and harvesting equipment and a custom-built distillery. For these reasons, a base of 300 or more acres is required for long-term profitability.

Mint is grown primarily in north central and northwestern Indiana, and the south central areas of Michigan and Wisconsin because of favorable soil types and a relatively high water table in this area. In some cases the water table can be controlled to help satisfy moisture needs of mint. Mint also requires a day length of at least 15 hours in midsummer for the highest oil yields. In Indiana, this occurs only on a line north of Indianapolis (40th parallel).

Soils and Nutrition

Mint is shallow-rooted and requires loose-textured soils for good root penetration and growth. It requires abundant moisture during the growing season for optimum growth and relatively high fertility (especially nitrogen).

The high organic (muck) soils found in northern Indiana and in Michigan and Wisconsin are ideal for mint production because they are deep, light soils with a high water table that can be controlled through drainage systems. Some of the moisture demands of mint can be met by controlling the water table, thus reducing the need for irrigation. However, light, well-drained mineral soils also are well suited for mint production, but they may require supplemental irrigation for best growth and oil production. Mineral soils have less than 5% organic matter and varying amounts of humus, silt, sand, and clay.

The optimum soil pH for growing mint is 5.5 to 6.5. Soil tests to determine base fertility levels are done before mint is planted. Mint requires a phosphorus (P_2O_5) level of 100 pounds per acre and a potassium (K_2O) level of 400 pounds per acre. Nitrogen is usually applied in split applications, the first at crop emergence and the second when plants are 10 to 12 inches tall. The amount of nitrogen varies, but the usual range is 125 to 200 units per acre. The equivalent of 50 pounds of phosphorus and 100 to 150 pounds of potassium is applied each year to maintain optimum fertility. After the first year, these can be applied at fall plowing.

Planting and Stand Maintenance

All commercial mint varieties are seed sterile and are propagated using the underground stolons (runners or rootstock) produced by existing plants. Mint stolons are dug from existing fields or nursery beds established for this purpose. Immediately before planting, dormant stolons are dug with a mechanical digger similar to a potato digger. The stolons cannot be stored for more than a few days since they deteriorate rapidly due to heating or dehydration. The short shelf life of the stolons limits the distance from the source to the new growing area.

Mint is planted either in the late fall or in the spring, using specially built mechanical planters. The planter cuts the stolons into 3- to 4-inch pieces and drops them into furrows. The furrows are closed and firmed by a packer wheel to assure good soil contact.

The volume of stolons required to plant an acre of new mint varies with row width, condition of stolons, and other factors. An acre of well-established mint will yield sufficient stolons to plant an average of 10 acres. New planting stock also may be purchased from a certified producer to establish nursery beds for plant increase. This is highly advisable, especially in new growing areas, because a number of serious diseases and insect pests can be introduced on contaminated planting stock from local sources.

In the first-year planting, mint is maintained in 30- to 36-inch rows (with a current trend toward narrower rows), but little cultivation is done. Growers rely on herbicides for weed control, and supplemental nitrogen applications are broadcast rather than sidedressed. In the following years the field is worked lightly before crop emergence to eliminate early weed growth and to facilitate herbicide applications.

Shoots and roots sprout from buds on the stolons in the spring to produce new plants. Crop emergence with row mint depends on the time of planting but is usually mid April to early May. In the following years, meadow mint crop emergence usually occurs in early to mid April in mineral soils and later in muck soils.

After harvest, the crop is permitted to regrow to increase stolon production to establish the next year's crop. Because the crop may be damaged by severe winter conditions, it is plowed under in the late fall after one or more killing frosts have induced dormancy. The depth of plowing does not exceed 4 to 5 inches, but the stolons and crop debris must be turned cleanly so they are fully covered by soil.

With "clean plowing" the soil becomes subject to wind erosion in late winter and early spring. In muck soils, rye is usually drilled in rows or lightly broadcast as a cover crop. However, in mineral soils, fall plowing is often done too late to establish a fall cover crop, so oats are broadcast in early spring. Growers also spread the crop refuse (after distillation) onto the field for protection against wind erosion. If available, irrigation is often used to limit soil losses by wind and to protect the emerging crop from damage by late spring frosts.

Irrigation

Mints have relatively high water demands during the growing season, yet they do not tolerate waterlogged soils; therefore, soils must be well drained. Also, since mints are shallow-rooted they quickly become stressed if rainfall is untimely or irrigation is unavailable. In muck soils, some of the moisture demands can be met by adjusting the headgates in drainage ditches to control the water table. However, season-long, optimum soil moisture for mint growth and development can rarely be maintained in either muck or mineral soils without supplemental irrigation. The amount of moisture provided by supplemental irrigation usually ranges from 4 to 8 acre-inches per season, depending on rainfall amount and timing. Pivots and traveling booms are the most common types of irrigation systems.

Harvest

Maximum oil yield depends upon both the stages of crop development and favorable environmental conditions. Under favorable weather conditions-bright sunny days with warm temperatures-oil increases rapidly as the plant approaches vegetative maturity, that is, when the plant begins to bloom. Optimum oil yield and quality is attained when approximately 10% of a peppermint crop is in full bloom. With the spearmints, harvest begins when all plants are in full bloom. Mint is harvested from late June to early September, depending on geographic location.

Oil yields tend to be slightly higher during the first crop year in row mint, declining somewhat in subsequent years. However, weather conditions have the biggest impact on yield in any given season.

Mint is cut and windrowed in much the same manner as is hay. Typically, mint is cut and windrowed with a swather, although other types of harvest equipment, such as a sickle bar or a rotary windrower, may be used. Mint foliage is allowed to partially dry in windrows in the field for 24 to 48 hours before it is collected for distillation. The field drying process is critical in obtaining maximum oil yield. If the leaves become too dry, they shatter, and oil will be lost. If the mint hay is too green or wet, distillation time is prolonged and the oil becomes difficult to recover.

The cured mint hay is picked up from the windrow with a field chopper and blown into a portable distillation tub for transport to the distillery. The tubs are equipped with perforated steam lines in the bottom and a closed top so that a steam line and vapor pipe can be attached at the distillery to recover the oil. A tub generally holds mint harvested from 0.75 to 1.25 acres, depending on yield.

Oil distillation

Mint oil is recovered from the cured mint hay in a mint distillery on the farm. Because distilling must be done in a timely manner, it is almost essential to have a distillery on the farm. Growers with smaller acreages often share a distillery.

The mint distillery consists of a high-pressure steam boiler, portable distillation tubs, a condenser, a receiver, and a redistillation unit. Although some of this equipment can be purchased from manufacturers, much of it is custom built locally or on the farm. Mint oil is recovered from the hay by applying steam to the distillation tub through a series of perforated pipes on the bottom of the tub. During distillation, the mint oil/steam mixture flows from the tub through a water-cooled condenser, and into a receiver where the mint oil floats on top of the water and is recovered.

Mint oil can be kept for two or more years if it is stored properly to reduce oxidation or heat deterioration. Growers raise mint primarily on contract with mint buyers. During harvest, oil buyers pick up oil almost daily from the growers. Often growers exceed the amount of oil stipulated in their contract, and in these instances oil buyers generally store the excess oil for future sales at no charge to the grower.

Mint oil buyers may further refine the oil and blend it for uniform quality before selling it to the end user. Quality standards for odor, taste, color, and freedom from unacceptable residues are very strict and outlined in the contract. Oil failing to meet the specified standards may bring reduced prices or result in termination of the contract.

Post –production management

At the end of the four- to five-year rotation the mint is allowed to regrow after harvest. The hay is cut a second time and distilled. The mint stand is then disked or otherwise "torn up" and left over winter. Generally there is little problem of volunteer mint growth the next season. Corn commonly follows mint in the crop rotation and the herbicides used for corn effectively control volunteer mint growth.

TIMELINE OF MINT PRODUCTION

Row Mint (First year):

February – March:

Mint roots (stolons) planted in rows.

March:

Cover crop (windbreak) of small grains planted in remaining mineral soils

April:

Crop emergence

Preemergence herbicides applied

Nitrogen applied

May:

Vegetative growth of spearmint and peppermint

Field scouting taking place for weeds, diseases, and insects

Postemergence herbicides applied, if needed

Azoxystrobin or myclobutanil applied for mint rust in spearmint, if needed

June:

Vegetative growth of peppermint

Spearmint begins to bloom

Postemergence herbicides applied, if needed

Late June – Early July:

Spearmint harvest

July:

Peppermint begins to bloom

Continued scouting for weeds, diseases, and insects

Early August

Peppermint harvest

Malathion applied for flea beetle, if needed, within three days of harvest

Late September – October:

Killing frost

October:

Clean plow (if using conventional tillage) and fertilizer application

November:

Cover crop (windbreak) of cereal grains planted in muck soils and some mineral soils

Meadow Mint (2 years and older):

March:

Cover crop (windbreak) of small grains planted in remaining mineral soils

April:

Crop emergence

Preemergence herbicides applied

Nitrogen applied

May:

Vegetative growth of spearmint and peppermint

Field scouting taking place for weeds, diseases, and insects

Postemergence herbicides applied, if needed

Azoxystrobin or myclobutanil applied for mint rust in spearmint, if needed

June:

Spearmint and peppermint begin to bloom

Postemergence herbicides applied, if needed

Late June:

Spearmint harvest

July:

Peppermint harvest begins

Continued scouting for weeds, diseases, and insects

Malathion applied for flea beetle, if needed, within three days of harvest

Late August – Early September:

Second cutting taken from spearmint fields and from peppermint fields being taken out of rotation

Late September – October:

Killing frost

October:

Clean plow (if using conventional tillage) and fertilizer application

November:

Cover crop (windbreak) of cereal grains planted in muck soils and some mineral soils

PEST MANAGEMENT

Insect Pests

The primary insect pests of Midwest mint production are the mint bud mite and the mint flea beetle. The mint bud mite causes a condition called “squirrely mint.” Damage from the mite causes stunting and distortion of the upper plant, and mint oil yields can be reduced as much as 80%. This damage has been seen mainly on peppermint, but spearmint can also be damaged. Damage is seen on both muck and mineral plantings. The mite is spread by infested rootstock, machinery, and natural conditions. Mint stands with mite infestations on 20% or more of the terminal buds are treated with diclofop (Kelthane MF) (except in Wisconsin) or propargite (Omite 6E, Comite (Wisconsin only)).

Adult flea beetles feed on the lower leaves in the inner canopy, causing little crop damage. However, eggs laid by adults will overwinter on the crown of the plant and in the soil and hatch in spring. The larvae feed on the fine roots and the main underground stem of the mint plant, causing the plants to be stunted and often die. Damage is usually most noticeable in the third year or later of mint stand. Damage to the underground stem also allows secondary infections from soil microorganisms to occur. Mint flea beetle is controlled by application of malathion or methomyl (Lannate) to mint stubble within three days after harvest. This eliminates remaining adults and interrupts egg laying.

Cropping systems such as planting certified rootstock, crop rotations of four years or less and fall plowing help to reduce populations of both mint flea beetle and mint bud mite. Regular scouting determines the presence and potential damage of insect pests; insecticides are applied only as needed.

Other pests that cause sporadic damage in mint include: mint looper, variegated cutworm, two-spotted spider mite, mint stem borer, mint root borer, and nematodes.

Diseases

Verticillium wilt and mint rust are the two major mint diseases in the Midwest. These are the only two diseases that routinely cause economic damage; however, other pathogens may cause severe losses under certain environmental conditions or management practices.

Verticillium wilt causes plants to be stunted and have smaller, twisted leaves and drastically reduced oil yields. Infected plants usually die before harvest. A soil-borne fungus causes this disease, which infects the plant through natural openings or wounds

on the roots. *Verticillium* spreads from field to field via diseased planting stock, soil-contaminated equipment, and wind-eroded soil. The fungus persists in the soil for many years regardless of crop rotation or management practices. There is no economically feasible chemical control for *Verticillium* wilt. Infestation of new growing areas can only be prevented through the use of certified, disease-free planting stock. Peppermint (particularly the cultivar, 'Black Mitcham') is most susceptible to *Verticillium* wilt while Scotch spearmint is less susceptible, and native spearmint is highly resistant.

Mint rust affects both peppermint and the spearmints in Wisconsin and Michigan, but only spearmint suffers damage in Indiana. Rusted leaves turn brown and drop off the plants resulting in reduced oil yields. Winter survival can be reduced as well. Fall plowing of mint can reduce infestations. Mint rust can be controlled using azoxystrobin (Quadris) or myclobutanil (Nova), or, less effectively, by sequential applications of chlorothalanil (Bravo). Early harvest of Spearmint prevents further damage to the plants and increases chances for overwinter survival, but may result in reduced oil yields.

Other diseases of mint in the Midwest include *Septoria* leaf spot, *Anthracnose* (Leopard Spot), and non-specific stolon decline (a complex of *Fusarium*, *Rhizoctonia*, *Sclerotinia*, *Alternaria*, *Phoma*, and *Pythium*). These diseases are sporadic and rarely occur at levels that require control. There are no known diseases affecting Midwest mint caused by viruses or mycoplasma-like organisms.

Weed Pests

Weeds are the most important pest category affecting mint. Uncontrolled weed infestations can significantly decrease oil yields in mint. Contamination of the mint hay during the distillation process can decrease oil quality by introducing off-flavors and odors to the oil.

Terbacil (Sinbar), Pyridate (Tough), and Bentazon (Basagran) are the most widely used mint herbicides. Terbacil offers effective control of grass and broadleaf weed species and can be applied preemergence or as a postemergence rescue treatment. However, carryover injury to corn and soybeans prevents growers from using this product at effective rates for the full mint rotation. Later in the rotation other, less effective, products must be used in place of terbacil. Pyridate is a highly effective postemergence broadleaf weed herbicide, which offers particularly good control of *Amaranthus* species, giant ragweed, and burcucumber, three major weeds in Midwest

mint production and these weeds (especially *Amaranthus* species) are poorly controlled by other labeled mint herbicides. Often pyridate is used in a three way tankmix with bentazon and terbacil in order to increase the efficacy on most weeds. The loss of pyridate will greatly hamper effective control of *Amaranthus* species. Loss of pyridate is the single biggest threat to weed control in mint and its subsequent effect on oil quality.

Although other herbicides are registered in mint, terbacil, pyridate, and bentazon are the most widely used since other labeled herbicides present too great of a potential for reducing their mint plant growth. Other registered herbicides for use in mint are: bromoxynil (Buctril), limited in use due to phytotoxicity concerns; oxyfluorfen (Goal), labeled only for preemergent use on soils with greater than 20% organic matter; clopyralid (Stinger), which is widely used primarily for spot treatment of Canada thistle; glyphosate (Roundup and others), a nonselective herbicide which can only be used for preemergence and spot treatments; paraquat (Gramoxone), another nonselective herbicide labeled for preemergence and spot use but is limited due to extreme damage potential to the crop; trifluralin (Treflan), which needs to be applied preemergence and incorporated and as such is not used in the Midwest, and two newly registered compounds, sulfentrazone (Spartan) and clomazone (Command).

Weed resistance is an increasing problem in mint production because terbacil, pyridate, and bentazon are all photosystem II inhibitors. In addition, the three postemergence grass control herbicides registered for use in mint are all ACCase inhibitors (quizalofop (Assure II), clethodim (Select) and sethoxydim (Poast)). This increases selection pressure for resistant biotypes. Biotypes of *Amaranthus* species resistant to terbacil, the most widely used mint herbicide, have been found in the Midwest. Grass species resistant to quizalofop and sethoxydim have also been found.

Many annual and perennial weeds can be adequately controlled by available herbicides. Notable exceptions include the *Amaranthus* species (redroot pigweed, waterhemp, smooth pigweed, Powell amaranth, prostrate pigweed, and tumble pigweed), which have limited products labeled for control and a narrow size window when they can be controlled; and white cockle, a weed that has become more problematic as tillage is reduced, and which is not controlled by any chemical control measure available. Loss of the herbicide pyridate (Tough) will particularly affect control of *Amaranthus* species.

In recent years, planting glyphosate- or glufosinate- tolerant crops in a field prior to beginning a mint rotation has been used as a weed management tool by many

producers. The effectiveness and broad spectrum activity of these products allows producers to reduce populations of troublesome weeds before the mint is planted. In contrast, many conventional herbicides, particularly sulfonylurea products, often have lengthy plant back restrictions before a grower can plant mint again. Consideration of a future mint rotation often limits growers' herbicide choices for other crops.

Weeds that cannot be controlled by chemical means are often removed by hand. This is an expensive treatment and is not feasible for producers.

PEST PROFILES

The remaining portion of this pest management plan gives a profile of the insect, disease, and weed pests affecting Midwest mint production. Pests in each section are presented in alphabetical order.

INSECTS

Cutworms (*Noctuidae* spp.)

- Occur sporadically in mint, however, can cause severe damage when present
- Need to be controlled when mint plants are emerging
- Both foliar and soil cutworms cause damage in mint
- Variegated cutworm of greatest concern

- **Organophosphate insecticides currently registered**
 - Acephate (Orthene 75S)
 - REI is 24 hours
 - PHI is 14 days
 - Excellent control

 - Chlorpyrifos (Lorsban)
 - REI is 24 hours
 - PHI is 90 days
 - Best fit into mint production cycle – cutworms need to be controlled when the mint is emerging; chlorpyrifos is only compound with soil activity
 - Excellent control

- **Carbamate insecticides currently registered**
 - Methomyl (Lannate)
 - REI is 48 hours
 - PHI is 14 days
 - Excellent control
 - Highly toxic – carries Danger-Poison label

- **B2 Carcinogens currently registered**
 - None

- **Other insecticides currently registered**
 - None

- **Non-chemical methods currently used**
 - Control of grass species in mint fields
 - Fall tillage

- **Pipeline materials**
 - Benzoic acid (Confirm 2E)
 - Biological control
 - Predator release
 - Mating disruption
 - *Bacillus thuringiensis*
 - Spinosad (Success)

- **“TO-DO” List**
 - Develop more effective scouting methods for presence of cutworm and thresholds for control measures.

Mint Bud Mite (*Tarsonemus pipermentha*)

- Severe pest in peppermint
- Associated with condition known as “squirrely peppermint”
- Mint bud mite is spread via infected rootstock or movement of soil in contact with infected root stock by machinery or wind.
- Infestations mainly on peppermint grown on muck soils, but many occur on Scotch spearmint and peppermint on muck or mineral soils under no-till management

- **Organophosphate insecticides currently registered**
 - None

- **Carbamate insecticides currently registered**
 - None

- **B2 Carcinogens currently registered**
 - Propargite (Omite, Comite (Wisconsin only))
 - REI is 7 days
 - PHI is 14 days
 - Offers suppression only
 - Propargite applications recommended when more than 10 mites are seen in 30% of terminal buds.
 - Two applications at intervals of 10 to 14 days necessary for best control
 - Comite currently labeled only for use in Wisconsin with Section 18 label. Manufacturer is seeking a national label for Comite.

- **Other insecticides currently registered**
 - Diclofol (Kelthane)
 - REI is 12 hours
 - PHI is 14 days
 - Not labeled for use in Wisconsin
 - Offers suppression only

- **Non-chemical methods currently used**
 - Crop rotations of four years or less
 - Use of certified root stock from mite-free areas

- **Pipeline materials**
 - Abamectin (Agri-Mek)
 - Milbemectin (Mesa)
 - Cyhexatin (Penstyl)

- **“TO-DO” List**
 - Develop better integrated pest management practices regarding scouting for Mint Bud Mite and timing of control measures.
 - Obtain national registration for Comite.
 - Investigate biology of bud mite to identify control potential
 - Investigate potential of biological control using fungi
 - Develop and register miticides labeled for use on both mineral and muck soils.

Mint Flea beetle (*Longitarsus waterhousei*)

- Severe insect pest , primarily in peppermint
- Larvae feed on fine roots and main underground stem of the plant in spring – adults feed on lower leaf canopy in summer.
- Effective control is achieved through control of the adult beetle on the mint stubble immediately after harvest, followed by tillage, and crop rotation.
- Secondary pathogenic infections can occur due to damage to the underground stem.
- Loss of malathion for control of this pest would be costly to mint industry
- Flea beetle infestations of particular concern in no-till production.

- **Organophosphate insecticides currently registered**
 - Malathion (Malathion 8)
 - REI is 12 hours
 - PHI is 5 days
 - Preferred treatment
 - Applied to mint stubble within 3 days following harvest
 - Excellent, cost-effective control

- **Carbamate insecticides currently registered**
 - Methomyl (Lannate)
 - REI is 48 hours
 - PHI is 14 days
 - Control comparable to Malathion, but far more costly

- **B2 Carcinogens currently registered**
 - None

- **Other insecticides currently registered**
 - None

- **Non-chemical methods currently used**
 - Crop rotation
 - Reduction of volunteer mint on field borders
 - Fall plowing following treatment of stubble

- **Pipeline materials**
 - Thiamethoxam (Actara)
 - Biological control
 - Predator releases
 - Nematodes
 - Sodium Aluminofluoride (Cryolite Bait)
 - Selective insecticides

- **“TO-DO” List**
 - Maintain registration of malathion.
 - Obtain registration for thiamethoxam

Mint Looper and other non-specific loopers (*Anacamptodes*)

- Can be a severe pest in Wisconsin, sporadic infestations occur in Michigan and Indiana
- Extensive crop damage occurs when pest is present
- **Organophosphate insecticides currently registered**
 - Acephate (Orthene 75S)
 - REI is 24 hours
 - PHI is 14 days
 - Excellent control
 - Malathion (Malathion 8)
 - REI is 12 hours
 - PHI is 5 days
 - Fair to good control if applied later in season
- **Carbamate insecticides currently registered**
 - Methomyl (Lannate)
 - REI is 48 hours
 - PHI is 14 days
 - Excellent control
- **B2 Carcinogens currently registered**
 - None
- **Other insecticides currently registered**
 - None
- **Non-chemical methods currently used**
 - Maintenance of overall plant health
- **Pipeline materials**
 - Biological control
 - Predator release
 - Viruses
 - Mating disruption
 - Benzoic Acid (Confirm 2E)
 - Spinosad (Success)
 - Methoxyfenozide (Intrepid 2F)
 - Indoxacarb (Avaunt)
- **“TO-DO” List**
 - Develop monitoring methods to anticipate infestation.
 - Register alternatives to organophosphate and carbamate insecticides

Mint Root Borer (*Fumibotys fomalis*)

- Sporadic pest in Indiana and Wisconsin, more severe infestations occur in Michigan due to longer no-till production rotations.
- Populations build up in no-till peppermint production
- Peppermint is healthy prior to harvest but does not regrow after first cutting
- Assessment is difficult, soil samples must be dug and populations assessed
- Key factor in infestations is tillage, fall-plowed peppermint is not affected

- **Organophosphate insecticides currently registered**
 - Chlorpyrifos (Lorsban)
 - REI is 24 hours
 - PHI is 90 days
 - Efficacy depends on timing – best control achieved if chlorpyrifos application is preceded and followed by rainfall
 - Offers fair to good control

- **Carbamate insecticides currently registered**
 - None

- **B2 Carcinogens currently registered**
 - None

- **Other insecticides currently registered**
 - None

- **Non-chemical methods currently used**
 - Tillage
 - Crop rotation

- **Pipeline materials**
 - Biological control
 - Mating disruption
 - Insect killing nematodes (BioVector)
 - Parasitoids
 - Ethoprop (Mocap)

- **“TO-DO” List**
 - Develop more effective scouting methods
 - Develop more effective methods of determining treatment thresholds

Nematodes

Needle nematode (*Longidorus sylvius*)

Pin Nematode (*Paratylenchus* spp.)

Rootknot Nematode (*Meloidogyne* spp.)

Root Lesion Nematode (*Pratylenchus penetrans*)

- Nematodes are present in all mint growing regions, but little economic damage is currently seen as mint plants have high tolerance to nematode populations due to continuously growing root system
- Potential exists for nematode damage if mint plants are weakened by disease, drought or other factors
- Severity of nematodes is greater in Wisconsin due to rotation of other vegetable crops, primarily potatoes, onions, cabbage, and carrots
- Interaction with *V. dahliae* (particularly that of root lesion nematode) can increase the severity of verticillium wilt on mint and other host crops (e.g. potatoes and tomatoes)

- **Organophosphate insecticides currently registered**
 - None

- **Carbamate insecticides currently registered**
 - None

- **B2 Carcinogens currently registered**
 - None

- **Other insecticides currently registered**
 - Oxymyl (Vydate)
 - REI is 48 hours
 - PHI is 21 days
 - Labeled for use in Wisconsin only
 - Offers poor to fair control of Pin Nematode and Root Lesion Nematode only
 - Very costly
 -

- **Non-chemical methods currently used**
 - Crop rotation with non-susceptible crops.
 - Use of nematode-free rootstock.

- **Pipeline materials**
 - Ethoprop (Mocap)

- **“TO-DO” List**
 - Maintain registrations of current control compounds

Two-spotted Spider Mite (*Tetranychus urticae*)

- Important pest under hot, dry growing conditions
- **Organophosphate insecticides currently registered**
 - Oxydemeton-methyl (Metasystox-R)
 - REI is 48 hours
 - PHI is 14 days
 - Offers fair to good control
- **Carbamate insecticides currently registered**
 - None
- **B2 Carcinogens currently registered**
 - Propargite (Omite, Comite (Wisconsin only))
 - REI is 7 days
 - PHI is 14 days
 - Treatment recommended when more than five mites per leaf are seen in sample.
 - Comite currently labeled only for use in Wisconsin with Section 18 label.
 - Manufacturer is seeking a national label for Comite.
- **Other insecticides currently registered**
 - Diclofol (Kelthane)
 - REI is 12 hours
 - PHI is 30 days
 - Not labeled for use in Wisconsin
 - Severely reduces populations of beneficial predator mites
- **Non-chemical methods currently used**
 - Crop rotation
- **Pipeline materials**
 - Biological control
 - Predator releases
 - Selective miticides
 - Abamectin (Agri-Mek)
 - Bifenazate (Acramite 50WS)

“TO-DO” List

- Obtain national label for Comite
- Register alternatives to Comite and Kelthane

The following insect pests can be severe pests in mint production in other regions of the U.S., but are not currently major pests in Midwest mint production:

Alfalfa looper (*Autographa californica*)
Aphids (*Aphidae*)
Beet Armyworm (*Spodoptera exigua*)
Bertha Armyworm (*Noctuidae*)
European Corn Borer (*Ostrinia nubilalis*)
Garden symphylan (*Scutigera immaculata*)
Grasshoppers (*Orthoptera*)
Leafhoppers (*Cicadellidae*)
Mint Stem Borer (*Pseudobaris nigrina*)
Root weevil (*Otiorychus* spp.)
Wireworms (*Aeolus mellius*)

DISEASES

Note: No organophosphate or carbamate pesticides are currently registered for disease control in peppermint or spearmint.

Mint Rust (*Puccinia menthae*)

- Affects both peppermint and the spearmints in Wisconsin and Michigan, occurs only on the spearmints in Indiana
- More severe in a cool, wet spring
- Most severe in no-till mint production

- **B2 Carcinogens currently registered**
 - Chlorothalonil (Bravo)
 - REI is 48 hours
 - PHI is 80 days
 - Applied at 10 to 14 day intervals beginning when the mint is 3-4 inches tall
 - Rate is 1 pound active ingredient per acre
 - 80 day PHI limits use, allows no time for scouting or IPM
 - Fair control
 - Least effective of fungicides registered in mint

- **Other pesticides currently registered**
 - Azoxystrobin (Quadris)
 - REI is 4 hours
 - PHI is 7 days
 - Excellent control
 - Applied on 10-14 day schedule
 - Limit of 3 applications per year for resistance management

 - Myclobutanil (Nova)
 - REI is 24 hours
 - PHI is 30 days
 - Applied on 14 to 21 day schedule
 - Fair to good control

- **Non-chemical methods currently used**
 - Early harvest of mint
 - Prevents disease from weakening plant and reducing winter survival, but reduces oil yield
 - Fall tillage to bury infected crop residue

- **Pipeline materials**
 - New varieties
 - Biotechnology

- **“TO-DO” List**
 - Better IPM strategies
 - Resistance management

Non-Specific Stolon Decline

- Complex of *Fusarium*, *Rhizoctonia*, *Sclerotinia*, *Alternaria*, *Phoma*, and *Pythium*
- Severe in areas of Wisconsin
- Sporadic, if any, occurrence in Indiana and Michigan
- Occurrence related to high water table and poor drainage
- No-snow winter and cold, wet spring contribute to appearance of disease

- **B2 Carcinogens currently registered**
 - None

- **Other pesticides currently registered**
 - None

- **Non-chemical methods currently used**
 - Use of chisel plow or ripper in early spring to break up frozen soil below surface

- **Pipeline materials**

- **“TO-DO” list**
 - Continued research to develop control strategies

Septoria Leaf Spot (*Septoria* spp.)

- Minor disease
- Threshold for chemical control rarely reached
- Can affect transplants of Scotch Spearmint

- **B2 Carcinogens currently registered**
 - Chlorothalonil (Bravo)
 - REI is 48 hours
 - PHI is 80 days
 - Rate is 1 pound product per acre
 - 80 day PHI limits use, allows no time for scouting or IPM
 - Fair control

- **Other pesticides currently registered**
 - None

- **Non-chemical methods currently used**
 - Use of certified disease free rootstock
 - Crop rotation
 - Fall plowing to bury contaminated plant material

- **Pipeline materials**
 - None

- **“TO-DO” List**
 - Include on azoxystrobin (Quadris) label

Verticillium Wilt (*Verticillium dahliae*)

- Most serious disease of peppermint and Scotch spearmint
- Currently no chemical control measures available other than pre-planting soil fumigation
- Soilborne fungus is readily spread by contaminated rootstock, equipment, or soil and is extremely persistent in the soil.
- 'Black Mitcham' variety of peppermint is highly susceptible, cultivars 'Todd's Mitcham', 'Murray Mitcham' and 'Robert's Mitcham' have moderate resistance
- Scotch spearmint is less susceptible than 'Black Mitcham' peppermint, native spearmint is highly resistant

- **B2 Carcinogens currently registered**
 - None

- **Other pesticides currently registered**
 - None

- **Non-chemical methods currently used**
 - Use of certified disease free-rootstock
 - Crop rotation to fields never planted to mint
 - Crop rotations of three years or less in mint followed by three or more years of corn, soybeans, or other non-host crop
 - Planting of native or Scotch spearmint or less susceptible varieties of peppermint (e.g. 'Murray Mitcham', 'Todd's Mitcham', or 'Robert's Mitcham')
 - Maintenance of overall plant health

- **Pipeline materials**
 - Biotechnology
 - Development of resistant varieties

- **"TO-DO" List**
 - Use of biotechnology to develop new peppermint lines resistant to Verticillium wilt

The following diseases occur on the mints in the Midwest, but cause little damage in the Midwest except under certain environmental conditions or crop management practices.

Alternaria

Cephalosporium

Fusarium Crown Rot

Leopard Spot (*Anthrachnose*)

Phoma

Powdery Mildew (*Erysiphe cichoracearum*)

Sclerotinia

WEEDS

Notes:

1) Herbicide Categories:

Herbicides have been separated into two categories: commonly used herbicides and other herbicides. Due to production concerns, some nationally registered herbicides are not well suited to Midwest mint production. These concerns are described below.

No organophosphate or carbamate herbicides are currently registered for weed control in peppermint or spearmint. No herbicides that are B2 carcinogens are currently labeled for use in mint.

2) All rates are expressed as product per acre.

3) Herbicides are listed alphabetically within each category.

4) Non-chemical control options:

In fall-tilled mint, mint plants and weed residue are buried with a moldboard or chisel plow. This plan assumes fall tillage does have a beneficial effect on weed control for all species and is not mentioned under non-chemical control options, unless fall tillage has a significant impact on management of that weed.

In-season tillage for weed control can only be done during the first four to six weeks of row mint production or severe root damage will occur. In reality, very little in-season tillage is done and it is not mentioned under non-chemical control options.

Hand weeding of severe weed infestations can be done, but it is an option not available to all producers and is expensive (= \$6 per man hour). Therefore, hand weeding is noted as a non-chemical weed control option only for those weed species with impacts severe enough to make this an economically feasible option (i.e. *Amaranthus* species).

Amaranthus species

- Redroot pigweed (*Amaranthus retroflexus* L.)
- Waterhemp (*Amaranthus tuberculatus* Moq. J.D. Sauer and *Amaranthus rudis* Sauer)
- Smooth pigweed (*Amaranthus hybridus* L.)
- Powell amaranth (*Amaranthus powellii* S. Wats.)
- Tumble pigweed (*Amaranthus blitoides* S. Wats.)
- Prostrate pigweed (*Amaranthus albus* L.)
 - *Amaranthus* species are considered to be the number one weed control problem of mint producers in Michigan, Indiana, and Wisconsin.
 - Infestations of *Amaranthus* species will negatively impact oil yield and oil quality.
 - All species except Waterhemp are monoecious, waterhemp is dioecious.
 - *Amaranthus* species are managed as a weed complex, rather than by individual species. However:
 - Waterhemp infestations may require more intensive management than other species, and populations are impacted more by herbicides used in rotational crops (e.g. use of acetolactate synthase (ALS) inhibitors)
 - Smooth pigweed is not as easily controlled by pyridate at larger heights.
 - Prostrate pigweed is not as easily controlled by terbacil and bentazon at larger sizes.
 - Increased dependence in the Midwest on ALS inhibitor herbicides for weed control in corn and soybeans in the past 10 years has increased the prevalence of *Amaranthus* species (especially that of waterhemp), many of which are resistant to ALS inhibitors.
 - Control of *Amaranthus* species is heavily dependent on the use of a three-way tank mix of pyridate, terbacil, and bentazon. Loss of pyridate would greatly reduce the efficacy of this tank mix.
- **Commonly used herbicides**
 - Bentazon (Basagran)
 - REI is 48 hours
 - Used postemergence
 - Only partially effective for control of *Amaranthus* species and must be tank-mixed with terbacil or terbacil and pyridate for complete control
 - Rate is 2-4 pints product per acre
 - Terbacil (Sinbar)
 - REI is 12 hours
 - PHI is 60 days
 - Used preemergence or post emergence
 - Repeated use of Sinbar, especially at higher rates will cause carryover injury to rotational crops – rates are limited in later years of mint rotation
 - Provides effective control; however, resistant weed species exist
 - Rate is 1-2 pounds product per acre preemergence, ½ pound per acre postemergence
 - Commonly tank mixed with bentazon or bentazon and pyridate

Amaranthus species, commonly used herbicides, continued

- Pyridate (Tough)
 - REI is 12 hours
 - Used postemergence
 - Provides excellent control as a stand-alone product, also commonly used as a three way tank-mix partner with bentazon and terbacil
 - Will control larger pigweeds than terbacil postemergence
 - Production by Syngenta is being discontinued
 - Loss of this product would result in yield losses and higher costs for replacement products that would not be as effective
 - Efficacy of pyridate-terbacil-bentazon tank mix significantly reduced with loss of pyridate
 - Rate is 12-24 ounces product per acre

- **Other Registered Herbicides**
- Bromoxynil (Buctril)
 - REI is 12 hours
 - PHI is 70 days
 - Used postemergence
 - Rate is 1-1.5 pints per acre
 - Use is limited due to phytotoxicity concerns, cannot be used if temperature is above 70° F or injury will occur
 - Can only be used when both the crop and weeds are very small (fewer than 4 leaves)
 - Has been used as an emergency treatment when no other options are available

- Glyphosate
 - REI is 4 hours
 - Rate is 20 – 40 ounces per acre, depending on target weed size
 - Non-selective, use limited to preemergence and spot treatment applications

- Oxyfluorfen (Goal 2E)
 - REI is 24 hours
 - Must be used preemergence
 - Rate is 4-6 pints product per acre
 - Current label limits use to muck soils with organic matter over 20%, however research supports use on mineral soils at a rate of 1-2 pints product per acre
 - Fair to good control

- Paraquat (Gramoxone)
 - REI is 12 hours
 - Non-selective, must be used preemergence
 - Growers reluctant to use it due to safety concerns
 - Rate is 1.0 – 2.0 pints per acre

***Amaranthus* species, other herbicides, continued**

- Sulfentrazone (Spartan)
 - REI is 12 hours
 - Used preemergence only
 - Rate is 0.50 – 0.75 pounds product per acre
 - Newly labeled product – not widely used yet due to concerns about efficacy and crop safety

- **Non-chemical methods currently used**
 - Hand weeding

- **Pipeline materials**
 - Flumioxazin (Valor)
 - Mesotrione (Callisto)
 - Pendimethalin (Prowl)

- **“TO-DO” List**
 - Maintain registration and production of pyridate.
 - Develop herbicides to replace pyridate, if necessary.
 - Conduct research into biology of *Amaranthus* species including possibility of interspecific hybridization and species shifts.
 - Conduct more research as to timing of herbicide applications.
 - Increased research of biological herbicides.
 - Obtain label for use of oxyfluorfen on mineral soils
 - Research specific effects of *Amaranthus* species on mint oil quality

Barnyardgrass (*Echinochloa crus-galli* L. Beauv.)

- Can be a severe weed in Wisconsin, present on muck soils in Michigan, infrequent in Indiana
- Extremely competitive if present

- **Commonly used herbicides**
 - Clethodim (Select)
 - REI is 24 hours
 - PHI is 21 days
 - Newly registered product, has received favorable reception due to good performance in other crops
 - Offers good control
 - Rate is 6-8 ounces per acre

 - Quizalofop-P-Ethyl (Assure II)
 - REI is 12 hours
 - PHI is 30 days
 - Used postemergence
 - Rate is 7-12 ounces product per acre

Barnyardgrass, commonly used herbicides, continued

- Sethoxydim (Poast)
 - REI is 12 hours
 - PHI is 20 days
 - Used postemergence
 - Rate is 1.0-2.5 pints product per acre

- **Other registered herbicides**
 - Clomazone (Command 3ME)
 - REI is 12 hours
 - Must be applied preemergence
 - Newly registered product, grower use is limited due to concerns regarding crop safety and efficacy
 - Rate is 2.0 pints per acre

 - Oxyfluorfen (Goal 2E)
 - REI is 24 hours
 - Must be used preemergence
 - Rate is 4-6 pints product per acre
 - Current label limits use to muck soils with organic matter over 20%, however research supports use on mineral soils at a rate of 1-2 pints product per acre

 - Trifluralin (Treflan HFP)
 - REI is 12 hours
 - Must be used preemergence when mint is still dormant
 - Must be incorporated or applied as a water-activated surface application
 - Does not control emerged weeds
 - Rate is 1-1.5 pints per acre, depending on soil type
 - Rarely used in the Midwest

- **Non-chemical methods currently used**
 - None

- **Pipeline materials**
 - Pendimethalin (Prowl)

- **“TO-DO” List**
 - Obtain label for use of oxyfluorfen on mineral soils.

Bindweed (*Convolvulus* spp.)

- Present in many mint fields
- Can cause harvest difficulties in severe infestations

- **Commonly used herbicides**
 - Bentazon (Basagran)
 - REI is 48 hours
 - Used postemergence
 - Rate is 2-4 pints product per acre
 - Offers fair to good control, must be applied twice

- **Other registered herbicides**
 - Trifluralin (Treflan HFP)
 - REI is 12 hours
 - Must be used preemergence when mint is still dormant
 - Must be incorporated or applied as a water-activated surface application
 - Does not control emerged weeds
 - Rate is 1-1.5 pints per acre, depending on soil type
 - Very rarely used in the Midwest

- **Non-chemical methods currently used**
 - Hand weeding in cases where infestations would interfere with mechanical harvest
 - Time mint rotation to follow use of glyphosate tolerant crop

- **Pipeline materials**
 - 2,4-DB (Butyrac)
 - MCPB (Thistrol)

- **“TO-DO” List**
 - Research trials looking at 2,4-DB and MCPB (Thistrol)

Burcucumber (*Sicyos angulatus* L.)

- Common weed problem in Indiana and Wisconsin, less severe in Michigan
- Extremely competitive with crop – vining growth habit causes it to canopy over the crop and block out sunlight
- Germinates throughout the season with germination spikes occurring after each rainfall
- Severe infestations can prevent mechanical harvesting
- Seed is spread by birds and animals
- Infestation is worse in low-lying areas

- **Commonly used herbicides**
 - Pyridate (Tough)
 - REI is 12 hours
 - Used postemergence
 - Provides good to excellent control
 - Weeds must be controlled before they are 4-6 inches tall
 - Provides excellent control as a stand-alone product, also commonly used as a three way tank-mix partner with bentazon and terbacil
 - Production by Syngenta is being discontinued
 - Loss of this product would result in yield losses and higher costs for replacement products that would not be as effective
 - Efficacy of pyridate-terbacil-bentazon tank mix significantly reduced with loss of pyridate
 - Rate is 12-24 ounces product per acre, depending on target weed size

 - Terbacil (Sinbar)
 - REI is 12 hours
 - PHI is 60 days
 - Used preemergence or post emergence
 - Provides excellent control of burcucumber when applied preemergence, good control when post applied
 - Post applied Sinbar must be applied before weeds are 4 inches tall for effective control
 - Repeated use of Sinbar, especially at higher rates will cause carryover injury to rotational crops – rates are limited in later years of mint rotation
 - Provides effective control; however, resistant weed species exist
 - Rate is 1-2 pounds product per acre preemergence, ½ pound per acre postemergence
 - Commonly tank mixed with bentazon or bentazon and pyridate when applied postemergence

Burcucumber, continued

- **Other registered herbicides**
 - Bromoxynil (Buctril)
 - REI is 12 hours
 - PHI is 70 days
 - Provides fair control
 - Weeds must be less than 4 inches tall
 - Used postemergence
 - Rate is 1-1.5 pints per acre
 - Use is limited due to phytotoxicity concerns, cannot be used if temperature is above 70° F or injury will occur
 - Can only be used when both the crop and weeds are very small (fewer than 4 leaves)
 - Has been used as an emergency treatment when no other options are available
 - **Non-chemical methods currently used**
 - Hand weeding, especially if weeds become too large to control or harvest will be impeded
 - **Pipeline materials**
 - None

“TO-DO” List

- Maintain registration and production of pyridate.
- Develop herbicides to replace pyridate, if necessary.
- Conduct more research as to timing of herbicide applications.

Canada Thistle (*Cirsium arvense* (L.) Scop.)

- Commonly present in Midwest mint production
- Patchy growth habit allows for spot spraying
- **Commonly used herbicides**
 - Clopyralid (Stinger)
 - REI is 12 hours
 - PHI is 45 days
 - Used postemergence, best results obtained from applying product after basal leaves are emerged but prior to bud stage
 - Offers excellent control
 - Often used as spot treatment
 - Can be applied in fall or spring at a rate of 0.33 – 1.0 pint per acre (maximum of 1 pint if multiple applications are used)

Canada thistle, continued

- **Other registered herbicides**
 - Bromoxynil (Buctril)
 - REI is 12 hours
 - PHI is 70 days
 - Used postemergence
 - Offers fair control
 - Rate is 1-1.5 pints per acre
 - Use is limited due to phytotoxicity concerns, cannot be used if temperature is above 70° F or injury will occur
 - Can only be used when both the crop and weeds are very small (fewer than 4 leaves)
 - Glyphosate
 - REI is 4 hours
 - Rate is 20 – 40 ounces per acre, depending on target weed size
 - Non-selective, use limited to preemergence and spot treatment applications
- **Non-chemical methods currently used**
 - Handweeding
 - Plant glyphosate resistant crop immediately before mint rotation in problem fields
- **Pipeline materials**
 - None
- **“TO-DO” List**
 - Maintain registration of currently labeled herbicides
 - Evaluate new herbicides and control measures as available

Cereal Grains (Windbreaks)

- Rye, oats, wheat and barley are commonly used as cover crops in mint production in order to prevent wind erosion in fall-tilled mint fields.
- The wind breaks are killed in the spring when they are 12 -18 inches tall.
- **Commonly used herbicides**
 - Quizalofop-P-Ethyl (Assure II)
 - REI is 12 hours
 - PHI is 30 days
 - Used postemergence
 - Offers excellent control if sprayed before boot stage
 - Rate is 12 ounces product per acre
 - Sethoxydim (Poast)
 - REI is 12 hours
 - PHI is 20 days
 - Used postemergence
 - Offers excellent control if sprayed before boot stage
 - Rate is 2.0-2.5 pints product per acre

Cereal grains, commonly used herbicides, continued

- Clethodim (Select)
 - REI is 24 hours
 - PHI is 21 days
 - Does not offer as good control of cereal grains as quizalofop and sethoxydim
 - Rate is 6-8 ounces per acre

- **Non-chemical methods currently used**
 - None

- **Pipeline materials**
 - None

- **“TO-DO” List**
 - Maintain currently labeled herbicides

Common Lambsquarters (*Chenopodium album* L.)

- Severe weed problem in all three states.
- Waxy leaf cuticle interferes with control in dry conditions.

- **Commonly used herbicides**
 - Bentazon (Basagran)
 - REI is 48 hours
 - Used postemergence
 - Offers good to excellent control
 - Rate is 2-4 pints product per acre, depending on size of target weed
 - Commonly applied in tank mix with pyridate and terbacil

 - Pyridate (Tough)
 - REI is 12 hours
 - Used postemergence
 - Provides excellent control
 - Provides excellent control as a stand-alone product, also commonly used as a three way tank-mix partner with bentazon and terbacil
 - Production by Syngenta is being discontinued
 - Loss of this product would result in yield losses and higher costs for replacement products that would not be as effective
 - Efficacy of pyridate-terbacil-bentazon tank mix significantly reduced with loss of pyridate
 - Rate is 12-24 ounces product per acre, depending on target weed size
 - Commonly applied in tank mix with terbacil and bentazon

Common lambsquarters, continued

- **Other registered herbicides**
 - Bromoxynil (Buctril)
 - REI is 12 hours
 - PHI is 70 days
 - Used postemergence
 - Rate is 1-1.5 pints per acre
 - Offers excellent control of small lambsquarters but phytotoxicity concerns greatly limit use
 - Has been used as an emergency treatment when no other options are available
 - Clomazone (Command 3ME)
 - REI is 12 hours
 - Must be applied preemergence
 - Newly registered product, grower use is limited due to concerns regarding crop safety and efficacy
 - Rate is 2.0 pints per acre
 - Oxyfluorfen (Goal 2E)
 - REI is 24 hours
 - Must be used preemergence
 - Rate is 4-6 pints product per acre
 - Current label limits use to muck soils with organic matter over 20%, however research supports use on mineral soils at a rate of 1-2 pints product per acre
 - Offers excellent control on muck soils
 - Excellent control on mineral soils achieved with 1 pint goal tank mixed with 0.4 pounds terbacil per acre
 - Sulfentrazone (Spartan)
 - REI is 12 hours
 - Used preemergence only
 - Rate is 0.50 – 0.75 pounds product per acre
 - Newly labeled product – not widely used due to uncertainty about efficacy and crop safety
 - Trifluralin (Treflan HFP)
 - REI is 12 hours
 - Must be used preemergence when mint is still dormant
 - Must be incorporated or applied as a water-activated surface application
 - Does not control emerged weeds
 - Rate is 1-1.5 pints per acre, depending on soil type
 - Very rarely used in the Midwest
- **Non-chemical methods currently used**
 - Hand weeding, in extreme situations

Common lambsquarters, continued

- **Pipeline materials**
 - Flumioxazin (Valor)
 - Pendimethalin (Prowl)
 - Mesotrione (Callisto)

- **“TO-DO” List**
 - Obtain label for use of oxyfluorfen on mineral soils.

Crabgrass (*Digitaria sanguinalis* (L.) Scop.)

- Common weed in Midwest mint production
- Particularly a problem in fields previously in seed corn

- **Commonly used herbicides**
 - Quizalofop-P-Ethyl (Assure II)
 - REI is 12 hours
 - PHI is 30 days
 - Used postemergence
 - Offers excellent control
 - Rate is 7-12 ounces product per acre

 - Sethoxydim (Poast)
 - REI is 12 hours
 - PHI is 20 days
 - Used postemergence
 - Offers excellent control
 - Rate is 1.0-2.5 pints product per acre

 - Clethodim (Select)
 - REI is 24 hours
 - PHI is 21 days
 - Offers good control
 - Rate is 6-8 ounces per acre

- **Other registered herbicides**
 - Clomazone (Command 3ME)
 - REI is 12 hours
 - Must be applied preemergence
 - Newly registered product, grower use is limited due to concerns regarding crop safety and efficacy
 - Rate is 2.0 pints per acre

 - Trifluralin (Treflan HFP)
 - REI is 12 hours
 - Must be used preemergence when mint is still dormant
 - Must be incorporated or applied as a water-activated surface application
 - Does not control emerged weeds
 - Rate is 1-1.5 pints per acre, depending on soil type

Crabgrass, continued

- **Non-chemical methods currently used**
 - None
- **Pipeline materials**
 - Mesotrione (Callisto)
- **“TO-DO” List**
 - Maintain currently labeled herbicides
 - Evaluate new herbicides and control strategies as available

Field Pansy (*Viola* spp.)

- This is a new weed species beginning to be more widespread in Midwest mint production.
- If present, is extremely competitive in the early season
- **Commonly used herbicides**
 - None
- **Other registered herbicides**
 - Oxyfluorfen (Goal 2E)
 - REI is 24 hours
 - Must be used preemergence
 - Rate is 4-6 pints product per acre
 - Current label limits use to muck soils with organic matter over 20%, however research supports use on mineral soils at a rate of 1-2 pints product per acre
 - Offers good control but can only be applied on > 20% organic matter containing soils
- **Non-chemical methods currently used**
 - Fall tillage
 - Field pansy infestations occur almost exclusively in no-till mint production
- **Pipeline materials**
 - None
- **“TO-DO” List**
 - Continue monitoring populations of field pansy to determine if this weed is spreading throughout the Midwest
 - Conduct field trials of herbicides, if necessary
 - Obtain label for use of oxyfluorfen on mineral soils

Foxtails (*Setaria* spp.)

- Severe weed problem throughout the Midwest, however, well controlled by current herbicides
- In general, yellow foxtail (*Setaria glauca* (L.) Beauv.) is the most difficult to control, green foxtail (*Setaria viridis* (L.) Beauv.) is intermediate, and giant foxtail (*Setaria faberi* Herrm.) is the easiest to control.
- Uncontrolled grass infestations will devastate mint yields.
- Control given by post emergence graminicides decreases under dry or stressful conditions

- **Commonly used herbicides**
 - Clethodim (Select)
 - REI is 24 hours
 - PHI is 21 days
 - Used postemergence
 - Newly registered product, has received favorable reception due to good performance in other crops
 - Offers excellent control
 - Rate is 6-8 ounces per acre

 - Quizalofop-P-Ethyl (Assure II)
 - REI is 12 hours
 - PHI is 30 days
 - Used postemergence
 - Offers excellent control
 - Rate is 7-12 ounces product per acre

 - Sethoxydim (Poast)
 - REI is 12 hours
 - PHI is 20 days
 - Used postemergence
 - Offers excellent control
 - Rate is 1.0-2.5 pints product per acre

 - Terbacil (Sinbar)
 - REI is 12 hours
 - PHI is 60 days
 - Offers good foxtail control when used preemergence, will also control very small grass when used postemergence
 - Rate is 1-2 pounds product per acre preemergence, ½ pound per acre postemergence

- **Other registered herbicides**
 - Clomazone (Command 3ME)
 - REI is 12 hours
 - Must be applied preemergence
 - Newly registered product, grower use is limited due to concerns regarding crop safety and efficacy
 - Rate is 2.0 pints per acre

Foxtails, other herbicides, continued

- Oxyfluorfen (Goal 2E)
 - REI is 24 hours
 - Must be used preemergence
 - Rate is 4-6 pints product per acre
 - Current label limits use to muck soils with organic matter over 20%, however research supports use on mineral soils at a rate of 1-2 pints product per acre
- Paraquat (Gramoxone)
 - REI is 12 hours
 - Non-selective, must be used preemergence
 - Growers reluctant to use it due to safety concerns
 - Rate is 1.0 – 2.0 pints per acre
- **Non-chemical methods currently used**
 - None
- **Pipeline materials**
 - Pendimethalin (Prowl)
- **“TO-DO” List**
 - Obtain label for use of oxyfluorfen on mineral soils.
 - Continue to evaluate new herbicides

Hemp Dogbane (*Apocynum cannabinum* L.)

- Common weed problem throughout the Midwest, tends to be patchy.
- Infestation severity increases through duration of mint rotation.
- **Commonly used herbicides**
 - None
- **Other registered herbicides**
 - Glyphosate
 - REI is 4 hours
 - Rate is 20 – 40 ounces per acre, depending on target weed size
 - Applied as a spot treatment or rope-wick application
 - Offers fair to good control, with best control occurring if herbicide applied at bloom.
- **Non-chemical methods currently used**
 - Plant glyphosate resistant crop immediately before mint rotation in problem fields
 - Hand weeding in severe situations
- **Pipeline materials**
 - None
- **“TO-DO” List**
 - Develop effective management strategies in rotation crops

Quackgrass (*Elytrigia repens* (L.) Nevski)

- Severe weed problem throughout the Midwest
- Frequency of infestations is increasing
- Patchy growth habit

- **Commonly used herbicides**
 - Clethodim (Select)
 - REI is 24 hours
 - PHI is 21 days
 - Newly registered product, has received favorable reception due to good performance in other crops
 - Offers good to excellent control
 - Rate is 6-8 ounces per acre

 - Quizalofop-P-Ethyl (Assure II)
 - REI is 12 hours
 - PHI is 30 days
 - Used postemergence
 - Offers good control if applied twice
 - Rate is 7-12 ounces product per acre

 - Sethoxydim (Poast)
 - REI is 12 hours
 - PHI is 20 days
 - Used postemergence
 - Offers fair control
 - Rate is 1.0-2.5 pints product per acre

- **Other registered herbicides**
 - None

- **Non-chemical methods currently used**
 - Plant glyphosate resistant crop immediately before mint rotation in problem fields
 - Use clean rootstock

- **Pipeline materials**
 - None

- **“TO-DO” List**
 - Maintain current herbicide registrations

Ragweed, Common (*Ambrosia artemisiifolia* L.)

- Commonly found throughout the Midwest, infestations more severe and sandy soils
- Well controlled by three way tank mix of terbacil, bentazon, and pyridate.
- Loss of pyridate would decrease control of this weed.

- **Commonly used herbicides**
 - Bentazon (Basagran)
 - REI is 48 hours
 - Used postemergence
 - Offers good control when tankmixed with terbacil and pyridate
 - Rate is 2-4 pints product per acre

 - Terbacil (Sinbar)
 - REI is 12 hours
 - PHI is 60 days
 - Used preemergence or post emergence
 - Provides excellent control preemergence
 - Provides good control alone when used postemergence, efficacy increases when tankmixed with bentazon and pyridate
 - Rate is 1-2 pounds product per acre preemergence, ½ pound per acre postemergence
 - Commonly tank mixed with bentazon or bentazon and pyridate

- **Other registered herbicides**
 - Bromoxynil (Buctril)
 - REI is 12 hours
 - PHI is 70 days
 - Used postemergence
 - Labeled for suppression only
 - Rate is 1-1.5 pints per acre
 - Use is limited due to phytotoxicity concerns, cannot be used if temperature is above 70° F or injury will occur
 - Has been used as an emergency treatment when no other options are available

 - Clopyralid (Stinger)
 - REI is 12 hours
 - PHI 45 days
 - Used postemergence
 - Offers good control

 - Clomazone (Command 3ME)
 - REI is 12 hours
 - Must be applied preemergence
 - Newly registered product, grower use is limited due to concerns regarding crop safety and efficacy
 - Labeled for suppression only
 - Rate is 2.0 pints per acre

Ragweed, common, other herbicides, continued

- Glyphosate
 - REI is 4 hours
 - Rate is 20 – 40 ounces per acre, depending on target weed size
 - Offers good control but non-selective - use limited to preemergence and spot treatment applications
- Paraquat (Gramoxone)
 - REI is 12 hours
 - Non-selective, must be used preemergence
 - Growers reluctant to use it due to safety concerns
 - Rate is 1.0 – 2.0 pints per acre
- Sulfentrazone (Spartan)
 - REI is 12 hours
 - Used preemergence only
 - Rate is 0.50 – 0.75 pounds product per acre
 - Labeled for control of groundcherry and Eastern black nightshade only
 - Newly labeled product – not widely used due to uncertainty about efficacy and crop safety
- **Non-chemical methods currently used**
 - None
- **Pipeline materials**
 - Mesotrione (Callisto)
- **“TO-DO” List**
 - Maintain registrations of terbacil and pyridate

Ragweed, Giant (*Ambrosia trifida* L.)

- Severe weed control problem in rotational crops (e.g. corn and soybeans).
- Currently well controlled through use of terbacil, pyridate, and bentazon tankmix. Loss of one or more tankmix partners would increase economic impact of this weed.
- Tall growth habit allows it to shade mint. Uncontrolled infestations can completely choke mint stand.
- **Commonly used herbicides**
 - Bentazon (Basagran)
 - REI is 48 hours
 - Used postemergence
 - Offers good control
 - Rate is 2-4 pints product per acre

Ragweed, giant, commonly used herbicides, continued

- Terbacil (Sinbar)
 - REI is 12 hours
 - PHI is 60 days
 - Used preemergence or post emergence
 - Provides excellent control preemergence
 - Provides good control alone when used postemergence, efficacy increases when tankmixed with bentazon and pyridate
 - Rate is 1-2 pounds product per acre preemergence, ½ pound per acre postemergence
 - Commonly tank mixed with bentazon or bentazon and pyridate

- **Other registered herbicides**
 - Bromoxynil (Buctril)
 - REI is 12 hours
 - PHI is 70 days
 - Used postemergence
 - Labeled for suppression only
 - Rate is 1-1.5 pints per acre
 - Use is limited due to phytotoxicity concerns, cannot be used if temperature is above 70° F or injury will occur
 - Has been used as an emergency treatment when no other options are available

 - Clopyralid (Stinger)
 - REI is 12 hours
 - PHI 45 days
 - Used postemergence
 - Offers good control

 - Glyphosate
 - REI is 4 hours
 - Rate is 20 – 40 ounces per acre, depending on target weed size
 - Offers good control but non-selective - use limited to preemergence and spot treatment applications

- **Non-chemical methods currently used**
 - Hand weeding

- **Pipeline materials**
 - Mesotrione (Callisto)

- **“TO-DO” List**
 - Maintain registrations of terbacil and pyridate

Solanaceous species

- Eastern Black Nightshade (*Solanum ptycanthum* Dun.)
- Common Groundcherry (*Physalis* spp.)
- Common Pokeweed (*Phytolacca Americana* L.)
- Horsenettle (*Solanum carolinense* L.)
- Solanaceous weed species significantly decrease oil quality if present in mint hay during the distillation process.
- Common Pokeweed is a severe problem in Indiana and Michigan. It is less common in Wisconsin. Prevalence of pokeweed is increasing, especially in those fields which have previously been in no-till soybean production.
- Horsenettle is commonly found in Indiana. Due to its short growth habit, it rarely outcompetes the crop for light; however, its presence reduces oil quality.
- Eastern black nightshade and groundcherry are less commonly found throughout the Midwest, but will contaminate distilled mint oil if not controlled.

- **Commonly used herbicides**
 - Bentazon (Basagran)
 - REI is 48 hours
 - Used postemergence
 - Applied alone, offers fair to poor control of Eastern Black Nightshade only
 - Offers good to excellent control of Eastern Black Nightshade if applied in tank mix with terbacil and pyridate
 - Rate is 2-4 pints product per acre

 - Terbacil (Sinbar)
 - REI is 12 hours
 - PHI is 60 days
 - Used preemergence
 - Offers good to excellent control of Eastern Black Nightshade, fair control of Horsenettle
 - Rate is 1-2 pounds product per acre

 - Pyridate (Tough)
 - REI is 12 hours
 - Used postemergence
 - Offers excellent control of Eastern Black nightshade
 - Effective control, however production by Syngenta is being discontinued
 - Rate is 12-24 ounces product per acre

Solanaceous species, continued

- **Other registered herbicides**
 - Bromoxynil (Buctril)
 - REI is 12 hours
 - PHI is 70 days
 - Provides fair control of Eastern Black nightshade only
 - Weeds must be less than 4 inches tall
 - Used postemergence
 - Rate is 1-1.5 pints per acre
 - Use is limited due to phytotoxicity concerns, cannot be used if temperature is above 70° F or injury will occur
 - Can only be used when both the crop and weeds are very small (fewer than 4 leaves)
 - Has been used as an emergency treatment when no other options are available
 - Clopyralid (Stinger)
 - REI is 12 hours
 - PHI 45 days
 - Used postemergence
 - Offers good control of Eastern Black Nightshade
 - Rate is 0.5-1 pint product per acre
 - Glyphosate
 - REI is 4 hours
 - Rate is 20 – 40 ounces per acre, depending on target weed size
 - Offers fair control of pokeweed when applied directly to growing point
 - Non-selective, use limited to preemergence and spot treatment applications
 - Oxyfluorfen (Goal 2E)
 - REI is 24 hours
 - Must be used preemergence
 - Rate is 4-6 pints product per acre
 - Current label limits use to muck soils with organic matter over 20%, however research supports use on mineral soils at a rate of 1-2 pints product per acre
 - Offers fair control of groundcherry and pokeweed, is labeled for control of Eastern black nightshade, however late season germination limits effectiveness of preemergence compounds
 - Paraquat (Gramoxone)
 - REI is 12 hours
 - Offers fair control of groundcherry, only kills above ground growth
 - Non-selective, must be used preemergence
 - Growers reluctant to use it due to safety concerns

Solanaceous species, other herbicides, continued

- Sulfentrazone (Spartan)
 - REI is 12 hours
 - Used preemergence only
 - Rate is 0.50 – 0.75 pounds product per acre
 - Labeled for control of groundcherry and Eastern black nightshade only
 - Newly labeled product – not widely used due to uncertainty about efficacy and crop safety

- **Non-chemical methods currently used**
 - Hand weeding
 - Generally only done for infestations of pokeweed that would impede mechanical harvest

- **Pipeline materials**
 - Flumioxazin (Valor)
 - Nightshade control only
 - Mesotrione (Callisto)
 - Control of Eastern black nightshade and horsenettle

- **“TO-DO” List**
 - Continue to evaluate herbicides for efficacy in controlling common pokeweed.
 - Research timing of herbicide applications for best control of pokeweed.
 - Obtain label for use of oxyfluorfen on mineral soils.

Smartweed, Pennsylvania (*Polygonum pennsylvanicum* L.)

- Commonly found in Indiana and Wisconsin, but controllable using terbacil.
- If terbacil were not available, infestations of Pennsylvania smartweed would be severe.

- **Commonly used herbicides**
 - Bentazon (Basagran)
 - REI is 48 hours
 - Used postemergence
 - Offers good control
 - Rate is 2-4 pints product per acre

 - Terbacil (Sinbar)
 - REI is 12 hours
 - PHI is 60 days
 - Used preemergence or post emergence
 - Provides excellent control alone or when used in a tank mix with bentazon and pyridate
 - Rate is 1-2 pounds product per acre preemergence, ½ pound per acre postemergence
 - Commonly tank mixed with bentazon or bentazon and pyridate

Smartweed, Pennsylvania, continued

- **Other registered herbicides**
 - Bromoxynil (Buctril)
 - REI is 12 hours
 - PHI is 70 days
 - Used postemergence
 - Offers fair to good control of small weeds
 - Rate is 1-1.5 pints per acre
 - Use is limited due to phytotoxicity concerns, cannot be used if temperature is above 70° F or injury will occur
 - Has been used as an emergency treatment when no other options are available
 - Clomazone (Command 3ME)
 - REI is 12 hours
 - Must be applied preemergence
 - Newly registered product, grower use is limited due to concerns regarding crop safety and efficacy
 - Rate is 2.0 pints per acre
 - Clopyralid (Stinger)
 - REI is 12 hours
 - PHI 45 days
 - Used postemergence
 - Offers good control
 - Rate is 0.5-1 pint product per acre
 - Glyphosate
 - REI is 4 hours
 - Rate is 20 – 40 ounces per acre, depending on target weed size
 - Offers good control but non-selective - use limited to preemergence and spot treatment applications
 - Oxyfluorfen (Goal 2E)
 - REI is 24 hours
 - Must be used preemergence
 - Rate is 4-6 pints product per acre
 - Current label limits use to muck soils with organic matter over 20%, however research supports use on mineral soils at a rate of 1-2 pints product per acre
 - Offers excellent control
- **Pipeline materials**
 - Pendimethalin (Prowl)
 - Mesotrione (Callisto)
- **“TO-DO” List**
 - Maintain registration of terbacil.
 - Obtain label for use of oxyfluorfen on mineral soils.

Smartweed, Swamp (*Polygonum coccineum* Muhl ex. Willd.)

- Severe weed control problem on muck soils throughout the Midwest.
- Perennial weed that spreads by rhizomes and tends to have a patchy growth habit.

- **Commonly used herbicides**
 - None

- **Other registered herbicides**
 - Glyphosate
 - REI is 4 hours
 - Rate is 20 – 40 ounces per acre, depending on target weed size
 - Offers good control but non-selective - use limited to preemergence and spot treatment applications

- **Non-chemical methods currently used**
 - Crop rotation with glyphosate tolerant corn or soybeans prior to mint production.

- **Pipeline materials**
 - None

- **“TO-DO” List**
 - Improve understanding of the growth habit and biology of this weed

Velvetleaf (*Abutilon theophrasti* Medicus)

- Severe weed problem throughout Midwest
- Well controlled by three-way tankmix of terbacil, bentazon and pyridate.

- **Commonly used herbicides**
 - Bentazon (Basagran)
 - REI is 48 hours
 - Used postemergence
 - Offers good control of small (< 4 inches) velvetleaf
 - Rate is 2-4 pints product per acre

 - Terbacil (Sinbar)
 - REI is 12 hours
 - PHI is 60 days
 - Used preemergence or post emergence
 - Provides good control when applied preemergence or when used postemergence in a tank mix with bentazon and pyridate
 - Rate is 1-2 pounds product per acre preemergence, ½ pound per acre postemergence

Velvetleaf, continued

- **Other registered herbicides**
 - Bromoxynil (Buctril)
 - REI is 12 hours
 - PHI is 70 days
 - Used postemergence
 - Offers fair to good control of small weeds
 - Rate is 1-1.5 pints per acre
 - Use is limited due to phytotoxicity concerns, cannot be used if temperature is above 70° F or injury will occur
 - Clomazone (Command 3ME)
 - REI is 12 hours
 - Must be applied preemergence
 - Offers excellent control
 - Newly registered product, grower use is limited due to concerns regarding crop safety
 - Rate is 2.0 pints per acre
 - Oxyfluorfen (Goal 2E)
 - REI is 24 hours
 - Must be used preemergence
 - Rate is 4-6 pints product per acre
 - Current label limits use to muck soils with organic matter over 20%, however research supports use on mineral soils at a rate of 1-2 pints product per acre
 - Offers good control
- **Non-chemical methods currently used**
 - None
- **Pipeline materials**
 - Pendimethalin (Prowl)
 - Mesotrione (Callisto)
- **“TO-DO” List**
 - Obtain label for use of oxyfluorfen on mineral soils.

Wild-proso Millet (*Panicum miliaceum* L.)

- Increasing weed problem in Wisconsin
- **Commonly used herbicides**
 - Clethodim (Select)
 - REI is 24 hours
 - PHI is 21 days
 - Used postemergence
 - Newly registered product, has received favorable reception due to good performance in other crops
 - Offers excellent control
 - Rate is 6-8 ounces per acre

Wild-proso millet, commonly used herbicides, continued

- Quizalofop-P-Ethyl (Assure II)
 - REI is 12 hours
 - PHI is 30 days
 - Used postemergence
 - Offers excellent control
 - Rate is 7-12 ounces product per acre

- Sethoxydim (Poast)
 - REI is 12 hours
 - PHI is 20 days
 - Used postemergence
 - Offers excellent control
 - Rate is 1.0-2.5 pints product per acre

- **Other registered herbicides**
 - None

- **Non-chemical methods currently used**
 - None

- **Pipeline materials**
 - None

- **“TO-DO” List**
 - Maintain currently labeled herbicides
 - Evaluate new herbicides and control measures as available

White cockle (*Silene alba* (Mill.) E.H.L. Krause)

- Emerging weed control problem
- Increasing in severity throughout the Midwest
- Particular weed control problem in no-till spearmint
- Currently no chemical control measures available in mint
- Mimics growth habit of mint
- Severe infestations greatly reduce mint yields

- **Commonly used herbicides**
 - None

- **Other registered herbicides**
 - None

White cockle, continued

- **Non-chemical methods currently used**
 - Hand-weeding
 - Fall tillage
 - Clean field management:
 - Grow mint roots in a nursery bed free of white cockle
 - Plant into a field free of white cockle
 - Spot spray any new infestations of white cockle with glyphosate
- **Pipeline materials**
 - Flumioxazin (Valor)
- **“TO-DO” List**
 - Continue evaluating new herbicides for effective control of white cockle.

Yellow Nutsedge (*Cyperus esculentus* L.)

- Commonly found weed throughout the Midwest
- When infestations are present, they are usually severe.
- **Commonly used herbicides**
 - Bentazon (Basagran)
 - REI is 48 hours
 - Used postemergence
 - Offers good control when applied twice with ten days between applications
 - Rate is 2-4 pints product per acre
 - Pyridate (Tough)
 - REI is 12 hours
 - Used postemergence
 - Offers good to excellent control
 - Rate is 12-24 ounces product per acre
 - Terbacil (Sinbar)
 - REI is 12 hours
 - PHI is 60 days
 - Used preemergence or post emergence
 - Provides good control
 - Rate is 1-2 pounds product per acre preemergence, ½ pound per acre postemergence
 - Commonly tank mixed with bentazon or bentazon and pyridate
- **Other registered herbicides**
 - Glyphosate
 - REI is 4 hours
 - Rate is 20 – 40 ounces per acre, depending on target weed size
 - Offers good control but non-selective - use limited to preemergence and spot treatment applications

Yellow Nutsedge, continued

- **Non-chemical methods currently used**
 - None

- **Pipeline materials**
 - None

- **“TO-DO” List**
 - Maintain currently labeled herbicides
 - Evaluate new herbicides and control strategies as available

Table 1 – Efficacy of Control Strategies for Insect Pests in Mint

Insecticides were rated by producers as being poor (P), fair (F), good (G), or excellent (E). Cultural practices are marked if they are known to be of benefit in management of that insect.

Insects	Insecticides								Cultural Practices		
	Acephate (Orthene 75S)	Chlorpyrifos (Lorsban)	Diclofol (Kelthane)	Malathion (Malathion 8)	Methomyl (Lannate)	Oxydemeton-methyl (Metasystox-R)	Oxymyl (Vydate)	Propargite (Omite, Comite)	Crop Rotation	Use of certified rootstock	Fall Tillage
Cutworms	E	E		G	E				X	X	X
Mint Bud Mite								P-F	X	X	X
Mint Flea Beetle				E	E				X		X
Mint Looper	E			G	E						
Mint Root Borer		F-G							X		X
Mint Stem Borer									X	X	
Needle Nematode									X	X	
Pin Nematode							P		X	X	
Rootknot Nematode									X	X	
Root Lesion Nematode							P		X	X	
Two-spotted spider mite			F			G		F	X		

Table 2 – Efficacy of Control Strategies for Disease Pests in Mint

Fungicides were rated by producers as being poor (P), fair (F), good (G), or excellent (E). Cultural practices are marked if they are known to be of benefit in management of that disease.

Diseases	Fungicides			Cultural Practices					
	Azoxystrobin (Quadris)	Chlorothalonil (Bravo)	Myclobutanil (Nova)	Early harvest	Fall tillage	Winter tillage	Use of certified rootstock	Crop rotation	Use of less susceptible cultivars
Mint Rust	E	P	F	X	X				
Non-specific Stolon Decline						X	X	X	
Septoria Leaf Spot	G	F		X	X		X	X	
Verticillium Wilt				X			X	X	X

Table 3 – Efficacy of Control Strategies for Weed Pests in Mint

Herbicides were rated by producers as being poor (P), fair (F), good (G), or excellent (E). Under cultural practices, hand weeding is noted only for those weed species where hand weeding is a common production practice. Fall tillage, rotation of glyphosate tolerant crops immediately prior to the mint rotation, and clean rootbeds is only noted for weed species where these practices have a significant impact on the management of that weed.

	Herbicides													Cultural Practices				
	Bentazon (Basagran)	Bromoxynil (Buctril)	Clethodim (Select)	Cimazone (Command)	Clopyralid (Stinger)	Glyphosate	Oxyfluorfen (Goal)	Paraquat (Gramoxone)	Pyridate (Tough)	Quizalofop-P-ethyl (Assure II)	Sethoxydim (Poast)	Sulfentrazone (Spartan)	Terbacil (Sinbar)	Trifluralin (Treflan)	Handweeding	Fall Tillage	Glyphosate-tolerant rotation	Clean rootstock
Redroot Pigweed	P ¹	G ²				G ²	F ²	G ²	E			G	G ⁻ E		X			
Waterhemp	P ¹	G ²				G ²	F ²	G ²	E			G	G ⁻ E		X			
Smooth Pigweed	P ¹	G ²				G ²	F ²	G ²	E			G	G ⁻ E		X			
Powell Amaranth	P ¹	G ²				G ²	F ²	G ²	E				G ⁻ E		X			
Tumble pigweed	P ¹	G ²				G ²	F ²	G ²	E				G ⁻ E		X			
Prostrate Pigweed	P ¹	G ²				G ²	F ²	G ²	E				G ⁻ E		X			
Barnyardgrass			E	G	E		G ²			E	E			G				
Bindweed	G ³					E ²											X	X
Burcucumber		F ²							G ⁻ E				G ⁻ E		X			
Canada thistle	G ³	P				G									X		X	X
Cereal Grains (Windbreaks)			F							E	E							
Common Lambsquarters	G ⁻ E	G ²					F		E				G	G	X			
Crabgrass			E	G						E	E			G				

	Bentazon (Basagran)	Bromoxynil (Buctril)	Clethodim (Select)	Clofoprop (Command)	Clopyralid (Stinger)	Glyphosate	Oxyfluorfen (Goal)	Paraquat (Gramoxone)	Pyridate (Tough)	Quizalofop-P-ethyl (Assure II)	Sethoxydim (Poast)	Sulfentrazone (Spartan)	Terbacil (Sinbar)	Trifluralin (Treflan)	Handweeding	Fall Tillage	Glyphosate-tolerant rotation	Clean rootstock
Field Pansy							G ¹ E											X
Foxtails			E	G			P	F ²		E	E	P						
Hemp Dogbane						G ³									X		X	X
Eastern Black Nightshade	P- F	F ²			F ²		G ²		E			P	G- E					
Common Groundcherry							P	F ²				P						
Common Pokeweed							G	F ²							X		X	
Horsenettle													F					
Ragweed, Common				F					G			G						
Ragweed, Giant									G						X			
Pennsylvania Smartweed	G	G ²		F	F ²	G ²	E ²					F	E					
Swamp Smartweed						G									X		X	
Quackgrass			G- E			G				G ³	F						X	X
Velvetleaf	G	F ²		F ²			G ²						G					
White Cockle															X		X	X
Wild-proso Millet			G							G	G							
Yellow Nutsedge	G ³					G			G- E			G	G				X	X

¹ Provides poor control as stand alone, improves efficacy of bentazon-terbacil-pyridate tankmix.

² Not commonly used due to production concerns described earlier.

³ Requires multiple applications.