

Crop Profile for Mint in Wisconsin

Prepared: January, 1999

General Production Information

Mint has been grown commercially in Wisconsin since 1943 when peppermint was introduced to the state on a trial basis to determine whether Wisconsin soils and climate were suitable for cultivation of the crop. Wisconsin ranks 2nd in the nation for spearmint (*Mentha spicata*, *M. cardiaca*) production with 6200 acres harvested in 1995 and 5th in the production of peppermint (*Mentha piperita*) harvesting 7300 acres according to the 1996 National Agricultural Statistics Service Report. Three percent of the nation's peppermint is grown in Wisconsin while 7% of the total spearmint is produced in the state. One-hundred percent of the spearmint and peppermint grown in Wisconsin is processed for mint oil. Uses include flavoring for chewing gum, candy, tooth paste and medicines. The average price per pound of peppermint oil in 1996 was \$13.60 with spearmint paying slightly less at \$12.00 per pound.

Production Costs

Production costs for bearing mint in Wisconsin range between \$450-600/acre depending upon whether the land is irrigated or not and whether additional herbicide applications are necessary. Other inputs included in this cost estimate are land, fertilizer, pesticides, labor and equipment costs, cultivate, weed, harvest, and distill the crop and overhead.

Cultural Practices

- The cultural information provided in this crop profile was taken from North Central Regional Extension Publication No.155 and the masters thesis for William G. Schmitt of the University of Wisconsin - Madison.
- Mint may be grown on muck or mineral soils in the Midwest. Organic soils are frequently used because of the shallow-rooted nature of the crop and its requirement for a rich, well-drained, loose-textured soil and abundant moisture. In addition, water tables can be controlled in drained muck soils, reducing the need for supplemental irrigation.
- While mint requires abundant water during the growing season, it does not tolerate water-logged

soils. In the Midwest, sprinkler irrigation is used to supplement rainfall, or to reduce frost damage or wind erosion of muck soils.

- A soil test is obtained prior to planting to determine the soil pH and levels of available macronutrients. The pH of the muck soil should be kept slightly alkaline, between 5.5 and 6.5. The soil should have at least 100 pounds available phosphorus and 400 pounds available potassium per acre. If the soil test indicates levels lower than what is recommended, fertilizer should be applied prior to planting.
- Since mint is grown as a perennial crop, it is important to have the soil as weed-free as possible prior to planting. Fall plowing and disking are done to reduce weed populations. Turning the soil over will also protect the plants from winter kill. Excessive weeds compete with mint and reduce yields, and may contribute off-flavors to the mint oil at harvest, resulting in lowered oil quality.
- Mint is planted in fall or early spring. An acre of well-established mint will usually yield enough stolons to plant 10-15 acres. Stolons are generally dug from a nursery bed in an existing planting. It is important to dig stolons from weed-free soils to prevent the introduction of insects, diseases, or perennial weeds such as quackgrass or toadflax into new plantings along with the mint. Small pieces of mint stolons are dropped in the row with a mechanical planter. The furrows into which the stolons are planted must not be made too far ahead of time so that adequate moisture is present at planting time. The stolons are then covered with 2 to 3 inches of soil. Stolons can not be planted if they have sprouted more than 2-3 inches. New plants become established as roots and shoots grow from the nodes on the stolons.
- Mint is cut and windrowed with a swather or sickle bar windrower. Recently growers have been using rotary windrowers because they move quickly through the field and cut closer to the ground so that oil yields per acre are increased. It also leaves the mint hay in smaller windrows so that it dries faster and is ready to distill sooner. Hay should be cut before it has reached 10% of full bloom to achieve high yields and high quality oil. After flowering the plant's production of mint oil decreases and existing oil begins to deteriorate in quality.
- After the mint is cut and windrowed, it is allowed to cure until the leaves are thoroughly wilted and partially dried. The hay should not be allowed to become too dry or left too green since it will be difficult to distill. The hay is picked up, chopped, and blown into the distilling tub by a conventional field chopper.
- The essential oils are removed from the mint hay through on-farm steam distillation. Because the essential oils in mint are insoluble in water, steam may be used to extract these oils under pressure. Custom-built, wagon-mounted distillation tubs are commonly used. Steam is introduced to the tubs through perforated pipes that run along the bottom of the tub. A high-pressure boiler generates steam for the distillation. After distillation, the steam-vaporized mint oil is run through a water-cooled condenser to recondense the oil which floats on top of the water and can be easily

extracted in its pure form.

- Mint is usually plowed under after the first killing frost to protect the stolons from winterkill. Stolons can not be plowed more than 4-5 inches under or they will not survive. There are many theories on how to plow. The consensus is that roots and stolons need to be on a slant after plowing to allow for shallow to deep placement of residue. This helps to insure that somewhere on the slant, the rootstock will survive.

Insect Pests

Many mint pests are most troublesome on older fields - 4 or more years of continuous mint. Picking rootstocks for planting new fields from old fields simply introduces pest problems into these new fields at an early stage.

Floridotarsonemus spp. - This recently discovered pest of peppermint has been found in several locations in Wisconsin in 1997 and 1998, although the condition called "squirrely mint" has been recognized for many years. It has become a serious pest of peppermint grown on muck soils in Wisconsin, especially on old stands. The extremely tiny mite infests the mint buds but produces no visible symptoms until late in the season. The upper two or three internodes are usually shortened and the new terminal leaves are reduced in size. Hay weight is not affected but oil yield may be reduced by up to 80% in infested fields. Oil quality is also affected with the oil having chemical profiles characteristic of immature hay. There are many generations of the mite per year and to date, no treatment threshold levels have been determined. Although it may occasionally be found on spearmint, it does not develop damaging populations in this crop.

Mint Flea Beetle (*Longitarsus ferrugineus = waterhousei*)- The mint flea beetle is a moderate to severe pest of both peppermint and spearmint in Wisconsin, but occurs slightly more frequently on peppermint. It is seen more often in older stands.

Mint flea beetles overwinter as eggs in the soil near the crown of mint plants. The eggs hatch in early spring and the resulting larvae feed on the small mint roots initially but later tunnel into the rhizomes. The larvae are fully developed by early June and pupate in the soil near the rhizomes for 3 to 4 weeks. Adults damage mint foliage as they chew small, round holes in the leaves, giving the plant a shot-hole appearance. Larval damage is far more serious than that caused by the adult beetles. At harvest, the adults disperse to adjacent fields or to uncut plants at the field margins. They continue to lay eggs until frost. There is only one complete generation per year.

Treatment should be targeted at the larvae in late May and the adult population in late July. The use of

degree-days is an effective way to predict the life cycle and the optimum time for treatment each season.

Variegated cutworm (*Peridroma saucia*)- Variegated cutworms along with other species of cutworms damage foliage and can cause complete defoliation in severe cases. They overwinter as a half-grown larvae in the soil or in plant debris left in, or around, fields. In April they resume feeding and mature in late April to early May when they pupate in the soil. Adults emerge in early June and lay eggs in clusters of 200-500 on the undersides of the leaves. The eggs hatch in 4-7 days and the larvae immediately begin feeding on the leaves for 4 to 6 weeks. This second generation of larvae then pupates, with second generation adults emerging in late August and laying more eggs. The larvae from this generation will feed until cold weather and then overwinter in the soil.

In Wisconsin, cutworms are a minor pest on both peppermint and spearmint. The optimum treatment period is when the first generation of larvae are present in late April and early May.

Alfalfa (*Autographa californica*) & **Cabbage Loopers** (*Trichoplusia ni*)- Loopers occur more often on peppermint than spearmint, but are considered a minor pest on both. Like cutworms, these pests are also foliar feeders. Both species overwinter as pupae in plant debris. Adults emerge in late March - April. The eggs are laid singly on winter annual weeds such as wild mustard. They hatch in 3 to 5 days and the larvae feed for approximately two weeks before they pupate. Because the total development time from egg to adult is only about 30 days, there are two to three generations each year. Larvae of the second generation, which are present in June and July, do the most damage to mint. This is the best time to treat to control loopers in mint.

Mint Aphid (*Ovatus crataegarius*)- These small, soft-bodied insects feed on plants by sucking the plant sap. They are typically found on the undersides of leaves. When aphid numbers are great enough, the plant's leaves may curl or the entire plant may be stunted. In severe cases, plants may die. Aphids are also vectors of diseases that can be more damaging than the aphid feeding itself.

Mint aphids overwinter around the bases of plants, on roots, beneath plant debris, and in cracks and crevices in the soil. Females give birth to mobile nymphs in the spring. A single generation may be completed in 7 to 10 days and as many as 12 to 15 generations may be produced in a year. The higher the temperature, the faster the rates of development and higher the population densities. Mint aphid is a minor problem on both peppermint and spearmint.

Twospotted Spider Mite (*Tetranychus urticae*)- Spider mites are a minor pest of both peppermint and spearmint in Wisconsin but are found more frequently on peppermint. They are typically found on the lower leaf surface but may occur anywhere on the plant during severe outbreaks. Stunted, bronze-colored leaves along with webbing on the underside of the leaves are indications of infestation by the twospotted spider mite.

Female mites overwinter in the soil and in plant debris. As soon as temperatures warm in the spring, they begin laying eggs on the undersides of leaves. The eggs hatch in 4 to 5 days. The complete life cycle takes 1 to 3 weeks depending on the temperature, therefore, mite populations can increase very quickly in hot, dry weather and during periods of moisture stress. Because of overlapping generations, treatment should be initiated as soon as the mites have been detected.

Insecticides

Until the emergence of the *Floridotarsonemus* mite in mint, insects posed less of a management problem for Wisconsin mint growers than weeds. Most growers surveyed made at least one insecticide application during the 1995 growing season.

- **Acephate** (Orthene) is registered for control of cutworms, loopers and mint aphids. It is applied at a rate of 1.33lbs. a.i./A one to two times per season by ground application when insects first appear. No more than 2.65 lb a.i./A acephate may be applied per season and it may not be applied within 14 days to harvest. In Wisconsin, 3.6% or 489 acres were treated at a rate of 1.0lbs a.i./A in 1995.
- ***Bacillus thuringiensis aizawai*** (Xen Tari) is a registered control of loopers in mint at a rate of 0.5 to 2 lbs. a.i./A. Higher label rates are used when there is heavy pest pressure. Plants with young larvae are treated and overhead and drop nozzles are used to provide good coverage. There was no report of Bta use in Wisconsin during the survey period.
- ***Bacillus thuringiensis Kurstaki*** (Biobit, Dipel, Gut Buster BT, Javelin) are registered to control loopers when populations are light. Btk is applied at a rate of 0.5 to 2.0 lbs. a.i./A and treatment can be repeated as necessary to maintain control up to the time of harvest. There was no reported use in Wisconsin during the survey period.
- **Chlorpyrifos** (Lorsban 4E, 4E-HF) is a registered control for armyworms, cutworms, and loopers at a rate of 1-2lbs a.i./A up until 90 days before harvest. The lower rate is used when larvae are less than 3/4 inch long and the higher rate on larger larvae. The long interval to harvest for this product limit its use to very early season applications.
- **Methomyl** (Lannate LV) is a restricted-use pesticide that controls variegated cutworm, alfalfa looper and flea beetles in mint. When treating cutworms and loopers it should be applied at a rate of 3 pints/A. Flea beetles can be controlled with 2.75 to 3.0 pints/A. Use higher rates for larger insects and heavier infestations. One to 3 applications of the highest recommended rate should be used to control severe infestations. Thereafter the lowest rate possible is used to maintain control. Methomyl should not be applied within 14 days of harvest and no more than 4 applications or 1.8 lb. a.i./A/crop should be applied. There is no reported use of methomyl on mint in Wisconsin during the survey period.

- **Propargite** (Omite) is registered for the control of *Floridotarsonemus* mites and spider mites on peppermint in Wisconsin. This is the only registered insecticide that has any significant effect on bud mite populations. Two applications are made 10-14 days apart at a rate of 3 pints/A in 50-60 gallons of water per acre. Use a higher gallonage and pressure for adequate bud penetration. Propargite cannot be applied less than 14 days before harvest.
- **Oxydemeton-methyl** (Metasystox-R) is a restricted-use pesticide registered to control aphids, but is also effective at suppressing mites. It should be applied at a rate of 3 pints in at least 20 gallons of water per acre with ground equipment. For established infestations, 2 applications should be made at least 10-14 days apart. For application by irrigation systems, apply specified dosage per acre. Do not apply within 14 days of harvest. Two percent, or 273 Wisconsin acres, were treated at a rate of 2.5 pts/A during 1995.
- **Malathion** (Malathion) is registered for the control of mint aphids and adult flea beetles. It may not be applied within 7 days of harvest and should not be applied at a rate higher than 0.94 a.i./A. Forty percent (5400 acres) of the mint acreage was treated in Wisconsin at a rate of 0.78 a.i./A. It is often sprayed on stubble after harvest to control adult fleabeetles. Malathion is an important insecticide used for the control of the mint fleabeetle. Lannate is also registered for fleabeetle control but at an increased cost to growers. The loss of malathion will pose a serious economic impact on mint production in Wisconsin.

Diseases

Verticillium Wilt (*Veticillium dahliae*) is the most serious and destructive plant disease faced by Wisconsin mint growers. It is a disease of many crops grown in the state although isolates from mint are most aggressive on mint and other isolates are crop specific as well. The fungus is soil-borne and can survive in the soil indefinitely once microsclerotia numbers build up in the soil. Infection occurs through natural openings and wounds on roots. Crop rotation is only effective if it has been done from the beginning, before the pathogen is well established. It is good to rotate with a non-susceptible crop every 3-4 years. Onions, corn and soybeans are good crops to rotate with mint to reduce the likelihood of buildup of verticillate propagules in the soil.

Symptoms of verticillium wilt include stunted, erect plants as a result of shortened internodes. Leaves become yellow and eventually reddish, and opposite leaves bend towards each other into a crescent shape because of asymmetric growth. Yellowed leaves tend to fall off.

Immediate losses from wilt occur when stands become thinned out as individual plants are killed. Chronic, non-lethal infections result in stunting of the plants, a reduction of the total leaf area, defoliation of the plants, and reduced oil production because of debilitating effects of the disease on the

bud. Severity and yield losses depend on the level of inoculum in the soil, weather conditions and cultivar susceptibility. Spearmint is less susceptible than peppermint. Native spearmint is least susceptible. Murray and Todd's Mitcham peppermint is less susceptible than Black Mitcham peppermint.

In Wisconsin, *Verticillium* wilt is a moderate to severe problem on peppermint and spearmint. All of farmers surveyed observed *Verticillium* wilt in their fields.

Mint Stolon Decay is caused by several species of fungi all of which are isolated in Wisconsin. The problem is most severe in years without adequate snow cover and deep penetration of frost. Fungi causing stolon decay seem to thrive in cool soils and it is the slow warming of soil that accentuates the problem. A wide range of chemical controls have been evaluated but none are satisfactory. Spring tillage tends to loosen the soil and facilitate a more rapid warm-up of the soil thus enhancing plant emergence and decreasing stolon decay losses. This problem is worse in older stands.

Mint rust (*Puccinia menthae*) is considered a severe problem in Wisconsin peppermint with 86% of the growers surveyed indicating they have had problems. Mint rust is a minor problem in spearmint plantings in Wisconsin with 90% of the growers reporting some infection. The symptoms include light-yellow, blister-like lesions on young shoots in the spring, and brownish-red spots surrounded by a yellow halo on the leaves later in the season. Rusted leaves fall off and defoliation can be severe. When rust infects young shoots, the shoots are usually twisted and break off at the infection point. Later in the season the leaf spots become dark brown and the overwintering spores are produced. Plantings with moderate to severe rust infection are weakened and winter survival is reduced.

It is important to plow the mint beds to bury overwintering spores. Elimination of volunteer mint plants will also reduce available rust inoculum.

Mint anthracnose (aka leopard spot) is caused by the fungus *Sphaceloma menthae*. In Wisconsin 60% of the mint farmers have had mint anthracnose in their plantings and consider it to be a minor problem.

Symptoms appear as small, sunken, brown spots on the lower leaves, stems, and stolons. These spots enlarge to form oval lesions with light-gray centers and reddish-brown borders. If lesions are numerous enough, they unite and cause defoliation, or cause large cankers which can split the stem. Long periods of wetness exacerbate anthracnose infections. Anthracnose overwinters on plant debris so clean fall plowing can prevent recurring infections next season.

Root lesion nematode (*Pratelnchus penetrans*) and other plant parasitic nematodes such as *Trichodorus* is commonly found on both peppermint and spearmint in Wisconsin. Eighty-six percent of Wisconsin peppermint and spearmint farmers surveyed have had problems with nematodes but consider them only a minor pest. Nematodes are soil-inhabiting pests that feed upon the roots and stunt plant

growth. Nematodes have a synergistic relationship with Verticillium wilt in that they will increase the number of wounds through which the verticillium can infect thus causing the plant to express more severe wilt symptoms.

Fungicides

- **Chlorothalonil** (Bravo, Terranil, Echo) is registered for the control of mint rust in Wisconsin at a rate of 1.2 lb a.i./A. It may not be used more than three times per season nor may it be applied within 80 days of harvest. There was no reported use of chlorothalonil on mint during 1995 because of the long pre-harvest interval. Shortening the PHI leads to unacceptable chlorothalonil residues in the mint oil. It is unlikely that the chlorothalonil PHI will be shortened in the foreseeable future.

Weeds

Weeds are the key pest of mint in Wisconsin. Excessive weed populations compete with mint to reduce yields, and may contribute off-flavors to the mint oil at harvest, resulting in lowered oil quality. Some weeds may contain volatile compounds which are extracted along with the mint oil during the distillation process. Up to a 40% yield loss may be realized as a result of weed pressure by pigweed, lambsquarter, and foxtail species. In addition to yield losses, certain weed species such as pigweed can reduce the marketability of the oil. Quality reduction is more difficult to quantify since quality loss is more subjective and determined by the processors.

Annual broadleaf weeds are troublesome in mint fields. Pigweed species are a severe problem in both peppermint and spearmint. One hundred percent of the farmers surveyed have problems with pigweed. All of the registered herbicides for broadleaf weed control in mint have some limitations which result in pigweed being a major pest. Common lambsquarters represents a problem in 90% of the peppermint and spearmint fields. Both pigweed and common lambsquarter (as well as other annual broadleaf weeds) must be controlled in early postemergence, before they are larger than 2 inches tall.

Annual grasses also pose a problem in mint fields. Giant foxtail is the most problematic annual grass weed and is a moderate problem with 95% of all farmers surveyed having some giant foxtail in their peppermint and spearmint fields. Like annual broadleaf weeds, annual grasses must be treated postemergence, in this case, before they are 1 inch tall.

Perennial weeds are generally considered to be a minor problem since eradication is targeted before the mint is planted. Crop rotation must be used to control other perennial weeds. Usually agronomic crops

are rotated so that stronger herbicides can be used without hurting the crops. Some hand removal of weeds may be necessary or spot spraying of herbicides for severe infestations of perennial weeds.

Perennial weeds are hard to control because the herbicides that are used have a long residual and phytotoxic effect, making application in the second and third years of the mint rotation unfeasible which often allows the weeds to get out of control. When perennial weeds are present, they are very difficult to control with the currently-registered herbicides. It is therefore important that perennial weeds be controlled prior to planting. Quackgrass and yellow nutsedge, two perennial weeds, are both hard to control and pose a moderate problem in nearly 100% of the peppermint and spearmint fields.

The most common cultural practice used in Wisconsin mint production to reduce weed competition is a three year mint rotation followed by three years in another crop, typically corn. Disking or dragging is also used as a form of mechanical weed control. During the first year, mint doesn't compete well with weeds and alternative weed management strategies are necessary. By the second year, mint forms dense stands similar to that of alfalfa and provides effective competition to annual weeds.

Herbicides

Weed control is a very important pest management activity in mint in Wisconsin. Excessive weed populations compete with mint and reduce yields, and may contribute off-flavors to the mint oil at harvest, resulting in lowered oil quality.

Weed control in Wisconsin is limited by the lack of a good pre-emergence grass herbicide and an herbicide that effectively controls pigweed species. All mint acreage in Wisconsin had at least one herbicide application made annually and generally most of the acreage was treated two or more times.

- **Terbacil** (Sinbar) is used as a postemergence herbicide for the control of annual broadleaves and grasses at a rate of 0.125 - 0.25 lb a.i./A on 100% of the peppermint, Scotch and native spearmint acreage in Wisconsin. Because Sinbar has a long residual activity, crops other than mint should not be planted within two years after the last application. The loss of this product would have a serious negative impact on Wisconsin mint production as there is currently no suitable herbicide to replace it.
- **Bentazon** (Basagran) is used as an early postemergence herbicide at a rate of 0.78 - 0.90 lb a.i./A to control annual broadleaf weeds on up to 95% of the peppermint and 90% of the Scotch spearmint acreage in Wisconsin. It should not be applied to newly planted mint and may cause crop injury if temperatures exceed 70F immediately following application.
- **Sethoxydim** (Poast) is used at a rate of 0.19 - 0.47 lb a.i./A on 100% of the spearmint and peppermint acreage in Wisconsin to control emerged grass weeds. No more than two applications should be made per season.

- **Bromoxynil** (Buctril) is used to control emerged annual broadleaf weeds in established mint at a rate of 0.25 lb a.i./A. Ten percent of the peppermint and 2% of spearmint acreage in Wisconsin is treated with bromoxynil.
- **Glyphosate** (Roundup) is used to control quackgrass, Canada thistle and other perennial weeds in Scotch spearmint and peppermint. Two of the mint acreage is treated at a rate of 1.5 lb a.i./A.
- **Oxyfluorfen** (Goal) is used to control germinating annual weeds on 8% of the peppermint acreage on muck soils in Wisconsin. It should be applied as a pre-emergent before the new mint growth emerges.

Alternative Pest Management Strategies

Cultural Controls:

Breeders have developed mint varieties that are certified true to type and are grown in culture. From these cultures are produced rooted cuttings that are grown in nursery production fields. After a year in an isolated block planting, the rooted cuttings are transplanted to virgin soil on a farm in northwest Wisconsin. The use of these cultured cuttings, prevents the introduction of serious problems such as verticillium wilt, stolon decay and fleabeetles which may be transferred from existing stands to new fields as has been the common practice in the past.

Through the use of biotechnology, several lines of mint with improved resistance to rust and verticillium wilt are being developed. Although these lines will be available in the near future, it may take some time for growers to accept them as suitable replacements to the old varieties.

Critical Pest Control Issues

Continued problems with verticillium wilt, rust, and mint fleabeetles as well as the emergence of the *Floridotarsonemus* mite are the current issues that demand attention. Effective tools to manage these pest problems are necessary for the continued economically-feasible production of mint in Wisconsin.

Outlook for New Registrations

- Because of the nature of the article of commerce (oil) some pesticides that are oil soluble are unlikely to be registered for use on mint.
- Assure 2 (quizalofop-p) a selective, postemergence annual grass herbicide that received a label

for use on mint in summer 1998.

- A label for mycobutanil for rust control may be expected soon.
- There are several IR-4 pesticides that are currently in the pipeline. As these products become available, resistance problems may be reduced. The following materials have been included in field trials:

Herbicides

- clethodim (Select) - selective, post-emergence herbicide for the control of annual and perennial grass weeds.
- clomazone (Command), broad-spectrum, pre-emergence herbicide for the control of annual grasses and broadleaf weeds.
- pendimethalin (Prowl), broad-spectrum, pre-emergence herbicide for the control of annual grasses and some broadleaf weeds.
- pyridate (Tough), broad-spectrum, postemergence broadleaf herbicide.
- sulfentrazone (Authority), broad-spectrum, pre-emergence or pre-plant incorporated herbicide for the control of broadleaf weeds.

Insecticides

- avermectin (Abamectin) a miticide.
- hexythiazox (Savey), a mite ovacide for two-spotted spider mite that won't interfere with predatory mite activity when treated eggs are eaten.
- spinosid, a reduced-risk, foliar insecticide for cutworms.

Fungicides

- azoxystrobin (Quadris) a biological fungicide.
- propiconizol (Tilt) for control of rust and powdery mildew.
- myclobutanil (Rally) for control of rust and powdery mildew.

IR-4 projects have also been completed for tebufenozide (Confirm) and insect growth regulator that could be used as a reduced-risk alternative to acephate for foliar worm control. Cyhexatin (Penstyl), a miticide for two-spotted spider mite would also serve as an alternative to oxydemeton-methyl.

There is also a joint project between Indiana and Wisconsin to conduct a species shift identification and evaluation of the amaranth (pigweed) family in mint to determine whether there are different species in different locations. Some of the herbicide resistant pigweeds may actually be tall water hemp.

Contacts

Rocky Lunde, Executive Director
Mint Industry Research Council
P.O. Box 971
Stevenson, WA 98648
(509) 427-3601

Acknowledgements

This crop profile was written by K. A. Delahaut of the Wisconsin PIAP Program and reviewed by Dr. Larry Binning, Vegetable Weed Scientist, Rocky Lunde, Executive Director of the Mint Industry Research Council, Dr. Susan Mahr, Vegetable Entomologist, Dr. Walt Stevenson, Vegetable Plant Pathologist, and Dr. Jeffrey Wyman, Vegetable Entomologist.

References

1. Berry, R. E. and G. Fisher. 1993. A Guide to Peppermint Insect and Mite Identification and Management. PNW #82. 37 pp.
2. Lacy, M. L., C. T. Stephens, R. J. Green, A. C. York. 1981. Mint Production in the Midwestern United States. NCR Publication #155. 18 pp.
3. Schmitt, W. G. 1996. The Impact of Weed Populations on the Production and Quality of Peppermint (*Mentha piperita*) Oil. Masters thesis from the University of Wisconsin-Madison.
4. Weller, S. C., & L. K. Binning. 1998. Pesticide Use Survey for the Midwestern Mint States of Indiana, Wisconsin, and Michigan.

5. Weller, S. C., & L. K. Binning. 1998. Pests and Pest Control Practices in the Midwestern mint States of Indiana, Wisconsin, and Michigan.
6. Wisconsin Department of Agriculture, Trade, and Consumer Protection. 1996. Wisconsin Agricultural Statistics Annual Summary, Wisconsin DATCP. Madison.