PEST MANAGEMENT STRATEGIC PLAN FOR THE NORTH CENTRAL REGION BLUEBERRY INDUSTRY

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PREVIOUS PMSP

On June 6-7, 2001, a group of blueberry growers, crop consultants, processors, specialists, and industry representatives met to develop a pest management strategic plan for the Michigan blueberry industry. At this meeting, the utility of pest management practices and tools for commercial blueberry production was discussed. Problems encountered by the industry were summarized as research, regulatory, and educational priorities. The authors of the 2001 PMSP were Lynnae Jess, Rufus Isaacs, Annemiek Schilder, Eric Hanson, and George Bird.

OUTCOMES OF PREVIOUS BLUEBERRY PMSP

Industry priorities outlined in the 2001 Pest Management Strategic Plan for the Michigan Blueberry Industry have the following outcomes:

TOP PRIORITIES

1. Japanese beetles are the most severe pest in Michigan - it is threatening the marketability of the Michigan blueberry industry, with potential long-term impacts on the reputation for quality fruit.

   a) Effective control strategies for adult and grub stage of Japanese beetle. The presence of adults at harvest time is the primary target currently, but effective control of grubs will reduce the population in the field.
   Reduced-risk and conventional insecticides have been tested for control of Japanese beetle adults and grubs, and these studies continue. Results to date have been transmitted to growers and manufacturers, and were used to gain IR-4 A-priority projects to gain registrations of new insecticide options. Cultural controls were tested including cover crops and tillage of row middles to remove grass that is an attractive egglaying site. Results from these trials have led to widespread adoption of a row-middle system sowing winter rye in the fall and tilling it in mid-June to provide bare ground row middles (and headlands at some farms) for beetle suppression.

   b) Effective post harvest sorting to remove Japanese beetles from berries in processing. This is the last place to remove beetles. Product contamination is an issue for buyers and consumers, and there is a zero tolerance for the presence of beetles or beetle parts.
   Studies were conducted to compare beetle removal rates from three of the common color sorting technologies. These results demonstrated over 90% removal effectiveness, with improved performance when multiple cameras were used and with particular settings optimized for beetle removal. Results of these studies were transmitted to the industry and have resulted in the processing industry adopting this technology to help ensure beetle-free product to its customers.

2. Replacement products for Benlate to control Phomopsis canker and twig blight, Botrytis fruit rot, anthracnose fruit rot, and mummy berry.

Field trials have been conducted since 2001 to evaluate Topsin M (thiophanate methyl) as a Benlate replacement. Since Topsin M worked well for control of various diseases, a Section 18 (Emergency exemption) was requested and granted by EPA for Michigan and six other states. EPA granted a Section 18 for Topsin M to Michigan for the past 7 years. In addition, other fungicides like Pristine (pyraclostrobin + boscalid), Cabrio (pyraclostrobin), Abound (azoxystrobin), Switch (cyprodinil and fludioxonil), Elevate (fenhexamid), ProPhyt (potassium phosphite), Indar (fenbuconazole), Orbit (propiconazole), etc. were evaluated and labeled for control of diseases previously controlled by Benlate, though few of these have the broad spectrum of control that Benlate had. In 2008, the request for Topsin M was not granted due to the registration of multiple new fungicides.

OTHER PRIORITIES

Research:

• Study the biology of causal fungi, disease cycles, and post harvest problems in the control of fruit rots.

Research has been conduced on the seasonal spore release patterns of *Colletotrichum acutatum*, *Alternaria tenuissima,* and *Monilinia vaccinii-corymbosi*. In addition, we have conducted investigations into the overwintering vestiges of *Colletotrichum acutatum.* The effect of temperature on ascospore release by *Monilinia vaccinii-corymbosi* has been *studied as well as the leaf wetness and temperature requirements for infection by C. acutatum* on blueberry fruit. In addition, we have studied the role of frost as a predisposing factor in the development of mummy berry shoot strikes.

• Pest modeling information to determine proper spray timing for anthracnose, Alternaria, cranberry fruitworm, mummy berry, Phomopsis and blueberry maggot.

Cranberry fruitworm degree day model has been developed and is currently being validated before widespread release. Blueberry maggot models were reported independently in NJ and ME, and these are being tested under Michigan conditions.

A model to predict infection risk by *Colletotrichum acutatum* is being developed based on leaf wetness-temperature data and spore release patterns. In addition, a frost-guided spray advisory has been developed and validated for improved control of mummy berry on blueberry.

• Refining a systems approach for managing pests in blueberries as new products are introduced into the system - especially as we lose broad spectrum controls - this creates the need to use more products to replace what one product controlled in the past.

On-farm evaluation of new insecticides was conducted under a USDA-RAMP project, providing growers with large-scale testing of new products as part of an overall insect control program. EPA's phase-out plan for azinphosmethyl in blueberries has also led to recent on-farm test focused on alternatives for fruitworm control.

New fungicides as well as cultural methods are evaluated annually for control of mummy berry, fruit rots, and Phomopsis twig blight. Spray timing is also studied to see if reduced fungicide spray programs are effective.

• Cover crop management and soil quality issues that impact pest complexes and plant health.
Cover crops were tested for Japanese beetle control (see above), and a trial was conducted during 2005 and 2006 as a collaboration between horticulture, entomology, and a cover crop expert. A new trial is underway to compare cover crops and mulches for blueberry production.
As part of an organic research trial, the effect of cover crops and soil management will be studied on plant health, including resistance to diseases.

• Genotype development and breeding programs for varietal resistance, especially for viruses, and fast track the process. Evaluate new genotypes for general tolerances to pests and diseases.
In-vitro screening of blueberry genotypes has been conducted to assess resistance to blueberry shoestring virus. In addition, an in-depth study is on-going to discover the mechanism of resistance to anthracnose fruit rot in Elliott blueberry.

• Microbial food safety research in light of current food safety issues - we need research into food microorganisms - identify source and methods to control. Also look at the microbe competition with plant pathogens found on blueberry.
Research has been conducted on the presence and types of microbes on blueberry fruit surfaces as well as at the different steps of fruit sorting and processing. Furthermore, enzyme production by fruit microbes has been studied. Various post-harvest control measures have been evaluated including treatment with chlorine dioxide gas.

• Research needed on pesticide resistance even with new products and alternatives to these products.
A baseline study has been conducted on resistance to strobilurin fungicides in *Colletotrichum acutatum* isolates. Future studies are needed to assess whether resistance has developed in *C. acutatum* and other pathogen populations.

• Need to generate more "real world" worker exposure data for pesticides.
Studies in 2004 and 2005 measured worker exposure when picking blueberries in fields managed under conventional or reduced-risk insecticide programs.

• Assess the levels of microbial contamination on blueberry fruit and compare the efficacy of sanitizers in reducing microbial loads during blueberry processing
Research has been conducted on the presence and types of microbes on blueberry fruit. Various post-harvest control measures have been evaluated including treatment with chlorine dioxide gas.

• Determine the interaction between the naturally occurring fructoplane microflora of blueberries, pathogen infection, and pesticide use.
Bacteria and yeasts collected from blueberry fruit surfaces were evaluated *in vitro* for biocontrol activity. Several isolates were antagonistic to common blueberry pathogens, incl. *C. acutatum, Botrytis cinerea,* and *Alternaria tenuissima* and have been tested in small plot field trials. Effects of insecticides on anthracnose fruit rot have indicated an increase in fruit rot incidence as a result of insecticide sprays.

Regulatory:

• Preharvest Intervals need to be shortened on some products and kept short on other products for at-harvest-time pests.
No PHI's were shortened, but manufacturers, IR-4 and EPA are more aware of the need for short PHI's in blueberry. This is reflected in registrations of new insecticides that have 1 or 3 day PHI's on the label, providing greater flexibility for growers. **All new fungicides, except Captevate, that have been labeled since 2001 have 0-day PHIs.**

• New control products need to be moved through the regulatory process at a faster pace.
The blueberry research community and commodity organizations have worked to generate the trial data so IR-4 can conduct the residue studies that can be used by EPA to register new pesticides. This has resulted in a significant number of new registrations for blueberry including alternatives to azinphosmethyl and benomyl.

• Awareness of impacts of changing or lengthening the PHIs and REIs of pesticides used in blueberries.
Through meetings with EPA staff, this issue has been highlighted.

• Maintain several classes of pesticides to maintain resistance management programs.
New insecticide classes have been registered including spinosyn, IGR, and neonicotinoid insecticides. three additional classes are expected to be registered in the next few years. **Additional classes of fungicides (e.g., strobilurins, anilinopyrimidines, carboxamides, phosphonates) have been added, however, one class (benzimidazoles) may have been lost if Topsin M does not get a full label.**

• Regulatory protections need to be instituted which are designed to safeguard the Michigan blueberry industry from introduction of the plant pathogens causing blueberry shock, blueberry scorch, and Sheep Pen Hill disease.
The Michigan Department of Agriculture has instated quarantine regulations for imported plant material to safeguard Michigan from importation of blueberry scorch, shock, and Sheep Pen Hill viruses.

Education:

• As new tools and pest management techniques become available growers will need to be educated about proper use including demonstration plots.
This has been done through MSU Extension, an IPM Scout Training program, a Blueberry IPM Update newsletter that goes out each week, and through on-farm demonstration plots.

• Extension materials need to be developed which provide reliable and up-to-date information on the identity, biology and life cycles, and current control methods for pests and diseases, as well as beneficial organisms, weeds, and abiotic disorders of blueberries.
Since this PMSP was prepared, MSU Extension specialists and educators have produced the following publications to address this priority:
E-154 Fruit Pest Management Guide (updated annually)
E-2829 A pocket guide to IPM scouting in highbush blueberries
E-2845 Japanese beetle
E-2847 Fruit rot identification

E-3039 Anthracnose fruit rot
E-3050 Blueberry aphid and blueberry shoestring virus
E-2846 Mummy berry (in press)
E-xxxx Virus- and viruslike diseases (in press)
We have also developd a central website for information related to blueberry production, at www.blueberries.msu.edu

• A pocket size scouting guide for blueberries should be developed.
Outcome: A pocket scouting guide for blueberries was published in 2004 and updated in 2008. A Spanish version of this guide is being published in 2008.

PEST MANAGEMENT STRATEGIC PLAN FOR THE NORTH CENTRAL REGION BLUEBERRY INDUSTRY

EXECUTIVE SUMMARY

The Pest Management Strategic Plan (PMSP) for the North Central Region blueberry industry was originally developed in 2001 and updated in 2008. This document describes the current utility of pesticides and pest management strategies for blueberry production in the North Central region. This PMSP encompasses pest management approaches for growing blueberries for fresh marketing, processing, and juice. Input for this document was received from Michigan and Indiana, the blueberry-producing states in the North Central Region which account for over 99% of total production. The meeting was organized as a round-table discussion with a moderator and was held on April 17, 2008 at the Michigan State University Trevor Nichols Research Complex in Fennville, Michigan. The meeting was attended by blueberry growers, industry representatives, research and extension personnel from Michigan State University, and representatives from the North Central IPM Center, the Michigan State Horticultural Society, and the Michigan Department of Agriculture. During this meeting, the moderator initiated discussion among the meeting participants to establish pest management, research, regulatory, and educational priorities for commercial blueberry production in the North Central Region. The various methods of control for the major diseases, insects, nematodes and weeds that are pests of blueberries in the North Central Region were discussed in detail. The effectiveness of each method was rated on a scale of excellent to poor by the group, and the responses were recorded. To increase grower representation for setting priorities, an electronic survey was created after the meeting, allowing growers to rank the research, regulatory, and educational priorities listed at the meeting. In addition to the six growers who attended the meeting, 22 growers responded to the survey (n=28), ranking each priority as high, medium, or low. Those priorities ranked highest in each category are listed as ‘top priorities’ in this document. The priorities ranked as medium or low were grouped together and are listed as ‘other priorities’ in this document. During the spring and summer of 2008, the first draft of this document was written. In July 2008, the draft was sent to blueberry specialists from Michigan State University and Purdue University, North Central IR-4, and industry representatives for review. Final edits were made to the document and it was submitted to the national PMSP database in August 2008.

PEST MANAGEMENT STRATEGIC PLAN FOR THE NORTH CENTRAL REGION BLUEBERRY INDUSTRY

CURRENT TOP PRIORITIES

- Research

  1. Effective management of Japanese beetle, cranberry fruitworm, cherry fruitworm, and blueberry maggot, including post-harvest strategies.

  2. Effective management of fruit rots, mummy berry, Anthracnose, Alternaria, and Phomopsis.

  3. Research on control of vine and perennial weeds.

  4. Research on contact herbicides for late spring applications that won't harm the bush.

  5. Investigate natural ways to solve insect/disease/weed problems.

- Regulatory

  1. Establish sanitary/phytosanitary tolerances (MRL's) in export countries outside of the United States for new pesticide chemistries.

  2. Keep pre-harvest intervals (PHI's) on pesticides short to allow control of pests near harvest.

  3. Aerial application of pesticides is an important pest management tool for the blueberry industry. Pesticide labels should continue to include aerial application.

  4. Obtain Section 3 registration for Topsin-M, an important fungicide for the control of Phomopsis twig blight and canker, Fusicoccum canker, Mummy berry, and Anthracnose.

- Education

  1. Educate growers on pesticide mode of action and resistance management.

  2. The Michigan Fruit Management Guide is an important resource for blueberry growers. Ensure that this publication (E-154) is continually updated and published online.

  3. Continue to publish the Blueberry IPM Update newsletter.

  4. Pesticide education.

CURRENT OTHER PRIORITIES

- Research

  1. Learn how to remove an old field, including its associated diseases and insect problems, giving growers the opportunity to plant a new field without such problems.

2. Plant breeding to develop late-season varieties that have good tasting berries. The blueberry industry does not currently have good varieties for this late- season window.

CURRENT OTHER PRIORITIES (Continued)

3. Due to increasing production costs and environmental concerns, create better spray technologies to maximize spray efficiency and eliminate off-target applications. Suggestions include a sprayer with a gravity drain, eliminating residual spray mix in tank and fertilizer spreaders to reduce fertilizer adherence to the inside of the sprayer.

4. With the addition of new pesticide chemistries, and subsequent loss of older products due to FQPA implementation, determine the long-term effects on beneficial insects and other organisms.

5. With the addition of new pesticide chemistries, determine their effect on secondary pests as a result of selective pesticides.

6. More research is needed on soils, nematodes, and their interactions with blueberry production. Additionally, soil surveys are needed to identify what nematodes exist in soils where blueberry is grown and what is necessary to control these organisms if they are identified as pests.

7. Investigate gall midge. Determine if it is just an oddity or an emerging pest.

8. Investigate questions on scale and other emerging pests.

9. Investigate red root pigweed resistance to herbicides.

10. Investigate the interaction between Phomopsis and plant health.

11. Monitor for viruses (scorch, stunt, shoestring, mosaic, sheep pen hill) in an effort to manage these diseases proactively.

12. Investigate effective repellents for birds.

13. The blueberry industry does not favor GMO blueberry research, especially related to plant breeding.

- Regulatory
  1. Prevention of introduction of blueberry viruses not currently in Michigan and other blueberry production states in the North Central region.

  2. Add additional blueberry pests on pesticide labels currently registered for use in blueberry.

  3. Resolve Calypso blueberry label in relation to the EPA’s "risk cup".

- Education

1. Provide one central location for research knowledge base of blueberry information.

PEST MANAGEMENT STRATEGIC PLAN FOR THE NORTH CENTRAL REGION BLUEBERRY INDUSTRY

BACKGROUND

The North Central region of the United States is ranked first nationally in cultivated blueberry production, with Michigan and Indiana leading the region in total production. In Michigan, output of cultivated blueberries was 93 million pounds in 2007, 33 percent of the U.S. total. Sixty-eight percent of Michigan's blueberries were frozen or canned. In 2007, there were 18,500 bearing acres of blueberries producing 5,030 pounds per acre. The three-year (2005-2007) average for Michigan production was 4,643 pounds per acre (USDA-NASS, 2007).

Average production from Indiana (2005-2007) of cultivated blueberries was 2.8 million pounds from 573 bearing acres. The three-year (2005-2007) average for Indiana production was 4,703 pounds per acre (similar to Michigan) (USDA-NASS, 2007).

For Michigan and Indiana combined, the average price per pound received in 2007 was $1.85 with a value of production at $168,146,000. There were 30,800,000 pounds of fresh market blueberries receiving $2.13 per pound, and 63,600,000 pounds of processed blueberries receiving $1.60 per pound (USDA-NASS, 2007).

According to the Michigan Fruit Inventory (USDA-NASS, 2007), the major blueberry-producing counties in Michigan include Van Buren, Allegan and Berrien in the southwest, and Ottawa and Muskegon in the west central parts of the state. The most popular variety of blueberries grown in Michigan is Jersey (ca. 7,000 acres) followed by Bluecrop (ca. 5,400 acres) Elliott (ca. 2,500 acres) and Rubel (1,500 acres). The major blueberry-producing region in Indiana is in the northern part of the state (La Porte, Jasper, St. Joseph, Starke, and Pulaski counties).

The highbush blueberry plants grown in the North Central Region are perennial with a shallow root system that is very fibrous but devoid of root hairs. No crop is harvested the first two years after planting, and the plant reaches maturity at 5 to 7 years of age. Well-maintained blueberry bushes remain productive for at least 15 to 20 years. Much of the Michigan blueberry acreage was planted 30 to 50 years ago.

Blueberries require fairly specific soil and climatic conditions. They require an average growing season of 160 days. Late spring or early fall frost can damage plants. The best blueberry soils in Michigan are acidic (pH below 5.5), and blueberries do best where the pH is between 4.5 and 5.0. Blueberries are grown on very sandy soils and on soils high in organic matter, such as peat soils. Organic matter increases the water holding capacity of sandy soils.

Irrigation is important because blueberry root systems are shallow. Seventy-five percent of Michigan's 18,500 acres of blueberries are irrigated by drip (ca. 3,000 acres), sub-soil (ca. 650 acres), traveling gun (ca. 2,400 acres), or overhead sprinklers (ca. 8,000 acres) (USDA-NASS 2007). Overhead irrigation is also important to mitigate injury caused by spring frosts. Spring frosts are a major factor that determines the total production of blueberries for a region in any given year. In a year with numerous or widespread frosts, blueberry yields tend to be low and prices are high. In years with few frosts, overproduction will result in low prices.

Blueberries are planted in the fall or early spring as soon as the soil can be worked. Plants are spaced 4 to 5 feet apart in the row on less fertile mineral soils or 5 to 6 feet apart on organic soils. Rows are spaced to accommodate equipment, usually 10 to 12 feet apart. Most blueberries are mechanically harvested. Less than 20 percent of the blueberries produced in the state are harvested by hand.

Blueberries require regular pruning to produce high yields of large fruit. The most fruitful canes are 4 to 6 years old and 1 to 1 ½ inches in diameter at the base. Blueberries are best pruned when dormant, in either late fall, winter or early spring. Spring pruning is usually preferred because canes injured during the winter can be identified and removed.

Blueberries require bees for pollination and fruit set. Though native bees may adequately pollinate small plantings, most commercial growers place honeybee hives in plantings for optimum fruit set.

Aerial application of pesticides is an important tool for controlling pests in this industry. Aerial application of pesticides is critical during the period of fruit ripening through harvest, because ground application equipment knocks off mature fruit before it can be harvested. To further exacerbate this problem, several key blueberry pests are present during this period, requiring control due to zero tolerance. Application of pesticides may also be needed early in the season due to wet fields, making it impossible to drive a tractor and sprayer down row middles.

Insects. The primary insect pests of blueberries in the North Central Region are Japanese beetle, blueberry maggot and cranberry fruitworm. Each of these insects can be harvested with the fruit during mechanical harvest, and there is a zero tolerance for these insects in fruit. Consequently, growers' insect management programs are targeted toward maintaining fruit free from these insects. During bloom, cranberry and cherry fruitworm lay their eggs on the young fruit, and the developing larvae are controlled by applications of Bacillus thuringiensis or tebufenozide during pollination. After petal fall, control of these species is typically by broadspectrum insecticides. Other Lepidoptera present at this time, such as leafrollers and loopers, will usually be controlled by the fruitworm management regime. Specific insecticide applications may be required for obliquebanded leafroller. Depending on location, blueberry maggot adults emerge from early June to late June, and females become sexually mature 10 days after emergence. This species is typically controlled by regular applications of organophosphate insecticides, and this overlaps with the activity of adult Japanese beetles. These begin emergence in early July, and continue through late September. The populations of Japanese beetles continue to expand in their geographic range, infesting the lower tier of counties across southern Michigan from Muskegon county westward, with some isolated infestations further north. Growers apply insecticides to maintain beetle-free fruit at harvest, and clean cultivation has been adopted in suitable fields to reduce the suitability for beetle development. Additional labor and post-harvest technologies have been purchased by many processors to improve the removal of beetles before packaging. Additional insect pests include plum curculio, blueberry tip borer, white marked tussock moth, blueberry aphid, Putnam scale, and gypsy moth. These are sporadic in their impact on Michigan blueberries, and are currently controlled by typical insecticide spray programs. Blueberry aphid is the vector of blueberry shoestring virus that can cause decline of susceptible blueberry cultivars. The importance of certain insect pests is likely to increase as pest management options change and more selective insecticides are integrated into blueberry production. Additionally, Oriental beetle has

been detected in west Michigan at low levels since 2004 and is expected to become a significant pest of Michigan blueberries in the future.

Diseases. Important blueberry diseases of the North Central Region are primarily caused by fungal pathogens, such as mummy berry, caused by Monilinia vaccinii-corymbosi; Phomopsis twig blight and canker, caused by Phomopsis vaccinii; Fusicoccum canker, caused by Fusicoccum putrefaciens; anthracnose fruit rot caused by Colletotrichum acutatum; and Alternaria fruit rot caused by Alternaria spp. Blueberry shoestring, caused by the blueberry shoestring virus, is the most important virus disease of blueberries in Michigan.

In the case of mummy berry, the causal fungus mummifies the fruit, resulting in hard, white fruit mummies that are undesirable in fresh and processed fruit. The fungus also causes significant dieback of young shoots, limiting yield potential for the following year. Mummy berry is especially a problem in wet sites. Currently several fungicides are available for control of mummy berry, with Indar being the most effective. Without chemical control, losses to this disease are estimated in the range of 10 to 50%.

Phomopsis twig blight and canker are present to variable extent in most blueberry fields in Michigan. Phomopsis vaccinii infects young fruiting twigs and can lead to fruit losses of two or three pints per bush on susceptible cultivars. Cankers can cause entire canes to wilt and die. The fungus is rainsplash dispersed and is active throughout most of the growing season. Wounds, such as caused by mechanical harvesting, and drought stress predispose plants to the disease. Captan and Benlate used to be the standard for control of Phomopsis, but since Benlate was withdrawn from the market, Indar, Orbit, Pristine and Cabrio are now recommended as control alternatives. Pruning out and destroying diseased canes is also recommended for control.

Fusicoccum canker is more common in the northern growing areas of Michigan. Symptoms are similar to Phomopsis canker, except the cankers have a more defined border. Captan and Benlate used to be the standards for control, but no fungicide trials have been done since Benlate was lost to try and find efficacious alternatives. It is assumed that Captan, Ziram, and Pristine have activity against Fusicoccum due to their broad-spectrum of activity. Thorough pruning is also recommended for control.

Fruit rots have been repeatedly indicated by Michigan growers as a major problem because they are difficult to control, even with currently available chemicals, resulting in lower marketable yields and lower prices due to downgrading of the harvested fruit. Yield losses to anthracnose fruit rot can range from 10 to 20% in Michigan. Losses during storage sometimes approach 100%. Anthracnose fruit rot can be managed with the following fungicides: Abound, Cabrio, Pristine, Switch, Captan, Aliette, Bravo, Ziram. Timely harvesting and post-harvest cooling of the fruit are also recommended for control. Alternaria fruit rot is more difficult to control and seems to become more prevalent as anthracnose fruit rot is suppressed. Fruit injury and phytotoxicity of tank mixes of certain pesticides are thought to predispose the fruit to infection. Switch, Aliette, Ziram, and Pristine are currently the recommended materials for Alternaria fruit rot control. However, Aliette is a very expensive product. Timely harvest and rapid cooling of the fruit are also recommended.

Other fungal diseases that occur in Michigan but usually do not present an economic threat are powdery mildew, caused by the fungus Microsphaera vaccinii; Botrytis leaf and blossom blight

and fruit rot, caused by Botrytis cinerea; leaf rust, caused by Pucciniastrum vaccinii; witches' broom, caused by Pucciniastrum goeppertianum; and red leaf disease, caused by Exobasidium vaccinii.

Phytophthora root rot, caused by the Oomycete Phythophthora cinnamomi, is not very common in Michigan. When it occurs, it is usually associated with heavy soils and poorly drained areas within fields. This disease affects the roots. Above-ground symptoms include defoliation, stunting, and dieback. Site selection and good drainage (including raised beds) are important management tools. Ridomil Gold, Aliette, ProPhyt and Phostrol are recommended for control.

Virus diseases are best controlled by planting virus-tested planting material. Several nurseries in Michigan sell virus-tested plants. Blueberry shoestring virus is the most important and widespread virus disease of blueberries in Michigan. It is spread by the blueberry aphid, and can be slowed by good control of aphids, as well as removing infected plants. Minor virus diseases in Michigan are blueberry red ringspot, blueberry mosaic, blueberry leaf mottle, necrotic ringspot, and tomato ringspot. Blueberry stunt is a potentially serious disease caused by a phytoplasma.

Weeds. Weeds compete with blueberries for water, nutrients, and sunlight. Competition delays establishment and returns in young plantings, and reduces yields in producing plantings. Weed species that grow up into blueberry canopies also reduce harvested yields by impeding hand pickers and mechanical harvesters. Weeds retain moisture in blueberry bushes, which can increase fruit rot diseases and possibly stem canker. Weeds can adulterate harvested blueberries by contributing foreign fruit that are difficult or impossible to remove. Some fruit are toxic (black nightshade) and present a health hazard.

Weeds in young plantings are controlled with combinations of pre-emergent and post-emergent herbicide use, cultivation, and hand weeding. Because young bushes are sensitive to most pre-emergent herbicides, these products are used sparingly during the first few years.

Established plants are more tolerant of herbicides and the area beneath the row is typically treated annually with simazine, diuron, terbacil, norflurazon, or various combinations of these herbicides. The goal is to keep a 45 foot wide strip beneath the bushes clear of weeds. The area between rows may be clean cultivated, seeded annually with rye, or maintained in a permanent, mowed cover. A permanent cover is essential in many fields to facilitate traffic during wet weather.

Several weed management problems are particularly challenging. Many growers are experiencing greater difficulty achieving full-season control of annual weeds. Standard pre-emergent herbicides applied in April or May begin to fail before harvest, and several late germinating weeds become problems during the harvest season. A continuing challenge is the management of perennial herbaceous weeds (blackberries, yellow nutsedge, goldenrod, milkweed), tree species (sassafras, oak, maple), and vines (virginia creeper, poison ivy, grapevine). Once these perennial species become established, standard pre-emergent herbicides have little effect. Growers typically resort to directed or shielded sprays of glyphosate, which is time consuming and hazardous to blueberry bushes. Another challenging area is the control of weeds in young plantings where crop safety limits the use of effective pre-emergent herbicides. One reason the industry is slow to replace old bushes with newer varieties with higher yields and quality is that young bushes take so long to reach maturity. Weed competition delays this process.

The effectiveness of the weed control program also influences Japanese beetle control programs. Several weed species are preferred hosts for Japanese beetle adults. Presence of these attractive food sources attracts more beetle adults to the planting. Tall or climbing weeds also prevent good coverage of control materials.

Nematodes. Nematodes are roundworms classified in the Phylum Nematoda of the Animal Kingdom. They are the most widely distributed and common animals on the planet. Nematodes feed on bacteria, fungi, algae, plant tissue or animal tissue. They inhabit all agricultural soils, including those used for blueberry production in Michigan. Although bacterial and fungal feeding nematodes are essential for the maintenance of high quality soil and high plant productivity, nothing is known about their occurrence and activities in blueberry soils. Specific plant feeding nematodes cause infectious diseases of blueberry plants, while others vector viruses that are pathogenic to this crop. Nothing is known about algal-feeding nematodes in agricultural soils. Some nematode species have been developed as biological control agents of insects.

There have been three blueberry nematode survey projects completed in Michigan and several others in the northeast. The most recent was completed in 1966. In 1953, Chitwood recovered three nematode species from blueberry soils during a nematode survey of Michigan agriculture. This was followed in 1955 by a blueberry nematode survey in four eastern states (Goheen and Braun). Between 1960 and 1966 there were five separate blueberry nematode survey initiatives, including two from Michigan (Hutchinson, 1960; Mai et al., 1960; Zuckerman, 1960; Knierim, 1963; Tjepkema, 1966). The following nematodes were common in blueberry soils: dagger nematodes (Xiphinema spp.), stubbyroot nematodes (Trichodorus and Paratrichodorus spp.), sheath nematodes (Hemicycliophora spp.), root lesion nematodes (Pratylenchus spp.), ring nematodes (Criconematididae spp.), needle nematode (Longidorus longicaudatus), Tetylenchus nematode (Tetylenchus joctus), and the Atylenchus nematode (Atylenchus decalineatus). Dagger nematodes are the most important of the plant parasitic nematodes associated with Michigan blueberry production. They function both as pathogens (cause of infectious diseases) and as vectors of viruses that cause infectious diseases.

Insecticide and Fungicide Application. Application of insecticides and fungicides is accomplished by both sprayers (namely airblast, cannon, tower) and aerial application contractors. The continued availability of the aerial application method is crucial to the blueberry industry. Nearly 100 percent of the Michigan blueberry acreage is treated aerially with fixed-wing or rotary-blade aircraft at some point during the production season. There is heavy reliance on this application technique, especially early in the season and during the harvest period. Early in the season, field conditions often do not allow equipment travel due to wet soil conditions. Aerial application is the only practical method. As the season progresses the crop canopy enlarges. Berries, found in the outer periphery of the bush, weigh down the canes, causing them to lean into the drive lane between the rows. Tractor/sprayer travel is not possible as the berries mature and the canes fill the “between row” area. Aerial application of pesticides is a critical aspect of highbush blueberry production in Michigan.

Methyl Bromide Fumigation. Methyl bromide fumigation of fresh blueberries is required in order to ship the fruit to the states of California, Oregon and Washington. This quarantine is in place for two insects, the blueberry maggot and plum curculio. Fumigation with methyl bromide is also required in order to satisfy the Canadian blueberry maggot certification program. The

Michigan industry is very concerned with the future of methyl bromide as a post harvest quarantine treatment, both in terms of the availability and cost of the treatment. As these markets continue to be critical avenues for fruit sales, it is important that alternatives are developed or regulatory relief be enacted.

Microbial contamination. Food safety and quality concerns have indirectly impacted producers and marketers in the form of buyer demands for microbial testing and increasingly stringent microbial specifications. In Michigan, producers sporadically observe high levels of yeasts and molds in frozen blueberries. Later harvests tend to have poorer-quality fruit and higher microbial counts. Colletotrichum acutatum (anthracnose fruit rot) is an important contributor to mold counts in blueberry fruit. In addition, high levels of fruit rot tend to increase mold, yeast, and bacterial counts. Blueberries destined for freezing are typically harvested by machine and sorted and cleaned with standard equipment including blowers, destemmers, tilt belts, water bath, and conveyer belts. Blowers and destemmers tend to reduce microbial load. In addition, conveyer surfaces can become infested with microbes from rotting fruit and can contaminate subsequent fruit lots. Water tanks used to remove buoyant immature fruit are typically treated with sodium hypochlorite, however, the amount is insufficient to significantly reduce microbe levels. Seasonal fungicide treatments are effective at reducing fruit rots and can improve quality of fruit before harvest. After harvest, chlorine dioxide gas sachets can be used to gas blueberries to reduce microbial levels before processing. They can only be used for blueberries that will be processed and rinsed and cannot be used on fresh fruit.

Economic Environment for U.S. Agriculture and Agribusiness. In order for blueberry growers to stay in farming, there needs to be policies and programs designed to: 1) foster U.S. farms as the major part of our food system; 2) enhance the viability of locally owned and locally operated farms; and 3) facilitate U.S.-based agribusiness in a way that allows these enterprises to provide cutting-edge services and products to the farm community on a long-term basis.

Food Safety. Microbial safety is a critical concern to all segments of the blueberry marketing chain. A single widely publicized outbreak of a food-related illness can have enormous consequences for the entire industry. Although the blueberry industry has not had to contend with such an event, food safety concerns have indirectly impacted producers and marketers in the form of buyer demands for microbial testing and increasingly stringent microbial specifications. Buyers of frozen blueberries are increasingly demanding microbial testing in order to assure that the product does not exceed their specifications.

Most customers have very low or no tolerance for human pathogens that have the potential to seriously impact food safety. In 1978, blueberries were epidemiologically linked to an outbreak of listeriosis and were just recently identified as the source of infection in an outbreak of hepatitis A. The fact that one producer was recently forced to recall an undetermined number of packages of frozen blueberries from California, Illinois and Australia due to contamination with Listeria monocytogenes (FDA Enforcement Report, 1998) illustrates that food safety is a legitimate concern. Some producer organizations routinely test for pathogens (E. coli O157:H7, Salmonella, L. monocytogenes) as part of their quality assurance programs. Coliform bacteria can be found at low levels in blueberries, and are thought to originate from pond water used for irrigation.

PEST MANAGEMENT STRATEGIC PLAN FOR THE NORTH CENTRAL REGION BLUEBERRY INDUSTRY

CURRENT AND FUTURE PEST MANAGEMENT OPTIONS

This section of the document is a pest by pest analysis of the current role of pesticides classified as organophosphates, carbamates, pyrethroids, and B2 carcinogen fungicides, the use of other pest management aids (chemical, cultural and otherwise) that offer some control but are not "stand-alone" tools, pipeline pest management tools (identified as effective but not yet available), and "to do" lists for research, regulatory and education needs.

INSECTS

1. Japanese Beetle (*Popillia japonica*)

- Rated as number one priority of 2001 PMSP.
- Is a key pest of blueberries because of its adult activity at harvest time.
- Zero tolerance for this insect in blueberries in the market place.
- Strong fliers (can fly over a mile) and are highly active during harvest period.
- Large insect and hard to control.
- Its feeding predisposes blueberries to fruit rots.
- Aerial application is important method of pesticide application near harvest to prevent berry injury.
- Most economically-important insect contaminant of processed fruit.
- Adult beetles are active from mid-June through September and re-infest fields after control applications.

Organophosphate insecticides currently registered:
Malathion (Malathion ULV Conc., Aqua Malathion 8EC)

- REI is 12 hours
- Label PHI is 0 days for ULV, 1 day for EC
- Fair control, short residual
- Weak knockdown sometimes leaves dead beetles in canopy
- Causes fruit spot and bad taste if used just before harvest

Azinphosmethyl (Guthion 50WP) – *being phased out*

- Restricted Use Pesticide
- REI is 48 hours for mowing, irrigating and scouting, 4 days for other activities
- Label PHI is 7 days
- Good control
- PHI prevents use close to harvest
- Being phased out by EPA
- Can no longer apply aerially after 2009

Phosmet (Imidan 70WP)

- REI is 24 hours
- Label PHI is 3 days
- Good control
- Short REI and PHI are essential for effective use near harvest
- Primary insecticide for Japanese Beetle control and blueberry maggot complex near harvest
- Tank water pH important for preventing hydrolysis (adjust to pH 5.5-6)

Diazinon (Diazinon)
- REI is 24 hours
- Label PHI is 7 days
- Good control
- PHI prevents use close to harvest, not used much in Michigan

Carbamate insecticides currently registered:
Methomyl (Lannate 90 SP, Lannate LV)
- Restricted Use Pesticide
- REI is 48 hours
- PHI is 3 days
- Fair to good control
- Slow acting for knock down and short residual
- Not labeled for U-pick operations

Carbaryl (Sevin XLR+, Sevin 80WSP)
- REI is 12 hours
- Label PHI is 7 days
- Good control
- Was primary control of Japanese beetle prior to the PHI being increased
- Short residual activity

Pyrethroid insecticides currently registered:
Note: The main concern with pyrethroids is the negative effects on insect natural enemies.

Esfenvalerate (Asana XL)
- Effective knockdown of beetles and residual control
- PHI of 14 days restricts use near harvest
- Not a strong product against blueberry maggot

Danitol
- Effective knockdown of beetles and residual control
- Works well against beetles by aerial application
- Label PHI of 3 days

Mustang Max
- New in 2007

- One day PHI
- Good control of beetles

Neonicotinoid insecticides currently registered:

Provado 2F

- Provides control of treated beetles if beetles are treated directly or if residues are fresh
- Causes knockdown and repellency action on beetles
- After approximately three days is absorbed into foliage and acts as anti-feedant
- Also active on blueberry aphid, maggot
- Price decreasing due to generic formulation
- Good control

Actara 25 WG

- Labelled in 2007
- Labelled for aphid and maggot
- PHI is three days

Assail

- Labeled in 2008
- Good activity on Japanese beetle, with highly activity on blueberry maggot and fruit-worms
- PHI is 1 day

Admire

Platinum

Other insecticides currently registered:

Evergreen EC 606

- Short residual control of Japanese beetle, with 0 day PHI
- Contains piperonyl butoxide to prevent detoxification of pyrethrum by beetles
- 12 hour REI
- Very expensive
- Excellent control for short term needs

Pyganic EC 1.4

- Organic pyrethrum insecticide
- Short residual control of Japanese beetle, with 0 day PHI
- Less effective than Evergreen

Azadirachtin (Ecozin 3%, Neemix)

- REI is 12 hours for Ecozin, 4 hours for Neemix
- Label PHI is zero days
- Primarily a repellent

- Very short residual
- Some formulations remove powdery fruit bloom, which causes cosmetic fruit damage. This is a temporary effect: bloom returns after a few days.

Kaolin (Surround WP)
- REI is 4 hours
- Label PHI is 0 days
- Primarily a repellent
- Cosmetic problems, surface residues are unacceptable especially in the fresh berry market

Other pest management aids:
Ground cover management (use of broadleaved plants to deter egglaying)
- Not stand alone
- May reduce resident grub population
- Avoid attractive plants in July/Aug, or mow

Mass trapping
- Is not effective and may attract beetles

Weed control
- removal of attractive plants

Biological Controls
- Predators
- Ground beetles consume eggs, larvae of JB
- Introduced biocontrols not common in Michigan
- Parasites
- More research needed
- Entomopathogenic nematodes
- Available for purchase
- New species discovered with high beetle activity but difficult to rear

Pipeline pest management tools:
- Ovavesicula biocontrol agent
- Metaflumizone

"To do" list for Japanese Beetle:
Research needs:
- Understand optimal performance of new insecticides
- Identify effective biocontrol agents
- Test ground cover alternatives
- Evaluate area wide strategies

Regulatory needs:
- Need to complete registration of Calypso for blueberry

- Add Japanese Beetle to Mustang Max label
- Ensure aerial application on new labels
- Ensure short PHI on new labels

Education needs:
- Life cycle of Japanese beetle and opportunities for grub control
- Efficacy of new insecticides
- Importance of removing alternate hosts

2. Blueberry Maggot (*Rhagoletis mendax*)
- There is a zero tolerance for blueberry maggot
- Common and widespread pest in Michigan
- Need for multiple sprays where present.
- Pest emerges over a long period of time.
- Control period is two months long.
- Adults can fly up to 1/4 mile and are highly active during harvest.
- Native pest, populations persist on wild blueberries also.

<u>Organophosphate insecticides currently registered:</u>
Malathion (Malathion ULV Conc., Aqua Malathion 8EC)
- REI is 12 hours
- Label PHI is 0 days for ULV, 1 day for EC
- Excellent to good control
- Applications have declined due to Japanese beetle which appears at the same time as blueberry maggot
- Malathion is less effective against Japanese beetle

Azinphosmethyl (Guthion 50WP) – *being phased out*
- Restricted Use Pesticide
- REI is 48 hours for mowing, irrigating and scouting, 4 days for other activities
- Label PHI is 7 days
- Used early in the season but not late due to the 7 day PHI
- EPA phaseout of this product underway, aerial restriction after 2009

Phosmet (Imidan 70WP)
- REI is 24 hours
- Label PHI is 3 days
- Excellent control, use has increased due to added control of Japanese beetle and short PHI
- The pH of the spray water is important

Diazinon (Diazinon)
- Used early in season but not late due to 7 day PHI
- Used early as an alternate spray to other materials

- Good control
- Not widely used in Michigan

Carbamate insecticides currently registered:
Methomyl (Lannate 90 SP, Lannate LV)

- Restricted Use Pesticide
- REI is 48 hours
- PHI is 3 days
- Excellent knock down but poor residual
- Not labeled for U-pick operations
- Not commonly used, used if aphids also present

Carbaryl (Sevin XLR+, Sevin 80WSP)

- REI is 12 hours
- Label PHI is 7 days
- Good control
- Was used frequently until PHI was lengthened to 7 days from 0 days

Pyrethroid insecticides currently registered:
Esfenvalerate (Asana XL)

- Active on maggot and other co-occurring insects
- Label PHI of 14 days
- Asana activity on maggot is good, but not excellent, at 14 day spray schedule
- RAMP Programs with Asana midseason had no maggot infestation.
- Not used widely for maggot due to long PHI

Danitol

- Registered in 2007
- 3 day PHI
- Little field experience with it yet
- Good for control of beetles and maggots

Mustang Max

- Registered in 2007
- 1 day PHI
- Not labeled for blueberry maggot
- It is important to note that pyrethroids are not as effective against Blueberry maggots as they are against Japanese beetles when applied on a typical 14 day application schedule.

Neonicotinoid insecticides currently registered:
Provado 1.6F

- Effective control of maggot flies and prevention of infestation
- Fields treated with Provado over 4 years in RAMP Project had no infestation
- 3 day PHI

Assail
- Registered in 2008
- Excellent activity on blueberry maggot in small plot trials

Actara
- Registered in 2007
- Blueberry maggot not on label, but efficacy expected.

Other insecticides currently registered:
SpinTor
- Fair control of maggot
- Susceptible to washoff, UV degradation
- To work, needs more frequent applications than every 2 weeks
- Not active on Japanese beetle so not used much in Michigan

Entrust
- Organic formulation of SpinTor
- Not active on Japanese beetle so not used much in Michigan
- Leading organic Blueberry Maggot control

Delegate
- Registered in 2008
- Maggot control expected, superior to SpinTor

GF120 fruit Fly bait
- Designed for aerial application/specialized ground sprayer
- Not active on Japanese beetle so not used much in Michigan

Azadirachtin (Ecozin 3%, Neemix)
- REI is 12 hours for Ecozin, 4 hours for Neemix
- Label PHI is 0 days
- Relatively expensive
- Repellency activity
- Used by organic growers
- Some formulations remove powdery fruit bloom, which causes cosmetic fruit damage. This is a temporary effect: bloom returns after a few days.

Kaolin (Surround WP)
- REI is 4 hours
- Label PHI is 0 days
- Good to poor control due to mode of action being nontoxic
- Residue on fruit makes it unsuitable for fresh market

Other pest management aids:
Baited yellow sticky traps

- Used for monitoring
- Tillage and good weed control can reduce buildup in fields
- Not effective on immigrant flies

Mass trapping
- Not cost effective
- 1 trap for every 5 bushes (~350/A)

Border spray strategy may be effective at preventing immigrant flies

Biological Controls
- Predators
- Ants, carabid beetles eat pupae
- Parasites
- Multiple species of native parasitoid, dominated by Diachasma alloeum, but not stand alone
- No commercial products

Pesticide treated spheres
- Works well if density is high enough
- Little if any worker exposure
- Attract and kill
- Impractical on commercial plantings to put out numerous treated spheres, but has utility for small plantings

Pipeline pest management tools:
- Alverde
- Altacor

"To do" list for blueberry maggot:
Research needs:
- Understand optimal performance of new insecticides
- Evaluate Mustang Max for blueberry maggot using ground and aerial application
- Refine monitoring tools, current system based on apple maggot
- Entomopathogenic nematodes for control of blueberry maggot

Regulatory needs:
- Calypso registration needed
- Mustang Max – add Blueberry Maggot

Education needs:
- Optimal monitoring and management

3. Cranberry fruitworm (*Acrobasis vaccinii*)
Direct fruit pest
- Key early-season pest

- One generation per year
- Important pest, primary early season pest during bloom and post bloom (June and July)
- Zero tolerance for worms in fruit
- Long emergence period, therefore long control period (multiple sprays needed)
- Control required during bloom, so bee safety is important

Note: Products targeted for cranberry fruitworm also aim to control cherry fruitworm.

<u>Organophosphate insecticides currently registered:</u>
Azinphosmethyl (Guthion 50 WP) – *being phased out*
- Used on over 60% of acreage (USDA-NASS survey)
- Restricted Use Pesticide
- REI is 48 hours for mowing, irrigating and scouting, 4 days for other activities
- Label PHI is 7 days
- Excellent activity and long duration of control
- Can only be used post bloom after bees are removed from field
- Being phased out by EPA

Phosmet (Imidan 70WP)
- REI is 24 hours
- Label PHI is 3 days
- Good to excellent control
- Provides long period of control but shorter residual than Guthion
- Can only be used post bloom after bees are removed from field
- The pH of the spray water is important to maintain activity

Diazinon (Diazinon)
- Good control
- REI is 24 hours
- Label PHI is 7 days
- Limited use due to other OPs having longer residual
- Can only be used post bloom after bees are removed from field

<u>Carbamate insecticides currently registered:</u>
Methomyl (Lannate 90 SP, Lannate LV)
- Restricted Use Pesticide
- REI is 48 hours
- PHI is 3 days
- Good control
- Relatively short residual
- Can only be used post bloom after bees are removed from field
- Can’t be used on U-pick operations
- Historically tank mixed with other materials

<u>Pyrethroid insecticides currently registered:</u>

Esfenvalerate (Asana)

- Label PHI of 14 days
- Only used after bloom for fruitworms
- Gives excellent control of fruitworms
- Low fruitworm infestation when used in 2 years of blueberry RAMP project

Danitol

- Registered in 2007

Mustang Max

- Registered in 2007

Neonicotinoid insecticides currently registered:

Assail

- Good activity on fruitworms in TNRC trials
- Registered in 2008
- No on-farm experience

Insect growth regulators currently registered:

Tebufenozide (Confirm 2F)

- REI is 4 hours
- Label PHI is 14 days
- Good to excellent control
- Can be used during bloom
- Provides long residual
- Relatively rain fast
- Good coverage and timing are essential for performance
- Larvicide and ovicide
- Has become option of choice for application during bloom

Methoxyfenozide (Intrepid 2F)

- Registered in 2008
- More active against fruitworms than Confirm
- More expensive than Confirm at equivalent rate, but lower rate/acre used for Intrepid
- Larvicide and ovicide
- Good coverage and timing essential for performance

Other insecticides currently registered:

- Pyriproxyfen (Esteem)
- Very expensive, slow acting
- Must be applied early in egglaying for greatest effect
- Not used much

Bt (Dipel)

- REI is 4 hours

- Label PHI is 0 days
- Good control if applied often enough
- Can be used during bloom – bee safe
- Effectiveness is weather dependent
- More effective on younger instars
- Registration of Confirm has reduced use
- Important organic material

SpinTor
- Not used due to short residual, high washoff potential

Entrust
- Organic formulation.

Delegate
- Registered in 2008
- Expected good control of fruitworms

Other pest management aids:
Pheromone traps
- Used for monitoring presence of pest
- Not stand alone

Degree day model in development to allow timing of sprays from trap-derived biofix

Scouting within fields to monitor egg laying and egg hatch

Biological Controls
- Parasites
- Parasitic wasps attack eggs and larvae of CBFW
- Trichogramma minutum available commercially but efficacy untested

Pipeline pest management tools:
- Belt
- Novaluron
- Altacor
- Alverde

"To do" list for cranberry fruitworm:
Research needs:
- GDD model development and implementation
- Optimize performance of new insecticides
- Test bio controls (Trichogramma wasps)
- Sprayable pheromones, area wide programs

Regulatory needs:

- Calypso registration
- Ensure aerial application on new labels

Education needs:
- Expectations or understanding mode of action of new IGR's
- Guthion phaseout – keep growers informed

4. Cherry Fruitworm (*Grapholita packardii*)
- A direct fruit pest.
- One generation per year.
- Important pest, primarily early season pest.
- Zero tolerance for larvae in fruit.
- Emerges slightly earlier than CBFW
- Long emergence period, therefore long control period.
- Control required during bloom so bee safety is important.
- Products targeted for cherry fruitworm also targeted for cranberry fruitworm.

Note: For efficacy expected from currently registered insecticides, see Cranberry Fruitworm above. Generally, because these pests are active at the same time, there is too little data to know about performance on cherry fruitworm.

<u>"To do" list for cherry fruitworm:</u>
Research needs:
- Life cycle and biology of this insect in blueberries
- Role of cherries in surrounding landscape
- GDD model for CFW
- Relative timing of activity compared with CBFW

Regulatory needs:
- Education needs:
- Identification of this pest
- Importance of monitoring for CFW

5. Blueberry Aphid (*Illinoia pepperi*)
- Sporadic pest and primary vector of shoestring virus.
- Overwinter as eggs
- Aphids are present June through September which makes PHI constraints critical.
- Preharvest control is important to avoid spreading aphids carrying the virus.
- Honeydew and insect parts can be a fruit contaminant if populations are high.

<u>Organophosphate insecticides currently registered:</u>
Note: Can disrupt biocontrol of aphids

Malathion (Malathion ULV Conc., Aqua Malathion 8EC)

- REI is 12 hours
- Label PHI is 0 days for ULV, 1 day for EC
- Not the material of choice
- Usage has dwindled to near zero with increasing Japanese beetle populations and availability of effective neonicotinoids

Diazinon (Diazinon)

- Can be used in U-pick operations
- Cost effective
- Longer control than Lannate
- REI is 24 hours
- Label PHI is 7 days
- Not allowed by certain processors?

Carbamate insecticides currently registered:

- Methomyl (Lannate 90 SP, Lannate LV)
- Restricted Use Pesticide
- REI is 48 hours
- PHI is 3 days
- Excellent control with relatively short residual activity
- Not allowed on U-pick operations
- Can disrupt biocontrol of aphids

Pyrethroid insecticides currently registered:
Note: Effective control, but disrupt biocontrol of aphids

Asana XL

- High activity on aphids

Danitol

- Not enough experience to know efficacy, but expected to be very active

Mustang max

- Not enough experience to know efficacy, but expected to be very active

Neonicotinoid insecticides currently registered:
Provado

- Highly effective
- Long term control

Actara

- Highly effective
- Long term control

Assail

- Highly effective

Platinum
- Soil application only, providing systemic protection of the bush

Admire
- Soil application only, providing systemic protection of the bush

Other pest management aids:
Biological Controls
- Predators
- Occur naturally and if conserved they can maintain low aphid populations
- Parasites
- No commercial products or applications tested
- Occur naturally and if conserved they can maintain low aphid populations

Pipeline pest management tools:
- Movento

"To do" list for aphids:
Research needs:
- Relative performance of insecticides on aphids in-season
- Performance of oil for dormant control
- Understand cultivar susceptibility of aphid vectored viruses
- Effect of new insecticides on natural enemies
- Preference of aphids for infected or healthy plants
- Evaluate insecticides for control of aphids

Regulatory needs:
- Quarantine prevention of infected plant material reaching Michigan

Education needs:
- Scouting for aphids, and identification of shoestring-infected plants
- Management of aphids and virus

6. Blueberry Tip Borer (*Hendecaneura shawiana*)
- Common pest in Michigan, but low levels.
- Biology not well understood.
- Too late to control when damage is seen.
- Not currently treating for tip borer, but sprays for other pests probably control it.
- Potential secondary pest as OPs are removed.

"To do" list for blueberry tip borer:
Research needs:

- Determine timing of moth flight and egglaying by tip borer
- Determine most effective controls for this pest
- Cultural control options
- Biological control of tip borer

Regulatory needs:

Education needs:
- Identification of tip borer damage
- Timing for control

7. Oblique Banded Leafroller (*Choristoneura rosaceana*)
- Documented evidence of resistance problems with OPs in some regions of blueberry production.
- Generation overwinters on or close to the bush so it chews on buds and there is also a summer generation.
- Control season is pre bloom and then July.
- First generation feeds on foliage, and second generation feeds on fruit.
- Has been less of a problem since fields treated for Japanese beetle.

<u>Organophosphate insecticides currently registered:</u>
Azinphosmethyl (Guthion 50WP) – *being phased out*
- Restricted Use Pesticide
- REI is 48 hours for mowing, irrigating and scouting, 4 days for other activities
- Label PHI is 7 days
- Fair to excellent due to resistance in some regions
- Used primarily for the summer generation
- Long period of effective control, long residual (10 to 14 days)

Phosmet (Imidan 70WP)
- REI is 24 hours
- Label PHI is 3 days
- Fair to good control due to resistance in some regions
- Slightly shorter residual than azinphosmethyl
- Controls summer generation

<u>Carbamate insecticides currently registered:</u>
Methomyl (Lannate 90 SP, Lannate LV)
- Restricted Use Pesticide
- REI is 48 hours
- PHI is 3 days
- Good control
- Short residual
- Material of choice for OP resistant populations
- Used for overwintering generation

Other insecticides currently registered:

Esfenvalerate (Asana)

- Label PHI of 14 days
- PHI too long, prohibits control of summer generation in early varieties.
- Reduces population of beneficials

Bt (Dipel)

- REI is 4 hours
- Label PHI is 0 days
- Fair control
- Short residual
- Weather dependent
- Effective on young instars but efficacy declines as larvae age
- Not effective on overwintering generation

Danitol

Mustang Max

Tebufenozide (Confirm 2F)

- REI is 4 hours
- Label PHI is 14 days
- Good to excellent control
- Effective on OP resistant populations
- Not effective on overwintering generation

Methoxyfenozide (Intrepid 2F)

- Similar to Confirm

SpinTor

- fair-good efficacy expected, but short residual

Entrust

- organic option, similar to SpinTor

Delegate

- recently registered, expected to be very effective against OBLR in blueberry

Other pest management aids:

Pheromone traps

- Used to monitor timing for control of summer generation

Degree day models

- Good model available, well tested in tree fruit

Biological Controls
- Parasites
- No commercial product available, but a complex of natural enemies suppress OBLR

Pipeline pest management tools:
- Belt

"To do" list for Oblique Banded Leafroller:
Research needs:
- Verify OBLR degree day model works in blueberry
- Identify natural enemies and sensitivity to insecticides

Education needs:
- Scouting for this pest, life cycle, and use of degree day model

8. Plum Curculio (*Conotrachelus nenuphar*)
- Occasional pest, could become a more important pest if OPs and carbamates are lost or removed.

Organophosphate insecticides currently registered:
Note: Pest is being controlled by Organophosphates that target cranberry fruitworm and cherry fruitworm

Azinphosmethyl (Guthion50WP) – *being phased out*
- Restricted Use Pesticide
- REI is 48 hours for mowing, irrigating and scouting, 4 days for other activities
- Label PHI is 7 days
- Excellent but not used

Phosmet (Imidan 70WP)
- REI is 24 hours
- Label PHI is 3 days
- Good control but not used

Diazinon (Diazinon)
- Good control but not used
- REI is 24 hours
- Label PHI is 7 days

Carbamate insecticides currently registered:
Note: Pest is being controlled by carbamates that are targeted for cranberry fruitworm

Methomyl (Lannate 90 SP, Lannate LV)
- Restricted Use Pesticide
- REI is 48 hours
- PHI is 3 days

- Not material of choice due to short residual

Carbaryl (Sevin XLR+, Sevin 80WSP)
- REI is 12 hours
- Label PHI is 7 days
- Good control
- Not used, prefer contact pesticides

Other insecticides currently registered:
Esfenvalerate (Asana)
- Label PHI of 14 days

Danitol
- Recently registered, so no experience with PC control

Mustang Max
- Recently registered, so no experience with PC control

Assail
- Recently registered, so no experience with PC control

Other pest management aids:
Biological Controls
- Few biological control options

Trapping
- Used as a monitoring tool for presence and timing of control

Pipeline pest management tools:
- None

"To do" list for Plum Curculio:
Research needs:
- Monitor populations as OPs are restricted from blueberry production

Regulatory needs:

Education needs:
- Identification of plum curculio injury symptoms, distinguishing PC larvae from BBM maggots

9. Spring Canker Worm (*Paleacrita vernata*)
- Early season pest, around bud break.
- Consumes the flower buds.
- Widespread but at sporadic levels, occasionally at economic levels.
- Sign of bud damage is usually first sign of this insect.

- Bee safety is a concern if damage occurs near bloom.

Organophosphate insecticides currently registered:
Azinphosmethyl (Guthion 50WP) – *being phased out*

- Restricted Use Pesticide
- REI is 48 hours for mowing, irrigating and scouting, 4 days for other activities
- Label PHI is 7 days
- Excellent control with long residual

Phosmet (Imidan 70WP)

- REI is 24 hours
- Label PHI is 3 days
- Excellent control with shorter residual than azinphosmethyl

Diazinon (Diazinon)

- Good control but azinphosmethyl or phosmet preferred
- REI is 24 hours
- Label PHI is 7 days

Carbamate insecticides currently registered:
Methomyl (Lannate 90 SP, Lannate LV)

- Restricted Use Pesticide
- REI is 48 hours
- PHI is 3 days
- Good control
- Short residual
- Can't be used on U-pick operations

Other insecticides currently registered:
Confirm

- expected to have some activity, but work best on young larvae that are actively molting

Intrepid

- expected to have some activity, but work best on young larvae that are actively molting

Danitol

- expected to be very active on this pest

Mustang Max

- expected to be very active on this pest

Asana

- expected to be very active on this pest

Bt (Dipel)

- REI is 4 hours
- Label PHI is 0 days

- Does not act fast enough to protect buds from feeding damage

Other pest management aids:
Biological Controls
- Ground predators attack larvae in the soil
- Not much information on biocontrol of spring lep larvae

Pipeline pest management tools:
- Belt
- Delegate

"To do" list for Spring Canker Worm:
Research needs:
- Development of economic thresholds
- Further testing of efficacy of insecticides
- Develop management strategies for control

Regulatory needs:

Education needs:
- Educate on management strategies for control
- Identifying problem and quick way to control

10. White Marked Tussock Moth (*Orgyia leucostigma*)
- Two generations per season
- Larvae develop during bloom and in midsummer.
- Common on deciduous trees, moves in to plantings.
- Female moths are flightless so spreads slowly in the field
- Larvae become mobile after first instar
- Have urticating spines, causing irritation to fruit pickers and packers.
- Can defoliate plant, especially young plants
- Contaminates harvested fruit
- Good coverage needed to control this pest

Organophosphate insecticides currently registered:
Malathion (Malathion ULV Conc., Aqua Malathion 8EC)
- REI is 12 hours
- Label PHI is 0 days for ULV, 1 day for EC
- Not widely used

Azinphosmethyl (Guthion 50WP)
- Restricted Use Pesticide
- REI is 48 hours for mowing, irrigating and scouting, 4 days for other activities
- Label PHI is 7 days
- First generation timing coincides with control of fruitworms

Phosmet (Imidan 70WP)

- REI is 24 hours
- Label PHI is 3 days
- Good control

Diazinon (Diazinon)

- REI is 24 hours
- Label PHI is 7 days
- Not widely used

Carbamate insecticides currently registered:

Methomyl (Lannate 90 SP, Lannate LV)

- Restricted Use Pesticide
- REI is 48 hours
- PHI is 3 days
- Good control with high rate
- Most common used for Tussock Moth during adult flight in harvest season to prevent contamination

Carbaryl (Sevin XLR+, Sevin 80WSP)

- REI is 12 hours
- Label PHI is 7 days
- Good control during second generation (late July-August)

Other insecticides currently registered:

Esfenvalerate (Asana)

- Label PHI of 14 days
- Effective at petal fall to control first generation

Confirm

- If applied for fruitworm control in bloom, usually prevents the later generation

Azadirachtin (Ecozin 3%, Neemix)

- REI is 12 hours for Ecozin, 4 hours for Neemix
- Label PHI is 0 days
- Organic option

Bt (Dipel)

- REI is 4 hours
- Label PHI is 0 days
- Organic option

Kaolin (Surround WP)

- REI is 4 hours
- Label PHI is 0 days

- Not used due to fruit residues

Danitol
- Activity expected

Mustang Max
- Activity expected

SpinTor
- Activity expected

Other pest management aids:
Biological Controls
- Predators attack young larvae
- Parasitoids have a cycle of abundance in association with Tussock Moth, which results in periods of high and low pest pressure

Diseases also cycle with Tussock Moth populations

Pipeline pest management tools:
- Belt

"To do" list for White Marked Tussock Moth:
Research needs:
- Determine natural enemies present in Michigan populations
- The Effect of insecticides on Tussock Moth's natural enemies
- Validate Degree Day model

Regulatory needs:
- Add Tussock Moth to current labels

Education needs:
- Educate growers on timing of this pest
- Use of Confirm or Intrepid at bloom for Tussock Moth control

11. Cutworms (multiple species)

Organophosphate insecticides currently registered:
Azinphosmethyl (Guthion 50WP) – *being phased out*
- Restricted Use Pesticide
- REI is 48 hours for mowing, irrigating and scouting, 4 days for other activities
- Label PHI is 7 days

Phosmet (Imidan 70WP)
- REI is 24 hours
- Label PHI is 3 days

Diazinon (Diazinon)
- REI is 24 hours
- Label PHI is 7 days

Carbamate insecticides currently registered:
Methomyl (Lannate 90 SP, Lannate LV)
- Restricted Use Pesticide
- REI is 48 hours
- PHI is 3 days

Carbaryl (Sevin XLR+, Sevin 80WSP)
- REI is 12 hours
- Label PHI is 7 days

Other insecticides currently registered:
Esfenvalerate (Asana)

Mustang Max

Danitol

Other pest management aids:
Biological Controls
- Predators
- Parasites
- Bacterial agents

Pipeline pest management tools:
- Belt

"To do" list for Cutworms:
Research needs:
- Develop scouting techniques and action thresholds

Regulatory needs:

Education needs:
- Identification of cutworm and its damage symptoms

12. Blueberry Bud Mite (*Acalitus vaccinii*)
- Very small mites that feed in buds.
- Can only be seen under a microscope
- Cause poor bud development.
- Reduced flowering on infested plants.

Organophosphate insecticides currently registered:

None

Carbamate insecticides currently registered:
None

Other insecticides currently registered:
Endosulfan (Thiodan)

- Most commonly used product
- Labeled in blueberry to control blueberry bud mite
- Apply after harvest in high gallonage with high pressure

Sulforix

- Provides some control when used as part of a disease management program

Oil

- Delayed dormant applications provide suppression of mite populations

Other pest management aids:
Biological Controls

- Predatory mites, predatory thrips
- Hirsutella thompsonii is a fungus that attacks the mites in humid conditions

Pipeline pest management tools:

- Envidor

"To do" list for Blueberry Bud Mite:
Research needs:

- Timing of movement during the season – most susceptible period
- Variation in varietal susceptibility
- Importance of biocontrol agents

Regulatory needs:

- Maintain endosulfan label for post-harvest use
- New in-season miticide options

Education needs:

- Identifying injury symptoms

13. Sharpnosed leafhopper

- Vector of blueberry stunt, a serious mycoplasma disease
- Sporadic virus issue
- Not actively managed

Organophosphate insecticides currently registered:

Phosmet (Imidan 70WP)

- REI is 24 hours
- Label PHI is 3 days

Diazinon (Diazinon)

- REI is 24 hours
- Label PHI is 7 days

Carbamate insecticides currently registered:
Methomyl (Lannate 90 SP, Lannate LV)

- Restricted Use Pesticide
- REI is 48 hours
- PHI is 3 days

Carbaryl (Sevin XLR+, Sevin 80WSP)

- REI is 12 hours
- Label PHI is 7 days

Other insecticides currently registered:
Azadirachtin (Ecozin 3%, Neemix)

- REI is 12 hours for Ecozin, 4 hours for Neemix
- Label PHI is 0 days

Provado

- Expected high activity on leafhoppers

Actara

- Expected high activity on leafhoppers

Assail

- Expected high activity on leafhoppers

Other pest management aids:
Ground cover management

- remove alternate hosts

Biological Controls

- Parasites
- Entomopathogens

Pipeline pest management tools:

- Movento

"To do" list for Leaf hoppers:
Research needs:

Regulatory needs:

Education needs:

14. Thrips

Organophosphate insecticides currently registered:
Malathion (Malathion ULV Conc., Aqua Malathion 8EC)

- REI is 12 hours
- Label PHI is 0 days for ULV, 1 day for EC

Azinphosmethyl (Guthion50WP) – *being phased out*

- Restricted Use Pesticide
- REI is 48 hours for mowing, irrigating and scouting, 4 days for other activities
- Label PHI is 7 days

Phosmet (Imidan 70WP)

- REI is 24 hours
- Label PHI is 3 days

Diazinon (Diazinon)

- REI is 24 hours
- Label PHI is 7 days

Carbamate insecticides currently registered:
Methomyl (Lannate 90 SP, Lannate LV)

- Restricted Use Pesticide
- REI is 48 hours
- PHI is 3 days

Carbaryl (Sevin XLR+, Sevin 80WSP)

- REI is 12 hours
- Label PHI is 7 days

Other insecticides currently registered:
Azadirachtin (Ecozin 3%, Neemix)

- REI is 12 hours for Ecozin, 4 hours for Neemix
- Label PHI is 0 days

SpinTor

- Highly effective in small plot trials

Delegate

- expected high activity

Other pest management aids:
Biological Controls

- Predatory thrips – not stand-alone

Pipeline pest management tools:
None

"To do" list for Thrips:
Research needs:

- Species causing economic injury

Regulatory needs:

- Bee-safe thrips controls for use during bloom

Education needs:

15. Scales

Organophosphate insecticides currently registered:
Azinophosmethyl (Guthion 50WP) – *being phased out*

- Restricted Use Pesticide
- REI is 48 hours for mowing, irrigating and scouting, 4 days for other activities
- Label PHI is 7 days

Phosmet (Imidan 70WP)

- REI is 24 hours
- Label PHI is 3 days

Diazinon (Diazinon)

- REI is 24 hours
- Label PHI is 7 days

Carbamate insecticides currently registered:
Methomyl (Lannate 90 SP, Lannate LV)

- Restricted Use Pesticide
- REI is 48 hours
- PHI is 3 days

Carbaryl (Sevin XLR+, Sevin 80WSP)

- REI is 12 hours
- Label PHI is 7 days

Other insecticides currently registered:
Esteem

- Highly effective and long lasting

Oils

- Applied as a dormant application to smother overwintering scales

Other pest management aids:
Biological Controls

- Parasites

Pipeline pest management tools:
None

"To do" list for Scales:
Research needs:

- Timing of crawler movement
- Monitoring system – sample size
- Importance of conserving natural enemies for scale management

Regulatory needs:

- New scale-active selective insecticides

Education needs:

- Identification of scale during scouting
- How to monitor for scale

OTHER INSECTS

Oriental beetle

- Present in Michigan
- Major pest in New Jersey blueberry
- Not currently managed
- Admire or Platinum are chemical options
- Nematodes available for control

"To do" list for Oriental beetle:
Research needs:

- Distribution and abundance in Michigan
- Economic impact on blueberry

Regulatory needs:

Education needs:

- Identification of OB in blueberry
- Timing of activity and potential injury

DISEASES

General statements:
Since the fungicide Benlate was withdrawn from the market in 2001, Topsin-M (thiophanate methyl) has been used as a substitute under an annual Section 18 (emergency exemption). Topsin M is usually used in a tankmix with Captan or Ziram for control of Phomopsis canker and twig blight, anthracnose fruit rot and mummy berry. However, due to the registration of multiple new fungicides in subsequent years, a Section 18 label request was not granted in 2008. Topsin M is therefore not included in the discussion below. As far as we know, the registrant is still pursuing a full (Section 3) label but the timeline is unclear.

While Captan was considered a B2 (possible) carcinogen in the past, a recent review of toxicology data by EPA has resulted in a reclassification whereby Captan is no more considered a possible carcinogen if it is used according to label instructions. The reason is that early toxicological studies were done with amounts of active ingredient that were several magnitudes higher than would be encountered in occupational or dietary exposure and were therefore unrealistic.

1. Mummy Berry (*Monilinia vaccinii-corymbosi*)

- Shoot strike phase is most growth-limiting disease, kills current-season growth.
- Zero tolerance for mummified berries for processing and fresh market.
- Mummy berry phase causes loss of fruit before harvest up to 75% in unsprayed fields.
- Shoot strike phase can kill 75% of the shoots.
- Easier to remove in postharvest sorting than fruit rots.
- Most of the mummies drop before harvest and serve as inoculum for the next year.
- Ascospores from mummified berries infect the shoots, and conidia from shoots infect the fruit so the plant is infected by the same pathogen twice.
- Ascospores are wind dispersed, whereas conidia are dispersed by bees, rain, and wind.

<u>B2 carcinogenic fungicides currently registered:</u>
Chlorothalonil (Bravo Weather Stik)

- REI is 48 hours
- Label PHI is 42 days
- Do not apply after full bloom (early petal fall)
- Fair control of shoot blight
- Poor control of fruit infection
- Not widely used

<u>Other fungicides currently registered:</u>
Fenbuconazole (Indar 75WSP, Indar 2F)

- REI is 12 hours
- Label PHI is 30 day
- Risk of resistance if not rotating
- Needs tank mix with protectant at bloom
- Primary product for mummy berry

- Good control of both phases with proper timing
- Locally systemic
- Efficacy improved when sprayed within 24 hr after frost

Propiconazole (Orbit, Propimax):
- Registration in 2008
- REI is 24 hours
- Label PHI is 30 day
- Systemic
- Good control of shoot strike phase, fair to good for fruit infection stage

Ziram (Ziram 76 DF, Ziram Granuflo)
- REI is 48 hours
- Label PHI is 14 days (for Ziram 76 DF on 24-C label until June 1, 2009)
- Fair control of both phases of disease

Azoxystrobin (Abound)
- REI is 4 hours
- Label PHI is 0 days
- Number of sprays limited to two consecutive and four total
- Systemic
- Poor control of shoot strikes, moderate control of fruit infection in research trials
- Control efficacy better in southern states than Michigan – related to temperature?

Fenhexamid and captan (Captevate)
- REI is 72 hours
- Label PHI is 0 days
- Two different chemistries – broader disease spectrum of control
- Locally systemic + protectant
- Number of sprays limited to two consecutive
- Fair control in research trials
- Fairly expensive

Pyraclostrobin + boscalid (Pristine)
- REI is 12 hours
- Label PHI is 0 days
- Two different chemistries – broader disease spectrum of control
- Number of sprays limited to two consecutive and four total
- Systemic
- Fair to good control in research trials
- More expensive than Cabrio or Abound

Calcium polysulfides (Lime Sulfur, Sulforix)
- REI is 4 hours
- Label PHI is 0 days

- Protectant/Eradicant fungicides
- Good control of shoot strikes under low disease pressure, poor to fair under high disease pressure as dormant or seasonal spray.

Bacillus subtilis (Serenade)

- REI is 4 hours
- Label PHI is 0 days
- Protectant fungicide
- Fair to good control of shoot strike, fair control of fruit infection
- Efficacy improved when sprayed within 24 hours of frost

Other pest management aids:

- Cultivating in and between the row to bury the mummies
- Remove wild blueberries in areas adjacent to commercial fields
- Mulching with 2" thick layer of mulch
- Burning off apothecia with urea application
- Plant resistant or less susceptible variety
- Spray after freeze to reduce shoot strikes
- Dormant sprays

Pipeline pest management tools:

- Quash (V10116)
- Biocontrol agents (e.g., Actinovate)

"To do" list for Mummy Berry:

Research needs:

- Disease prediction model
- Fungicide mode of action and efficacy
- Varietal resistance
- Biocontrol
- Quantify economic losses
- Better understanding of biology and spray timing

Regulatory needs:

- Topsin registration
- Need other mode of action

Education needs:

- Educate growers on disease prediction models and biocontrols
- Utility of scouting

2. Anthracnose (Colletotrichum acutatum)

- Most important fruit rot in Michigan.
- Especially common in overripe berries.
- A problem every year.
- Don't see problem until fruit ripens.
- Contributor to high microbial load in processed fruit
- Early-season control important as well as late-season control.
- Zero tolerance in berries for processing or fresh market
- Causes blossom blight, cankers on younger canes, twig blight

<u>B2 carcinogenic fungicides currently registered:</u>

Chlorothalonil (Bravo, Echo, Chlorothalonil) used widely

- REI is 48 hours
- Do not apply after full bloom or PHI of 42 days
- Good control
- Broad spectrum
- Long PHI limits use of product
- Phytotoxicity limits use to prebloom period
- Not effective standalone material
- Also provides mummy berry shoot strike suppression

<u>Other fungicides currently registered:</u>

Captan (Captan 50WP, Captan 80WP, Captan 80 WDG, Captec 4L)

- Captan taken off B2 carcinogen list
- REI is 3 or 4 days
- Label PHI is zero days
- Good control
- Usually used in combination with Topsin M for better control
- Broad spectrum

Fosetyl-Al (Aliette WDG)

- REI is 12 hours
- Label PHI is 0 days
- Good control
- Very expensive, limits economic utility
- Not material of choice
- Not widely used, works well with aerial because it is systemic

Ziram (Ziram 76 DF, Ziram Granuflo)

- REI is 48 hours
- Label PHI is 14 days (for Ziram 76 DF on 24-C label until June 1, 2009)
- Fair to good control
- Usually used with Topsin M to increase effectiveness, but Topsin M has no label
- Used in resistance management

Azoxystrobin (Abound)

- REI is 4 hours

- Label PHI is 0 days
- Number of sprays limited to two consecutive and four total
- Locally systemic
- Excellent control in research trials
- More expensive
- Risk of resistance

Pyraclostrobin (Cabrio)

- REI is 24 hours
- Label PHI is 0 days, available at harvest
- Number of sprays limited to two consecutive and four total
- Locally systemic
- Excellent control

Pyraclostrobin + boscalid (Pristine)

- REI is 12 hours
- Label PHI is 0 days
- Two different chemistries – broader disease spectrum of control
- Number of sprays limited to two consecutive and three total
- Systemic
- Excellent control
- More expensive than Cabrio or Abound

Cyprodinil + fludioxonil (Switch)

- REI is 12 hours
- Label PHI is 0 days
- Two different chemistries – broader disease spectrum of control
- Systemic and protectant
- Good to excellent control
- Also controls other fruit rots
- Would be used more if aerial application allowed
- Good for at harvest strobilurin replacement for resistance

Fenhexamid and captan (Captevate)

- REI is 72 hours
- Label PHI is 0 days
- Two different chemistries – broader disease spectrum of control
- Locally systemic + protectant
- Number of sprays limited to two consecutive sprays
- Expensive
- Fair to good against anthracnose because of captan component

Potassium phosphite (ProPhyt)

- REI is 4 hours
- Label PHI is 0 days

- Fair control, though not enough tests done
- Highly systemic
- Labeled for Phytophthora root rot, Alternaria fruit rot, Septoria leaf spot, anthracnose
- Relatively inexpensive

Fenbuconazole (Indar 75WSP, Indar 2F)

- REI is 12 hours
- Label PHI is 30 day
- Indar has anthracnose on the label but in research trials was ineffective or increased anthracnose fruit rot

Other pest management aids:
Note: Not stand alone

- Detailed/specific pruning to remove diseased twigs and increase air circulation
- Regular pruning
- Timely harvesting
- Properly timed overhead irrigation to avoid excessive foliar wetting
- Postharvest cooling
- Ground cover management to reduce humidity
- Resistant or less susceptible varieties
- Dormant sprays (copper and sulfur and lime sulfur, Sulforix)

Pipeline pest management tools:

- Quash (metconazole – V10116) Valent
- Possible organic options: Compost tea, biocontrol products, etc.

"To do" list for Anthracnose:
Research needs:

- Disease forecast model
- Test phosphites for efficacy
- Basic biology needed
- Sulforix testing (as dormant spray)

Regulatory needs:

- Zero day PHI is critical – don't take away, continue aerial applications

Education needs:

- Use of forecasting models
- Disease lifecycle for control
- Fungicide timing

3. Alternaria Fruit Rot (*Alternaria spp.*)

- Common fruit rot, mostly late harvest.
- Bluecrop and blueray more susceptible to preharvest rot.
- If anthracnose is controlled, this becomes a major fruit rot.

- Most infections occur later in the season.
- Injury to the fruit or wax layer by JB or birds is thought to predispose fruit to infection.
- Timely harvests can reduce the amount of soft rot.
- It's difficult to apply fungicides by ground equipment at the appropriate time.
- Aerial necessary, ground equipment destroys crop (add to all harvest pesticides)

<u>B2 carcinogenic fungicides currently registered:</u>
None

<u>Other fungicides currently registered:</u>
Captan (Captan 50WP, Captan 80WP, Captan 80 WDG, Captec 4L)

- Captan taken off B2 carcinogen list
- REI is 4 days
- Label PHI is 0 days
- Fair control
- Usually used in combination with Topsin M for better control, but Topsin M is not yet registered for blueberries and did not get a Section 18 label in 2008

Fosetyl-Al (Aliette WDG)

- REI is 12 hours
- Label PHI is 0 days
- Good control
- Very expensive, limits economic utility

Ziram (Ziram 76 DF, Ziram Granuflo)

- REI is 48 hours
- Label PHI is 14 days, PHI limits use
- Fair to good control
- Usually used with Topsin M to increase effectiveness, but Topsin M is not yet registered for blueberries and did not get a Section 18 label in 2008

Azoxystrobin (Abound)

- REI is 4 hours
- Label PHI is 0 days
- Number of sprays limited to two consecutive and four total
- Locally systemic
- Poor to fair control in research trials (probably due to anthracnose control)
- More research needed

Pyraclostrobin (Cabrio)

- REI is 24 hours
- Label PHI is 0 days
- Number of sprays limited to two consecutive and four total
- Locally systemic
- Poor to fair control in research trials (probably due to anthracnose control)

- More research needed

Pyraclostrobin + boscalid (Pristine)
- REI is 12 hours
- Label PHI is 0 days
- Two different chemistries – broader disease spectrum of control
- Number of sprays limited to two consecutive and four total
- Systemic
- Fair to good control in research trials
- More expensive than Cabrio or Abound

Cyprodinil + Fludioxonil (Switch)
- REI is 12 hours
- Label PHI is 0 days
- Two different chemistries – broader disease spectrum of control
- Systemic and protectant
- Good to excellent control
- Also controls other fruit rots
- Used at harvest, 0 PHI is critical – works well
- Aerial needed
- Multiple harvests requires spray applications between harvests (multiple harvests need low PHI)

Potassium phosphite (ProPhyt)
- REI is 4 hours
- Label PHI is 0 days
- Moderate control
- Highly systemic
- Labeled for Phytophthora root rot, Alternaria fruit rot, Septoria leaf spot, anthracnose
- Relatively inexpensive
- More research needed

Other pest management aids:
Note: Not stand alone
- Remove dead canes to reduce spore supply
- Harvest frequently to prevent overripe fruit
- Cool berries rapidly after harvest
- Avoid wounding or bruising fruit during harvest
- Sanitation of harvest and processing equipment
- Surface disinfectants for harvesting and processing equipment

<u>Pipeline pest management tools:</u>
None

<u>“To do” list for Alternaria:</u>

Research needs:

- Disease modeling prediction
- Biology and timing
- Role of pesticides/fruit injury in infection
- Varietal resistance
- Investigate chemigation (chemigation not widely used in MI blueberry)
- Quantify economic losses

Regulatory needs:

- Aerial application

Education needs:

- Educate growers on modeling, biology and varietal resistance

4. Botrytis Fruit Rot and Blossom blight (*Botrytis cinerea*)

- Mainly a postharvest fruit rot
- Sometimes blossom blight

<u>B2 carcinogenic fungicides currently registered:</u>
Iprodione (Rovral)

- REI is 24 hours
- Label PHI is 0 days
- Good to excellent control if no resistant strains present
- Extremely expensive

<u>Other fungicides currently registered:</u>
Captan (Captan 50WP, Captan 80 WDG, Captec 4L)

- REI is 4 days
- Captan Label PHI is 0 days
- Moderate control

Fenhexamid (Elevate)

- REI is 12 hours
- Label PHI is 0 days
- Locally systemic
- Good control in research trials
- Fairly expensive

Cyprodinil + fludioxonil (Switch)

- REI is 12 hours
- Label PHI is 0 days
- Systemic + protectant
- Excellent control in research trials
- Also controls Alternaria and anthracnose fruit rot

Pyraclostrobin + boscalid (Pristine)

- REI is 12 hours
- Label PHI is 0 days
- Maximum number of sprays: 2 consecutive and 4 total
- Systemic + protectant
- Good control in research trials
- Excellent control in research trials
- Also controls Alternaria and anthracnose fruit rot

Ziram (Ziram 76 DF, Ziram Granuflo)

- REI is 48 hours
- Label PHI is 14 days
- Protectant
- Moderate efficacy against Botrytis
- Broad spectrum disease control

Sodium tetraborohydrate decahydrate (Prev-Am)

- REI is 12 hours
- Label PHI is 0 days
- Protectant/Contact fungicide
- Efficacy unknown, more research needed
- Also used as a surfactant, may need defoamer in tank
- Relatively inexpensive

Bacillus subtilis (Serenade)

- REI is 4 hours
- Label PHI is 0 days
- Protectant fungicide
- Even though Botrytis is on the label, efficacy is unknown in blueberries
- More research needed

<u>Other pest management aids:</u>

- Pruning to open up canopy and reduce humidity
- Provide frost protection (low temperature damage predisposes tissue to infection)

<u>Pipeline pest management tools:</u>

- V10135

<u>"To do" list for Botrytis Fruit Rot:</u>
Research needs:

- Interaction with other fruit rots
- Diagnostic tool for rapid response
- Biology and infection conditions

Regulatory needs:

Education needs:
- Infection indicator chart from Maine

5. Phomopsis Twig Blight and Canker (*Phomopsis vaccinii*)
- Common in Michigan blueberry plantings.
- Twig blight and canker are current year's infection, but cane may not die until the next year.
- Twig blights kill the current year's fruiting lateral and attached fruit, resulting in current season yield losses.
- Cankers cause perennial yield losses due to latent infections overwintering and killing canes 24 years later.
- Control difficult because obvious symptoms appear after damage already done.
- Fungus spread by splashing rain .
- Fungus active throughout most of season, making spray timing difficult.
- Wounding by frost and mechanical harvesting seems to predispose plants to Phomopsis
- Topsin M was fungicide of choice, but Section 18 was not granted in 2008

<u>B2 carcinogenic fungicides currently registered:</u>
Chlorothalonil (Bravo, Echo, Chlorothalonil) used widely
- REI is 48 hours
- Do not apply after full bloom or PHI of 42 days
- Good control though not specifically labeled for Phomopsis
- Long PHI limits use of product
- Phytotoxicity limits use to prebloom period

<u>Other fungicides currently registered:</u>
Fenbuconazole (Indar 75WSP, Indar 2F)
- REI is 12 hours
- Label PHI is 30 day
- Good control when applied on mummy berry schedule but 30-day PHI limiting
- Application after harvest is allowed for late-season control

Propiconazole (Orbit, Propimax):
- Registration in 2008
- REI is 24 hours
- Label PHI is 30 day
- Systemic
- Not used yet by growers, but field trials showed good control of Phomopsis with Orbit

Ziram (Ziram 76 DF, Ziram Granuflo)
- REI is 48 hours
- Label PHI is 14 days (for Ziram 76 DF on 24-C label until June 1, 2009)

- Good control of Phomopsis at 4 lb rate

Azoxystrobin (Abound)
- REI is 4 hours
- Label PHI is 0 days
- Number of sprays limited to two consecutive and four total
- Systemic
- Fair control

Pyraclostrobin (Cabrio)
- REI is 24 hours
- Label PHI is 0 days
- Number of sprays limited to two consecutive and four total
- Locally systemic
- Good control of Phomopsis twig blight

Pyraclostrobin + boscalid (Pristine)
- REI is 12 hours
- Label PHI is 0 days
- Two different chemistries – broader disease spectrum of control
- Number of sprays limited to two consecutive and four total
- Systemic
- Good control of Phomopsis twig blight
- More expensive than Cabrio or Abound

Calcium polysulfides (Lime Sulfur, Sulforix)
- REI is 4 hours
- Label PHI is 0 days
- Protectant/Eradicant fungicides
- Fair control when applied as dormant sprays – eradication of overwintering inoculum

<u>Other pest management aids:</u>
- Selective pruning of diseased canes and destroy prunings
- Avoid wounding/freeze or winter damage
- Plant resistant or less susceptible variety
- Optimal plant nutrition
- Quality planting material

<u>Pipeline pest management tools:</u>
- No specific materials targeted at Phomopsis

<u>"To do" list for Phomopsis Twig Blight and Canker:</u>
Research needs:
- More research on biology of the disease

- Predictive model to guide spray timing
- Varietal resistance
- New materials
- Efficacy of fall sprays
- Quantify economic loss values

Regulatory needs:

Education needs:
- Educate growers on biology and predictive modeling
- Nursery education

6. Fusicoccum Canker (*Fusicoccum putrefaciens*)
- This disease is more common in northern areas of Michigan (e.g., north of Grand Haven).
- This disease is a limiting factor to production of blueberries in cold climates, e.g., the Upper Peninsula of Michigan
- Symptoms similar to Phomopsis canker.
- Fungus spread by splashing rain.
- Benomyl and Captan were long considered standard fungicides for control, but Benlate was withdrawn from the market
- No new fungicide trials have been conducted since.

<u>B2 carcinogenic fungicides currently registered:</u>
None

<u>Other fungicides currently registered:</u>
No fungicides are specifically registered for control of Fusicoccum canker, although Captan, Pristine, and Ziram are expected to work due to the fact that they are broad-spectrum materials

<u>Other pest management aids:</u>
- Prune out cankered branches and destroy

<u>Pipeline pest management tools:</u>
- Pristine
- Cabrio
- ProPhyt

<u>"To do" list for Fusicoccum canker:</u>
Research needs:
- Identify efficacious fungicides and application timing
- Add Fusicoccum to labels of available fungicides
- Evaluate alternatives for Fusicoccum control

Regulatory needs:

- Add Fusicoccum to labels of available fungicides based on efficacy testing

Education needs:
- Diagnosis and biology of Fusicoccum canker

7. Phytophthora Root Rot (*Phytophthora cinnamomi*)
- Not common in Michigan.
- Could be a problem on heavier soils and poorly drained areas and in years with heavy precipitation

<u>B2 carcinogenic fungicides currently registered:</u>
None

<u>Other fungicides currently registered:</u>
Mefenoxam (Ridomil Gold EC)
- REI is 48 hours
- Label PHI is 0 days
- Systemic
- Excellent control
- Will not revitalize plants showing moderate to severe root rot symptoms

FosetylAl (Aliette WDG)
- REI is 12 hours
- Label PHI is 0 days
- Highly systemic
- Good to excellent control
- Expensive

Potassium and other phosphites (ProPhyt, Phostrol)
- REI is 4 hours
- Label PHI is 0 days
- Expected to have excellent control based on trials conducted in Georgia but no efficacy trials have been done in Michigan due to lack of the disease
- Highly systemic
- Relatively inexpensive

<u>Other pest management aids:</u>
- Site selection and good drainage
- Raised beds

<u>Pipeline pest management tools:</u>
None

<u>"To do" list for Phytophthora Root Rot:</u>
Research needs:

- Correct diagnosis for symptomatic fields

Regulatory needs:

Education needs:

8. Powdery mildew (*Microsphaera vaccinii*)

- Common, but not considered very harmful – Jersey is particularly susceptible
- Symptoms usually show up in early summer, may resemble virus symptoms
- Sulfur which is used in other crops for control of powdery mildew is phytotoxic on blueberries
- Since most of powdery mildew seems on lower leaf surface, systemic products may work better unless coverage is excellent.

<u>B2 carcinogenic fungicides currently registered:</u>
None

<u>Other fungicides currently registered:</u>
Paraffinic oil (JMS Stylet Oil)

- REI is 4 hours
- PHI is 0 days
- May affect wax on berries
- Poor to fair efficacy as preventative, but may work better as eradicant
- More trials needed

Potassium bicarbonate (Armicarb, Kaligreen)

- REI is 4 hours
- PHI is 0 days
- Poor to fair efficacy as preventative, but may work better as eradicant
- More trials needed

Fenbuconazole (Indar 75WSP, Indar 2F)

- REI is 12 hours
- Label PHI is 30 day
- Needs tank mix with protectant at bloom
- Expected to be effective against powdery mildews, but no data from Michigan

Propiconazole (Orbit, Propimax):

- Registration in 2008
- REI is 24 hours
- Label PHI is 30 day
- Systemic
- Trial done in Michigan showed good efficacy against powdery mildew in blueberries

Azoxystrobin (Abound)

- REI is 4 hours
- Label PHI is 0 days
- Number of sprays limited to two consecutive and four total
- Locally systemic
- Trial done in Michigan showed only fair efficacy against powdery mildew in blueberries

Pyraclostrobin (Cabrio)

- REI is 24 hours
- Label PHI is 0 days
- Number of sprays limited to two consecutive and four total
- Locally systemic
- Expected to provide good control, but no trials done in Michigan

Pyraclostrobin + boscalid (Pristine)

- REI is 12 hours
- Label PHI is 0 days
- Two different chemistries – broader disease spectrum of control
- Number of sprays limited to two consecutive and four total
- Systemic
- Expected to provide good control, but no trials done in Michigan

Sodium tetraborohydrate decahydrate (Prev-Am)

- REI is 12 hours
- Label PHI is 0 days
- Protectant/contact fungicide
- Efficacy against powdery mildew is unknown, research needed
- Also used as a surfactant, may need defoamer in tank
- Relatively inexpensive

Other pest management aids:

- Reduce humidity in canopy

Pipeline pest management tools:

- V10116 or other triazoles

"To do" list for powdery mildew:
Research needs:

Regulatory needs:

Education needs:

9. Leaf rust (*Naohidemyces vaccinii*)

- Not common in Michigan.
- A problem near hemlock trees.

B2 carcinogenic fungicides currently registered:
None

Other fungicides currently registered:
Fenbuconazole (Indar 75WSP, Indar 2F)

- REI is 12 hours
- Label PHI is 30 day
- Needs tank mix with protectant at bloom
- Expected to be effective against rust, but no data from Michigan

Propiconazole (Orbit, Propimax):

- Registration in 2008
- REI is 24 hours
- Label PHI is 30 day
- Systemic
- Expected to be effective against rust, but no data from Michigan

Azoxystrobin (Abound)

- REI is 4 hours
- Label PHI is 0 days
- Number of sprays limited to two consecutive and four total
- Locally systemic
- Expected to be effective against rust, but no data from Michigan

Pyraclostrobin (Cabrio)

- REI is 24 hours
- Label PHI is 0 days
- Number of sprays limited to two consecutive and four total
- Locally systemic
- Expected to be effective against rust, but no data from Michigan

Pyraclostrobin + boscalid (Pristine)

- REI is 12 hours
- Label PHI is 0 days
- Two different chemistries – broader disease spectrum of control
- Number of sprays limited to two consecutive and four total
- Systemic
- Expected to be effective against rust, but no data from Michigan

Other pest management aids:

- Reduce humidity in canopy
- Remove alternate host (hemlock) within 1/4 mile of blueberry planting
- Plant resistant or less susceptible variety

Pipeline pest management tools:
None

"To do" list for Leaf rust:
Research needs:

Regulatory needs:

Education needs:

- Diagnosis/recognition of the disease

10. Witches' broom (*Pucciniastrum goeppertianum*)

- Rare in Michigan.
- Disease becomes systemic in the plant.
- More of a problem in lowbush blueberries

B2 carcinogenic fungicides currently registered:
None

Other fungicides currently registered:
No fungicides have been tested specifically for Witches' broom, but sterol inhibitors (Indar, Orbit) and strobilurins (Pristine, Abound, Cabrio) are expected to be effective based on their known efficacy against rusts in other crops.

Other pest management aids:

- Rogue out infected plants
- Eradicate alternate host (fir trees) within 500 m of planting

Pipeline pest management tools:
None

"To do" list for Witches' broom:
Research needs:

Regulatory needs:

Education needs:

11. Red leaf disease (*Exobasidium vaccinii*)

- Occurs occasionally in Michigan.
- Disease becomes systemic in the plant.

B2 carcinogenic fungicides currently registered:

None

Other fungicides currently registered:
None

Other pest management aids:
- Rogue out and destroy infected plants

Pipeline pest management tools:
None

"To do" list for Red leaf disease:
Research needs:

Regulatory needs:

Education needs:
- Diagnosis/recognition

12. Virus/MLO Diseases
- Blueberries in Michigan are affected by at least seven different diseases caused by viruses and phytoplasmas

The main virus and virus-like diseases in this group are:
A. Blueberry Shoestring
- Most widespread virus disease of highbush blueberry.
- Aphid vectored.
- Documented yield reductions of 25 percent.
- Very limited resistance among cultivars currently planted.
- Virus is present in wild clones.
- Roguing of bushes is not a recommended practice because of the long latent period before symptoms develop.
- Well-timed applications of effective aphicides are the principal control strategy.
- Virus tested planting stock should be planted as preventive measure.

B. Blueberry Stunt
- Caused by blueberry stunt phytoplasma
- Vectored by the sharpnosed leafhopper.
- Causes stunting of vegetative and reproductive development and yield reductions of 75%.
- All cultivars of highbush blueberry are susceptible.
- Controls include planting clean stock, rouging of infected plants, and insecticide sprays.

C. Necrotic Ring Spot
- Caused by tobacco ring spot virus, spread by dagger nematode and infected plant material or wild hosts

- Common disease, widespread, variety susceptibility differs
- Methyl bromide being phased out, need new products

D. Tomato Ring Spot

- Caused by tomato ring spot virus, spread by dagger nematode and infected plant material or wild hosts
- Common disease, widespread, variety susceptibility differs
- Methyl bromide being phased out, need new products

<u>"To do" list for Virus/MLO diseases:</u>
Research needs:

- More research is needed on development of rapid diagnostic tests (e.g., PCR for blueberry stunt phytoplasma) and unknown virus diseases.

Education:

- Quarantine education is needed for growers on shock and scorch and sheep pen hill (NJ strain of scorch).
- Education is generally needed on recognition/diagnosis of symptoms

WEEDS

First Year and Established Plantings

Annual/perennial grasses and broadleaf weeds:

Herbicides currently registered:
FluazifopP (Fusilade DX 2E)

- REI is 12 hours
- PHI is one year
- Little use due to PHI
- Expensive for grass control only
- Control depends on the stage of grass growth
- No residual activity
- Nursery use for propagation plants

Glyphosate (Roundup and other generic designations)

- REI is 4 hours
- Label PHI is 14 days
- Crop safety limits use
- Very effective and popular due to broad spectrum of control
- Improved shields are available now for in-row applications
- Longterm impact of injury to young canes
- Important to the industry

Oryzalin (Surflan 4 AS)

- REI is 24 hours
- No post emergent activity
- Requires rain or irrigation to incorporate
- Effective on annual grasses, weak on broadleaves

Isoxabin (Gallery 75 DF)

- REI is 12 hours
- Preemergent activity on broadleaf weeds only
- Nonbearing plants

Sethoxydim (Poast 1.5 E)

- REI is 12 hours
- Label PHI is 30 days
- Expensive for grass control only
- No residual activity
- Control depends on the stage of grass growth
- Nursery use for propagation plants
- Two applications often required for perennial grasses

Sulfosate (Touchdown 4 L)

- REI is 12 hours
- Label PHI is 14 days
- Variable control, inconsistent activity
- Crop safety limits use

Select (clethodim)

- For post emergent grasses

Other pest management aids:
Cultivation and hand weeding are important in new plantings

Mulching with bark, sawdust or other organic materials is effective on some weeds but expensive

Established One Year or More

Annual/perennial grasses and broadleaf weeds:

Herbicides currently registered:
Carfentrazone (Aim 1.9 EW)

- REI 12 hours
- 0 day PHI
- Burndown of small broadleaf weeds, no residual activity
- injures young canes and leaves of blueberry

Dichlobenil (Casoron 4G, Casoron CS)

- REI is 12 and 24 hours
- Expensive
- Granular formulation is difficult to apply accurately.
- Liquid Casoron CS just labeled, may increase use
- Used for spot treatment of difficult weeds
- Requires incorporation with water
- Good for control of some perennial weeds
- Not as effective in fluctuating water tables (experience in cranberry)

Diuron (Karmex 80 DF)

- REI is 12 hours
- Very important, widely used material
- Good crop safety
- Broad range of species controlled
- Some resistant weeds (marestail, smartweed)
- important to the industry

Flumioxazin (Chateau)

- New supplemental label on blueberry, limited information
- postemergent and preemergent activity
- only on bushes at least 2 years-old
- Use limited by Label restricted to before bud break
- Issue with dust from mowing
- Appears to provide long residual control of many annual broadleaf weeds
- New mode of action for blueberries; helpful in resistance management.

Glufosinate (Rely 1 L)

- Label PHI 14 days
- Good burndown of annuals, no residual action
- Good for roundup resistance weeds (especially marestail)
- Expense limits use

Hexazinone (Velpar 2L)

- REI is 24 hours
- Label PHI is 90 days (makes it tough to use)
- Crop safety has limited its use
- Need ability for fall application, label requires use before bud break
- Resistance and groundwater issues
- Very effective for dewberry, blackberry control

Mesotrione (Callisto)

- New supplemental label on blueberry, limited information (broadleaf not grasses)
- Can be used on bearing and nonbearing bushes
- Apply before bloom
- Different mode of action; may help in resistance management

Napropamide (Devrinol 50 DF)

- REI is 12 hours
- Weaker preemergent herbicide
- Requires incorporation with water
- Narrow weed spectrum, primarily grasses
- Most commonly used on young planting (Crop safely)

Norflurazon (Solicam 80 DF)

- REI is 12 hours
- Label PHI is 60 days
- Effective broad spectrum preemergent material
- Would be used more if PHI was shorter
- Different mode of action than other standard herbicides
- Common mix partner with broadleaf preemergents
- Becoming more popular
- Some crop safety concerns with repeated applications

Paraquat (Gramoxone Extra 2.5L)

- REI is 12 hours
- Not stand alone material
- Good burn down of annuals
- No control of perennials
- Restricted Use Pesticide
- Commonly used
- Good alternate for roundup for preharvest burndown

Pronamide (Kerb 50 W)

- REI is 24 hours
- Seldom used
- Fall grass herbicide
- Expensive
- Restricted Use Pesticide

Simazine (Princep 90 WG)

- REI is 12 hours
- Do not apply when fruit is present
- Effective preemergent herbicide, controls a broad spectrum of weeds
- Inexpensive
- Fairly high crop safety
- Ground water quality and resistant weeds (marestail, smartweed)
- Along with diuron the most commonly used herbicides in blueberries
- Important to the industry

Terbacil (Sinbar 80 W)

- REI is 12 hours
- Widely used broad spectrum product, strong on grasses
- Crop safety an issue
- Ground water quality and resistance issues
- Usually applied in combination with simazine or diuron
- Important to the industry

<u>Other pest management aids:</u>
Hand weeding is not practical on a commercial scale except for some vines and woody weeds

Cultivation/mechanical hoeing can be effective but is time consuming and may damage bushes

Mulching is effective im suppressing some but not all weeds, and costs of materials and application limit use.

Mowing of row middles

Chemical mowing of row middles

Pipeline pest management tools:

Spartan
- Controls perennial sedges which is a problem weed

Dual Magnum
- Controls perennial sedges which is a problem weed

Clopyralid (Stinger)
- Pre- and post-emergent control of some difficult perennials (goldenrod, wild bean)

Matrix
- ALS inhibitor, no other ALS inhibitors registered for blueberry
- used at very low rates
- good pre-emergence herbicide
- nice addition to the blueberry herbicide arsenal to avoid weed resistance.

Select (for bearing bushes)

Sandea

<u>"To do" list for weeds:</u>

Research needs:
- Identify cost effective alternatives to simazine, diuron and terbacil
- Identify effective controls for woody perennials and yellow nutsedge
- Identify season long weed control methods
- Determine the distribution of triazine resistant weeds
- Develop preplant practices that minimize weed competition during first years.
- Determine efficacy of fall applied Velpar
- Determine efficacy of Matrix FNV

Regulatory needs:
- Shorter PHI for Solicam
- Shorter PHI for Poast and Fusilade
- Shorter PHI for Velpar (60 days)
- Registration of pipeline products
- Increase Matrix FNV label to include blueberry

Education needs:
- Field demonstrations of new products on different soil and bush ages
- Testing for glyphosate and triazine resistant weeds
- Training program for proper herbicide application

NEMATODES

1. Dagger Nematodes (*Xiphinema americanum* and *X. rivesi*)

- Ectoparasitic pathogen resulting in stunted plants, poor root growth and low yields.
- Virus vector of TRSV, ToRSV, PRMV and BRSV.
- Major pest of cutting wood plants, nursery stock and bearing plantings.

Halogenated hydrocarbon nematicides (soil fumigants) currently registered:
Methyl bromide – *being phased out*

- Excellent control of dagger nematodes (also weed and fungus and insect control)
- Expensive
- Used only for nursery and cutting wood stock plantings
- Difficult to apply, tarp required
- Usually applied by commercial custom applicator
- Only fumigant nematicide formulated as a gas
- Preplant application only
- Applicator health risks
- Ozone depletion in the stratosphere
- To be phased out according to the Montreal Protocol

Telone II

- Good control of dagger nematodes
- Not labeled for weed or fungus control
- Soil fumigation equipment required for application
- Liquid formulation
- Preplant application only
- Alternative for methyl bromide in nursery and cutting wood stock plantings

Carbamate nematicides currently registered:
Metham (Vapam)

- Good control of dagger nematodes
- Weed and fungus control available at high dosage
- Multiple product manufacturers
- Multiple application methods (chemigation procedures or ground driven equipment)
- Preplant application only
- Alternative for methyl bromide in nursery and cutting wood stock plantings

Organophosphate nematicides currently registered:
Nemacur

- No longer commercially available

Other nematicides currently registered:
None

Other pest management strategies, tactics and procedures:
Production of nematode-vectored virus-free nursery stock

Ground cover management
- Designed to reduce population densities of dagger nematodes

Soil quality building
- Designed to reduce population densities of dagger nematodes

Essex rape (cover crop)

Pipeline products:
- oxamyl (Vydate), field residues trials initiated in 2008, post plant – both soil and foliar?

2. Stubbyroot Nematodes (*Trichodorus christiei, Trichodorus. spp.* and *Paratrichodorus spp.*)
- Ectoparasitic pathogen resulting in stunted plants, severely deformed root systems and low yields.
- Potential virus vector of tobraviruses.
- Major pest of cutting wood plants, nursery stock and bearing plantings.
- Problem in MI unknown
- Same changes as dagger nematode

Halogenated hydrocarbon nematicides (soil fumigants) currently registered:
Methyl bromide – *being phased out*
- Excellent stubbyroot nematode control (also weed and fungus control)
- Expensive
- Used only for nursery and cutting wood stock plantings
- Difficult to apply, tarp required
- Usually applied by commercial custom applicator
- Only fumigant nematicide formulated as a gas
- Preplant application only
- Applicator health risks
- Ozone depletion in the stratosphere
- To be phasedout according to the Montreal Protocol

Telone II
- Good stubbyroot nematode control
- No weed or fungus control
- Soil fumigation equipment required for application
- Liquid formulation
- Preplant application only
- Alternative for methyl bromide in nursery and cutting wood stock plantings
- Not widely used for blueberry plantings in Michigan

Carbamate nematicides currently registered:
Metham

- Good stubbyroot nematode control
- Weed and fungus control available at high dosage
- Multiple product manufacturers
- Multiple application methods (chemigation procedures or ground driven equipment)
- Preplant application only
- Alternative for methyl bromide in nursery and cutting wood stock plantings
- Not used for blueberry plantings in Michigan

Organophosphate nematicides currently registered:
Nemacur

- Liquid formulation
- Only postplant blueberry nematicide (only used on cutting wood and nursery plantings)
- Efficacy less for stubbyroot nematodes than with broad-spectrum soil fumigants
- Efficacy only fair for stubbyroot nematodes
- Used only under the MI 24(c)) nursery crop registration

Other nematicides currently registered:
None

Other pest management strategies, tactics and procedures:
Production of nematode-free nursery stock

Ground cover management

- Designed to reduce population densities of stubbyroot nematodes

Soil quality building

- Designed to reduce population densities of stubbyroot nematodes

3. Sheath Nematodes (*Hemicycliophora similis* and *Hemicycliophora spp.*)

- Ectoparasitic pathogen resulting in stunted plants, swollen root tips and low yields.
- Sporadic pest of cutting wood plants, nursery stock and bearing plantings.
- Same changes as dagger

Halogenated hydrocarbon nematicides (soil fumigants) currently registered:
Methyl bromide – *being phased out*

- Excellent sheath nematode control (also weed and fungus control)
- Expensive
- Used only for nursery and cutting wood stock plantings
- Difficult to apply. Tarp required.
- Usually applied by commercial custom applicator
- Only fumigant nematicide formulated as a gas
- Preplant application only
- Applicator health risks
- Ozone depletion in the stratosphere

- To be phased out according to the Montreal Protocol

Telone II
- Good sheath nematode control
- No weed or fungus control
- Soil fumigation equipment required for application
- Liquid formulation
- Preplant application only
- Alternative for methyl bromide in nursery and cutting wood stock plantings
- Not widely used for blueberry plantings in Michigan

Carbamate nematicides currently registered:
Metham
- Good sheath nematode control
- Weed and fungus control available at high dosage
- Multiple product manufacturers
- Multiple application methods (chemigation procedures or ground driven equipment)
- Preplant application only
- Alternative for methyl bromide in nursery and cutting wood stock plantings
- Not used for blueberry plantings in Michigan

Organophosphate nematicides currently registered:
Nemacur
- Liquid formulation
- Only postplant blueberry nematicide (only used on cutting wood and nursery plantings)
- Efficacy less for sheath nematodes than with broad spectrum soil fumigants
- Efficacy only fair for sheath nematodes
- Used only under the MI 24(c)) nursery crop registration

Other nematicides currently registered:
None

Other pest management strategies, tactics and procedures:
Production of nematode free nursery stock

Ground cover management
- Designed to reduce population densities of sheath nematodes

Soil quality building
- Designed to reduce population densities of sheath nematodes

4. Ring Nematodes (*Criconematoides xenoplax* and other *Criconematidae spp.*)
- Ectoparasitic pathogen resulting in stunted plants, reduced root systems and low yields.
- Sporadic pest of cutting wood plants, nursery stock and bearing plantings.
- Same changes as for dagger

Halogenated hydrocarbon nematicides (soil fumigants) currently registered:
Methyl bromide – *being phased out*

- Excellent ring nematode control (also weed and fungus control)
- Expensive
- Used only for nursery and cutting wood stock plantings
- Difficult to apply, tarp required
- Usually applied by commercial custom applicator
- Only fumigant nematicide formulated as a gas
- Preplant application only
- Applicator health risks
- Ozone depletion in the stratosphere
- To be phased out according to the Montreal Protocol

Telone II

- Good ring nematode control
- No weed or fungus control
- Soil fumigation equipment required for application
- Liquid formulation
- Preplant application only
- Alternative for methyl bromide in nursery and cutting wood stock plantings
- Not widely used for blueberry plantings in Michigan

Carbamate nematicides currently registered:
Metham

- Good ring nematode control
- Weed and fungus control available at high dosage
- Multiple product manufacturers
- Multiple application methods (chemigation procedures or ground driven equipment)
- Preplant application only
- Alternative for methyl bromide in nursery and cutting wood stock plantings
- Not used for blueberry plantings in Michigan

Organophosphate nematicides currently registered:
Nemacur

- Liquid formulation
- Only postplant blueberry nematicide (only used on cutting wood and nursery plantings)
- Efficacy less for ring nematodes than with broad spectrum soil fumigants
- Efficacy only fair for ring nematodes
- Used only under the MI 24(c)) nursery crop registration

Other nematicides currently registered:
None

Other pest management strategies, tactics and procedures:

Production of nematode free nursery stock

Ground cover management
- Designed to reduce population densities of ring nematodes

Soil quality building
- Designed to reduce population densities of ring nematodes

Other nematicides with potential for use in blueberry production systems:
Basamid
- Possibly registered for use under blueberry nursery stock production conditions
- Not widely used in Michigan on any commodity
- Efficacy has not been widely demonstrated under Michigan conditions

Oxamyl
- Has a nursery crop registration
- Needs to be checked to determine if blueberry nursery stock is included within this registration

Nematicides under development:
Methyl iodide (current registration)
- Broad spectrum soil fumigant under development as a methyl bromide alternative
- Should be excellent for use in blueberry cutting wood and nursery plantings

Harpin (Messenger)
- Novel protein nematicide under development to provide induced resistance
- Could be a new tool for use in all aspects of the blueberry system
- Avermectin (evicta)Chancellor (biological) B. firmus Ditera
- Biopesticide (killed fungus)
- Efficacy has not been good under Michigan conditions

Other nematode management strategies, tactics and procedures:
Regulatory program to assure virus and nematode-free nursery stock

Ground cover management
- Recent studies in Michigan have demonstrated that ground cover management procedures have significant impacts on population development of plant parasitic nematodes (essex rape)

Soil quality building
- Recent research at Michigan State University indicates that soil quality building procedures result in significant reductions in population densities of phytopathogenic nematodes

"To do" list for nematodes:
Research needs:
- Nematode survey of the Michigan blueberry industry (last one of previous three was conducted in 1966)Nematode survey should be conducted using GPS agriculture technology

- Study of the role of ground cover management systems in relation to nematode community structure and soil nutrient mineralization
- Investigation of the impact of soil quality on nematode community structure (bacterial and fungal feeding nematodes are major rhizosphere mineralizers of organic matter in soil nutrient cycles)
- Cooperate with new organic project
- Need nematicide for application post plant due to loss of Nemacur

Regulatory needs:

- Continuation of the excellent blueberry nursery stock virus regulatory program
- Enhance the nematode component of the current regulatory program through the use of GPS technologies
- Registration of nematicides post plant

Education needs:

- There is a need for a general nematode education program and soil biology for the Michigan blueberry industry. This should be done as an integral component of a broader blueberry educational initiative.

TABLE 1. GENERAL TIMEINE OF CROP STAGES, WORKER ACTIVITIES, AND CONTROL OF KEP PESTS.

Crop Stage	Mar		Apr		May		Jun		Jul		Aug		Sep		Oct		Nov		Dec	
Dormancy																				
Bud break																				
Early green tip																				
0.25” green																				
Early pink bud																				
Late pink bud																				
25% bloom																				
Full bloom																				
Petal fall																				
Early green fruit																				
Late green fruit																				
Fruit coloring																				
1st harvest																				
2nd harvest																				
3rd harvest																				
Late harvest																				
Postharvest																				
Workers activity	**Mar**		**Apr**		**May**		**Jun**		**Jul**		**Aug**		**Sep**		**Oct**		**Nov**		**Dec**	
Pruning																				
Dormant spray																				
Frost protection																				
IPM scouting																				
Disease control																				
Insect control																				
Weed control																				
Fertilization																				
Irrigation																				
Harvest																				

TABLE 2. EFFICACY OF PEST MANAGEMENT TOOLS FOR CONTROL OF INSECTS

Ratings of Control are **E**=excellent, **G**=good, **F**=fair, **P**=poor, **NS**=not stand alone, **?**=undetermined, more research needed, ▲= OMRI listed insecticides for organic production			Diazinon	Guthion	Imidan	Lannate	Malathion	Provado	Sevin	Superior Oil	Thiodan	Asana	B.t.'s ▲	Danitol	Spintor	Confirm	Esteem	Surround ▲	Neem compounds ▲	Pyganic ▲	Evergreen	Actara	Sulforix	Entrust ▲	GF120 Fruit Fly Bait ▲	Admire/Admire Pro	Platinum	Delegate	Mustang Max	Baited yellow sticky traps	Ground cover management	Mass Trapping	Pheromone traps	Degree day models	Post-harvest handling	Biological controls	Predators	Parasites	Entomopathogens	Bacterial agents	Entomopathogenic nematodes
Insect Pests	Blueberry Aphid	Active	G			G		E				F							G			E				E	E			NS							?	?			
	Blueberry Bud Mite	Egg/Active								G	E												G																			
	Blueberry Maggot	Adult	G	E	E	G	G	G	G			G		G	F			E	F/G			G		G	G			F	F	NS				?			?	?			
	Blueberry Tip Borer	Adult	G	E	E				G																																
	Canker Worms	Larva				E			E			G		G	G													G													
	Cherry Fruitworm	Larva/Egg	G	E	E				E			E	F/G	E	G	G	G							G				G	G				NS								
	Cranberry Fruitworm	Larva/Egg	G	E	E	G			G			E	G	E	G	G	G							G				G	G				NS	?							
	Gypsy Moth	Larva											G			G												G													
	Japanese Beetle	Adult		G	G	F	F	G	G			G		G				F	F	F	G	G				F	F				NS	NS	NS		NS		?	?	?	?	
	Japanese Beetle	Larva																								E	E				NS						?	?	?	?	
	Obliquebanded Leafroller	Larva/Egg		E	E	G						E	G	E	E	G	G							G				E	G												
	Plum Curculio	Adult	G	E	E			G	G			G		G								G						F	G												
	Redbanded Leafroller	Larva		E	E	G						E	G	E	E	E	G											E	G												
	Thrips	Active	G	G				G							G								G						G												
	Tussock Moth	Larva				E			E			E	G	E	G	E								G				G	G												

TABLE 3. EFFICACY OF PEST MANAGEMENT TOOLS FOR CONTROL OF DISEASES

Fungicide	Mummy berry		Phomopsis twig blight and canker	Fusicoccum canker	Alternaria fruit rot	Anthracnose fruit rot	Botrytis blight and fruit rot	Phytophthora root rot
	Shoot	Fruit						
Abound	+ / ++	+ / ++	++	?	++	++++	+	?
Aliette	0	0	++ / +++	?	+++	+++	?	+++
Topsin M + Captan	++	++	+++	+++				
Ziram	+/++	+/++	++++		+	+++	+++	0
Bravo	++	+	+++	+++	+	+++	++	0
Cabrio	+ / ++	+ / ++	+++	?	++	++++	+	?
Captan	+	+ / ++	++	+	+	++ / +++	+	0
Captevate	++	++	++	?	?	++	++++	0
Elevate	+	+	+	?	0	0	++++	0
Indar	+++	+++	+++ / ++++	?	+	0	?	0
Lime sulfur	?	?	++*	?	?	++	?	0
Orbit	+++	++	?	?	?	?	?	0
Phostrol	+	+	++	?	++	++	?	+++
Pristine	++	+++	+++	?	++/+++	++++	+++	?
ProPhyt	+	+	++	?	++	++	?	+++
Rovral	0	0	0	0	0	0	++++	0
Ridomil	0	0	0	0	0	0	0	++++
Serenade	++ / +++	++ / +++	+ / ++	?	?	0	?	?
Sulforix	+++	++	?	?	?	+	?	?
Switch	+	++	+ / ++	?	++++	+++	+++	?
Ziram (3 lb)	++	+	++	++	+*	++	+	0
Ziram (4 lb)	++	++	+++	++ / +++	++*	+++	++	0
Pruning			NS	NS		NS		
Timely harvest					NS	NS	NS	
Remove dead canes			NS	NS		NS		
Good drainage								NS
Raised beds								NS
Sanitation	NS	NS	NS	NS	NS	NS	NS	
Timely overhead irrigation			NS	NS	NS	NS	NS	
Ground cover management	NS	NS	NS	NS	NS	NS	NS	
Post-harvest berry cooling					NS	NS	NS	
Harvest handling					NS			

Ratings of control are:
0 = not effective,
+ = poor,
++= fair,
+++ = good,
++++ = excellent,
? = not known.

Ratings are based on published information and observations in Michigan.

* Based on data from New Jersey and Michigan. Fall and spring dormant application used.

TABLE 4. EFFICACY OF PEST MANAGEMENT TOOLS FOR CONTROL OF WEEDS
Ratings: Poor, Fair, Good, Excellent

Pest Management Tools	Annual grasses	Perennial grasses	Annual Broad-leaves	Perennial Broad-leaves	Woody Peren-nials	Nutsedge
Dichlobenil (Casoron) Preemergence	E	G	G	G	P	P
Diuron (Karmex) Preemergence	G	P	E	F	P	P
FluazifopP (Fusilade) Postemergence	E	G	P	P	P	P
Glyphosate (Roundup) Postemergence	E	E	E	E	G	F
Hexazinone (Velpar) Preemergence	G	G	G	G	FG	P
Napropamide (Devrinol) Preemergence	G	P	F	P	P	P
Norflurazon (Solicam) Preemergence	G	F	G	P	P	F
Oryzalin (Surflan) Preemergence	G	P	P	P	P	P
Paraquat (Gramoxone) postemergence	E	P	E	P	P	P
Pronamide (Kerb) Preemergence	G	G	P	P	P	P
Sethoxydim (Poast) Postemergence	E	G	P	P	P	P
Simazine (Princep) Preemergence	G	F	E	P	P	P
Sulfosate (Touchdown) Postemergence	PE	PE	PE	PE	P	P
Terbacil (Sinbar) Preemergence	G	F	G	F	P	P
Clethodim (Select) Postemergence	G	G				P
Hand weeding	FP	FP	FP	P	FP	
Cultivation	F	P	F	P	P	
Mowing (under bushes)	P	P	F	P		
Mulching	G	F	G	F	P	

TABLE 5. EFFICACY OF PEST MANAGEMENT TOOLS FOR CONTROL OF NEMATODES
Ratings: Poor, Fair, Good, Excellent
? = Undetermined, more research needed

Pest Management Tools	Dagger Nematode	Lesion Nematode	Sheath Nematode	Stubby Root Nematode	Ring Nematode
Methyl Bromide (Preplant)	E	E	E	E	E
Telone II (Preplant)	G	G	?	G	G
Metham	?	E	?	?	?
Nemacur (no longer commercially available)	F	E	?	?	F
Basamid	?	F	?	?	?
Pipeline					
Methyl Iodide	?	?	?	?	?
Harpin (Messenger)	?	?	?	?	?
Micro XX	?	?	?	?	?
Ditera	?	?	?	?	?
Alternative Management Tools					
Nematode/Virus free nursery stock	G	G	G	G	G
Ground cover management	?	?	?	?	?
Soil quality building	?	?	?	?	?

TABLE 6. TOXICITY OF PESTICIDES TO BENEFICIAL INSECTS
Update August 2008

Ratings against beneficials are T=highly toxic, M=moderately toxic, S=relatively safe		Diazinon	Guthion	Imidan	Lannate	Malathion	Provado	Sevin	Superior Oil	Thiodan	Asana	B.t.'s ▲	Danitol	Spintor	Confirm	Esteem	Surround ▲	Neem compounds ▲	Pyganic ▲	Evergreen	Actara	Sulforix	Entrust ▲	GF120 Fruit Fly Bait ▲	Admire/Admire Pro	Platinum	Delegate	Mustang Max
Beneficials	Bees	T	T	T	T	T	T	T	S	M	T	S	T	M	S	S	S	S	S	M	T	S	M	S	M	S	M	T
	Predator Mites	M	S	S	T	M	S	T	S	M	T	S	T	S	S	S	M	S	S	S	S	M	S	S	S	S	S	T
	Insect Predators	T	M	M	T	M	M	T	S	M	T	S	T	M	S	S	M	S	S	S	M	S	M	S	S	S	M	T

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