

**A PEST MANAGEMENT STRATEGIC PLAN
FOR THE MICHIGAN BLUEBERRY INDUSTRY**

June 6-7, 2001

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TOP PRIORITIES OF MICHIGAN BLUEBERRY PRODUCTION

Research:

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.

Priorities:

1) 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 (see page 30).

2) 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.

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

The following priorities are not necessarily in order of importance:

- Study the biology of causal fungi, disease cycles, and post harvest problems in the control of fruit rots.
- Pest modeling information to determine proper spray timing for anthracnose, Alternaria, cranberry fruitworm, mummy berry, Phomopsis and blueberry maggot.
- 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.
- Cover crop management and soil quality issues that impact pest complexes and plant health.
- 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.

- 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.
- Development of replacement products for persistent broad spectrum herbicides.
- Research needed on pesticide resistance even with new products and alternatives to these products.
- Need to generate more “real world” worker exposure data for pesticides.
- Assess the levels of microbial contamination on blueberry fruit and compare the efficacy of sanitizers in reducing microbial loads during blueberry processing
- Determine the interaction between the naturally occurring fructoplane microflora of blueberries, pathogen infection, and pesticide use.
- Develop efficacious treatments to replace postharvest methyl bromide fumigation of blueberry fruit.

Regulatory:

- Preharvest Intervals need to be shortened on some products and kept short on other products for at-harvest-time pests.
- New control products need to be moved through the regulatory process at a faster pace.
- Awareness of impacts of changing or lengthening the PHIs and REIs of pesticides used in blueberries.
- Maintain several classes of pesticides to maintain resistance management programs.
- Provide relief from export restrictions on blueberry fruit destined for Canada.
- 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.

Education:

- Consumer education about who, what, where, how and why blueberries are grown in Michigan including at the lower education and college level.
- As new tools and pest management techniques become available growers will need to be educated about proper use including demonstration plots.
- Increased funding for educational efforts at the state and federal levels.
- 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.
- A pocket size scouting guide for blueberries should be developed.

BACKGROUND

Michigan is ranked first nationally in cultivated blueberry production. Michigan's output of cultivated blueberries was 62 million pounds, 40 percent of the U.S. total in 2000. Sixty-nine percent of Michigan's blueberries were frozen or canned. In 2000, there were 16,700 bearing acres of blueberries producing 3,710 pounds per acre. The five-year (1996-2000) average production was 3,566 pounds per acre. The average price per pound received in 2000 was \$0.89 with a value of production at \$55,140,000. There were 19 million pounds of fresh market blueberries receiving \$1.25 per pound, and 43 million pounds of processed blueberries receiving \$0.73 per pound. Major blueberry producing counties in Michigan include Van Buren and Allegan 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 followed by Bluecrop and Elliott.

The highbush blueberry plant grown in Michigan is a perennial, consisting of 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. Sixty-eight percent of Michigan blueberries are irrigated. Overhead irrigation is also important to mediate spring frosts. Spring frosts are probably the 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.

Insects

The primary insect pests of Michigan blueberries 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 low or 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 broad-spectrum 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 oblique-banded 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. Populations of Japanese beetles have increased markedly in west Michigan in the past five years, and some growers are applying increasing amounts of insecticides to maintain beetle-free fruit. 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, and gypsy moth. These are sporadic in their impact on Michigan blueberries, and are currently controlled by a typical insecticide spray program. Their importance is likely to increase as pest management options change and more selective insecticides are integrated into blueberry production.

Diseases

Important blueberry diseases 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. Shoestring, caused by the blueberry shoestring virus, is the most important virus disease in Michigan.

In the case of mummy berry, the fungus mummifies the fruit, resulting in hard, white structures 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 only one effective fungicide, Indar, is available under an emergency exemption for mummy berry disease control. Without chemical control, losses to this disease are estimated in the range of 10-50%.

Phomopsis twig blight and canker has been an increasing problem in Michigan in the last three to four years. *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 rain-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 provide good control. Indar applied on the same schedule as for mummy berry also reduces twig blight incidence. The difficulty is in timing the fungicide applications. 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 and thorough pruning are 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: Captan and Benlate, Aliette, Bravo and 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. Aliette is currently the recommended material 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 fungal-like organism *Phytophthora 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 and Aliette are recommended for control.

Virus diseases are best controlled by planting virus-tested planting material. Several nurseries in Michigan sell virus-tested plants. 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 roguing of infected plants. Minor virus diseases in Michigan are red ringspot, mosaic, blueberry leaf mottle, and necrotic 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 preemergent and postemergent herbicide use, cultivation, and hand weeding. Because young bushes are sensitive to most preemergent 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 either simazine, diuron, terbacil, norflurazon, or various combinations of these herbicides.

The goal is to keep a 4-5 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 preemergent 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), tree species (sassafras, oak, maple), and vines (virginia creeper, poison ivy). Once these perennial species become established, standard preemergent 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 preemergent herbicides.

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.), Stubby-root 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) or as vectors of viruses that cause infectious diseases.

Insecticide and Fungicide Application

Application of insecticides and fungicides is accomplished by both airblast sprayers 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 alternatives be developed or regulatory relief be enacted.

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.

OUTLINE OF PLAN

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

PEST PROFILES

INSECTS

1. **Blueberry Aphids** (Family *Aphidae*)

- Sporadic pest and primary vector of shoestring virus - adults are present June through September which makes PHI constraints critical.
- Preharvest control critical to avoid spreading aphids that vector the virus.
- Honeydew and insect parts can be a fruit contaminant.

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 the material of choice
 - In a U-pick operation, this is the only material used if aphids are present and fruit is close to harvest, due to the shorter PHI
 - Usage has dwindled to near zero with increasing Japanese beetle populations
 - Allowed as a rescue treatment only by certain processors
- 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
 - Disrupts beneficials
 - Not allowed on U-pick operations
 - Relatively expensive

Other insecticides currently used:

Other pest management aids :

Biological Controls:

- Predators
 - No commercial applications
 - Occur naturally - not stand alone
- Parasites
 - No commercial applications
 - Occur naturally - not stand alone

Pipeline pest management tools:

- Canola oil
 - Possible use as a dormant spray only

- Compatibility problem with Captan use
- Imidacloprid (Admire, Provado)
 - Should be highly effective against aphids, does well on crops where registered
 - Reduced risk pesticide
 - Waiting for EPA registration
 - Long term control
 - Admire is very expensive at current use rates
 - A 3 day PHI will be necessary
 - Provado is a translaminar systemic
- Pyriproxyfen (Esteem)
 - No data for blueberry aphid available yet
 - Very expensive (current formulation)
- Thiamethoxam (Actara)
 - Long term control, no need to reapply frequently
 - A 3 day PHI will be necessary
 - May be more actively systemic than Provado

“To do” list for aphids :

Research needs :

- Application rates, timing and efficacy need to be determined for pipeline chemistries
- Efficacy of Spinosad (Spintor), Kaolin (Surround) and azadirachtin need to be determined
- Impact of new compounds on non-target organisms
- Seasonal changes in population between the aphid and parasite/predator complex
- Development of shoestring virus resistant blueberries
- Development of “real world” worker exposure data

Regulatory needs :

- Expedited registration reviews of aphid controls used on other crops
- Expanded EUP program

Education needs :

- As new tools become available educate growers on strengths, weaknesses and changes in pest control programs
- Program for educating growers on importance of controlling virus spread

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 are strong fliers (can fly up to 1/4 mile) and are highly active during harvest.
- Native pest, populations persist on wild blueberries also.

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
 - Excellent to good control
 - Applications have declined due to Japanese beetle which appears at the same time as blueberry maggot- malathion doesn't work as well as alternative insecticides against Japanese beetle
- Azinphos-methyl (Guthion 50WP)
 - 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
- 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
- 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

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
- 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
- Esfenvalerate (Asana)
 - Label PHI of 14 days
 - Difficult to use with 14 day PHI because Blueberry maggot is active up to harvest

Other insecticides currently registered:

- Azadirachtin (Ecozin 3%, Neemix)
 - REI is 12 hours for Ecozin, 4 hours for Neemix
 - Label PHI is 0 days
 - Not currently used because it just received registration

- Relatively expensive
- Repellency activity
- Kaolin (Surround WP)
 - REI is 4 hours
 - Label PHI is 0 days
 - Good to poor control due to mode of action being non-toxic
 - Currently under research - promising fruit protection
 - Can not be used on fresh market blueberries - cosmetic appearance
- Rotenone
 - Used by organic growers
 - Very expensive
 - Toxic to fish
- Pyrellin (Rotenone + Pyrethrum)

Other pest management aids :

- Baited yellow sticky traps
 - Used for monitoring
- Ground cover management
 - Used with other pest management tactics
 - Not effective on immigrant flies
- Mass trapping
 - Not 100% effective
 - 1 trap for every 5 bushes (~\$350/A)

Biological Controls:

- Predators
 - Ants, carabid beetles
 - No commercial products
- Parasites

- Multiple species, not stand alone
- No commercial products

Pipeline pest management tools:

- Imidacloprid (Provado)
 - Not currently on proposed label but moderately effective against adults
- Spinosad (Success, Spintor)
 - Slow acting on adults but effective
 - Timing is critical
- Thiamethoxam (Actara)
 - Promising, appears to be effective on adults
- Fenpropathrin (Danitol)
 - Fast knock down but short residual activity, also active against Japanese beetle which is active at same time
 - Short PHI will be necessary
- Pesticide treated spheres
 - Works well if density is high enough
 - Needs more research, not yet approved by EPA
 - Little if any worker exposure
 - Attract and kill
 - Impractical on commercial plantings to put out numerous treated spheres

“To do” list for blueberry maggot:

Research needs:

- Study biology to determine if it would be possible to disrupt the life cycle
- Border applications
- Degree day models
- Improve monitoring systems
- Look at combination strategies (Kaolin with spheres)

- Study biology of predators and parasitoids
- Sterile release system
- Develop way to sort out blueberry maggot infested fruit
- Need methyl bromide replacement for fruit fumigation

Regulatory needs:

- Expedited registration reviews
- Expanded EUP program
- Shorter PHIs for Imidan and Sevin
- Eliminate export restrictions both within US and outside US

Education needs:

- As new tools become available will need to educate growers on strengths, weaknesses and changes in pest control programs
- Program for educating growers on importance of maggot control

3. Blueberry Tip Borer (*Hendecaneura shawiana*)

- Common pest.
- Biology not understood.
- Too late to control when damage is seen.
- Not currently treating for tip borer.

Organophosphate insecticides currently registered:

Carbamate insecticides currently registered:

Other insecticides currently registered:

Other pest management aids :

Biological Controls:

Pipeline pest management tools:

- Esfenvalerate (Asana)
 - Label PHI of 14 days

- Might be effective, but no research has been done

“To do” list for blueberry tip borer:

Research needs :

- Biology of pest needs to be understood
- Optimal timing for control
- Economic impact of pest needs to be studied

Regulatory needs :

Education needs :

- Biology of pest
- Optimal timing of control

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.
- 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.

Organophosphate insecticides currently registered:

- Azinphos-methyl (Guthion 50 WP)
 - Restricted Use Pesticide
 - REI is 48 hours for mowing, irrigating and scouting, 4 days for other activities
 - Label PHI is 7 days
 - Excellent control
 - Provides long period of control
 - Can only be used post bloom after bees are removed from field

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

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
 - Relatively short residual
 - Can only be used post bloom after bees are removed from field
 - Can't be used on U-pick operations

Other insecticides currently registered:

- Bt (Dipel)
 - REI is 4 hours
 - Label PHI is 0 days
 - Good control if applied often enough

- Can be used during bloom
- Short residual
- Effectiveness is weather dependent
- More effective on younger instars
- 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
 - Relatively new product, need more experience with product
- Esfenvalerate (Asana)
 - Label PHI of 14 days
 - Highly toxic to bees which limits use
 - Short residual

Other pest management aids :

- Pheromone traps
 - Not stand alone
 - Use for monitoring of presence of pest
- In field scouting to monitor egg laying and egg hatch

Biological Controls:

- Parasites
 - No commercial products available, though parasites and diseases have been identified

Pipeline pest management tools:

- Pyriproxyfen (Esteem)
 - Very expensive, slow acting

- Does not prevent infestations
- Spinosad (Spintor)
 - Need more data
- Fenpropathrin (Danitol)
 - Highly toxic to bees
 - Short residual
 - Currently not labeled

“To do” list for cherry fruitworm:

Research needs :

- Determine level of resistance to OPs
- Develop economic/action threshold for adults
- Develop a sampling plan for eggs and larvae
- Degree model for pest emergence, egg laying and egg hatch
- Need to test new pipeline products
- Impact of new products on parasitism

Regulatory needs :

- Expedite review of pipeline products

Education needs :

- Educate growers on thresholds and sampling plans when available
- Use of new insecticide technologies
- Understanding of mode of action and pattern of use for pipeline and new insecticides

5. Cranberry fruitworm (*Acrobasis vaccinii*)

- Direct fruit pest.
- One generation per year.
- Important pest, primary early season pest.
- Zero tolerance for worms in fruit.

- Long emergence period, therefore long control period.
- Control required during bloom so bee safety is important.
- Suspected OP resistance in some areas.
- Products targeted for cranberry fruitworm also targeted for cherry fruitworm.

Organophosphate insecticides currently registered:

- Azinphos-methyl (Guthion 50 WP)
 - Restricted Use Pesticide
 - REI is 48 hours for mowing, irrigating and scouting, 4 days for other activities
 - Label PHI is 7 days
 - Excellent control
 - Provides long period of control
 - Can only be used post bloom after bees are removed from field
- Phosmet (Imidan 70WP)
 - REI is 24 hours
 - Label PHI is 3 days
 - Good to excellent
 - Provides long period of control but shorter residual than Guthion
 - Can only be used post bloom after bees are removed from field
 - Least expensive of the OPs
- 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

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
- Relatively short residual
- Can only be used post bloom after bees are removed from field
- Can't be used on U-pick operations

Other insecticides currently registered:

- Bt (Dipel)
 - REI is 4 hours
 - Label PHI is 0 days
 - Good control if applied often enough
 - Can be used during bloom
 - Short residual
 - Effectiveness is weather dependent
 - More effective on younger instars
- Esfenvalerate (Asana)
 - Label PHI of 14 days
 - Highly toxic to bees which limits use
 - Short residual
- 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

- Relatively new product, need more experience with product

Other pest management aids :

- Pheromone traps
 - Not stand alone
 - Use for monitoring of presence of pest
- In field scouting to monitor egg laying and egg hatch

Biological Controls:

- Parasites
 - No commercial products available

Pipeline pest management tools :

- Pyriproxyfen (Esteem)
 - Very expensive, slow acting
 - Does not prevent infestations
- Spinosad (Spintor)
 - Need more data
- Fenpropathrin (Danitol)
 - Highly toxic to bees
 - Short residual
 - Currently not labeled

“To do” list for cranberry fruitworm:

Research needs :

- Research on resistance to OPs
- Economic/Action threshold for adults
- Sampling plan for eggs and larvae
- Degree model for pest emergence, egg laying and egg hatch
- Testing new pipeline products
- Impact of new products on parasitism

Regulatory needs :

- Expedite registration of pipeline products

Education needs :

- Educate growers on thresholds and sampling plans
- Use of new insecticide technologies
- Understanding of mode of action and pattern of use for pipeline and new insecticides

6. Gypsy Moth (*Lymantria dispar*)

- Populations in wooded areas around blueberries, ballooning on wind into fields.
- Population varies throughout the state, sporadic numbers.
- Can appear in very high numbers and can defoliate the bush.
- Early season pest.
- Fairly long egg hatch period.

Organophosphate insecticides currently registered:

- Currently labeled OPs are effective against this pest but generally not used due to bloom restrictions

Carbamate insecticides currently registered:

- Currently labeled carbamates are effective against this pest but generally not used due to bloom restrictions

Other insecticides currently registered:

- Bt (Dipel)
 - REI is 4 hours
 - Label PHI is 0 days
 - Good control if applied often enough
 - First instars most susceptible
 - Weather dependent
 - Short residual, multiple applications needed

- Tebufenozide (Confirm 2F)
 - REI is 4 hours
 - Label PHI is 14 days
 - Good to excellent control
 - Lower rate used (½ rate) compared to fruitworm rate
 - Insect growth regulator
 - Longer residual control than Bt (10-14 days longevity)
 - Less weather dependent than Bt for control
 - More rain fast than Bt
 - Reduced risk pesticide

Other pest management aids :

Biological Controls:

- Predators
 - Products available commercially
- Parasites
 - Products available commercially
- Entomopathogens
 - Naturally occurring
- Fungal and viral pathogens

Pipeline pest management tools:

“To do” list for gypsy moth:

Research needs :

Regulatory needs :

Education needs :

- Ongoing state and national activities are sufficient at this time

7. Japanese Beetle (*Popillia japonica*)

- Relatively new pest, populations have increased dramatically in the blueberry growing region within the last 5 years.
- Zero tolerance in the market place.
- Strong fliers (can fly up to 1/4 miles) and are highly active during harvest period.
- Large insect and hard to control.
- Can really ruin a good blueberry pie ?!!!.
- Most economically damaging pest to blueberry industry in Michigan.
- Predisposes blueberries to fruit rots.
- Appears in large quantities in short period of time and reappears 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
- Azinphos-methyl (Guthion50WP)
 - 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
- 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
- Diazinon (Diazinon)

- REI is 24 hours
- Label PHI is 7 days
- Good control
- PHI prevents use close to harvest

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
 - 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

Other insecticides currently registered:

- Esfenvalerate (Asana)
 - Effective knockdown of beetles and residual control
 - Label PHI of 14 days restricts use during multiple harvests
- 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

- Kaolin (Surround WP)
 - REI is 4 hours
 - Label PHI is 0 days
 - Primarily repellent
 - Cosmetic problems, surface residues unacceptable
- Pyrellin (Rotenone + Pyrethrum)
 - Fair to good control
 - Very expensive
 - Short residual
 - Primary repellent

Other pest management aids :

- Ground cover management
 - Not stand alone
 - More research needed
 - May reduce resident grub population
- Mass trapping
 - Not stand alone
 - Effective at attracting beetles
- Pheromone traps
 - Can be used for monitoring
 - Also attracts beetles to plants, use outside the field

Biological Controls:

- Predators
 - More research needed
- Parasites
 - More research needed
- Entomopathogens

- More research needed
- Bacterial agents
 - More research needed
- Entomopathogenic nematodes
 - More research needed

Pipeline pest management tools:

- Imidacloprid (Admire, Provado)
 - Provides lethal and sublethal activity against adults for Provado but more research needed
 - Admire highly effective against grubs
 - Section 18 pending for both products
- Thiamethoxam (Actara, Platinum)
 - Provides lethal and sublethal activity against adults for Actara but more research needed
 - Platinum targets grubs
- Fenpropathrin (Danitol)
 - Excellent knock down of adults
 - Currently in IR-4 process
 - Short PHI necessary

“To do” list for Japanese Beetle:

Research needs :

- Need to research efficacy of pipeline products
- Post harvest sorting technology
- Distribution of grubs
- Ground cover management and cover crops
- Perimeter trapping studies
- Biological controls

Regulatory needs :

- Expedite registration of pipeline products

- Reduce REI and PHI of currently labeled insecticides, especially carbaryl

Education needs :

- Educate growers on ground cover management, cover crops, trapping and biological controls

8. 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.

Organophosphate insecticides currently registered:

- Azinphos-methyl (Guthion 50WP)
 - 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
 - Used primarily for the summer generation
 - Long period of effective control, long residual (10-14 days)
- Phosmet (Imidan 70WP)
 - REI is 24 hours
 - Label PHI is 3 days
 - Fair to good control due to resistance
 - Slightly shorter residual than azinphos-methyl
 - Controls summer generation

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
- 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
 - First year of registration (2001)
- Bt (Dipel)
 - REI is 4 hours
 - Label PHI is 0 days
 - Fair control
 - Short residual
 - Weather dependent
 - Used on early instars
 - Not effective on overwintering generation
- 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

Other pest management aids :

- Pheromone traps
 - Not stand alone
 - Used to monitor timing for control of summer generation
- Degree day models
 - Good model available

Biological Controls:

- Parasites
 - No commercial product available

Pipeline pest management tools:

- Pyriproxyfen (Esteem)
 - Very expensive, slow acting
 - Juvenile hormone - reduced risk insecticide
- Spinosad (Spintor)
 - Should be effective

“To do” list for Oblique Banded Leafroller:

Research needs :

- Need more documentation of resistance, extent and distribution of resistance
- Experience with newer chemistries for this pest, optimal timing of control
- Impact of biocontrol agents

Regulatory needs :

- Expedited review of pipeline products

Education needs :

- More info on life cycle as it applies to blueberries

9. Plum Curculio (*Conotrachelus nenuphar*)

- Occasional pest, could become a more important pest if OPs and carbamates are lost or removed.

Organophosphate insecticides currently registered:

- Pest is being controlled by OPs that target cranberry fruitworm and cherry fruitworm

- Azinphos-methyl (Guthion50WP)
 - 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:

- 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
 - Should be effective, but not data available

Other pest management aids :

Biological Controls:

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

Pipeline pest management tools:

- Imidacloprid (Provado)
 - Should be effective
 - Reduced risk insecticide
- Thiamethoxam (Actara)
 - Shown activity in apples so potential in blueberries

“To do” list for Plum Curculio:

Research needs :

- Determine impact of plum curculio in blueberries
- Determine phenology and presence in blueberries

Regulatory needs :

- If OPs and carbamates are removed, need cost effective products to take their place

Education needs :

- Educate growers on phenology in blueberries

10. 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.

Organophosphate insecticides currently registered:

- Azinphos-methyl (Guthion 50WP)
 - 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 azinphos-methyl
- Diazinon (Diazinon)
 - Good control but azinphos-methyl 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:

- Esfenvalerate (Asana)
 - Label PHI of 14 days
 - Should be effective
- 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:

Pipeline pest management tools:

- Pyriproxyfen (Esteem)
 - Very expensive, slow acting
 - Does not prevent damage
- Spinosad (Spintor)

- Would not prevent damage
- Fenpropathrin (Danitol)
 - Should be effective

“To do” list for Spring Canker Worm:

Research needs :

- Development of economic thresholds
- Further testing of efficacy needed
- Develop management strategies for control

Regulatory needs :

- Registration of Danitol through IR-4

Education needs :

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

11. White Marked Tussock Moth (*Orgyia leucostigma*)

- Larvae develop in mid-summer.
- Have urticating spines.
- Cause irritation to fruit pickers and packers.

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
- Azinphos-methyl (Guthion 50WP)
 - 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)
 - Label PHI of 14 days
 - Expected to be effective
- Azadirachtin (Ecozin 3%, Neemix)
 - REI is 12 hours for Ecozin, 4 hours for Neemix
 - Label PHI is 0 days
- Bt (Dipel)
 - REI is 4 hours
 - Label PHI is 0 days
- Kaolin (Surround WP)
 - REI is 4 hours
 - Label PHI is 0 days
- Tebufenozide (Confirm 2F)
 - REI is 4 hours
 - Label PHI is 14 days
- Rotenone
- Pyrellin (Rotenone + Pyrethrin)

Other pest management aids:

Biological Controls:

- Predators
- Parasites

- Bacterial agents

Pipeline pest management tools:

- Canola oil
- Imidacloprid (Admire, Provado, Gaucho)
- Pyriproxyfen (Knack, Distance or Esteem)
 - Very expensive, slow acting
 - Does not prevent infestations
- Spinosad (Success, Spintor)
- Thiamethoxam (Actara)
- Fenpropathrin (Danitol)

“To do” list for White Marked Tussock Moth:

Research needs :

Regulatory needs :

Education needs :

- Educate growers on biology of insect and phenology in blueberries
- Guide for identification of young larvae

12. Leafrollers

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
- Azinphos-methyl (Guthion 50WP)
 - 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)
 - Label PHI of 14 days
- Azadirachtin (Ecozin 3%, Neemix)
 - REI is 12 hours for Ecozin, 4 hours for Neemix
 - Label PHI is 0 days
- Bt (Dipel)
 - REI is 4 hours
 - Label PHI is 0 days
- Tebufenozide (Confirm 2F)
 - REI is 4 hours
 - Label PHI is 14 days

Other pest management aids:

- Pheromone traps
- Degree day models

Biological Controls:

- Predators
- Parasites
- Entomopathogens
- Bacterial agents

Pipeline pest management tools:

- Spinosad (Success, Spintor)

- Thiamethoxam (Actara)
- Fenpropathrin (Danitol)
- Pesticide treated spheres

“To do” list for Leafrollers :

Research needs :

- Test degree-day model in blueberry
- Examine use of pheromones for mating disruption

Regulatory needs :

Education needs :

- Educate growers on use of traps and development model.

13. Cutworms

Organophosphate insecticides currently registered:

- Azinphos-methyl (Guthion 50WP)
 - 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)
 - Label PHI of 14 days

Other pest management aids :

Biological Controls:

- Predators
- Parasites
- Bacterial agents

Pipeline pest management tools:

- Fenpropathrin (Danitol)

“To do” list for Cutworms :

Research needs :

- Develop scouting techniques and action thresholds

Regulatory needs :

Education needs :

14. Blueberry Bud Mite (*Acalitus vaccinii*)

- Very small mites that feed in buds.
- Cause poor bud development.
- Reduced flowering on infested plants.

Organophosphate insecticides currently registered:

Carbamate insecticides currently registered:

Other insecticides currently registered:

- Endosulfan (Thiodan)
 - Only registered product labeled in blueberry to control blueberry bud mite
 - Application post harvest only

Other pest management aids :

Biological Controls:

- Predators
- Entomopathogens

Pipeline pest management tools:

- Esfenvalerate (Asana)
 - Label PHI of 14 days
 - Not labeled for mites

“To do” list for Blueberry Bud Mite:

Research needs :

- Understand the biology and the most sensitive time for control
- Determine distribution and economic impact
- Find new effective acaricides

Regulatory needs :

Education needs :

- Biology of this pest
- Identification of damage
- Effective control programs

15. Leaf hoppers

- Vector of Stunt, a serious mycoplasma disease

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

Other pest management aids:

- Ground cover management
- Degree day models

Biological Controls:

- Parasites
- Entomopathogens

Pipeline pest management tools:

- Imidacloprid (Admire, Provado, Gaucho)
- Pyriproxyfen (Knack, Distance or Esteem)
 - Very expensive, slow acting
- Thiamethoxam (Actara)
- Fenpropathrin (Danitol)

“To do” list for Leaf hoppers:**Research needs:****Regulatory needs:****Education needs:**

- Role in virus transmission

16. 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
- Azinphos-methyl (Guthion50WP)
 - 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

Other pest management aids :

Biological Controls:

- Predators
- Parasites
- Entomopathogens
- Bacterial agents

Pipeline pest management tools:

- Canola oil
- Imidacloprid (Admire, Provado, Gaucho)
- Pyriproxyfen (Knack, Distance or Esteem)
 - Very expensive, slow acting
 - Does not prevent infestations
- Spinosad (Success, Spintor)

- Received a Section 18 in Georgia for thrips
- Thiamethoxam (Actara)
- Fenpropathrin (Danitol)
- Pesticide treated spheres

“To do” list for Thrips :

Research needs :

- Understand timing of movement into blueberries
- Develop scouting and monitoring approaches
- Economic impact
- Develop economic/action thresholds

Regulatory needs :

Education needs :

17. Scales

Organophosphate insecticides currently registered:

- Azinophos-methyl (Guthion 50WP)
 - 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:

Other pest management aids:

Biological Controls:

- Predators
- Parasites
- Entomopathogens
- Bacterial agents

Pipeline pest management tools:

- Canola oil
- Imidacloprid (Admire, Provado, Gaucho)
- Pyriproxyfen (Knack, Distance or Esteem)
 - Very expensive, slow acting
 - Does not prevent infestations

“To do” list for Scales:

Research needs:

Regulatory needs:

Education needs:

- Identification and control program

DISEASES

1. **Anthracnose** (*Colletotrichum acutatum*)

- Most important fruit rot in Michigan.
- Especially common in over-ripe berries.
- A problem every year.
- Don't see problem until fruit ripens.
- Early-season control important as well as late-season control.

- Zero tolerance in berries for processing or fresh market.

B2 carcinogenic fungicides currently registered:

- Chlorothalonil (Bravo Weather Stik)
 - Section 24(c) until 4/18/06
 - REI is 48 hours
 - Do not apply after full bloom or PHI of 42 days
 - Good control
 - Long PHI limits use of product
 - Phytotoxicity limits use to pre-bloom period
 - Not effective stand-alone material
 - Also provides mummy berry shoot strike suppression
- Captan (Captan 50WP and Captec 4L)
 - REI is 4 days
 - Label PHI is 0 days
 - Fair control
 - Usually used in combination with Benlate for better control
- Benomyl + Captan (Benlate 50WP plus Captan 50WP or Captec 4L)
 - Benomyl REI is 24 hours
 - Benomyl Label PHI is 21 days
 - Captan REI is 4 days
 - Captan Label PHI is 0 days
 - Good control
 - Benlate registration is being canceled and withdrawn by manufacturer

Other fungicides currently registered:

- Fosetyl-AI (Aliette WDG)
 - REI is 12 hours
 - Label PHI is 0 days
 - Good control
 - Very expensive, limits economic utility
 - Not material of choice
- Ziram (Ziram 76 DF, Ziram Granuflo)

- Section 24(c) until 06/01/04 for Ziram 76 DF
- REI is 48 hours
- Label PHI is 14 days for Ziram 76 DF
- Ziram Granuflo can be applied up to 3 weeks after full bloom
- Fair to good control
- Usually used with Benlate to increase effectiveness (Benlate being canceled)
- Azoxystrobin (Abound)
 - Registered for blueberries November 2001
 - REI is 4 hours
 - Label PHI is 0 days
 - Number of sprays limited to two consecutive and three total
 - Surface-systemic
 - Excellent control in research trials

Other pest management aids: (Not stand alone)

- Prune to remove diseased twigs and increase air circulation
- Timely harvesting
- Properly timed overhead irrigation to avoid excessive foliar wetting
- Post-harvest cooling
- Ground cover management to reduce humidity
- Plant resistant or less susceptible variety

Pipeline pest management tools:

- Pyraclostrobin (BAS 500F/Cabrio)
 - Excellent control in research trials
 - Registration pending
- Cyprodinil + Fludioxonil (Switch)
 - Good control
 - Also controls other fruit rots
 - Registration in progress - candidate for EPA 2002 work plan
- Thiophanate-methyl (Topsin-M)
 - Potential Benlate replacement
 - Section 18 requested for 2002

“To do” list for Anthracnose:

Research needs :

- More research needed on efficacy for Topsin-M or other Benlate replacements
- Disease modeling - prediction
- Biology and timing
- More research on resistance to fungicides
- Varietal resistance
- Quantify economic losses

Regulatory needs :

- Retain Benlate tolerance for blueberries
- Register Benlate replacement

Education needs :

- Disseminate research results
- Fungicide resistance management

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

- Common fruit 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 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.

B2 carcinogenic fungicides currently registered:

- Chlorothalonil (Bravo Weather Stik)
 - Section 24(c) until 4/18/06
 - REI is 48 hours
 - Do not apply after full bloom or PHI of 42 days
 - Poor control
- Benomyl + Captan (Benlate 50WP plus Captan 50WP or Captec 4L)
 - Benomyl REI is 24 hours
 - Benomyl Label PHI is 21 days

- Captan REI is 4 days
- Captan Label PHI is 0 days
- Poor control with Benlate and Captan
- Seems to increase the Alternaria due to anthracnose control
- Captan provides fair control
- Benomyl production has been discontinued

Other fungicides currently registered:

- Fosetyl-Al (Aliette WDG)
 - REI is 12 hours
 - Label PHI is 0 days
 - Good control
 - Very expensive, cost limits use
- Ziram (Ziram 76 DF)
 - Section 24 (c) until 06/01/04
 - REI is 48 hours
 - Label PHI is 14 days
 - Fair control
- Azoxystrobin (Abound)
 - Registered for blueberries November 2001
 - REI is 4 hours
 - Label PHI is 0 days
 - Number of sprays limited to two consecutive and three total
 - Surface-systemic
 - Poor to fair control

Other pest management aids: (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

Pipeline pest management tools:

- Cyprodinil + Fludioxonil (Switch)

- Good control in research trials
- Also controls anthracnose and Botrytis rots

“To do” list for Alternaria:

Research needs :

- Disease modeling - prediction
- Biology and timing
- Role of pesticides/fruit injury in infection
- Varietal resistance
- Investigate chemigation
- Quantify economic losses

Regulatory needs :

- Registration for Switch

Education needs :

- Educate growers on modeling, biology and varietal resistance

3. Botrytis Fruit Rot (*Botrytis cinerea*)

B2 carcinogenic fungicides currently registered:

- Benomyl + Captan (Benlate 50WP + Captan 50WP or Captec 4L)
 - Benomyl REI is 24 hours
 - Benomyl Label PHI is 21 days
 - Captan REI is 4 days
 - Captan Label PHI is 0 days
 - Good to excellent control
 - Benomyl production has been discontinued
- Iprodione (Rovral)
 - REI is 24 hours
 - Label PHI is 0 days
 - Good to excellent control if no resistant strains present
 - Extremely expensive

Other fungicides currently registered

- Ziram (Ziram 76 DF, Ziram Granuflo)

- Section 24(c) until 06/01/04
- REI is 48 hours
- Label PHI is 14 days for Ziram 76 DF
- Ziram Granuflo can be applied up to 3 weeks after full bloom
- Do not apply later than 3 weeks after full bloom

Other pest management aids :

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

Pipeline pest management tools:

- Fenhexamid (Elevate)
 - Good control in research trials
- Cyprodinil + Fludioxonil (Switch)
 - Good control in research trials

“To do” list for Botrytis Fruit Rot:

Research needs :

- Interaction with other fruit rots
- Determine efficacy of Topsin-M or other Benlate alternatives

Regulatory needs :

Education needs :

4. Fusicoccum Canker (*Fusicoccum putrefaciens*)

- This canker more common in northern areas of Michigan (e.g., north of Grand Haven).
- Symptoms similar to Phomopsis canker.
- Fungus spread by splashing rain.

B2 carcinogenic fungicides currently registered:

- Benomyl + Captan (Benlate 50WP plus Captan 50WP or Captec 4L)
 - Benomyl REI is 24 hours
 - Benomyl Label PHI is 21 days
 - Captan REI is 4 days
 - Captan Label PHI is 0 days
 - Benomyl production has been discontinued

- Captan (Captan 50WP)
 - REI is 4 days
 - Label PHI is 0 days
- Chlorothalonil (Bravo Weather Stik)
 - Section 24(c) until 4/25/06
 - REI is 48 hours
 - Label PHI is 42 days
 - Do not apply after full bloom (early petal fall)

Other fungicides currently registered

- Fosetyl-Al (Aliette WDG)
 - REI is 12 hours
 - Label PHI is 0 days
- Ziram (Ziram 76 DF, Ziram Granuflo)
 - Section 24(c) until 06/01/04
 - REI is 48 hours
 - Label PHI is 14 days for Ziram 76 DF
 - Ziram Granuflo can be applied up to 3 weeks after full bloom
 - Do not apply later than 3 weeks after full bloom

Other pest management aids :

- Prune cankered branches and destroy

Pipeline pest management tools:

- Topsin-M (as replacement for Benlate)

“To do” list for Fusicoccum canker:

Research needs :

- Identify efficacious fungicides and application timing
- Evaluate alternatives for Fusicoccum control

Regulatory needs :

Education needs :

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

- Most yield-limiting disease in Michigan.

- 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 post-harvest 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 and wind.

B2 carcinogenic fungicides currently registered:

- Chlorothalonil (Bravo Weather Stik)
 - Section 24(c) until 4/18/06
 - 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
- Benomyl + Captan (Benlate 50WP plus Captan 50WP or Captec 4L)
 - Benomyl REI is 24 hours
 - Benomyl Label PHI is 21 days
 - Captan REI is 4 days
 - Captan Label PHI is 0 days
 - Fair control of shoot strikes
 - Good to excellent control of fruit infection
 - Benlate production has been discontinued

Other fungicides currently registered:

- Fenbuconazole (Indar 75WSP)
 - Section 18 (04/01/01 to 09/01/01) - new Sec. 18 requested for 2002
 - REI is 12 hours
 - Label PHI is 30 day
 - Good control of both phases with proper timing

- Registration is pending
- Locally systemic
- Ziram (Ziram 76 DF)
 - Section 24(c) until 6/1/04
 - Label PHI is 14 days
 - Fair control of both phases
 - Needs to be used with Benlate (or replacement) for good control of fruit infection phase
- Azoxystrobin (Abound)
 - Registered for blueberries November 2001
 - REI is 4 hours
 - Label PHI is 0 days
 - Number of sprays limited to two consecutive and three total
 - Surface-systemic
 - Poor control of shoot strikes, moderate control of fruit infection in research trials

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

Pipeline pest management tools:

- *Bacillus subtilis* (Serenade) biofungicide
 - Moderate control in research trials
 - Could be an option for organic growers
 - Registration is a potential
- Fenbuconazole (Indar)
 - Pending registration
 - Good control of both phases of the disease
 - Does not hold up well under high disease pressure, probably because of limited back action
- Orbit

- Good on shoot strike in research trials
- Poor to fair control of fruit infection in research trials

“To do” list for Mummy Berry:

Research needs :

- Disease prediction model
- Fungicide mode of action and efficacy
- Varietal resistance
- Biocontrol
- Quantify economic losses

Regulatory needs :

- Indar registration
- Replacement for Benlate

Education needs :

- Educate growers on disease prediction models and biocontrols

6. Phomopsis Twig Blight and Canker (*Phomopsis vaccinii*)

- Common in Michigan blueberry plantings, especially the last four years.
- 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 2-4 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.

B2 carcinogenic fungicides currently registered:

- Benomyl + Captan (Benlate 50WP plus Captan 50WP or Captec 4L)
 - Benomyl REI is 24 hours
 - Benomyl Label PHI is 21 days

- Captan REI is 4 days
- Captan Label PHI is 0 days
- Good to excellent control
- Benomyl production has been discontinued
- Captan (Captan 50WP)
 - REI is 4 days
 - Label PHI is 0 days
 - Poor to fair control
- Chlorothalonil (Bravo Weather Stik)
 - Section 24(c) until 4/18/06
 - REI is 48 hours
 - Label PHI is 42 days
 - Do not apply after full bloom (early petal fall)
 - Good control

Other fungicides currently registered

- Fenbuconazole (Indar 75WSP)
 - Section 18 (04/01/01 to 09/01/01), new Sec. 18 requested for 2002
 - REI is 12 hours
 - Label PHI is 30 days
 - Good control of twig blight on a mummy berry spray schedule in research plots
 - Long PHI does not allow the multiple applications necessary to provide adequate control under commercial conditions
- Fosetyl-Al (Aliette WDG)
 - REI is 12 hours
 - Label PHI is 0 days
 - Good control
 - Expensive
- Ziram (Ziram 76DF)
 - Section 24 (c) until 06/01/04
 - REI is 48 hours
 - Label PHI is 14 days

- Good control
- Azoxystrobin (Abound)
 - Registered for blueberries November 2001
 - REI is 4 hours
 - Label PHI is 0 days
 - Number of sprays limited to two consecutive and three total
 - Surface-systemic
 - Moderate control in research trials

Other pest management aids :

- Selective pruning of diseased canes and destroy prunings
- Avoid wounding/frost damage
- Plant resistant or less susceptible variety

Pipeline pest management tools:

- Pyraclostrobin (BAS 500/516)
 - Fair control

“To do” list for Phomopsis Twig Blight and Canker.

Research needs :

- More research on biology of the disease
- Predictive model to guide spray timing
- Varietal resistance
- New materials
- Quantify economic loss values

Regulatory needs :

Education needs :

- Educate growers on biology and predictive modeling

7. Phytophthora Root Rot (*Phytophthora cinnamomi*)

- Not common in Michigan.
- Would be a problem on heavier soils and poorly drained areas.

B2 carcinogenic fungicides currently registered:

- None

Other fungicides currently registered:

- Mefenoxam (Ridomil Gold EC)
 - REI is 48 hours
 - Label PHI is 0 days
 - Excellent control
 - Will not revitalize plants showing moderate to severe root rot symptoms
- Fosetyl-Al (Aliette WDG)
 - REI is 12 hours
 - Label PHI is 0 days
 - Good control

Other pest management aids :

- Site selection and good drainage
- Raised beds

Pipeline pest management tools:**“To do” list for Phytophthora Root Rot:****Research needs :**

- Correct diagnosis for symptomatic fields

Regulatory needs :**Education needs :****8. Powdery mildew (*Microspheera vaccinii*)**

- Common, but not considered very harmful.

B2 carcinogenic fungicides currently registered:

- None

Other fungicides currently registered:

- Wettable sulfur
 - REI is 24 hours
 - PHI is 0 days
- JMS Stylet Oil
 - REI is 4 hours
 - PHI is 0 days

- May affect wax on berries

Other pest management aids :

- Reduce humidity in canopy

Pipeline pest management tools:

“To do” list for powdery mildew:

Research needs :

Regulatory needs :

Education needs :

9. Leaf rust (*Pucciniastrum vaccinii*)

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

B2 carcinogenic fungicides currently registered:

- None

Other fungicides currently registered:

- Fenbuconazole (Indar 75WSP)
 - Section 18 (04/01/01 to 09/01/01), new Sec. 18 requested for 2002
 - REI is 12 hours
 - Label PHI is 30 days
 - Not tested against leaf rust, but expected to have efficacy since it is an SI fungicide

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:

“To do” list for Leaf rust:

Research needs :

Regulatory needs :

Education needs :

10. Witches’ broom (*Pucciniastrum goeppertianum*)

- Rare in Michigan.
- Disease becomes systemic in the plant.

B2 carcinogenic fungicides currently registered:

- None

Other fungicides currently registered:

- Fenbuconazole (Indar 75WSP)
 - Section 18 (04/01/01 to 09/01/01), new Sec. 18 requested for 2002
 - REI is 12 hours
 - Label PHI is 30 days
 - Not tested against withes' broom, but expected to have efficacy since it is an SI fungicide

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 :

Virus/MLO Diseases

Blueberries in Michigan are affected by seven different diseases caused by viruses and mycoplasma-like organisms (MLOs). The two most serious and yield-limiting are shoestring and stunt. Both disease organisms are vectored by insects.

1. 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.

2. Stunt

- Caused by a mycoplasma-like organism (MLO).
- Vectored by the sharp-nosed 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.

WEEDS

Annual/perennial grasses and broadleaf weeds :

1. First Year and Established Plantings:

Herbicides currently registered:

- Fluazifop-P (Fusilade DX 2E)
 - REI is 12 hours
 - Label 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 Ultra 4L)
 - 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
 - Long-term impact of injury to young canes is not clear
- Oryzalin (Surflan 4 AS)
 - REI is 24 hours
 - No post emergent activity
 - Requires rain or irrigation to incorporate
 - Weaker product overall
- 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 6 L)
 - REI is 12 hours
 - Label PHI is 14 days
 - Poor to excellent control, inconsistent activity

Other pest management aids :

- Cultivation and hand weeding are important in new plantings
- Mulching with bark, sawdust or other organic materials is effective but expensive

2. Established One Year or More

Herbicides currently registered:

- Dichlobenil (Casoron 4G)
 - REI is 12 hours
 - Expensive
 - Granular formulation is difficult to apply accurately
 - Used for spot treatment of difficult weeds
- Diuron (Karmex 80 DF)
 - REI is 12 hours
 - Very important, widely used material
 - Good crop safety
 - Broad range of species controlled
 - Possible weed resistance
- Hexazinone (Velpar 2L)
 - REI is 24 hours
 - Label PHI is 90 days
 - Crop safety has limited its use
 - Resistance and groundwater issues
- Napropamide (Devrinol 50 DF)
 - REI is 12 hours

- Weaker preemergent herbicide
- Requires incorporation with water
- Narrow weed spectrum, primarily grasses
- 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
- 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
- Pronamide (Kerb 50 W)
 - REI is 24 hours
 - 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 with broad spectrum of weeds controls a broad spectrum of weeds
 - Inexpensive
 - Fairly high crop safety
 - Ground water quality and resistance issues
 - Along with diuron the most commonly used herbicides in blueberries
- Terbacil (Sinbar 80 W)
 - REI is 12 hours

- Widely used broad spectrum product
- Crop safety an issue
- Ground water quality and resistance issues
- Usually applied in combination with simazine or diuron

Other pest management aids :

- Hand weeding is not practical on a commercial scale except for some vines and woody weeds
- Cultivation/mechanical hoeing - can be effective but time consuming
- Mulching
- Mowing of row middles
- Chemical mowing of row middles

Pipeline pest management tools :

- Milestone
 - In progress
 - Provides season-long control of annual weeds
 - Appears to have high crop safety
- Dual Magnum
 - Controls perennial sedges
- Glufosinate
- Clopyralid (Stinger)

“To do” list for weeds :

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 pre-plant practices that minimize weed competition during first years.
- Determine long-term impact of glyphosate injury to base of young canes

Regulatory needs :

- Shorter PHI for Solicam
- Shorter PHI for Poast
- Milestone registration

Education needs :

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
 - Excellent control of dagger nematodes (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
 - Pre-plant 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
 - No weed or fungus control
 - Soil fumigation equipment required for application
 - Liquid formulation
 - Pre-plant 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 control of dagger nematodes

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

Organophosphate nematicides currently registered:

- Nema-cur
 - Liquid formulation
 - Only post-plant blueberry nematicide (only used on cutting wood and nursery plantings)
 - Efficacy less on dagger nematodes than broad-spectrum soil fumigants
 - Efficacy only fair for dagger nematodes (vectors of TRSV, ToRSV, PRMV and BNRSV)
 - Used only under the MI 24(c) nursery crop registration

Other nematicides currently registered:

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

2. Stubby-root Nematodes (*Trichodorus christiei*, *T. spp.* and *Paratrichodorus spp.*)

- Ectoparasitic pathogen resulting in stunted plants, severely deformed root systems and low yields.
- Potential virus vector of tobnaviruses.
- Major pest of cutting wood plants, nursery stock and bearing plantings.

Halogenated hydrocarbon nematicides (soil fumigants) currently registered:

- Methyl bromide
 - Excellent stubby-root 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

- Pre-plant application only
- Applicator health risks
- Ozone depletion in the stratosphere
- To be phased-out according to the Montreal Protocol
- Telone II
 - Good stubby-root nematode control
 - No weed or fungus control
 - Soil fumigation equipment required for application
 - Liquid formulation
 - Pre-plant 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 stubby-root nematode control
 - Weed and fungus control available at high dosage
 - Multiple product manufacturers
 - Multiple application methods (chemigation procedures or ground-driven equipment)
 - Pre-plant 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 post-plant blueberry nematicide (only used on cutting wood and nursery plantings)
 - Efficacy less for stubby-root nematodes than with broad-spectrum soil fumigants
 - Efficacy only fair for stubby-root nematodes
 - Used only under the MI 24(c)) nursery crop registration

Other nematicides currently registered:

Other pest management strategies, tactics and procedures:

- Production of nematode-free nursery stock

- Ground cover management designed to reduce population densities of stubby-root nematodes
- Soil quality building designed to reduce population densities of stubby-root nematodes

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

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

Halogenated hydrocarbon nematicides (soil fumigants) currently registered:

- Methyl bromide
 - 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
 - Pre-plant 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
 - Pre-plant 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)
- Pre-plant application only
- Alternative for methyl bromide in nursery and cutting wood stock plantings
- Not used for blueberry plantings in Michigan

Organophosphate nematicides currently registered:

- Nematicur
 - Liquid formulation
 - Only post-plant 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:

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 Criconeematidae spp.)

- Ectoparasitic pathogen resulting in stunted plants, reduced root systems and low yields.
- Sporadic pest of cutting wood plants, nursery stock and bearing plantings.

Halogenated hydrocarbon nematicides (soil fumigants) currently registered:

- Methyl bromide
 - 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
 - Pre-plant 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
 - Pre-plant 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)
 - Pre-plant 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 post-plant 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:

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
 - 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 major new tool for use in all aspects of the blueberry system
- MicroXX
 - Novel biological (mixture of bacteria and fungi) nematicide
 - Could be an important new tool for use in blueberry production
- 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
 - State statutory law in place
 - Administrative law successfully implemented for viruses and virus vectors
 - Implementation not usually enforced for blueberry nematodes other than virus vectors
- Ground cover management
 - Recent studies in Michigan have demonstrated that ground cover management procedures have significant impacts on population development of plant parasitic nematodes

- 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 state-of-the-art precision 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)

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 modern precision agriculture technologies

Education needs:

- There is a need for a general plant parasitic nematode education program for the Michigan blueberry industry. This should be done as an integral component of a broader blueberry educational initiative
- Michigan State University is in the process of producing a major new document entitled, *Michigan Fruit Ecology and Management*. This educational contribution should be used for a stand-alone educational event for the blueberry industry. The initiative will contain a significant component of the role of bacterial and fungal feeding nematodes in the transformation and transport of energy and matter in relation to plant health

Table 1. Insect Pest Management Efficacy Table - Blueberries - Michigan

Prepared 6/6/01.

Ratings: **P**oor, **F**air, **G**ood, **E**xcellent, **N**ot Stand Alone

X= registered/used

? = Registrant claims activity, research may be needed to back up claim

UK =Unknown activity

NU = Not Used

	Early Season							Mid Season							Harvest/Late Season			
Pests	Blueberry Tip Borer	Canker worm	Spring Canker Worm	Cutworms	Blueberry budmite	Thrips	Scales	Cherry fruitworm	Cranberry Fruitworm	Gypsy Moth	OBLR	Leafrollers	Plum Curculio	White Marked Tusk Moth	Aphids	Blueberry maggot	Japanese Beetle	Leafhoppers
Management tools																		
OPs Used																		
Azinphos-methyl (Guthion) (long PHI)		G-E	E	E		P/N U		E	E	G-E	E-F	E	E/N U					
Malathion															P-F	E-G	F	
Phosmet (Imidan)			E	G				G-E	G-E	G-E	G-F	G	G			E	G	G-F
Diazinon			G	G			G-F	G	G		G	G	G		G	G		
Carbamates																		

	Early Season							Mid Season							Harvest/Late Season				
Pests																			
Management tools	Blueberry Tip Borer	Canker worm	Spring Canker Worm	Cutworms	Blueberry budmite	Thrips	Scales	Cherry fruitworm	Cranberry Fruitworm	Gypsy Moth	OBLR	Leafrollers	Plum Curculio	White Marked Tusk Moth	Aphids	Blueberry maggot	Japanese Beetle	Leafhoppers	
Carbaryl (Sevin)													G	G-E		G	G	G/N U	
Methomyl (Lannate)			G	G					F-G	G	G			G-E	E	G	F-G	G-E	
Other insecticides used																			
Azadirachtin (Neemix, Ecozin)																?	?		
Bt (Dipel)								F	F	G	F	F							
Kaolin (Surround)																G?	?		
Tebufozide (Confirm)								G-E	G-E	G-E	G-E	?							
Rotenone																?	?		
Pyrellin (Pyrethrin + Rotenone)																?	F-G		

	Early Season							Mid Season							Harvest/Late Season				
Pests																			
Management tools	Blueberry Tip Borer	Canker worm	Spring Canker Worm	Cutworms	Blueberry budmite	Thrips	Scales	Cherry fruitworm	Cranberry Fruitworm	Gypsy Moth	OBLR	Leafrollers	Plum Curculio	White Marked Tusk Moth	Aphids	Blueberry maggot	Japanese Beetle	Leafhoppers	
Pipeline (New Chemistries) IR-4																			
Canola oil: (registered)					?		?								?				
Esfenvalerate: Asana (registered)	?	?	?	?	?		?	?	?		G-E		?					?	
Imidacloprid: Admire, Provado, Gaucho (pending)						?	?						?		?	?	?	?	
Pyriproxyfen: Esteem (potential)		?	?				?	?	?		?			?	?			?	
Spinosad: Spintor (pending)		?	?		?	?	?	?	?		?			?		?			

	Early Season							Mid Season							Harvest/Late Season				
Pests																			
Management tools	Blueberry Tip Borer	Canker worm	Spring Canker Worm	Cutworms	Blueberry budmite	Thrips	Scales	Cherry fruitworm	Cranberry Fruitworm	Gypsy Moth	OBLR	Leafrollers	Plum Curculio	White Marked Tusk Moth	Aphids	Blueberry maggot	Japanese Beetle	Leafhoppers	
Thiamethoxam Actara (in progress)						?							?		?	?	?		
Fenpropathrin: Danitol (in progress)				?	?			?	?							?	?	?	
Pesticide Treated Sphere (Imidacloprid)								?	?							E?			

Table 2. Efficacy of Other Insect Monitoring Tools and Biological Controls - Blueberries - Michigan

NS = Not Stand Alone

? = May be potential but more research needed

	Early Season							Mid Season							Harvest/Late Season			
Pests	Blueberry Tip Borer	Canker worm	Spring canker worm	Cutworm	Blueberry bud mite	Thrips	Scales	Cherry fruitworm	Cranberry fruitworm	Gypsy moth	OBLR	Leafroller	Plum curculio	White marked tussock moth	Blueberry magot	Aphids	Japanese beetle	Leafhopper
Other Management Aids																		
Baited yellow sticky traps															NS	NS		NS
Ground cover management															?		NS	
Mass trapping															?		NS	
Pheromone traps		NS					NS	NS		?							NS	
Degree day models																		
Post harvest handling																	NS	
Biological Controls																		
Predators															?	?	?	
Parasites									?		?				?	?		
Entomopathogens																	?	
Bacterial agents																	?	

Entomopathogenic nematodes																		
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Table 3. Disease Management Efficacy Table - Blueberries - Michigan

Prepared 6/6/01

Ratings: **P**oor, **F**air, **G**ood, **E**xcellent

- = No Effect

? = Not Known

NU = Not Used

NS = Not Stand Alone

Disease	Anthracnose	Alternaria Fruit Rot	Botrytis Fruit Rot	Fusicoccum Canker	Mummy Berry/Shoot strike	Mummy Berry/Fruit infection	Phomopsis Twig Blight and Canker	Phytophthora Root Rot
Management Tools								
B2 Carcinogens Used								
Benomyl + Captan (Benlate + Captan)	G	P	G-E	G-E	F	G-E	G-E	-
Captan (Captan)	F-G	F	P	P	P	P-F	G	-
Chlorothalonil(Bravo Weather Stik)	G	P	F	?	F	P	G	-
Iprodione (Rovral)	-	-	G-E/NU	-	-	-	-	-
Other Fungicides Used								
Fosetyl-AI (Aliette)	G	G	?	?	-	-	F-G	G
Ziram (Ziram)	G	F	F	F-G	F	F	G	-
Fenbuconazole (Indar)	-	P	?	?	Sec. 18 G	Sec. 18 G	G-E	-
Mefenoxam (Ridomil)	-	-	-	-	-	-	-	E
Lime Sulfur				G/NS			G/NS	
Other Management Aids								
Pruning	NS			NS			NS	
Timely harvest	NS	NS	NS					
Remove dead canes	NS			NS			NS	
Good drainage								NS
Raised beds								NS

Disease								
Management Tools	Anthraco	Alternaria Fruit Rot	Botrytis Fruit Rot	Fusicocum Canker	Mummy Berry/Shoot strike	Mummy Berry/Fruit infection	Phomopsis Twig Blight and Canker	Phytophthora Root Rot
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	
Cooling berries post harvest	NS	NS	NS					
Harvest handling		NS						
Pipeline (New Chemistries) IR-4								
Azoxystrobin (Abound) (newly registered 2002)	E	P	P	?	P-F	F	F	?
Cyprodinil + Fludioxonil (Switch) (In progress)	G?	G?	G?	?			P?	?
Fenbuconazole (Indar) (Pending)	P?	P?	P?	?	G?	G?	G-E?	?
Fenhexamid (Elevate) (In progress)	P?	P?	G?	?	P?	P?	F?	?
Propiconazole (Orbit) (Pending)	?	?	?	?	G?	P-F?	?	?
Harpin Protein (Messenger) (Registered)	P	?	?	?	P	P	F-G	?
BAS 500 (Cabrio) (Pending)	E	P	P	?	F	F	F	?
BAS 516	E	?	?	?	?	?	E	?
Cinnamaldehyde (Cinnacure, Cinnamite) (Registered)	?	?	?	?	?	?	?	?
Phosphonic Acid (Foli-R-Fos) (Potential)	?	?	?	?	?	?	?	?
Potassium bicarbonate (Armicarb 100) (registered)	P	P	P	?	F	F	F	?
Thiophanate-methyl (Topsin-M)	?	?	?	?	?	?	?	?
Bacillus subtilis (Serenade) (Potential)	-	?	?	?	F-G	F-G	P-F	?

Table 4: Weed Pest Management Efficacy Table - Blueberries - Michigan

Prepared 6/6/01

Ratings: **P**oor, **F**air, **G**ood, **E**xcellent, **N**ot Stand Alone

X = registered/used

? = registrant claims activity, research may be needed to back up claim

Pests						
Pest Management Tools	Annual grasses	Perennial grasses	Annual Broadleaves	Perennial Broadleaves	Woody Perennials	Nutsedge
Dichlobenil (Casoron) Preemergence	E	G	G	G	P	P
Diuron (Karmex) Preemergence	G	P	E	F	P	P
Fluazifop-P (Fusilade) Postemergence	E	G	P	P	P	P
Glyphosate (Roundup) Postemergence	E	E	E	E	G	F
Hexazinone (Velpar) Preemergence	G	G	G	G	F-G	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	P-E	P-E	P-E	P-E	P	P
Terbacil (Sinbar) Preemergence	G	F	G	F	P	P
Clethodim (Select) Postemergence	G	G				P
Other pest management aids						
Hand weeding	F-P	F-P	F-P	P	F-P	
Cultivation	F	P	F	P	P	
Mowing (under bushes)	P	P	F	P		
Mulching	G	F	G	F	P	
Pipeline (New Chemistries) IR-4						
Azafenidin (Milestone) (In progress) Preemergence	E	?	E	?		

Pests Pest Management Tools	Annual grasses	Perennial grasses	Annual Broadleaves	Perennial Broadleaves	Woody Perennials	Nutsedge
alpha-metolachlor (Dual magnum) Potential, PPI	?	?	?	?		G
Thiazopyr (Visor) Potential			?	?		
Glufosinate (Liberty) (In progress) Postemergence	G	G	G	G	F	
Clopyralid (Stinger) (In progress) Pre and Postemergence	P	P	G	F	P	

Table 5. Nematode Pest Management Efficacy Table - Blueberries - Michigan

Prepared 6/6/01

Ratings: **P**oor, **F**air, **G**ood, **E**xcellent, **N**ot Stand Alone

X = registered/used

? = registrant claims activity, research may be needed to back up claim

Pests	Dagger Nematode	Lesion Nematode	Sheath Nematode	Stubby Root Nematode	Ring Nematode
Pest Management Tools					
Methyl Bromide (Preplant)	E	E	E	E	E
Telone II (Preplant)	G	G	?	G	G
Metham	?	E	?	?	?
Nemacur	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	?	?	?	?	?