



## Crop Profile for Highbush Blueberry in New Jersey

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### General Production Information

- *Vaccinium corymbosum* (highbush) is the blueberry species primarily grown commercially in the United States and New Jersey. It belongs to EPA Crop Group 13, Berries. Nearly 39,000 acres of highbush blueberries were harvested nationwide in 1997; 7,410 of those acres were harvested in New Jersey.
  - Approximately 173 million pounds of blueberries were produced in the United States in 1997. National sales of blueberries in 1997 totaled more than 140 million dollars.
  - The blueberry yield in 1997 for New Jersey was approximately 4,500 pounds per acre, compared to the national average of 4,340 pounds per acre. New Jersey ranked second only to Michigan in cultivated blueberry production; a total of nearly 34 million pounds were produced in New Jersey.
  - Blueberry was the fifth top agricultural commodity sold in New Jersey in 1997. It accounted for 4.1% of New Jersey's total farm receipts that year.
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### Production

North America is the world's leading producer of blueberry, accounting for nearly 90% of its production annually. Commercial blueberry production in the United States first began in New Jersey, then moved to Michigan, and subsequently across the country to areas with acid soils and locations where other crops were unsuccessful. The largest blueberry production areas nationally are in Michigan, New Jersey, and the Pacific Northwest. Other important production areas are North Carolina, the south-central States, and the northeastern States.

Blueberries are sold fresh, ready to be frozen, or processed into jelly, syrups, pies, and pastries nationally. Most of the blueberries produced by western states are sold for fresh market and processing, while the majority of northeast blueberry crops are produced for fresh market sale. In New Jersey, blueberries are sold in farmers markets, pick-your-own operations, or through sales to direct market supermarkets.

There were 209 commercial blueberry production farms in New Jersey encompassing 7,410 acres in 1997. Burlington and Atlantic counties produced more than 98% of the State's commercial highbush blueberry crop on 150 farms. Other New Jersey counties with farms in commercial blueberry production include Camden, Cumberland, Gloucester, Hunterdon, Monmouth, Ocean, Salem, Sussex, and Warren.

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### Cultural Practices

Blueberry is a long-lived perennial deciduous woody shrub native to the United States. The shrub is shallow-rooted with woody canes growing from the center crown of the plant. Cultivated blueberry stock that is true-to-type, vigorous, and disease-free is fundamental to commercial blueberry production

New plants are set in early spring in rows that are 10 to 12 feet apart; this allows for tractor mowing or spraying. Plants are situated such that they receive a minimum of 15% full sunlight in order to initiate flower buds in the spring. Typically, no crop will be harvested the first two years.

Blueberry requires fairly specific soil and climatic conditions. In order to achieve optimum growth and productivity, blueberries grow best in well-drained acidic sandy loam soils with organic matter content exceeding 3%. Blueberry should be fertilized with materials that supply nitrogen in the form of ammonium ions (e.g., ammonium nitrate or di-ammonium phosphate). The optimum pH range for growth of blueberry is 4.0 to 4.8 pH units; monitoring is necessary as an excessively high pH may induce nutrient deficiencies in the crop. As part of New Jersey's Blueberry Integrated Crop Management program, both soil testing and tissue sampling for nutrients (in August) are provided as a service to growers. This allows growers to augment the soil to maximize crop production, and minimize the problems caused by over-fertilization.

Soils suiting blueberry production are often found in topographically low areas; thus, these blueberries would have a greater probability of being subject to spring frosts. Spring temperatures below -15 °C are not suitable for blueberry production since buds become damaged. Frosts are probably the major factor in determining the total production of blueberries for a region in any given year. Blueberry varieties that bloom in early spring must be protected from freezing temperatures once the blossoms are open. Thus, late spring or early fall frost can damage plants unless protective

measures are employed. Overhead irrigation is used to mediate spring frosts. Irrigation also promotes maximum fruit yield by relieving drought stress (and possible bush mortality) in dry seasons. Irrigation is important because blueberry root systems are shallow and lack root hairs; this puts them at a disadvantage when surface soil dehydrates due to high temperatures and/or lack of rain. Drought during fruit ripening reduces fruit size and may affect fruit flavor.

Areas with high temperatures are not suitable for blueberry production as both flower and vegetative buds require a period of dormancy at temperatures below 45°C for 600 to 1,000 hours before resuming growth the next season.

Fruit development occurs for the two to three months following bloom. Blueberry requires an average growing season of 120 to 160 degree days depending upon cultivar, plant vigor, and growing conditions. Highbush varieties begin to ripen in New Jersey in late June. Blueberry varieties are classed according to when ripening season occurs as *early*, *early midseason*, *midseason*, *late midseason*, and *late*. New Jersey supplies eastern fresh markets for the eight-week harvest period by growing at least six varieties with a succession of different ripening dates. Varieties commonly raised in New Jersey include: *Earliblue*, *Collins*, *Blueray*, *Bluecrop*, *Berkely*, *Herbert*, *Coville*, *Jersey*, *Darrow*, and *Weymouth*.

Blueberry harvest in New Jersey begins in early June, and typically lasts for several weeks depending upon temperature. Highbush blueberries will be of best quality when picked every five to seven days. Most growers use mechanical harvesters rather than hand picking. Both blueberries and insects are indiscriminately vibrated off the bushes when mechanical harvesters are employed. Since there is a 'zero tolerance' for the presence of pests when berries are destined for fresh market, growers must take control measures. If the berries are processed on a cleaning belt prior to being packaged into pints, these fringe insect pests can be removed. Otherwise, growers that harvest directly into pints must control these fringe insects in their fields to meet the zero tolerance.

Integrated pest management is integral to blueberry productivity in New Jersey. Cultural practices such as annual pruning of dead wood and older canes help to maintain plant vigor, eliminate disease inoculum, and reduce populations of bud mites and scale insects. Field sanitation and cultivation are practiced to diminish ground sources of insect, disease, and weed pests. Rutgers Cooperative Extension publishes annual pest control guidelines that correspond to seven stages of the blueberry plant growth cycle. Specifically, the stages characterized are: dormant, budbreak, pre-bloom, bloom, post-pollination, fruit maturation/harvest, and post-harvest. This alerts growers to key periods of possible pest activity.

New Jersey blueberry growers rely upon insect monitoring and economic thresholds to determine the appropriateness and timing of chemical controls. During the growing season, fields are scouted for pests from April 1st to August 30<sup>th</sup> as part of the Blueberry Integrated Crop Management program in New Jersey. Scouts monitor fields to determine presence and number of pests using a variety of techniques. Based upon scouting reports and anticipated pests, growers receive weekly advisories in Rutgers Cooperative Extension's [Blueberry Bulletin](#) on cultural, biological, and chemical pest controls.

Insecticides toxic to bees should not be applied during bloom when pollinators are active. Blueberry growers must be strictly observant of label restrictions due to toxicity of pesticides to pollinators. Many pesticides for blueberry are specifically prohibited from use during bloom. Further, pesticides that are extremely toxic to bees should not be applied to blossoms at any time because even their residue is toxic to bees. These include: diazinon, azinphos-methyl, phosmet, carbaryl, methomyl, and Malathion D. Malathion EC is also highly toxic; but it can be sprayed with caution late at night when plants are in bloom. Pesticides used on blueberry of moderate toxicity to bees that may be sprayed only late at night, night, or early morning include: superior oil and simazine. Pesticides used on blueberry with slight or no toxicity to bees include: benomyl, captan, diuron, lime-sulfur, paraquat, and terbacil.

New Jersey growers typically supplement natural honeybee populations and enhance pollination during bloom by using domesticated honeybees at a rate of one hive per acre of blueberries. Honeybee hives are typically placed in New Jersey fields when three percent of *Weymouth* variety flowers are open, rather than on a specific date. Thus, bees are released to coincide with bloom so they don't migrate elsewhere. This typically occurs in early April to May in New Jersey.

The most fruitful blueberry canes are four to six years old and 1 to 12 inches in diameter at the base. As a plant ages, it produces more and more lateral growth, unless canes are pruned. Pruning initiates new cane growth, rather than extended lateral growth. Blueberry require regular pruning to increase yields and fruit size by producing more strong wood. It takes eight to twelve years for blueberries to reach full production. Properly managed plantings will yield 400 to 800 lbs/acre the third season and 1,400 to 2,000 lbs/acre by the fourth year. Full crops of 4,000 to 6,000 lbs/acre are generally harvested after six to eight years, although mature plantings can yield in excess of 10,000 lbs/acre under optimal conditions. Well-maintained blueberry bushes remain productive for at least 15 to 20 years.

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## Insect and Mite Pests of Blueberry

Arthropods that attack blueberries may be classified into two groups: direct and indirect pests. Direct pests reduce blueberry crop yield by feeding on flowers, buds, and/or fruit. These pests cause the most severe economic losses because they reduce the yield of marketable fruit. Those direct pests active just after bloom represent the greatest potential injury to a blueberry crop because they damage the fruit. Alternately, indirect pests feed on leaves, stems, or roots. Although indirect pests may somewhat impact yield, they appreciably diminish the vigor and longevity of a field planting.

### ***Common Insect and Mite Pests of Blueberry in New Jersey***

Insect pests of blueberry in New Jersey versus other parts of the nation vary in terms of relative importance. Significant direct insect pests in blueberry plantings in New Jersey are the **blueberry maggot/fly**, and **cranberry fruitworm**. Other direct insect pests of blueberry crops in New Jersey include **plum curculio**. Direct pests sporadically troublesome to New Jersey blueberry include **blueberry bud mite**, **gypsy moth**, and **spanworms**.

Scale insects, including **Putnam scale** are common indirect pests of blueberry. **Leafrollers**, **blueberry leafminer**, and **fall webworm** are 'fringe insects' that have become indirect pests in New Jersey when mechanical harvesting is used. Insects that are vectors of disease are another type of indirect pest to blueberry. The **sharp-nosed leafhopper** is the only known carrier of blueberry stunt disease, and a common pest of New Jersey blueberry. **Blueberry aphids** are vectors of virus, including Red Ringspot disease.

Some insects, including **scarab beetles** like the **Japanese beetle**, are both direct and indirect pests in New Jersey.

Significant insect pests for New Jersey blueberry are listed directly below (in order of significance).

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#### **Blueberry maggot/fly (*Rhagoletis mendax*)**

- **Biology:** There is one generation per growing season of this **direct** pest. Blueberry maggots overwinter in the soil below blueberry bushes enclosed in a brown puparium buried one to two inches deep in the soil. They lay dormant until environmental conditions are suitable to emerge as adults (early June for New Jersey).
- Female blueberry maggot flies do not begin laying eggs until about 10 days after emergence, typically corresponding to when the blueberry fruit turns blue. Flies lay one egg per berry under the fruit skin. The egg hatches in five to seven days. Maggots feed for about three weeks inside ripening and harvested fruits. Infested fruits are soft and drop to the ground. The cycle is perpetuated as these larvae then pupate in the soil under the bushes from which they have dropped.
- Maggot-infested berries cannot be separated from sound berries during harvest and packing, and maggots may emerge from the berries at the point of sale. Blueberry maggot is the most significant blueberry pest in New Jersey because processors will reject any load of blueberries in which they discover a single maggot. This zero tolerance makes it essential for growers to be certain that their fruit is free of maggots.
- Further, continuous migration from the wild makes it difficult to keep cultivated blueberries free of maggots if they are grown near areas containing stands of wild plants.
- **Cultural Control Practices:** Disking can reduce the population of pupa.
- Determining the onset of adult fly activity is essential to the control of blueberry maggot, as protective sprays must be applied in the 7 to 10 day period before oviposition begins. As part of the Blueberry Integrated Crop Management program in New Jersey, fields are actively scouted from April 1<sup>st</sup> to August 30<sup>th</sup>.
- Regular monitoring of blueberry maggot emergence is done with yellow baited sticky traps. A trap and lure system has been developed that increases blueberry maggot fly capture. Pherocon AM yellow sticky boards baited with ammonium acetate, and green or red spheres baited with ammonium acetate work effectively in monitoring (and possibly suppressing) the blueberry maggot fly. The trap system is not sufficient to control the insect population; but it can provide guidance for growers in planning spray schedules. If high numbers of flies are captured, chemical control may be needed. Trapping serves three purposes: to detect blueberry maggot populations before they reach a damaging level; to optimize timing of insecticide sprays; and to reduce the amount of insecticide applied by spraying only those areas actually infested.
- Research has shown that some varieties of blueberry are more susceptible to blueberry maggot fly than others. Early cultivars showing some resistance or non-preference by these flies are *Earlyblue* and *Bluetta*.
- **Biological Controls:** Parasitism and predation do not effect maggot infestation, so pesticides are needed to produce clean fruit.
- **Chemical Controls:** Chemical control of the blueberry maggot egg or larvae is not effective once the egg is laid (and thus protected) inside the fruit. Alternately, pre-harvest sprays of malathion can control adults. Treatment

should be initiated within 10 days after the first maggot adult catch by scouts; this is usually the third week of June in New Jersey. Registered insecticides for use against blueberry maggot fly include: malathion, diazinon, phosmet (organophosphates), and carbaryl and methomyl (carbamates). Applications are repeated every ten days through harvest. New Jersey growers are advised to spray at least five gallons of spray mix per acre when aerial spray is employed to ensure adequate coverage.

- **Alternatives:** There are no effective cultural or biological alternatives to the organophosphate and carbamate insecticides currently used to control these major pests of blueberry in New Jersey. It is predicted that losses would be great and many growers reported they would be unable to produce marketable crops.

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#### **Cranberry fruitworm (*Acrobasis vaccinii*)**

- **Biology:** The cranberry fruitworm is a serious **direct** pest of blueberries in the eastern U.S. (It is notable that the cranberry fruitworm is considered a major pest of blueberry but rarely found on cranberry in New Jersey; the direct opposite is found in Massachusetts). Some fields have suffered 50 to 75% losses of fruit, with earlier varieties usually being the most infested.
- Cranberry fruitworm overwinter as fully-grown larva encased in a hibernaculum. Adults emerge and deposit eggs singly at the blossom end of berries. The larvae pupate in the spring and complete their development. Adult moths emerge, mate, and lay eggs in mid-June to late July coinciding with blueberry bloom through fruit set. Adults are small, night-flying moths with dark grayish-brown wings. The eggs are deposited on the berries, almost always on or inside the calyx cup (blossom end) of unripe fruit. Eggs hatch in about five days.
- Young larvae move to the stem end of the fruit, enter, and feed on the flesh. A single larva may feed within as many as eight berries in completing its development. They move within a cluster, from one berry to another, and usually web the berries together with silk. The character of injury by the cranberry fruitworm is very different compared to other fruitworms. Specifically, the frass of the larvae fills the tunnels in the berries and clings to the silk webbing, producing very messy feeding sites, which easily distinguish cranberry fruitworm damage from others. Once larvae are fully-grown, they drop to the ground and spin a hibernation chamber where they overwinter under the soil surface. There is only one generation per year.
- **Cultural Control Practices:** Weedy unkempt plantings, as well as stands of wild blueberries and cranberries are likely to have higher populations of cranberry fruitworm. Plantings in proximity of these are more likely to have problems with this pest. Bed sanitation can be helpful by removing debris that would otherwise protect overwintering cocoons of fruitworm larvae.
- Cranberry fruitworm-infested berries are easily distinguished since they ripen early and are webbed. So, handpicking is practicable on small plantings with light infestation. This is not practical in large plantings where fruitworm-infested berries may be harvested without detection, resulting in larvae contamination of packaged berries.
- **Biological Controls:** *Bacillus thuringiensis* (Bt) can be used to control cranberry fruitworm. Bt may be used effectively early in the season at egg hatch to control newly hatched first instar larvae. Growers with blueberry crops with cranberry fruitworm infestations during bloom can use Bt safely in the presence of pollinating bees. Bt is moderately effective if weather conditions are right following application.
- **Chemical Controls:** Phosmet, carbaryl, azinphos-M, or diazinon (organophosphates), or methomyl (a carbamate) all provide adequate control when application timing is appropriate. The control period often extends seven to eight weeks and begins prior to complete petal fall. None of the aforementioned insecticides may be used during the pollination period. Applications 10 and 20 days after blossom drop are important to control severe infestations of cranberry fruitworm. In states where cherry fruitworm is also a problem, carbaryl provides excellent control of cherry fruitworm and is preferred where cranberry fruitworm and cherry fruitworm are both present.
- **Alternatives:** Cultural or biological alternatives for control of cranberry fruitworm in blueberry in New Jersey would be not be universally adequate in the absence of the organophosphate and carbamate insecticides currently used.

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#### **Blueberry bud mite (*Acalitis vaccinii*)**

- **Biology:** Blueberry bud mites are **direct pests** that attack and destroy the buds of blueberry plants in late winter and early spring (before bloom). Blueberry bud mites feed throughout the winter on flower buds; this injured tissue swells with distinctive red blisters on in early spring. Developing fruit is also subject to feeding injury; the affected berries appear roughened or misshapen and also display the characteristic red blisters.
- The extent of damage varies from year to year and site to site. *Weymouth* and *Berkeley* varieties have recently shown an increase in the number of fruit buds attacked by bud mites. *Burlington* reportedly escapes damage by this pest. Population growth appears to be greatest during cool weather, and consequently, bud injury tends to be most severe following a mild winter. Persistent feeding by large mite populations may result in irreversible damage by mid-August.

- **Cultural Control Practices:** Recently, pruning styles in New Jersey have changed to accommodate mechanical harvesting. Older canes are retained, making conditions more favorable for blueberry bud mite. Pruning out old canes prevents heavy bud mite infestations.
- **Biological Controls:** Bud mites are controlled by oil sprays applied post-harvest from September 15<sup>th</sup> to 30<sup>th</sup>.
- **Chemical Controls:** The use of endosulfan (rather than oil spray) is recommended post-harvest if bud mite is the only concern.
- **Alternatives:** Cultural and biological alternatives for control of these pests of blueberry in New Jersey would be adequate. The practice of pruning out old canes is being re-established in New Jersey.

#### Cranberry weevil (*Anthonomous musculus*)

- **Biology:** It is notable that the cranberry weevil is considered a major **direct pest** of blueberry but rarely found on cranberry in New Jersey; the direct opposite is found in Massachusetts. It is alternately called the 'blueberry blossom weevil'.
- Cranberry weevil adults overwinter under the shelter of debris and fallen leaves. As they become active, adults cut into swelling fruit and leaf buds. Cranberry weevil lay eggs into the flower buds of blueberry in early summer, and emerge as adults in mid-July. Specifically, eggs hatch in three to nine days, typically the last half of June. Larvae develop as they consume the flower bud. They then pupate within the flower bud, reaching maturity in about ten to fourteen days. Buds easily break off the vine when shaken if cranberry weevil is present.
- There is evidence that there are least two complete generations of cranberry weevil in both New Jersey and Massachusetts. The second generation is thought to feed on the blueberry leaves.
- **Cultural Control Practices:** Removal of debris from under bushes minimizes hiding places for overwintering weevil adults.
- **Biological Controls:** None.
- **Chemical Controls:** Phosmet or azinphos-methyl (organophosphates), or esfenvalerate (a synthetic pyrethroid) are applied at budbreak when the leaf buds show green, and the blossom buds show white and are separating in the cluster. These same insecticides may be applied at pre-bloom, just before early blossoms open.
- **Alternatives:** EPA issued a Section 24(C) special local need for Asana XL (efenvalerate) for use on blueberry in New Jersey in 1995 that is effective five years from the date of issue.

#### Gypsy moth (*Lymantria dispar*)

- **Biology:** There is a single generation per year. As many as 800 eggs are fastened in a clustered 'egg mass' to canes low in the bush. Overwintering eggs are often killed extensively in northern New England when temperatures drop below 25°C.
- Gypsy moth larvae hatch in late spring to early summer, and emerge to feed in the blossom cluster of the blueberry flower, especially on the main stem. In New Jersey, these gypsy moth caterpillars then enter the pupal stage during June, and adult moths emerge after 10 to 14 days.
- Blueberry crops in New Jersey are not subject to gypsy moth infestations under typical conditions. However, gypsy moth can become very destructive if heavily infested areas are nearby and larvae are blown into fields at flowering time. This occurs by wind drift of newly hatched larvae, dropping of larvae from overhanging trees, and crawling of later stage larvae onto fields from surrounding tracts. This **direct pest** has now become a problem for some Ocean, Burlington, and Atlantic County commercial crops where gypsy moth-infested oak trees are prominent along edges of blueberry fields. In most cases larvae are present along the edges of the field.
- **Cultural Control Practices:** Destruction of gypsy moth eggs should be part of the pruning process as the eggs are easily spotted in blueberry. Specific attention should be given to the perimeter of blueberry fields adjacent to infested areas.
- **Biological Controls:** If the larvae are abundant, bacterial spray of *Bacillus thuringiensis* (Bt) during at pre- and mid-bloom is necessary to prevent significant crop damage. Specific attention should be given to the perimeter of blueberry fields adjacent to infested areas.
- **Chemical Controls:** Tebufenozide (Confirm 2F) is an option for control when gypsy moth infestation is apparent; specific attention should be given to the perimeter of blueberry fields adjacent to infested areas. It received a Section 24(C) special local need registration in April 1999. It can be used on blueberry during bloom since it is not toxic to bees.
- **Alternatives:** None.

#### Plum curculio (*Conotrachelus nenuphar*)

- **Biology:** Plum curculio adults overwinter in debris. Adults become active in May in New Jersey, and feed on flowers and fruit. Female plum curculios cut a characteristic crescent-shaped wound in the green fruit before laying an egg. Developing larvae burrow into the fruit pulp for about two weeks, causing infested berries to ripen

early and to fall to the ground. Mature larvae enter the ground, pupate, and emerge as adult snout beetles in approximately one month. After several weeks of active feeding, these adults will enter diapause. Plum curculio infestations are increasing in New Jersey, especially in some areas of Atlantic County.

- **Cultural Control Practices:** Plum curculio infestations are more common in weedy fields and those under sod culture. Blueberry varieties of *Weymouth*, *Earliblue*, *Bluetta*, and *June* are the only varieties heavily attacked by this **direct pest** in New Jersey. In these varieties, curculio larvae may be present in ripe fruit at harvest time. Later varieties are very rarely infested and when they are, the berries usually drop to the ground before harvest.
- **Biological Controls:** None.
- **Chemical Controls:** Methomyl, malathion, or diazinon are recommended for application during the first post-pollination spray if plum curculio is found to be a problem. Organophosphates azinphos-methyl, phosmet, and diazinon all offer good control. Carbamates methomyl and carbaryl, and organophosphate malathion are weak against plum curculio.
- **Alternatives:** None. Cultural or biological alternatives for control of these pests of blueberry in New Jersey would not be adequate in the absence of the organophosphate insecticides currently used.

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#### **Scale** (including Putnam scale)

- **Biology:** Putnam scale (*Diaspidiotus ancyclus*) is the most common scale to attack blueberry. This **indirect pest** feeds on plant sap, reducing bush vigor and fruit yield. Damage is worse on older bushes and branches, where rough bark provides protection from sprays. Some *Bluecrop* variety blocks in New Jersey blueberry fields have shown heavy Putnam scale infestations. Adult scales are protected from insecticides by waxy coverings. Control measures, therefore, must be aimed at unprotected immature 'crawlers' (by insecticides), or the overwintering stage (by dormant oil).
- **Cultural Control Practices:** The retention of older canes to accommodate mechanical harvesting is making conditions more favorable for Putnam scale. Pruning out old canes weakened by scales prevents heavy infestations.
- **Biological Controls:** Heavy Putnam scale infestation requires oil sprays. Dormant oils are effective on the overwintering stage of most species, but they can only be applied in early spring before leaves appear. Superior oil is applied from dormancy to 0.25 inch leaf opening using a handgun for best control. Oil spray will control Putnam as well as other scales. Thorough coverage is necessary for oil to be an effective control.
- **Chemical Controls:** During the summer, control requires accurate identification of the pest species so that hatching dates of crawlers can be determined. Once the pest is identified and proper timing known, insecticides can be used. Lime-sulfur is applied in lieu of oil when *Phomopsis* as well as scale is a problem. Both superior oil and lime sulfur can be phytotoxic if applications are made once buds are showing more than 1/4 of an inch of green tissue.
- **Alternatives:** Cultural and biological alternatives for control of these pests of blueberry in New Jersey currently provide adequate control.

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#### **Spanworms** (Lepidoptera: Geometridae)

- **Biology:** Blueberry plants that have been attacked by spanworms usually have large **irregular holes** chewed in the flower buds. Most of these buds turn brown and die. They continue feeding in early spring as the buds expand and begin to bloom. These **direct** pests often consume entire flower clusters prior to fruit set. Spanworms attack and destroy the buds of blueberry plants in late winter and early spring (before bloom). The extent of damage varies from year to year and site to site.
- **Cultural Control Practices:** None.
- **Biological Controls:** It is documented that a complex of natural enemies adequately controls spanworms. If warranted, spanworms are suppressed with a pre-bloom and/or mid-bloom spray of a formulation of *Bacillus thuringiensis* (Bt).
- **Chemical Controls:** Spanworms are not usually numerous enough in New Jersey blueberry to warrant chemical control. However, Confirm 2F (tebufenozide) is a new reduced-risk insecticide recommended in New Jersey pest control guidelines on blueberry when spanworm feeding damage or threshold is reached. It can be used during bloom since it is not toxic to bees.
- **Alternatives:** Cultural or biological alternatives for control of spanworm in blueberry in New Jersey are currently adequate.

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#### **Japanese beetle** (*Popillia japonica*) and other scarab beetles

- **Biology:** The adult *Popillia japonica* beetle is about one-half inch long and copper-colored, with metallic green markings and tufts of white hairs on the abdomen. They typically emerge in midsummer at blueberry harvest time and feed on blueberry fruit as well as the upper surface of blueberry foliage. Leaves are typically skeletonized during mid to late summer. These **direct pests** cause significant yield loss via feeding injury to the berries and

associated decay from fruit-rotting pathogens. Adults live four to six weeks and females deposit eggs for most part of this period. Females lay between 40 to 60 eggs during their life. Eggs hatch in about two weeks and larvae require five to seven weeks to reach the mature, third instar stage.

- Scarab grubs live in the top four to six inches of the soil, feeding mostly on the roots of blueberries, grasses, and weeds. These **indirect pests** thereby cause a weakening of the plants. They can be a problem in weedy fields or where sod culture is practiced. Other scarab grubs, including those of the oriental beetle (*Exomala orientalis*) and Asiatic garden beetle, have become more common in New Jersey fields in recent years.
- Adult beetles can also be **indirect pests**. If mechanical harvesting of blueberry fruit is used, these beetles can easily be vibrated off the bushes with berry clusters and contaminate fruit. Since there is a zero tolerance for Japanese beetles in processing blueberries, careful watch at the cleaning belt is warranted. The adults are hard to remove because they are similar in weight and size to blueberries. Adult beetles will quickly re-infest sprayed fields.
- **Cultural Control Practices:** Currently, no effective control measures are available against adult Japanese beetles. To help avoid problems with scarab grubs, fields should be allowed to lie fallow at least one year before planting, with repeated disking in hot weather to destroy any living roots, as well as pupae in the soil.
- Pheromone traps placed near plantings are effectively used for monitoring emergence of adult beetles. Alternately, the use of traps as a management technique has not provided an adequate control, and exacerbates the problem by attracting more beetles to the site than would have *Heterorhabditis* spp., are being studied for control of these root-feeding grubs. Treatment of nearby lawn areas should reduce the numbers of beetles. *Bacillus popilliae* is a registered bacterial insecticide employed in the control of such pests in turf; this control does not provide quick knock down for acute infestations.
- **Chemical Controls:** There are currently no registered insecticides for use in blueberry plantings for control of the grub stage in soil. If these larval populations are not suppressed by ecological or biological factors, foliar sprays may be subsequently applied in an effort to control emerging adult beetles to protect ripening fruit. Organophosphate malathion, typically used as a maggot spray, is not effective against these beetles. While several insecticides could provide good control of adult beetles, only those with relatively short re-entry interval (e.g., phosmet) are typically used due to the frequency of harvest. Carbaryl is registered for use as a foliar spray for adult beetle control, and is considered the only alternative where these insects are abundant. The use of this carbamate insecticide as a primary control for adult Japanese beetles has been hampered due to the extension of its pre-harvest interval to seven days. The alternative pesticide is phosmet, which has a shorter three-day interval.
- **Alternatives:** Cultural or biological alternatives for control of these pests of blueberry in New Jersey would not be adequate in the absence of the organophosphate phosmet currently used. In surveys undertaken during 1995 and 1996, the **Oriental beetle** was found to be the predominant grub species found in a majority of locations surveyed in Atlantic and Burlington Counties. The current adulticides only provided control with direct contact and were generally ineffective. Due to the absence of an insecticide for grub control, EPA authorized emergency use of imidacloprid (Admire 2F) on blueberries to control the Oriental beetle in New Jersey; this Section 18 emergency exemption extended for the period May 14, 1999 to August 15, 1999, and extended for the period May 10, 2000 to August 10, 2000.

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#### **Blueberry leafminer (*Gracilaria vacciniella*)**

- **Biology:** This **indirect pest** is both a leafminer and leafroller. In its early larval instars, it is a true leafminer, feeding between the upper and lower epidermis of the blueberry leaf. It then migrates out of the mine and becomes a leafroller, forming a neat triangular tent within which it feeds (this tent resembles a tepee, which has suggested the name of "tepee maker" for this insect).
- There is no feeding on blueberries, but the triangular "tepee" is easily vibrated off the bush during mechanical picking. Since this pest has three generations a year, tremendous numbers of blueberry leafminer can be found in some New Jersey fields by autumn.
- **Cultural Control Practices:** Ordinarily, the blueberry can sustain a very high population of these insects without appreciable reduction of the crop potential. However, the tendency of the larvae to contaminate the pints is problematic. As with leafrollers, passage of berries over a cleaning belt is indicated.
- **Biological Controls:** Monitoring and timing of controls is critical. This pest is most vulnerable when first hatching. Bacterial insecticide, such as *Bacillus thuringiensis* (Bt), is typically applied at mid-bloom to control the early hatching leafminers detected by monitoring.
- **Chemical Controls:** The organophosphate malathion is no longer effective against these insects. The carbamate methomyl, or the organophosphates diazinon, azinphos-M, or phosmet may be substituted for maggot treatments where these fringe insects have become a problem. Diazinon is the preferred insecticide for post-pollination application when leafminer is the primary problem.
- **Alternatives:** Monitoring and timing of biological and cultural controls are critical to be effective.

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## Leafrollers

- **Biology:** At least five species of leafroller attack blueberry in New Jersey. The oblique-banded and red-banded leafrollers are the most abundant of these. Specifically, they attack young shoots, leaves, and flower clusters of the blueberry. Leafrollers feed on a wide variety of plants commonly found around blueberry fields, and can become numerous enough to cause problems, especially where mechanical harvesters are used. There is no feeding on blueberries, but the triangular "tepee" is easily vibrated off the bush during mechanical picking.
- **Cultural Control Practices:** Ordinarily, the blueberry can sustain a very high population of these **indirect pests** without appreciable reduction of the crop potential. However, the tendency of the larvae to contaminate the pints is problematic. As with leafminers, passage of berries over a cleaning belt prior to packaging is indicated.
- **Biological Controls:** Monitoring and timing of controls is critical. This pest is most vulnerable when first hatching. Bacterial insecticide, such as *Bacillus thuringiensis* (Bt), is typically applied at pre- and/or mid-bloom to control the early hatching leafrollers detected by monitoring.
- **Chemical Controls:** The organophosphate malathion is no longer effective against these leafrollers. The carbamate methomyl, or the organophosphates diazinon, azinphos-M, or phosmet may be substituted for maggot treatments where these fringe insects have become a problem. However, these four insecticides are not used during bloom because of their toxicity to bees. But, Confirm 2F (tebufenozide) is a new reduced-risk insecticide recommended in New Jersey pest control guidelines on blueberry when leafroller damage or threshold is reached. It can be used during bloom since it is not toxic to bees. It received a Section 24(C) special local need registration including use for control of variegated, oblique-banded, and red-banded leafrollers in New Jersey blueberry in April 1999.
- **Alternatives:** Monitoring and timing of biological and cultural controls are critical to be effective. Bt is effective at early instar stages only. Both biological and chemical controls have limited efficacy on leafrollers once webbing and sheltering begins.

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## Fall webworm (*Hyphantria cunea*)

- **Biology:** Fall webworm is a minor **indirect pest** that occasionally attacks blueberries. Caterpillars build a loosely constructed webbed tent on the ends of infested branches, and are visible in late summer. Although these insects cause unsightly messes, they have rarely caused significant damage. They present a problem only in mechanically harvested fields where berries are not passed over a cleaning belt prior to packaging.
- **Cultural Control Practices:** Passage of the berries over a cleaning belt is indicated prior to packaging for fresh market sale.
- **Biological Controls:** Summer foliar sprays of *Bacillus thuringiensis* var. *kurstaki* control this minor pest.
- **Chemical Controls:** The organophosphate malathion is no longer effective against these insects. The carbamate methomyl, or the organophosphates diazinon, azinphos-M, or phosmet may be substituted for maggot treatments where these fringe insects have become a problem.
- **Alternatives:** Monitoring and timing of biological and cultural controls are critical to be effective.

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## Blueberry aphids (*Fimbriaphis fimbriata*) and (*Illinoia pepperi*), and the green peach aphid (*Myzus persicae*)

- **Biology:** Blueberry aphids can **indirectly** damage blueberry in the process of feeding as a virus vector. These three species of aphid have recently become abundant in some New Jersey blueberry fields. All three have been shown to be vectors of the Blueberry Scorch virus (BBSv). It is speculated that recent aphid infestation is the result of the destruction of natural predators of aphids by the organophosphate azinphos-methyl, as well as poor coverage afforded by insufficient aerial application.
- **Cultural Control Practices:** None.
- **Biological Controls:** None.
- **Chemical Controls:** Organophosphates malathion or diazinon, or the carbamate insecticide methomyl are the currently registered insecticides recommended for blueberry aphids. New Jersey growers are advised to spray at least five gallons of spray mix per acre when aerial spray is employed in order to insure adequate spray coverage.
- **Alternatives:** None. Inadequate control of aphids with the existing labeled insecticides resulted in the spread of Blueberry Scorch virus in New Jersey. Thus, EPA authorized the emergency use of Provado 1.6 F (imidacloprid) on blueberries to control blueberry aphids in New Jersey; this Section 18 emergency exemption extended for the period May 14, 1999 to August 15, 1999; it was re-issued for the period May 10, 2000 to August 10, 2000.

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## Sharp-nosed leafhopper (*Scaphytopius magdalenis*)

- **Biology:** Leafhoppers are abundant in the woods where they feed on wild blueberries and other Ericaceae. The sharp-nosed leafhopper is an **indirect pest of blueberry** because it transmits a phytoplasma that is presumed to

be the pathogen of blueberry stunt disease. Although there are other leafhoppers implicated in the spread of blueberry stunt disease, the sharp-nosed leafhopper is the primary vector in New Jersey.

- Leafhoppers pick up the pathogen by feeding on infected plants and then carry the disease to other plants in subsequent feedings. Eggs are laid in the tissues of fallen blueberry leaves. These overwintered eggs begin to hatch from mid-May, and nymphs reach adult stage in June after completing five instars. They complete two generations per year in New Jersey.
- **Cultural Control Practices:** None.
- **Chemical Controls:** Phosmet, malathion, azinphos-M, or diazinon (organophosphates); or methomyl or cabaryl (carbamates) are recommended insecticides for this pest in New Jersey. Fruitworm sprays if applied after petal fall usually control the first generation; maggot sprays if applied before harvest control the second generation. An application of malathion is recommended in late September or early October to control third generation sharp-nosed leafhoppers. Confirm 2F (tebufenozide) is a new reduced-risk insecticide recommended in New Jersey pest control guidelines on blueberry when leafhopper threshold is reached. It can be used during bloom since it is not toxic to bees.
- **Biological Controls:** None.
- **Alternatives:** Natural host plant resistance to the leafhopper has been found in several commercial cultivars of the rabbiteye blueberry and in selections from four other *Vaccinium* species that are not grown commercially. Efforts are currently underway to transfer this resistance into commercial highbush blueberries.

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## Other Blueberry Insect Pests

### Cherry fruitworm (*Grapholita packardii*)

- **Biology:** The cherry fruitworm is a **direct pest** of concern in other parts of the United States such as Rhode Island and Michigan. The cherry fruitworm has one generation per year. It overwinters as mature larvae in hibernacula on the tree. The larvae pupate in the spring with an average length of 29 days. The emergence of the first adult moths varies with seasonal conditions. The moth flight starts two to four weeks after petal fall and continues for two to three weeks. The moths are most active during dusk and late evening. The adult moths mate immediately after emergence, after which the female is ready to lay eggs. The eggs are laid on the unripe fruit and incubate in 10 days.
- The cherry fruitworm causes severe damage to ripening blueberries by boring into the fruit. This early injury can be detected shortly after hatching. A maturing larva may damage more than one fruit through feeding and produce unmarketable fruit.
- **Cultural Control Practices:** None.
- **Biological Controls:** None.
- **Chemical Controls:** None recommended in New Jersey pesticide control guidelines. However, Confirm 2F is labeled for use on blueberry for cherry fruitworm control.
- **Alternatives:** The cherry fruitworm is not considered a significant blueberry pest in New Jersey, and there are no State control recommendations for blueberry.

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### Blueberry tip borer (*Hendecaneura shawiana*)

- **Biology:** Eggs are laid on the underside of young blueberry leaves. Larvae enter the soft tips of the current year's wood channel into the wood. Thus, fruit production tips are damaged causing no fruit to be produced the following year.
- **Cultural Control Practices:** Rhode Island growers reportedly prune out damaged tips and burning infected canes.
- **Biological Controls:** None.
- **Chemical Controls:** This **direct** pest is of concern in other parts of the United States. General broad-spectrum insecticides such as malathion, cabaryl, phosmet, methomyl, and azinphos-methyl are reportedly effective in controlling this insect pest in Rhode Island.
- **Alternatives:** The blueberry tip borer is not considered a significant blueberry pest in New Jersey, and there are no State control recommendations for blueberry tip borer.

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### Cutworms (Lepidoptera: Noctuidae)

Cutworms attack and destroy the buds of blueberry plants in late winter and early spring (before bloom). The extent of damage varies from year to year and site to site. The **blueberry budworm**, *Rhynchagrotis anchocelioides* is a type of cutworm that develops in weeds under bushes. Their larvae may eat blueberry fruit buds. Although a pest elsewhere in the United States, cutworms are not considered a significant blueberry pest in New Jersey; accordingly, there are no State control recommendations.

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## Insect and Mite Controls

Monitoring thresholds are initiated to help growers determine whether chemical pest control is actually necessary to prevent economic damage to blueberry crops from occurring. In New Jersey, weekly scouting of fields is conducted from April 1<sup>st</sup> to August 30<sup>th</sup> in support of the Rutgers Cooperative Extension's (RCE) Blueberry Integrated Crop Management program. Accordingly, advisories and recommendations are then provided via a weekly Blueberry Bulletin and/or RCE staff.

### ***Common Insecticides and Miticides Used on Blueberry in New Jersey***

Insecticide applied to New Jersey blueberry in 1997 was compiled from grower records submitted to the Pesticide Control Program of the New Jersey Department of Environmental Protection (NJDEP). Growers reported use of ten insecticides on blueberry that year. The top seven insecticides applied to New Jersey blueberry in 1997, by order of total pounds active ingredient reported, were: malathion, diazinon, methomyl, Superior oil, azinphos-methyl, carbaryl, and phosmet. Significantly lesser amounts were reported for *Bacillus thuringiensis*, esfenvalerate, and imidacloprid. Several insecticides have been made available for use on blueberry under time-limited exemptions or registrations: esfenvalerate, imidacloprid, and tebufenozide.

Estimates of percent insecticide applied for 1997 do not include sulfur. For this crop profile, all sulfur applications were assumed to be for fungus control, rather than insect. Sulfur is registered in the United States by EPA for use as an insecticide, fungicide, and rodenticide on several hundred foods and feed crops, ornamentals, turf, and residential sites. It is also used as a fertilizer or soil amendment for reclaiming alkaline soils. New Jersey growers are not required to report the target pest when reporting their pesticide use to the Department of Environmental Protection. It is unknown if sulfur was applied for use as an insecticide or as a fungicide. Accordingly, the total pounds of sulfur reported (7,470.33 lbs ai) applied to blueberry in New Jersey in 1997 were included and computed as 'fungicide' rather than 'insecticide'.

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**Malathion** is a non-systemic, wide-spectrum organophosphate insecticide, suited for the control of sucking and chewing insects on fruits and vegetables, among others.

- **Formulations:** Malathion 8F, Malathion ULV, Malathion 8E, Malathion 57EC, Cythion.
- **Target pests:** plum curculio, blueberry aphids, sharp-nosed leafhopper, cranberry fruitworm, blueberry leafminer, leafrollers, blueberry maggot, and fall webworm.
- **Amount of active ingredient applied:** Malathion ranked first of insecticides used on New Jersey blueberry crops in 1997. A total of 7,347.75 pounds was applied; this was equivalent to approximately 33.46% of the insecticide and 11.67% of the total pesticide applied to the crop that year (NJDEP).
- **Type of applications:** Air blast sprayer or aerial application.
- **Application rates:** 1.5 to 2.5 pts product/A (i.e., 1.5 lbs ai/A to 2.5 lbs ai/A).
- **Numer of applications:** not available.
- **Timing:**
  - Since malathion is toxic to bees, all beehives are removed before it is applied.
  - Applied post-pollination for blueberry aphid and plum curculio
  - Applied at fruit maturation (July and August) for leafrollers, leafminer, and fall webworm.
  - Applied at 10-day intervals following the first maggot adult catch in the traps (usually in the third week of June) for blueberry maggot control. Repeated every 10 days until harvest.
  - Applied post-harvest for sharp-nosed leafhopper.
- **Re-entry interval:** 12 hours.
- **Pre-harvest interval:** 1 day.
- **Use in resistance management programs:** Maggots of some insects that were formerly well suppressed by malathion treatment have developed resistance to the chemical. These insects include leafminer, leafroller, and fall webworm. In these cases, it may be necessary to use diazinon, azinphos-M, or phosmet (organophosphates); or the carbamate methomyl as an alternative maggot spray.
- **Efficacy issues:** Malathion continues to provide good control of blueberry maggot, and is its primary use in New Jersey blueberry. It is the preferred organophosphate due to its short-residual time when maggot is the only pest of interest. Aerial application requires at least five gallons of spray mix per acre for adequate coverage.

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**Diazinon** is a non-systemic **organophosphate** insecticide used for the control a wide variety of interior and exterior pests, including sucking and leaf eating insects.

- **Formulations:** Diazinon 50W, Diazinon AG600.

- **Target pests:** sharp-nosed leaf hopper, cranberry fruitworm, blueberry leafminer, leafrollers, blueberry aphid, plum curculio, blueberry maggot, and fall webworm. (*In North Carolina, diazinon is used as a mound drench to control fire ants at active nest sites; this considered a major pest in blueberry production*).
- **Amount of active ingredient applied:** Diazinon ranked **second of insecticides** used on New Jersey blueberry crops in 1997. A total of 3,693.93 lbs active ingredient was used; this is equivalent to 16.82% of the insecticide and 5.86 % of the total pesticide applied (NJDEP).
- **Type of applications:** aerial or groundspray .
- **Application rates:** 1 lb ai/ A .
- **Number of applications:** 5-application maximum per growing season at 14-day intervals.
- **Timing:**
  - Applied post pollination for cranberry fruitworm, blueberry leafminer, and leafroller as diazinon is highly toxic to bees, fish, and birds.
  - First post-pollination spray applied specifically June 1<sup>st</sup> to 10<sup>th</sup> for the sharp-nosed leafhopper; subsequent post-pollination spray 7 to 12 days after first cover. Diazinon also controls blueberry aphids and plum curculio post pollination.
  - Applied at fruit maturation (July and August) for leafrollers, leafminer, and fall webworm. Applied at 10-day intervals following the first maggot adult catch in the traps (usually in the third week of June for New Jersey) for blueberry maggot control.
- **Re-entry interval:** 24 hrs.
- **Pre-harvest interval:** 7 days.
- **Use in resistance management programs:** not reported.
- **Efficacy issues:** Mixing formulations of diazinon with captan or Captec may cause crop injury. Therefore, diazinon and captan formulations should not be tank-mixed. Since diazinon is toxic to bees, all beehives are removed before it is applied.

**Methomyl** is a broad-spectrum carbamate, effective as both a contact and systemic insecticide.

- **Formulations:** Ferbam, Carbamate WDG, Lannate 90SP, Lannate LV (RCEy2k).
- **Target pests:** Sharp-nosed leafhopper, cranberry fruitworm, blueberry leafminer, leafrollers, blueberry aphids, plum curculio, fall webworm, and blueberry maggot.
- **Amount of active ingredient applied:** Methomyl ranked **third of insecticides** used on New Jersey blueberry crops in 1997. A total of 3,444.29 lbs active ingredient was used; this is equivalent to 15.69% of the insecticide and 5.47% of the total pesticide applied (NJDEP).
- **Type of applications:** Air blast sprayer.
- **Application rates:** Rate varies from 0.45 lb ai/A to 0.90 lb ai/A according to the target pest. When applied for the control of blueberry maggot alone, a lower rate of 0.225 lb ai/A is applied.
- **Number of applications:** 4-application maximum. Not to exceed 3.6 lbs ai/crop.
- **Timing:**
  - Since methomyl is highly toxic to bees by both direct contact and ingestion, it should not be used during bloom. All beehives are removed prior to application.
  - Applied post pollination for cranberry fruitworm, blueberry leafminer, leafroller, blueberry aphids, and plum curculio. First post-pollination spray applied specifically June 1<sup>st</sup> to 10<sup>th</sup> for the sharp-nosed leafhopper; subsequent post pollination spray 7 to 12 days after first cover.
  - Applied at fruit maturation (July and August) for leafroller, leafminer, and fall webworm. Applied at 10-day intervals following the first maggot adult catch in the traps (usually in the third week of June) for blueberry maggot control.
  - Applied post-harvest for sharp-nosed leafhopper.
- **Re-entry interval:** 48 hrs.
- **Pre-harvest interval:** 3 days.
- **Use in resistance management programs:** Used primarily as a rescue treatment to control major insect problems because of broad-spectrum control and short re-entry interval. May also be used to control organophosphate-resistant pests.
- **Efficacy issues:** Although translocated in plants following root absorption, malathion is not phytotoxic. Since methomyl is toxic to bees, all beehives are removed before it is applied. Methomyl is only labeled for commercial and farm plantings since it is a fast-acting contact insecticide; it is not appropriate for use in fields that may become 'pick-your-own' operations.

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## Superior Oil–

- **Formulations:**
  1. 70-second oil [viscosity at 66 to 74 seconds, gravity at 33 to 34 (A.P.I. degrees), and unsulfonatable residue is 92% or higher]; and
  2. 100-second spray oil [viscosity at 90 to 120 seconds, gravity at 32 minimum (A.P.I. degrees), and unsulfonatable residue is 92%].
- **Target pests:** 70-second superior oil is used on blueberry crops as a winter (dormant) oil for control of scale insects, and as a summer oil for the control of blueberry bud mites.
- **Amount of active ingredient applied:** Superior Oil **ranked fourth of insecticides** used on New Jersey blueberry crops in 1997. A total of 2,887.43 lbs active ingredient was used; this is equivalent to 13.15% of the insecticide and 4.58 % of the total pesticide applied (NJDEP).
- **Type of applications:** Best pest control results when the oil is applied using a handgun, applying the spray at a pressure of 300 to 400 psi. Thorough coverage is essential when using oil, because it only acts after coating the insect or mite.
- **Application rates:** 3.0 gal product per acre. For scale control, a minimum of 300 to 400 gallons of the oil spray mix is required for thorough coverage.
- **Number of applications:** It is usually applied once or twice per season at two to three gallons per acre.
- **Timing:**
  - Applied at dormancy to 0.25-inch leaf opening for control of scale;
  - Applied post harvest from September 15<sup>th</sup> to 30<sup>th</sup> in New Jersey for the control of blueberry bud mites.
- **Re-entry interval:** Re-entry can be made once when spray is dry.
- **Pre-harvest interval:** Pre-bloom.
- **Efficacy issues:** Superior oil cannot be used on very cold days as it may freeze before drying; it should be applied only when there is no danger of freezing for 24 hours. Otherwise, it may damage the plants. Lime-sulfur should be applied instead of Superior oil when *Phomopsis* as well as scale is a problem; it should not be used within 14 days of oil spray.

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## Azinphos-methyl–

- **Formulations:** Guthion 2L, Guthion 50WP, Azinphos-M 50W.
- **Target pests:** cranberry fruitworm, leafrollers, and blueberry maggot.
- **Amount of active ingredient applied:** Azinphos-methyl **ranked fifth of insecticides** used on New Jersey blueberry crops in 1997. A total of 1,750.47 lbs active ingredient was used; this is equivalent to 7.97% of the insecticide and 2.78% of the total pesticide applied (NJDEP).
- **Type of applications:** Air blast sprayer or aerial application.
- **Application rates:** 0.5 to 0.75 lbs ai/A.
- **Number of applications:** Regardless of rate or formulation used, only three azinphos-methyl sprays per season are allowed; spray interval is 10 days.
- **Timing:**
  - Azinphos-methyl is highly toxic to bees exposed to direct treatment or residues. It should not be applied to blossoms at any time.
  - Applied post pollination when cranberry fruitworm, and leafroller are a problem.
- **Re-entry interval:** 48 hrs.
- **Pre-harvest interval:** 7 days.
- **Use in resistance management programs:** Azinphos-methyl has been used in New Jersey for both pre- and post-bloom sprays for control of early season pest complex since it tends to be more active than other materials at low temperatures. However, aphids have recently become abundant in some New Jersey blueberry fields. It is speculated that this is the result of the destruction of natural predators of aphids by azinphos-methyl, as well as poor coverage afforded by insufficient aerial application.
- **Efficacy issues:** It is a highly persistent, broad-spectrum insecticide that works as both a contact insecticide and a stomach poison. Since it is non-systemic, it is used primarily as a foliar application against leaf feeding insects. But, adequate coverage of blueberry plants is important to maximize pest ingestion and contact.

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**Carbaryl** is a wide-spectrum carbamate insecticide, molluscicide, and acaricide.

- **Formulations:** Sevin 80WSP, Sevin 4F.
- **Target pests:** Sharp-nosed leafhopper, cranberry fruitworm, blueberry leafminer, leafrollers, blueberry maggot, Japanese beetle, and other scarab beetles. New Jersey growers are cautioned that the use of carbaryl may be detrimental to non-target beneficials, such as aphid predators.

- **Amount of active ingredient applied:** Carbaryl ranked sixth of insecticides used on New Jersey blueberry crops in 1997. A total of 1,523.69 lbs active ingredient was used; this is equivalent to 6.94% of the insecticide and 2.42 % of the total pesticide applied (NJDEP).
- **Type of applications:** Air blast sprayer or aerial application.
- **Application rates:** 1 to 2 lbs ai/A, depending upon target pest.
- **Number of applications:** Applications are repeated up to 5 times, at a minimum of a 7-day interval between sprays.
- **Timing:**
  - Not sprayed during pollination due to toxicity to pollinators.
  - Applied post pollination for cranberry fruitworm, blueberry leafminer, and leafrollers. Includes post-pollination spray for the sharp-nosed leafhopper applied specifically 7 to 12 days after first cover. Carbaryl (Sevin) is not recommended in New Jersey for use as a first post-pollination control.
  - Applied at fruit maturation (July and August) for leafrollers, leafminer, fall webworm, Japanese beetle, and other scarab beetles. Applied at 10-day intervals following the first maggot adult catch in the traps (usually in the third week of June) for blueberry maggot control.
- **Re-entry interval:** 12 hrs.
- **Pre-harvest interval:** 7 days. **Use in resistance management programs:** Rotated with organophosphate insecticides for early season control of the fruitworm leafroller complex. In states where cherry fruitworm is also a problem, carbaryl provides excellent control of cherry fruitworm and is preferred where cranberry fruitworm and cherry fruitworm are both present. Carbaryl was previously the primary Japanese beetle control when its PHI was a shorter 3 days. The recent label change of lengthening the PHI to seven days has reduced late season use on Japanese Beetle. Further, resistance of adult Japanese beetle to carbaryl has developed; this material no longer guarantees beetle-free fruit.
- **Efficacy issues:** Carbaryl works whether it is ingested into the stomach of the pest or absorbed through direct contact. Carbaryl is lethal to many non-target insects, including bees and beneficial insects.

**Phosmet** is a non-systemic organophosphate insecticide with a wide range of use, including fruit crops, ornamentals, and vines for the control of aphids, suckers, mites, and fruit flies.

- **Formulations:** Imidan 70WS.
- **Target pests:** cranberry weevil, sharp-nosed leafhopper, cranberry fruitworm, blueberry leafminer, leafrollers, blueberry maggot, and fall webworm.
- **Amount of active ingredient applied:** Phosmet ranked seventh of insecticides used on New Jersey blueberry crops in 1997. A total of 1,207.67 lbs active ingredient was reported; this is equivalent to 5.50% of the insecticide and 1.92% of the total pesticide applied (NJDEP).
- **Type of application:** air blast sprayer or aerial application.
- **Application rates:** 1.33 lbs product/ A (i.e., 0.931 lbs ai/A).
- **Timing:**
  - Phosmet is very toxic to honeybees, and therefore should not be applied during pollination.
  - Applied at budbreak (when leaf buds show green; blossom buds show white and are separating in the cluster) for cranberry weevil.
  - Applied at pre-bloom (just before early blossoms open) for cranberry weevil.
  - Applied post pollination for cranberry fruitworm, blueberry leafminer, and leafrollers. First post-pollination spray applied specifically June 1<sup>st</sup> to 10<sup>th</sup> for the sharp-nosed leafhopper; subsequent post-pollination spray is applied 7 to 12 days after first cover.
  - Applied at fruit maturation (July and August) for leafrollers, leafminer, and fall webworm. Applied at 10-day intervals following the first maggot adult catch in the traps (usually in the third week of June for New Jersey) for blueberry maggot control.
- **Number of applications:** A second application can be made for infestation control.
- **Re-entry interval:** 24 hours.
- **Pre-harvest interval:** 3 days.
- **Use in resistance management programs:** Phosmet is less toxic to beneficial insects than other organophosphate insecticides; its use is less likely to result in aphid infestations due to lack of beneficial control.
- **Efficacy issues:** Phosmet is the preferred organophosphate, relative to carbaryl, for Japanese Beetle and other late season pests because of its greater efficacy and relatively shorter PHI of 3 days.

#### **Bacillus thuringiensis (Bt)-**

- **Formulations:** Dipel, Dipel DF, Javelin DWG, Agree WG, Crymax.
- **Target pests:** gypsy moth, leafrollers, spanworms (loopers).

- **Amount of active ingredient applied:** Bt ranked a distant eighth of those insecticides used on New Jersey blueberry crops in 1997. A total of 48.43 lbs active ingredient was reported; this was equivalent to 0.22% of the insecticide and 0.08% of the total pesticide applied for the crop that year (NJDEP).
- **Type of applications:** Air blast sprayer or aerial application.
- **Application rates:** 1 lb/ A.
- **Number of applications:** not reported.
- **Timing:** It is used during bloom to control fruitworm complex, as it does not have the toxic effect on bees that the majority of pesticides do.
  - Applied at pre-bloom (just before early blossoms open) for leafrollers, spanworms, and gypsy moth. (RCEy2k).
  - Applied at mid-bloom for leafrollers, spanworms, and gypsy moth.
- **Re-entry interval:** 4 hrs.
- **Pre-harvest interval:** None; Bt may be sprayed up to and on the day of harvest for all formulations.
- **Use in resistance management programs:** not reported.
- **Efficacy issues:** These microbial insecticides are used for control of most lepidopteron larvae with high gut pH. To be effective, Bt must be eaten at the larval stage, as it is ineffective against adult insects; it is also not effective on later (therefore larger) instars of larvae. Less than lethal doses and weather conditions influence efficacy. For Bt treatment to be effective, thorough coverage is necessary, and fields should not be irrigated for 24 to 48 hours to prevent washoff of product.

**Fenvalerate** a synthetic pyrethroid insecticide used on a wide range of pests including moths, flies, and beetles.

- **Formulations:** Esfenvalerate, Asana XL. Asana XL was issued a **Section 24(C)** special local need registration for blueberry in New Jersey in 1995; this will remain in effect for five years from the date of issue.
- **Target pests:** cranberry weevil.
- **Amount of active ingredient applied:** A total of 10.40 lbs active ingredient was used on New Jersey blueberry crops in 1997; this was equivalent to 0.05% of the insecticides and 0.02% of the total pesticide applied (NJDEP).
- **Type of applications:** Applied to the ground.
- **Application rates:** 0.025 lb ai/A to 0.05 lb ai/A in a minimum of 50 gallons water per acre.
- **Number of applications:** A maximum of 0.2 lb ai/A per season.
- **Timing:**
  - Although toxic to bees as a spray, dried spray residues are not expected to pose a threat. However, it can act as a bee repellent and should not be used within one week of bloom.
  - Applied at budbreak (when leaf buds show green; blossom buds show white and are separating in the cluster) for cranberry weevil.
  - Applied at pre-bloom (just before early blossoms open).
- **Re-entry interval:** 12 hours.
- **Pre-harvest interval:** 14 days.
- **Use in resistance management programs:** Good alternative to organophosphate azinphos-methyl for resistance management.
- **Efficacy issues:** It may be mixed with a wide variety of other types of pesticides such as carbamate compounds or organophosphates. Esfenvalerate has replaced the naturally occurring compound fenvalerate for use in the U.S. The synthetic contains the same insecticidally active isomer; but proportionately more. As a result, esfenvalerate requires lower application rates than fenvalerate, is less chronically toxic, and is a more powerful insecticide.

**Imidacloprid** is a systemic, chloro-nicotinyl insecticide with soil, seed, and foliar uses for the control of certain sucking insects.

- **Formulations:** Provado 1.6F, Admire 2F.
- **Target pests:** blueberry aphids, Oriental beetle.
- **Amount of active ingredient applied:** New Jersey growers reported use of 7.15 pounds of the insecticide imidacloprid on blueberry in 1997; this is equivalent to 0.03% of the insecticide and 0.01% of the total pesticide sprayed (NJDEP).
- **Type of applications:**
  - Provado 1.6F for blueberry aphid control: Ground application of a minimum of 20 gallons spray mix per acre; five foliar applications; and aerial application in a minimum of five gallons spray mix per acre.
  - Admire 2F for Oriental beetle control: Ground application to soil of a minimum of 20 gallons spray mix per acre in an 18-inch band on either side of the rows of blueberry plants. Application through trickle irrigation system.

- **Application rates:**
    - Provado 1.6F for blueberry aphids: foliar application of 0.038 to 0.05 lb ai/A.; 0.24 to 0.30 lb ai/A.
    - Admire 2F for Oriental Beetle: 0.25 to 0.30 lb ai/A.
  - **Number of applications:** One ground application per season of Admire 2F; five foliar applications of Provado 1.6 F. Total applied by ground, aerially, or irrigation not to exceed a total of 0.2 lb ai/A per growing season.
  - **Timing:** Imidacloprid is highly toxic to bees if used as a foliar application, and should not be used during bloom; however, it is not a hazard to bees when used as a seed treatment.
  - **Re-entry interval:** 12 hours
  - **Pre-harvest interval:** not available.
  - **Use in resistance management programs:** Inadequate control of aphids with the labeled existing insecticides in blueberry resulted in the spread of Blueberry Scorch virus. EPA authorized time-limited emergency use of imidacloprid on blueberries under **Section 18 to control blueberry aphids in New Jersey** for the period May 14, 1999 to August 15, 1999; EPA extended this exemption for a second period of May 10, 2000 to August 10, 2000. IR-4 is expected to submit a tolerance petition in 2000.
  - **Efficacy issues:** not reported.
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**Tebufenozide** is a fat-soluble insecticide used to control lepidopterous pests in fruits, vegetables, and other crops. It mimics the action of the insect moulting hormone, ecdysone. Lepidopteron larvae cease to feed within hours of exposure and then undergo a lethal, unsuccessful moult.

- **Formulations:** Confirm 2F.
  - **Target pests:** Gypsy moth, spanworms, oblique-banded leafrollers, and red-banded leafrollers.
  - **Amount of active ingredient applied:** This reduced risk insecticide received a **Section 24 (C)** special local need registration for control of lepidopterous insects in blueberry in New Jersey in April 1999; this registration will be effective for five years from the date of issue. Accordingly, New Jersey growers did not report use of the insecticide tebufenozide on blueberry in 1997 (NJDEP).
  - **Type of applications:** Ground applications are made to blueberry by boom or airblast sprayer in a minimum of 30 gallons spray mix per acre. Aerial applications are made in a minimum of 10 gallons spray mix per acre.
  - **Application rates:**
    - Applied at 0.25 lb ai/A for oblique-banded and redbanded leafrollers, and cranberry or cherry fruitworm.
    - Applied at 0.06 to 0.12 lb ai/A for gypsy moth.
  - **Number of applications:** The total amount of active ingredient applied in a season to an acre of blueberry can't exceed one pound.
  - **Timing:** Confirm 2F can be applied during bloom since it is not toxic to honeybees.
    - Applied at pre-bloom (just before early blossoms open) for leafrollers, spanworms, and gypsy moth. (RCEy2k).
    - Applied at mid-bloom for leafrollers, spanworms, and gypsy moth.
    - Applied post pollination for cranberry fruitworm, blueberry leafminer, and leafrollers. First post-pollination spray applied specifically June 1<sup>st</sup> to 10<sup>th</sup> for the sharp-nosed leafhopper; subsequent post-pollination spray is applied 7 to 12 days after first cover .
  - **Re-entry interval:** 4 hours.
  - **Pre-harvest interval:** 14 days.
  - **Use in resistance management programs:** The manufacturer recommends that this product not be used on more than three successive generations of a given pest. Since tebufenozide is selective, it can be applied without harm to beneficials.
  - **Efficacy issues:** This insecticide is primarily effective by ingestion of treated plants; thus, thorough coverage of plants is important. Tebufenozide is best not applied within six hours of when rain is predicted to allow thorough drying of the application and minimal washoff. Application timing will relate directly to the feeding behavior (when and what part of the plant) for the target pests. Reapplication may have to be made when there is a flush of new plant growth. This reduced risk pesticide has no activity against honeybees and therefore can be used safely during pollination.
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**Endosulfan** is a type of chlorinated hydrocarbon called a cyclodiene.

- **Formulations:** Phaser 50 WSB, Thiodan 3 EC, Thiodan 50W.
- **Target pests:** Blueberry bud mite.
- **Amount of active ingredient applied:** Growers did not report application of endosulfan to blueberry in 1997.
- **Type of applications:** Ground application in a minimum of 10 gallons spray mix per acre; aerial applications with a minimum of 20 gallons spray mix per acre treated.
- **Application rates:** 1.5 lbs ai/A in 300 gallons of water.

- **Number of applications:** May be applied up to twice in a growing season, not to exceed 3 lbs ai/A.
- **Timing:** Applied immediately after harvest (typically September 15<sup>th</sup> to 30<sup>th</sup> for New Jersey), and repeated six to eight weeks later.
- **Re-entry interval:** 24 hours.
- **Pre-harvest interval:** not reported.
- **Use in resistance management programs:** not reported.
- **Efficacy issues:** Thorough coverage is essential. Endosulfan is applied after buds are well formed to target the winter-feeding blueberry bud mites.

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Use of insecticides when pest threshold levels are reached can prevent severe damage or infestation from direct fruit pests such as cranberry fruitworm and plum curculio. Further, they can be used to control serious indirect pests such as blueberry aphids or sharp-nosed leafhopper that are vectors of disease. In New Jersey, insecticide use on blueberry crops in 1997 was moderate to high at approximately 35% of the total pesticide applied to the crop that year. The top four insecticides (according to pounds of active ingredient) applied that year were **malathion** (7,347.75 lbs ai); **diazinon** (3,693.93 lbs ai); **methomyl** (3,444.29 lbs ai); and **superior oil** (2,887.43 lbs ai) .

Insecticides granted time-limited use by EPA have permitted New Jersey blueberry growers to minimize effects of recent pest outbreaks. This has included: Section 18 emergency exemptions for **imidacloprid** use on blueberry aphids and Oriental beetle; and 24(C) special local need registrations of **Confirm 2F (tebufenozide)** for control of lepidopterous pests, and **Asana XL (esfenvalerate)** for control of cranberry weevil.

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## Diseases of Blueberry

### *Common Diseases of Blueberry in New Jersey*

Fungal diseases tend to be the most serious in regions with long growing seasons and relatively high summer temperatures, such as are encountered in New Jersey. The most common diseases (and their causal organisms) found in New Jersey blueberry include: **primary** and **secondary mummy berry infection** (*Monilinia vaccinii-corymbosi*), **Phytophthora root rot** (*Phytophthora cinnamomi*), **Botrytis blossom blight and berry rot** (*Botrytis cinerea*), **Anthracnose fruit rot** (*Colletotrichum gloeosporioides*), **Alternaria leaf spot and fruit rot**, and **Phomopsis canker and twig blight** (*Phomopsis vaccinii*).

Cultural, biological, and chemical controls for diseases of blueberry are used together to minimize the spread of inoculum. Several techniques especially important for blueberry are: use of disease-resistant cultivars; pruning and field sanitation; and chemical control. New Jersey growers implement controls based upon monitoring reports and State advisories of disease conditions. A discussion of these controls relative to New Jersey blueberry production follows for each common disease.

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#### **Mummy Berry** (*Monilinia vaccinii-corymbosi*)

- **Biology:** The most serious disease of blueberry in New Jersey is mummy berry. The initial infection of leaf and flower buds is known as **primary infection**; the infection of the flowers that results in a dry rot that 'mummies' the fruit is known as **secondary infection**.
- The fungus overwinters in mummies from the previous season. In the spring, disease is spread via spores (ascospores) produced by fungal fruiting cups (apothecia) that grow from mummies that are either on or near the soil surface. Since spore production occurs shortly after buds open, this young tissue is susceptible to disease. Leaf and shoot growth expanding from newly opened leaf buds blacken in the center and eventually wilt and die; the death of the infected shoots is called **shoot blight** and typically develops during bloom. Spore production may last three weeks or more. Rain, wind, and insect pollinators spread the infection. Infection causes rapid deterioration and wilt in blueberry that often resembles frost damage.
- A second type of spore (conidia) is produced on blighted flowers and shoots three weeks later. These spores are spread to healthy flowers by wind, rain, and insects (including honeybees). Infected flowers turn brown and wither. Berries produced by infected flowers initially appear healthy, but as they near maturity (mid-summer in New Jersey), they become a reddish buff or tan color. Mature mummied berries are gray, shriveled, and hard. Typically, diseased berries drop off the bushes before healthy ones are harvested. Mummy berries may remain viable in or on the soil for years.
- **Cultural Control Practices:** Resident fungus becomes highly adapted to the cultivar of blueberry in the field such that the fruiting bodies of the fungus often emerge the same day that buds begin to show green tissue

susceptible to infection. Thus, it is critical to reduce inoculum levels prior to bud break with clean cultivation. Another effective cultural practice used to reduce infection spread is covering mummies with a new layer of mulch or soil at least two inches thick. The goal of cultivation and/or mulching is to remove or bury the mummies so they can't discharge spores that cause primary infection in young blueberry tissue. Thus, growers cultivate prior to mummy cup formation (typically the March 20<sup>th</sup> in New Jersey). In very small plantings, mummies can be raked up and burned. In larger plantings, mummies are buried by cultivation in (and disking between) rows.

- Native stands of blueberries can be another significant source of windblown spores. Eradication of wild blueberries in areas adjacent to the commercial fields will reduce the disease inoculum in the immediate vicinity. Cultivation supplemented with ground treatments of urea usually gives adequate control of the **primary phase** of mummy berry in most New Jersey blueberry fields. A urea mix consisting of 50% urea sprills and 50% inert material has been effective in destroying mummy cups on the ground. It is considered only a supplement to cultivation. Neither method is adequate by itself. Two hundred pounds of the mix furnishes 45 lbs of nitrogen per acre. Mature bushes at peak production require another 35 lbs. Good fertilization results have been obtained with application of 200 lbs of the mix in early April or late March, followed by 350 lbs of 10-10-10 fertilizer (with 2% magnesium) in late May.
- **Biological Controls:** None.
- **Chemical Controls:** Timely application of fungicide is key for protection against both primary and secondary phases of mummy berry infection. Fungicides are applied at bud break to protect against **primary** mummy berry infection. Triforine (Funginex) was previously the leading control used by New Jersey growers for mummy berry. However, the manufacturer voluntarily canceled its registration. Lacking other effective controls, time-limited emergency exemptions were granted for use of propiconazole (Section 18: 1999), and fenbuconazole (Section 18s: 1998, 1999, and 2000) to control mummy berry disease on blueberry in New Jersey.
- EPA issued a Section 24(C) special local need registration for ziram for control of **mummy berry shoot blight**, Phomopsis twig blight, Anthracnose, and Botrytis blossom blight in blueberry in New Jersey in 1998; this registration will be effective for five years from the date of issue.
- Several chlorothalonil formulations have been granted Section 24(C) registrations for control of mummy berry and Anthracnose in blueberry in New Jersey. Section 24(C) special local need registrations have been granted for use on blueberry in New Jersey for Bravo 720 and Bravo 825 (1996), and Bravo Ultrex and Bravo Weather Stik (1999). Each of these Section 24(C) registrations is effective for five years from date of issue.
- Benomyl (Benlate) is a systemic fungicide applied at bloom that protects the unfertilized flowers against **secondary infection** of the fruit and causes the mummification of the berry. If heavy spore loads are suspected, a second application can be made in 10 to 14 days till petal fall. No further secondary infection can occur once the petals have fallen and blueberry fruit is set.
- **Alternatives:** not reported.

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#### **Phomopsis canker and twig blight (*Phomopsis vaccinii*)**

- **Biology:** *Phomopsis* infects the wood of fruiting lateral branches of blueberry bushes, the stem of blueberry flower and fruit clusters, and more rarely, the wood of large blueberry canes. The disease is spread by conidiospores released from infected wood. The greatest numbers of spores are released during bloom and petal fall, and are spread by splashing rain from bud-break through late August during the growing season. Infection of twigs or canes is facilitated by injuries to the wood, particularly those caused by winter damage, mechanical harvesters, pruning, or early spring frosts. The most common symptom of *Phomopsis* is the drying of fruit and flowers as the wood below turns brown, cutting off moisture and nutrients. A *Phomopsis* canker appears as an elongated flattened necrotic area of disease. *Phomopsis* overwinters in infected twigs and canes. The disease is most prevalent after severe winters, especially when there is little snow cover, or after winters during which mild weather is interspersed with extreme cold. Under severe disease conditions, several canes may be affected on a single blueberry bush. After the stems have been infected for a season, they will wilt during the summer months. This one-year lag between infection and stem collapse makes detection of disease and subsequent control difficult.
- **Cultural Control Practices:** Control of *Phomopsis* in New Jersey currently depends largely on cultural methods. New Jersey growers are advised to avoid wounding plants during pruning, cultivating, and harvesting. It is reported that the best method to control *Phomopsis* in established fields in New Jersey is by thoroughly pruning infected stems and all small twiggy wood. Pruning can be done at any time infected stems are observed, but care should be taken to cut well below the infected area. Pruning not only removes infection from the bushes; it reduces the number of spores released. Avoiding stress will also help prevent this disease. So, it is especially important that blueberry are well watered through prolonged periods of dry weather in the summer due to their shallow root system. Also, the crop should not be fertilized in late summer.

- **Chemical Control:** Lime-sulfur can be applied once in early spring at delayed dormancy for Phomopsis control. Either benomyl or lime-sulfur is used for post-harvest control of Phomopsis twig blight; application is made after two-thirds of the leaves on *Weymouth* and *Berkeley* varieties drop.
- **Alternatives:** EPA subsequently issued a **Section 24(C)** special local need registration in 1998 for ziram for control of several diseases in blueberry in New Jersey, including Phomopsis twig blight; this registration will be effective for five years from the date of issue. In New Jersey, ziram reportedly provides good control of Phomopsis canker when used with benomyl.

#### **Botrytis blossom blight and berry rot (*Botrytis cinerea*)**

- **Biology:** The common name of the disease is Gray Mold, and it is a widespread problem on many crops. The fungus overwinters on dead twigs and organic matter in the duff. In spring, spores are produced and spread the infection to tender young green twigs, blossoms, leaves, and fruit. Thus, over-fertilized rapidly growing shoots are more susceptible to infection. Affected plant parts first appear water-soaked and browned. Botrytis **berry rot** becomes apparent after harvest on fruit infected earlier in the season. Fruit production is diminished by blossom blight and fruit rot during the year a plant becomes infected by Botrytis.
- **Botrytis fruit and cluster blight** can be extremely severe in New Jersey in wet years, especially following freeze damage to the blossoms. Although the fungus is present every year, it causes serious economic loss only during years when weather is cool and damp for several consecutive days. The most susceptible period for infection occurs when there is rainy or foggy weather during bloom. Poor air circulation further enhances disease. If severe, infected twigs and blossoms become covered with the characteristic gray fuzzy fungus.
- **Cultural Control Practices:** The retention of old canes is likely to cause an increase in the amount of *Botrytis*. Pruning out old or dead canes prevents heavy *Botrytis* infestation. (RCEy2k). Adjusting soil pH and avoiding over-fertilization also minimize this disease.
- **Chemical Controls:** Chemical control is focused at preventing infection of the flower petals during bloom. Since bloom occurs over an extended period, several protective sprays will be needed for satisfactory control of Botrytis blossom blight. Fungicides currently recommended for the control of Botrytis disease in New Jersey blueberry include benomyl and captan. An initial application is made at mid-bloom, with subsequent sprays at 7- to 10-day intervals through petal fall.
- EPA issued a Section 24(C) special local need registration for ziram for control of mummy berry shoot blight, Phomopsis twig blight, Anthracnose, and **Botrytis blossom blight** in blueberry in New Jersey in 1998; this registration will be effective for five years from the date of issue.
- **Biological Controls:** None.
- **Alternatives:** not reported.
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#### **Anthracnose (*Colletotrichum gloeosporioides*)**

- **Biology:** Anthracnose is caused by *Colletotrichum gloeosporioides*. The fungus overwinters in dead and diseased twigs and spores are released in the spring. Infected spores spread to healthy fruits and cause significant post-harvest losses. This disease is usually a post-harvest fruit rot, but infection can occur as early as bloom. Heavy nitrogen fertilization and failure to harvest ripe fruit promptly may increase the amount of anthracnose.
- The fruit are asymptomatic until they begin to ripen. The earliest symptom is the presence of shoot blight. Usually causing a few blossom clusters to turn brown or black. Spores are not formed on these blossom clusters. When fruit is ripening and turning blue there are vast numbers of spores on each fruit that spread to other fruit on the bush by rain or after harvest, when one fruit touches another. The spores can cause blossom cluster blight. The ripening fruit is the most susceptible tissue.
- **Cultural Control Practices:** There are several cultural control measures that can be taken: harvest frequently to prevent overripe fruit; cool berries rapidly after harvest; thoroughly prune bushes to remove dead twig tips and wood to reduce inoculum; and avoid overhead irrigation. The retention of old canes is also likely to cause an increase in the amount of *Phomopsis*, *Botrytis*, and Anthracnose. Pruning out old canes and small twiggy wood with hand shears reduces the severity of the disease. Further spread of the disease is minimized by not picking wet fruit and unnecessarily spreading inoculum. Also, heavy nitrogen fertilization should be avoided.
- **Biological Controls:** None.
- **Chemical Controls:** When dictated by disease conditions, New Jersey growers employ protectant fungicides for Anthracnose control, beginning at mid-bloom and continuing at 7- to 10-day intervals until harvest. During the pink bud stage and 25% bloom stage, the following fungicides are used as controls: benomyl plus captan tank mix, chlorothalonil, or fosetyl-AI. During full bloom and first cover stages benomyl plus captan or fosetyl-AI can be used. During the second, third, and fourth cover stages a captan - benomyl mix or fosetyl-AI can be

used. During pre-harvest, captan or fosetyl-AI can be used. Since captan is a preventative fungicide, it is better to apply before a predicted rain than after when Anthracnose is evident

- Triforine (Funginex) was previously recommended for ripe rot; however, production of triforine has ceased and stocks are depleted. Accordingly, chlorothalonil products Bravo 720, Bravo 90DG, and Bravo Ultrex were issued Section 18 emergency exemptions for use to control Anthracnose on blueberry in New Jersey in 1995. Subsequently, Section 24(C) registrations were granted for use on blueberry for Anthracnose (and mummy berry) in New Jersey for Bravo 720 and Bravo 825 (1996), and Bravo Ultrex and Bravo Weather Stik (1999). Each of these Section 24(C) registrations is effective for five years from date of issue.
- EPA issued a Section 24(C) special local need registration for ziram for control of mummy berry shoot blight, Phomopsis twig blight, **Anthracnose**, and Botrytis blossom blight in blueberry in New Jersey in 1998; this registration will be effective for five years from the date of issue.
- **Alternatives:** *Berkeley*, *Coville*, and *Bluecrop* are the most susceptible varieties, but the disease can occur on all varieties when conditions are favorable.

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#### **Phytophthora root rot (*Phytophthora cinnamomi* Rands):**

- **Biology:** The causal organism of this root rot is *Phytophthora cinnamomi*, which typically attacks the small feeder roots of woody plants. Root infection is favored by abundant soil moisture (typically poorly drained areas) with temperatures between 20°C and 32°C. Under these conditions, infection occurs rapidly via zoospore germination, penetration, and establishment of the fungus in blueberry roots. Early symptoms are yellowing of leaves, necrosis of roots, and lack of new growth. Subsequently, leaves of infected blueberry may become stunted and redden. Ultimately, leaves become chlorotic and some defoliation may occur. The primary overwintering structures of this disease are chlamydospores that are formed in the infected roots and dispersed throughout the surrounding soil.
- **Cultural Control Practices:** Phytophthora root rot occurs in excessively wet areas and is rare on well-drained soils. Before beginning a fungicide control program, an accurate diagnosis is necessary. If *Phytophthora* spp. is present, drainage in the field should be improved before applying fungicide.
- **Biological Controls:** None.
- **Chemical Controls:** Chemical controls of Phytophthora root rot are typically applied at budbreak in New Jersey. Fosetyl-AI (Aliette) is labeled for both root and fruit rots. In addition to fosetyl-AI, metalaxyl (Ridomil) was applied at budbreak. Although metalaxyl is no longer available, it has been replaced with its R-enantiomer, mefenoxam.
- **Alternatives:** not reported.

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#### **Blueberry stunt disease**

- **Biology:** Blueberry stunt disease is an insect-vectorized phytoplasma. The causal agent is transmitted in the field by the sharpnose leafhopper and by cuttings taken from stunt-infected plants. The stunt organism overwinters in the vascular tissue of infected stems and roots. In early spring, the phytoplasma bodies increase in number in the sieve tubes of the leaves. Leaf symptoms include yellowing between lateral veins, and along the margins. Further, there is reduced plant vigor. Leaf cupping, interveinal chlorosis, and shortened internodes give the young branches a bushy appearance. In late summer or early fall, the chlorotic areas in leaves redden brilliantly. Fruit on infected plants never develop normal sugar content and ripen late or not at all.
- **Cultural Control Practices:** Stunt symptoms are most noticeable during mid-June and late-September. Growers should inspect fields at these times and remove all infected plants.
- **Biological Controls:** None.
- **Chemical Control:** The spread of virus is suppressed by controlling its vectors with insecticide sprays, and by roguing to remove infected plants. The fields should be treated with an insecticide to minimize the movement of leafhopper vectors to healthy plants when infected plants are removed.
- **Alternatives:** None.

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#### **Virus Susceptibility of Highbush Blueberry**

The highbush blueberry has a known susceptibility to several plant viruses, including red ringspot caulimovirus, scorch caulovirus, shoestring sobemovirus, leaf mottle nepovirus, and necrotic shock nepovirus. Since virus cannot be identified in dormancy when plants are typically purchased, stock certification is one method growers can be assured of reliable sources of clean mother plants.

Diseased bushes cannot be cured; they should be removed from the field as soon as diagnosed. But, vector control can minimize spread to healthy plantings. This is not possible in case where the specific vectors of a virus have yet to be identified.

Although of minor importance in other states such as North Carolina, **Red Ringspot** (Virus) is a problem in New Jersey. Virus spreads to other regions via diseased plants. Characteristic red spots and rings, and oak-leaf patterns may initially develop on the upper surfaces of older leaves. There is variability in susceptibility and how symptoms are manifest between different cultivars. Early identification of virus-infected plants is very important to minimize spread to healthy plants. There are no biological or chemical controls for Red Ringspot. The only effective control is roguing of infected plants because the vector of this virus is not known.

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## ***Other Diseases of Blueberry***

Several species of fungi cause leaf spots on blueberry that develop in mid-summer. Light infestations are generally inconsequential, but severe ones can cause premature defoliation, weaken the plant, and reduce fruiting potential for the following year.

### ***Alternaria leaf spot and fruit rot (Alternaria spp.)***

- **Biology:** *Alternaria* leaf spot and fruit rot is caused by the fungi *Alternaria* spp. The fungus overwinters in and on the twigs, and in debris on the ground. Infection occurs after the fruit begins to ripen, and is more prevalent in wet or humid conditions. The earliest symptom is the presence of a blackish, dark-greenish sporulation (moldy growth) on the blossom end of the fruit. This appears a week or two before harvest. *Alternaria*'s major effect is a leaky watery fruit rot near harvest
  - **Cultural Control Practices:** There are three primary cultural control measures that are taken for control of *Alternaria* in New Jersey: frequent harvest to prevent overripe fruit; avoiding wounding or bruising fruit during harvest; and rapid cooling of berries after harvest. Also, fruit should not be harvested when wet.
  - **Biological Controls:** None.
  - **Chemical Controls:** *Alternaria* leaf spot is not typically a widespread blueberry pest in New Jersey; accordingly, there are no State control recommendations.
  - **Alternatives:** This is not a significant pest of blueberry in New Jersey.
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### ***Fusicoccum canker (Godronia cassandrae)***

- **Biology:** *Fusicoccum* is a fungus that infects blueberry stems causing dieback and plant decline. Losses from this disease can be serious. The fungus overwinters in cankers (necrotic localized areas of disease) on stems and crowns of infected plants. Conidia are released during wet weather and dispersed by splashing rain. Conidia account for nearly all infections and spread of disease. Infection occurs from bud swell (early spring) through early leaf drop in the autumn. Natural openings in the bark may also serve as infection sites. In early spring, infections appear on current year stems at bud sites or wounded areas as small reddish-brown areas. Cankers enlarge each year and eventually may girdle stems, causing them to wilt and die.
  - **Cultural Control Practices:** Sanitation is essential. Cankered branches should be pruned out and destroyed. A fungicide program should be used where incidence of the disease is high. Varieties differ in their resistance to this disease.
  - **Biological Controls:** None.
  - **Chemical Control:** *Fusicoccum* canker is not considered a significant blueberry pest in New Jersey. Accordingly, there are no State chemical control recommendations.
  - **Alternatives:** This is not currently a significant pest of blueberry in New Jersey.
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## ***Fungicide Use on New Jersey Blueberry Crops***

Monitoring thresholds are initiated to help growers determine whether pest control is actually necessary to prevent economic damage to blueberry crops from occurring. In New Jersey, weekly scouting of fields is conducted from April 1st to August 30th in support of the Rutgers Cooperative Extension's (RCE) Blueberry Integrated Crop Management program. Accordingly, advisories and recommendations are then provided via a weekly Blueberry Bulletin and/or RCE staff. No one fungicide controls adequately the major fungal diseases of blueberry in New Jersey. In some situations where more than one disease is active, more than one fungicide will be needed.

Fungicide applied to New Jersey blueberry in 1997 was compiled from grower records submitted to the Pesticide Control Program of the New Jersey Department of Environmental Protection (NJDEP). Growers reported use of six fungicides on blueberry that year. The top three fungicides applied to blueberry in 1997 by order of total pounds active ingredient reported were: **captan**, **sulfur**, and **benomyl**. Significantly lesser amounts were reported for **chlorothalonil** and **triforine**.

New Jersey growers are not required to report the target pest when reporting their pesticide use to the Department of Environmental Protection. Currently, sulfur is registered in the U.S. by EPA for use as an insecticide, fungicide, and rodenticide on several hundred food and feed crop, ornamental, turf and residential sites. It is unknown if sulfur was applied for use as an insecticide or as a fungicide. For this crop profile, all sulfur applications were assumed to be for fungus control, rather than insect. Accordingly, the total pounds of sulfur reported (7,470.33 lbs ai) applied to blueberry in New Jersey in 1997 were included and computed as 'fungicide' rather than 'insecticide'.

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**Captan** is a non-systemic phthalimide protectant fungicide used to control diseases of many fruit, ornamental, and vegetable crops (Exttoxnet).

- **Formulations:** Captan 50WP, Captec 4L, Captan 80WP.
  - **Target pests:** Anthracnose and *Botrytis*.
  - **Amount of active ingredient applied:** Captan ranked first of the fungicides (and total pesticide) used on New Jersey blueberry crops in 1997. A total of 23,402.13 lbs active ingredient was reported applied; this was equivalent to 69.26% of the fungicide, and 37.15% of the total pesticide applied to blueberry crops that year (NJDEP).
  - **Type of applications:** Air blast sprayer or aerial applications.
  - **Application rates:** 2.5 lbs ai/A.
  - **Number of applications:** The total amount of active ingredient that can be applied in a growing season is not to exceed 35 lbs of captan per acre.
  - **Timing:**
    - For Anthracnose, captan application is made at mid-bloom, and is repeated every seven days; at first post-pollination; at later post-pollination; and at fruit maturation.
    - For *Botrytis*, application is made at mid-bloom with subsequent sprays made every 7 to 10 days through petal fall.
  - **Re-entry interval:** 4 days.
  - **Pre-harvest interval:** None.
  - **Use in resistance management programs:** Captan can be tank-mixed with benomyl to increase the spectrum of control and prevent resistance to benomyl.
  - **Efficacy issues:** Tank mixing formulations of diazinon with captan or Captec is not recommended as this mixture may cause crop injury.
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**Sulfur** is a non-systemic contact and protectant fungicide with secondary acaricidal activity.

- **Formulations:** Lime-sulfur.
  - **Target pests:** *Phomopsis* twig blight, scale insects.
  - **Amount of active ingredient applied:** Sulfur ranked second of the fungicides used on New Jersey blueberry crops in 1997. A total of 7,470.33 pounds of active ingredient was reported applied by growers; this is equivalent to 22.11% of the fungicide, and 11.86% of the total pesticide applied to blueberry that year. (NJDEP) *The total pounds of sulfur reported (7,470.33 lbs ai) applied to blueberry in New Jersey in 1997 were included and computed as 'fungicide' rather than 'insecticide'.*
  - **Type of applications:** not reported.
  - **Application rates:** 5.0 gallons of product per acre.
  - **Number of applications:** Twice per season (once in spring and again in autumn) if appropriate.
  - **Timing:**
    - For *Phomopsis* twig blight, lime-sulfur should be applied once in the early spring at the delayed dormant stage.
    - It may be applied a second time in late October where *Phomopsis* a problem; timing of this application corresponds to when two-thirds of the leaves drop on *Weymouth* and *Berkeley* varieties.
  - **Re-entry interval:** 48 hours.
  - **Pre-harvest interval:** not reported.
  - **Use in resistance management programs:** not reported.
  - **Efficacy issues:** Due to phytotoxicity, sulfur should not be mixed with oils, or applied within 14 days of oil spray. New Jersey growers are advised not to tank mix sulfur with other insecticides or fungicides. Further, sulfur should not be applied when the temperature will reach above 75°C.
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**Benomyl** is a systemic benzimidazole fungicide that is selectively toxic to microorganisms and can be used against a wide range of fungal diseases.

- **Formulations:** Benlate SP.

- **Target pests:** Botrytis blossom blight, mummy berry (secondary infection), and Phomopsis canker.
  - **Amount of active ingredient applied:** Benomyl ranked a distant third of fungicides used on New Jersey blueberry crops in 1997. A total of 2,469 lbs active ingredient was reported applied; this is equivalent to 7.31% of the fungicide, and 3.92% of the total pesticide. (NJDEP)
  - **Type of applications:** Air blast sprayer or aerial application.
  - **Application rates:** 0.5 lb ai/A.
  - **Number of applications:** not reported.
  - **Timing:**
    - For Botrytis blossom blight, it is applied at pre-bloom (green tip), and repeated at 7- to 10-day intervals through petal fall.
    - In New Jersey, benomyl is applied at mid-bloom for secondary infection of mummy berry, and repeated at 7- to 10-day intervals through petal fall.
    - For Phomopsis twig blight, apply post-harvest in late October (or when two-thirds of the leaves drop on *Weymouth* and *Berkely* varieties).
  - **Re-entry interval:** 24 hours.
  - **Pre-harvest interval:** 21 days.
  - **Use in resistance management programs:** Benomyl is tank mixed with captan to reduce the development of resistant fungal strains.
- Efficacy issues:** Benomyl is compatible with many other pesticides, and provides good control of Phomopsis canker when used with captan.

**Chlorothalonil** is a broad-spectrum fairly persistent organochlorine fungicide.

- **Formulations:** Bravo 90DG, Bravo 720, Bravo Ultrex, Bravo Weather Stik.
- Bravo 720, Bravo 90DG, and Bravo Ultrex were issued **Section 18** emergency exemptions for use to control Anthracnose on blueberry in New Jersey for the period of April 12, 1995 to December 31, 1995. Subsequently, EPA issued a **Section 24(C)** special local need registration in 1996 for Bravo 720 and Bravo 825 for use on blueberry in New Jersey. The NJDEP granted an additional Section 24(C) registration for a fourth Bravo chlorothalonil product, Bravo Weather Stik. Each of the Section 24(C) registrations specified use for control of mummy berry and Anthracnose in blueberry in New Jersey; they are effective for five years from date of issue.
- **Target pests:** Botrytis blossom blight and Anthracnose.
- **Amount of active ingredient applied:** Chlorothalonil ranked a distant fourth of the fungicides used on New Jersey blueberry crops in 1997. A total of 286.04 lbs active ingredient was reported applied; this was equivalent to 0.85% of the fungicide and 0.45% of the total pesticide applied. (NJDEP)
- **Type of applications:** Air blast sprayer or aerial application.
- **Application rates:** 1.8 to 2.4 lbs ai/A.
- **Number of applications:** Three applications, with a maximum of nine pounds of chlorothalonil per acre per growing season.
- **Timing:**
  - For Botrytis blossom blight, it is applied at pre-bloom/green tip, and repeated at 7- to 10-day intervals.
  - For *Botrytis* and Anthracnose, it is applied at mid-bloom and repeated in 7 to 10 days.
- **Re-entry interval:** 48 hrs.
- **Pre-harvest interval:** 42 days.
- **Use in resistance management programs:** Chlorothalonil can be rotated with other fungicides to reduce the likelihood of DMI resistance in mummy berry due to its different mode of action
- **Efficacy issues:** This broad-spectrum fungicide gives poor- to-moderate control of mummy berry. Chlorothalonil causes fruit spotting when applied during late bloom.

**Triforine** is a piperazine derivative used as a systemic fungicide with protectant, eradicator, and curative characteristics; it is also active against storage diseases of fruit.

- **Formulations:** Funginex 1.6 EC.
- **Target pests:** primary stage of mummy berry.
- **Amount of active ingredient applied:** Triforine ranked a distant fifth of the fungicides used on New Jersey blueberry crops in 1997. A total of 158.68 lbs. triforine was reported applied; this was equivalent to 0.47% of the fungicide and 0.25% of the total pesticide applied. (NJDEP)
- **Type of applications:** Air blast sprayer or aerial application, including aerial sprays applied by air raft.
- **Application rates:** no longer produced.
- **Number of applications:** Limited to three applications.

- **Timing:** Applied at budbreak (when leaf buds show green); repeated twice at 10-day intervals until the pink bud stage. It was recommended in especially wet years when cultivation was not practical, or in fields where this disease was typically severe.
- **Re-entry interval:** 12 hours.
- **Pre-harvest interval:** pre-bloom.
- **Use in resistance management programs:** Production of triforine has ceased and stocks are depleted.
- **Efficacy issues:** Triforine is translocated in plants upward through the root system. Triforine provided excellent control of the **primary stage of mummy berry** that infects the leaves and flowers. However, production of triforine has ceased and stocks are depleted. EPA issued a Section 18 emergency exemption for use of fenbuconazole (Indar) in blueberry as a replacement for triforine.

#### **Fenbuconazole (Indar)-**

- **Formulations:** Indar 75 WSP.
- **Target pests:** mummy berry.
- **Amount of active ingredient applied:** New Jersey growers did not report use of fenbuconazole on blueberry in 1997 (NJDEP), as growers continued to use existing stocks of triforine. The future use pattern of fenbuconazole is expected to be similar to triforine.
- There are no registered alternatives to control mummy berry disease in blueberries. EPA first issued a **Crisis Exemption** in April 1998 for the use of fenbuconazole to control mummy berry in New Jersey blueberry. EPA then issued a **Section 18** emergency exemption for 1999, and again in 2000. The last exemption expired on June 30, 2000.
- **Type of applications:** Ground application by air blast sprayer or aerial application.
- **Application rates:** 1.5 ounces ai/A.
- **Number of applications:** Application of fenbuconazole is limited to five per year, not to exceed a total of 7.5 ounces ai per acre.
- **Timing:** Green tip, pink bud, 25% bloom and full bloom.
- **Re-entry interval:** not reported.
- **Pre-harvest interval:** 30 days.
- **Use in resistance management programs:** Fenbuconazole can be tank mixed with a protectant, or rotated with a fungicide with a different mode of action to delay development of resistant fungus strains.
- **Efficacy issues:** Fenbuconazole is effective at a small dose in relation to other fungicides registered for blueberry.

#### **Fosetyl-AI-**

- **Formulations:** Aliette 80WDG, Aliette 50WP.
- **Target pests:** Phytophthora root and Anthracnose.
- **Amount of active ingredient applied:** New Jersey growers did not report use of fosetyl-AI on blueberry in 1997 (NJDEP) It was not yet labeled for blueberry in 1997 when growers submitted their pesticide use reports.
- **Type of applications:** Foliar applications in a three-foot band in a minimum of 20 gallons spray mix.
- **Application rates:** Four lbs ai/A.
- **Number of applications:** Four-application maximum per year, not to exceed 20 lbs product/A (i.e., 16 lbs ai/A)
- **Timing:**
  - For Phytophthora root rot, it is applied at budbreak before the plants begin active growth.
  - For Anthracnose fruit rot, it is applied post pollination at 14- to 21-day intervals, and at fruit maturation.
- **Re-entry interval:** 12 hours.
- **Pre-harvest interval:** None required. Applications can be made the day of harvest.
- **Use in resistance management programs:** Fosetyl-AI has a different mode of action than other registered blueberry fungicides.
- **Efficacy issues:** Fosetyl-AI is a systemic fungicide for canker diseases; provides broad-spectrum control of summer diseases. Adequate volume of spray mix must be used to get good coverage, and disease control. It may be incompatible with foliar fertilizers and copper compounds. Expense is the major drawback to widespread use.

#### **Metalaxyl -**

- **Formulations:** Ridomil The registration of metalaxyl was effectively cancelled on May 31, 1996, with sale allowed until December 31, 1998 or until supplies are exhausted. Accordingly, State recommendations for use of Ridomil on blueberry continued to be published as an aid to growers with existing stocks.
- **Target pests:** Phytophthora root rot.
- **Amount of active ingredient applied:** New Jersey growers did not report any use of metalaxyl on blueberry in 1997. (NJDEP).
- **Type of applications:** Applications are broadcast as an 18-inch band over each row of new plantings, and a 3-foot band over each row of established plantings.
- **Application rates:** For fields established (i.e., harvestable fruit) over one year, the rate applied is 1.8 lbs ai/A; for fields established less than one year, the application rate is 0.45 lbs ai/A.
- **Number of applications:** 2-application maximum.
- **Timing:** At budbreak, before the plants begin active growth. A second application can be made when conditions are favorable for root rot development.
- **Re-entry interval:** 48 hours.
- **Pre-harvest interval:** pre-bloom/ post harvest.
- **Use in resistance management programs:** no longer produced.
- **Efficacy issues:** The manufacturer voluntarily canceled all registrations of metalaxyl. There will be no loss of uses, as metalaxyl will be replaced with its *R*-enantiomer, mefenoxam. Mefenoxam is considered a reduced-risk pesticide by EPA. It provides the same level of efficacy as metalaxyl; but at half the rate. Mefenoxam is formulated as Ridomil Gold, Apron XL, and Subdue MAXX.

**Ziram** is an agricultural dithiocarbamate protectant fungicide used on a wide variety of plant fungi and diseases. It may be applied to the foliage of plants, but it is also used as a soil and/or seed treatment. Another use of the compound is as a bird and rodent repellent.

- **Formulations:** Ziram 76DF.
- **Target pests:** mummy berry shoot blight, Phomopsis twig blight, Anthracnose fruit rot, **Alternaria**, Botrytis blossom blight.
- **Amount of active ingredient applied:** New Jersey growers did not report any use of ziram on blueberry in 1997 (NJDEP). EPA had not issued a **Section 24(C)** special local need registration for ziram for control of mummy berry shoot blight, Phomopsis twig blight, Anthracnose, and Botrytis blossom blight in blueberry in New Jersey until 1998; this registration will be effective for five years from the date of issue.
- **Type of applications:** Air blast sprayer or aerial application.
- **Application rates:** 2.28 lbs ai/A.
- **Number of applications:** two applications.
- **Timing:** When conditions for disease development exist, ziram is applied as a protectant at bud break (when bud scales are loose), and seven days later.
- **Re-entry interval:** 48 hours.
- **Pre-harvest interval:** Not to be applied three weeks post-bloom.
- **Use in resistance management programs:** not reported.
- **Efficacy issues:** In New Jersey, it is reported that ziram provides good control of Phomopsis canker when used with benomyl. Also, sufficient water should be used in the spray mix for thorough coverage.

#### **Propiconazole -**

- **Formulations:** Orbit.
- **Target pests:** Primary phase of mummy berry disease.
- **Amount of active ingredient applied:** New Jersey growers did not report any use of propiconazole on blueberry in 1997. (NJDEP).
- **Type of applications:**
- **Application rates:** 0.17 lbs ai/A for each aerial application.
- **Number of applications:** A maximum of five treatments of propiconazole per growing season may be applied.
- **Timing:** not reported.
- **Re-entry interval:** 24 hours.
- **Pre-harvest interval:** 30 days.
- **Use in resistance management programs:** not reported.
- **Efficacy issues:** The New Jersey Department of Environmental Protection first issued a **Crisis Exemption** for the use of propiconazole on blueberries to control mummy berry disease on April 8, 1999; this program ended on

June 30, 1999. EPA subsequently authorized a **Section 18 emergency exemption** for use of propiconazole on blueberries in New Jersey to control mummy berry for the period of April 22, 1999 to June 30, 1999.

In New Jersey, fungicide use on blueberry crops is high. Fungicides accounted for nearly 54% of the pesticides applied on blueberry in the State in 1997; the top three fungicides applied that year were:

- **captan** (23,402.13 lbs ai);
- **lime-sulfur** (7,470.33 lbs ai); and
- **benomyl** (2,469.00 lbs ai).

EPA granted time-limited use of specific fungicides to minimize effects of acute disease outbreaks in New Jersey blueberry when registrations were lacking. Section 18 emergency exemptions for **propiconazole** and **fenbuconazole** were issued to mediate the loss of **triforine** for the control of mummy berry. Minimal use of existing stocks of the cancelled fungicide, **triforine** (158.68 lbs ai) was reported for 1997.

Alternately, EPA issued special local need registrations in the absence of registered fungicides for diseases frequent to New Jersey blueberry. EPA issued a Section 24(C) registration for **ziram** for control of mummy berry shoot blight, Phomopsis twig blight, Anthracnose, Alternaria, and Botrytis blossom blight.

Growers did not report use of cancelled fungicide **metalaxyl**, or its reduced-risk replacement **menofoxam** in 1997; both are used to control Phytophthora root rot. **Fosetyl-AI** was recently registered for the control of Phytophthora root and fruit rots, as well as Anthracnose.

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## ~~Weeds of Blueberry~~

~~Annual grasses and broadleaf weeds are the most common weeds encountered in blueberry plantings. These include annual or perennial grasses, and broadleaf weeds such as goldenrod, greenbriar, red sorrel, broomsedge, red root, and smilax. In New Jersey, the roundleaf greenbriar, *Smilax rotundifolia* L., is a persistent prickly-stemmed woody plant that forms impenetrable thickets or climbs other vegetation. It is especially difficult to remove it by its deeply situated tubers (Muencher). Pigweed (*Amaranthus albus*) is a problem weed in July in New Jersey with the appearance of a light green tumbleweed. Another weed found in many blueberry fields is common groundsel, or ragwort. It reproduces by seed, and germination begins in early spring and continues until late autumn. In New Jersey, flower heads can be present from April to October and are composed of several disk flowers. Open flowers can develop fully mature seed after plants have been killed by cultivation or herbicides. Certain weeds have been designated with a 'zero tolerance' threshold in New Jersey; these weeds should not be allowed to become established in all crops, including blueberry. Zero tolerance weeds are: mugwort, Jerusalem artichoke, nutsedge, quackgrass, milkweed, hemp dogbane, horsetail, and Canada Thistle.~~

~~Weeds reduce yield and quality of blueberry planting by competing for nutrients, water, air, and sunlight. Blueberry is a poor competitor with weeds since their root systems are shallow and lack root hairs. Weeds also compete with a blueberry crop for pollination; June flowering weeds and blueberry compete directly for pollinators. Indirectly, weed canopies reduce effective pollination by concealing cranberry blossoms from pollinators such as bees. In addition, weeds will harbor insects and disease vectors. Thus, good weed control is essential if optimum growth and yields are to be realized.~~

~~Weed control is best accomplished when it is begun one to two years before planting a blueberry field. Standard field preparations for New Jersey blueberry include plowing sod, planting grain and green manure crops to destroy weeds and their seeds, and incorporating nutrients according to soil testing. Cover crops increase organic matter when mowed and plowed or rototilled into the upper soil surface~~

~~A combination of techniques is usually needed to control weeds in blueberry plantings. Included in mechanical techniques is cultivation of the soil by hand weeding and hoeing. The middles are cultivated with a tapered disk while newly planted blueberries are hand hoed. In-row weed control eases fruit harvest. Cultural practices also include mulching around blueberry plantings with organic mulches. Mulching with bark, wood chips, or sawdust serves a dual purpose of suppressing weed growth and enhancing soil composition. Although blueberries benefit from mulching for weed control, the process may not be economically feasible on commercial-size plantings.~~

~~Chemical control has been widely adopted to reduce weed competition for water, nutrients, and sunlight; this is also true~~

~~applied to both rows and middles, but more typically, they are applied only to the row. Where persistent or perennial weeds need to be controlled, herbicide is recommended to be applied on non-cropped land.~~

~~Organic matter is often highly variable within blueberry fields, ranging from less than one percent to greater than eight percent. This complicates selection of herbicide (and application rate) because many compounds lose effectiveness when applied to highly organic soils. Enough herbicide to give satisfactory control in 6% organic matter on one end of a row is likely to damage or kill bushes on the other end of the row where organic matter is only 1.5%. Higher labeled rates of some herbicides may be necessary because blueberries are typically grown in soil with high organic matter content. Herbicides have a tendency to be adsorbed, or become attached tightly, to soil particles or organic matter in soil, thus rendering them less active.~~

~~Most pre-emergent herbicides applied in the spring are successful in controlling early germinating weeds. **Norflurazon** is the most common active ingredient used for pre-emergent and weed management in blueberries in New Jersey. Many growers combine a broadleaf weed control material with annual grass control product, as well as alternate between various pre-emergent herbicides to reduce herbicide resistance. The most commonly used active ingredients used in New Jersey for pre-emergent weed control for blueberry are **terbacil, diuron, napropamide**, and **oryzalin**. Other pre-emergent controls that are recommended for use Statewide for blueberry but had little or no reported use by growers in 1997 when the most recent New Jersey Department of Environmental Protection pesticide use survey was conducted (NJDEP) were: clethodim, propyzamide (commonly known as pronamide), fluazifop-p-butyl, metolachlor, oxadiazon, hexazinone, dichlobenil, and simazine. Application of these active ingredients was less than 1% of herbicide and total pesticide applied to blueberry, and in most cases, made by one grower.~~

~~As the season progresses, post-emergent products are used to supplement any cultural weed management already in progress. Weeds more difficult to control are treated with products containing active ingredients **paraquat, glyphosate**, and **sethoxydim**. Post-emergent herbicides are more typically used in New Jersey to control weeds in blueberry between discing or mowing. Spot treatment is common. However, measures are taken to prevent the spray from contacting the blueberry plants as these herbicides injure green blueberry tissues (leaves, young bark). Some (paraquat) only kills treated green tissues, whereas others (glyphosate) is absorbed by green tissue and moves within plants. Growers employ methods to selectively treat weeds and avoid sensitive parts of blueberry plants when using products with such active ingredients.~~

~~The top seven herbicides applied to New Jersey blueberry in 1997 were: norflurazon, terbacil, diuron, paraquat, napromide, oryzalin, and glyphosate according to grower records of total pounds active ingredient applied (NJDEP). Specifics of each of these weed controls follows.~~

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## **Principle Pre-emergence Herbicides:**

### **Norflurazon**

- **Formulations:** Solicam 80DF.
- **Target pests:** Annual weeds.
- **Amount of active ingredient applied:** Norflurazon **ranked first of the herbicides** used for weed control in blueberry in New Jersey in 1997. A total of 3,775.75 pounds was applied to blueberry; this is equivalent to 5.99% of the total pesticide and 52.17% of the herbicide applied that year to blueberry in New Jersey (NJDEP).
- **Type of applications:** Norflurazon is applied by directed spray or banded application to a weed-free surface. It can be used on newly planted or established plants.
- **Application rates:** Rate varies according to soil texture:
  - Coarse soils: two pounds active ingredient per acre (label)
  - Medium soils: three pounds active ingredient per acre (label)
  - Fine soils: four pounds active ingredient per acre (label)
- **Number of applications:** One per year maximum.
- **Timing:** Norflurazon is applied in fall for pre-emergent weed control, or in the very early spring for post-emergent weed control.
- **Re-entry interval:** 12 hours.
- **Pre-harvest interval:** 60 days.
- **Use in resistance management programs:** Due to Norflurazon's different mode of action, it can be either rotated or tank-mixed with triazine herbicides to control triazine-resistant weeds.
- **Efficacy issues:** It does not control established weeds. Thus, the soil surface should be weed-free before its application. Norflurazon is used primarily on young plantings when few other materials are registered. This annual weed control is typically combined with or followed by a broadleaf herbicide.

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## Terbacil:

- **Formulations:** Sinbar 80DF.
- **Target pests:** ~~Terbacil is a selective pre-emergent herbicide that controls annual grasses, broad-leaved weeds, and some perennial weeds by inhibiting photosynthesis.~~
- **Amount of active ingredient applied:** ~~Terbacil ranked second of the herbicides used for weed control in blueberry in New Jersey in 1997. A total of 1,172.16 pounds was applied; this was approximately 16% of the total herbicide applied and approximately 1.86% of all pesticides applied that year on blueberries in New Jersey (NJDEP).~~
- **Type of applications:** ~~Terbacil is soil applied by directed spray. Application is made as a single band or broadcast to the ground under blueberry bushes.~~
- **Application rates:** ~~1.6 to 2.4 lbs ai/A. The lower rate is used on sand or loamy sand soils as terbacil is water-soluble and moves readily in sandy soil. It should not be applied to sandy soils having less than 3% organic matter, particularly if the water table is shallow~~
- **Number of applications:** ~~Once per season.~~
- **Timing:** ~~Pre-emergence. In New Jersey, it is sprayed on soil surfaces in spring preferably just before, or during, the period of active weed growth. Blueberries must be at least one year old prior to using this herbicide in the rows. (RGEy2k)~~
- **Re-entry interval:** ~~12 hours.~~
- **Pre-harvest interval:** ~~not reported.~~
- **Use in resistance management programs:** ~~Terbacil is a substituted uracil that can be rotated or tank mixed with triazine herbicides to control triazine-resistant weeds. Terbacil can be used in combination with diuron to control a broader spectrum of weeds than either material alone (RGEy2k). In North Carolina, it is used to control broomsedge when not controlled adequately by hexazinone (NC cp).~~
- **Efficacy issues:** ~~Soils high in clay or organic matter require higher dosages than soil low in clay or organic matter to obtain equivalent herbicide performance. Moisture is required to activate the chemical; best results occur if rainfall (or sprinkler irrigation) occurs within two weeks of application.~~
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Diuron is a substituted urea herbicide that controls a wide variety of annual and perennial broadleaf and grassy weeds (as well as mosses) by inhibiting photosynthesis. (Extoxnet)

- **Formulations:** Karmex 80DF.
- **Target pests:** Annual and perennial broadleaf and grassy weeds.
- **Amount of active ingredient applied:** ~~Diuron ranked third of the herbicides used for weed control in blueberry in New Jersey in 1997. A total of 976.69 pounds was applied; this is equivalent to a total of 13.5 % of the herbicide and 1.55% of all pesticide applied Statewide to blueberry that year (NJDEP).~~
- **Type of applications:** ~~Direct spray beneath foliage.~~
- **Application rates:** ~~1.6 to 2.4 lbs ai/ A.~~
- **Number of applications:** ~~Once per season.~~
- **Timing:** ~~Pre-emergence. It is applied to weed-free soil beneath blueberry plants in early to mid-spring at least 60 days before harvest.~~
- **Re-entry interval:** ~~12 hours~~
- **Pre-harvest interval:** ~~60 days~~
- **Use in resistance management programs:** ~~Due to a differing mode of action, diuron is rotated or tank mixed with triazine herbicides to control triazine-resistant weeds.~~
- **Efficacy issues:** ~~Diuron does not control established weeds. Thus, the soil surface should be weed-free before its application. It is moderate to highly persistent in soils, and appears to last longer than simazine. Diuron is readily absorbed through the root system of plants and less readily through the leaves and stems. It should not be applied to exposed blueberry roots. It can be tank mixed with another herbicide such as norflurazon, napromide, or oryzalin for residual grass control; however, it is applied at half the full rate according to the soil texture and organic matter.~~

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Napropamide is a selective systemic amide herbicide applied to soils to control a number of annual grasses and broad-leaved weeds.

- **Formulations:** Devrinol 50DF
- **Target pests:** pre-emergent.
- **Amount of active ingredient applied:** ~~Napropamide ranked fifth of the herbicides used for weed control in blueberry in New Jersey in 1997. A total of 264 pounds of napropamide was applied; this is equivalent to 3.65% of the herbicide, and 0.42% of total pesticides applied to the crop that year. (NJDEP).~~

- **Type of applications:** ~~Napropamide is either applied to the soil surface directly, or incorporated into soil around the plants. This herbicide is safe on both newly planted and established blueberry plants, and can be used amidst the blueberry crop.~~
- **Application rates:** ~~4.0 lbs active ingredient per acre.~~
- **Number of applications:** ~~Once per season.~~
- **Timing:** ~~Pre-emergence. Napropamide is applied in the spring to weed-free soil surface.~~
- **Re-entry interval:** ~~12 hours.~~
- **Pre-harvest interval:** ~~not reported.~~
- **Use in resistance management programs:** ~~not reported.~~
- **Efficacy issues:** ~~Napropamide does not control established weeds. Thus, the soil surface should be weed-free before its application. It is typically absorbed through the roots, and in some species, translocated throughout the plant.~~

### Oryzalin -

- **Formulations:** ~~Surflan 4AS~~
- **Target pests:** ~~Selective pre-emergence surface-applied herbicide used for control of annual grasses and broadleaf weeds.~~
- **Amount of active ingredient applied:** ~~Oryzalin ranked a weak sixth of the herbicides used for weed control in blueberry in New Jersey in 1997. A total of 165.12 pounds of oryzalin was applied; this is equivalent to 0.26% of all pesticide and 2.28% of the total herbicide applied to the crop that year in New Jersey (NJDEP).~~
- **Type of applications:** ~~Broadcast, band (label). It is used on both non-bearing and bearing highbush blueberry (not lowbush).~~
- **Application rates:** ~~2.0 to 4.0 lbs ai/A~~
- **Number of applications:**
- **Timing:** ~~early spring.~~
- **Re-entry interval:** ~~24 hours.~~
- **Pre-harvest interval:** ~~not reported.~~
- **Use in resistance management programs:** ~~Oryzalin is typically tank mixed with diuron, terbacil, or paraquat for use on weeds in blueberry to control a broader spectrum of weeds than either alone.~~
- **Efficacy issues:** ~~It alone does not control established weeds. Surflan A.S. should not be applied on soils containing more than 5% organic matter. To be activated, it requires irrigation or about an inch of rain to move the product to the zone where weeds are germinating.~~

### Principle Post-emergence Herbicides:

Paraquat is a quaternary nitrogen herbicide widely used for broadleaf weed control. It is a quick-acting, non-selective compound that destroys green plant tissue on contact and by translocation within the plant. It is also used as a crop desiccant and defoliant, and as an aquatic herbicide.

- **Formulations:** ~~Gramoxone Extra.~~
- **Target pests:** ~~Primarily used as a burn-down treatment for emerged annual and perennial weeds when used in blueberries.~~
- **Amount of active ingredient applied:** ~~Paraquat ranked fourth of the herbicides used for weed control in blueberry in New Jersey in 1997. 611.77 pounds of paraquat was reported applied; this is equivalent to 8.45% of herbicides, and 0.97% of total pesticide applied to the crop that year. (NJDEP)~~
- **Type of applications:** ~~Directed spray, banded application with protected spray boom to minimize contact with blueberry shoots.~~
- **Application rates:** ~~0.5 to 0.9 lb ai/A . The higher rate should be used when perennial weeds are present.~~
- **Number of applications:** ~~1 per season~~
- **Timing:** ~~Post-emergence. Paraquat is typically applied in spring to weeds that have grown one to six inches before bud break. If applied to young shoots or canes, they will be injured.~~
- **Re-entry interval:** ~~12 hours.~~
- **Pre-harvest interval:** ~~None required.~~
- **Use in resistance management programs:** ~~not reported.~~
- **Efficacy issues:** ~~Paraquat has no soil action. Paraquat is a contact weed killer and will not stop germination of weed seeds. Therefore, a residual type herbicide such as diuron or simazine must be used for residual weed control.~~

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**Glyphosate** is a 'reduced-risk' broad-spectrum non-selective organophosphate herbicide without residual action, registered for control of many annual and perennial grasses and broadleaf weeds.

- **Formulations:** Roundup, Roundup ULTRA, or PRO-TOGOL.
- **Target pests:** Annual and perennial emerged weeds in blueberry.
- **Amount of active ingredient applied:** Glyphosate ranked a distant seventh of the herbicides used for weed control in blueberry in New Jersey in 1997. 136.08 pounds of glyphosate were reported applied; this is equivalent to 1.88% of herbicides and 0.22% of the total pesticide applied that year on the crop. (NJDEP)
- **Type of applications:** It is applied as a pre-plant broadcast or as a directed spray in established plantings; it is also applied post-planting by banded application with protected spray boom to minimize contact with blueberry shoots, or as a wiper application.
- **Application rates:** It is applied per weed species identified in the field at the rate listed on the label.
- **Number of application:** not reported.
- **Timing:** Post-emergence. It is applied to actively growing weeds before they grow taller than six inches in height.
- **Re-entry interval:** 12 hours.
- **Pre-harvest interval:** 14 days.
- **Use in resistance management programs:** not reported.
- **Efficacy issues:** Glyphosate may be translocated throughout the plant, including to the roots. It is greatly metabolized by some plants, while remaining intact in others. Glyphosate can seriously injure or kill blueberries, even if only a small amount of green tissue is treated. Spray landing on the green bark at the base of young canes will stunt or kill the entire cane. Thus, it is only used to spot treat problem weeds and woody perennials. When it is used to control perennial weeds, a hooded sprayer to reduce drift and protect blueberries should be employed.

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#### **Sethoxydim -**

- **Formulations:** Poast.
- **Target pests:** Apply for control of emerged annual and perennial grasses in non-bearing blueberries.
- **Amount of active ingredient applied:** Sethoxydim ranked a distant eighth of the herbicides used for weed control in blueberry in New Jersey in 1997. A total of 20.67 pounds of sethoxydim was applied to blueberry in New Jersey in 1997; this is equivalent to 0.29% of herbicide and 0.03% of the total pesticide applied that year (NJDEP).
- **Type of applications:** Band, broadcast, or spot spray application to non-bearing blueberry fields only.
- **Application rates:** 0.47 lb ai/A. (2.5 pints Poast/A.)
- **Number of applications:** Up to 0.94 lb ai/A (5.0 pints Poast)
- **Timing:** Post-emergence. But, it is especially important to apply early while weeds are small in young blueberries. It is non-toxic to bees.
- **Re-entry interval:** 12 hours (label)
- **Pre-harvest interval:** 30 days (label)
- **Use in resistance management programs:** Sethoxydim received pesticide tolerances for various crops, including blueberry, effective in June of 1999; this replaces the previous time-limited tolerance for sethoxydim for the commodity.
- **Efficacy issues:** A crop oil concentrate or spray adjuvant must be used along with sethoxydim to allow for thorough wetting. Sethoxydim is absorbed rapidly by roots and foliage, and moves both upward and downward in plants from the point of absorption. Sethoxydim is rapidly detoxified in most tolerant plants (Extoxnet).

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Approximately 12% of the pesticides applied to blueberry in 1997 were herbicides. The top four herbicides applied to blueberry in 1997 in New Jersey were **norflurazon** (Solicam) at 52%, **terbacil** (Sinbar) at 16.2%, **diuron** (Karmex) at 13.5%, and **paraquat** (Gramoxone) at nearly 8.5% (NJDEP). The amounts of other herbicides applied (as well as relative of blueberry growers) were negligible in comparison to these four, which account for nearly 90% of the total herbicide applied.

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## **Vertebrate Pests**

In New Jersey, the most serious pests in blueberry plantings are wildlife. Birds, deer, and small mammals all enjoy the blueberry fruit. No chemical controls are available other than repellents. Physical barriers are considered the best method to prevent damage by wildlife.

**Bird Management** Birds cause considerable damage to blueberries as they peck at fruits. Damage to fruit is caused by holes punctured in the fruit, which allows rots to develop. A nationwide survey of blueberry growers in 1989 found that 10% of the crop was lost to birds, costing growers \$8.5 million. Many growers experience losses of 30% annually (BB) Methyl anthranilate a bird repellent that is exempt from the requirement of a tolerance for use in blueberry, cherry, and grape; this tolerance exemption was issued in 1995. This biochemical is directly applied as a dilute foliar spray to blueberry to repel birds and reduce bird depredation.

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## Other Blueberry Pest Controls Strategies

The Interregional Research Project #4 (IR-4) program carries out research and petitions EPA to obtain tolerances or exemptions for specific uses of pest controls needed for minor crops. For blueberry, IR-4 initially targeted pesticide tolerances at risk of being lost during the tolerance reassessment process to include: azinphos-methyl, benomyl, captan, cabaryl, chlorpyrifos, diazinon, dichloroprene, iprodione, malathion, metam, methomyl, parathion, methyl, phosmet, and pronamide. (RNN). Its goals include assisting in obtaining registration of reduced-risk pesticides, as well as facilitating reduced-risk patterns for existing tolerances. Once a project is selected for research, IR-4 estimates that the process averages approximately four to five years to complete (IR-4). Pesticide tolerances or exemptions on blueberry that IR-4 has obtained include: captan, chlorpyrifos, esfenvalerate, glyphosate, hexazinone, norflurazon, methyl anthranilate, terbacil, fosetyl-Al, oxyfluorfen, 2,4-D, and chlorothalonil. (IR4web) IR-4 projects for insecticides, fungicides, and herbicides are ongoing.

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### **Rutgers Cooperative Extension Blueberry Weekly Bulletin:**

- **[The BLUEBERRY BULLETIN: A Weekly Update to Growers;](http://www.rce.rutgers.edu/pubs/blueberrybulletin/index.html)**  
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