

Blueberries

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INTRODUCTION

Blueberries are grown throughout the Mid-Atlantic region. A large, well-organized blueberry industry is located in New Jersey where “berryland soils,” a type of soil made up primarily of sand and a small amount of organic matter, are found. Other areas of the region with well-drained, low-pH soils, where native indicator plants such as wild blueberries, rhododendrons, and mountain laurel grow, are also well suited to blueberry production. Blueberries are cultivated by many growers on heavier soils with a high native pH, but special well-planned measures must be taken if production is to be successful. When the soil type is too heavy (clays or clay loams) and/or the soil is of a limestone parent material, yields will likely be low and struggles with nutrient availability and plant vigor are likely to be continual.

Blueberries are long-lived plants. The commercial life of a blueberry planting can be 50 years or longer, making it worthwhile to take the time during establishment to make sure that plant needs are being met.

TYPES OF PLANTS

Several species of blueberries are indigenous to the United States. These include the lowbush blueberry (*Vaccinium angustifolium*), commercially important primarily in Maine and Canada; the rabbiteye blueberry (*V. ashei*), grown commercially in the southern United States; and the highbush blueberry (*V. corymbosum*), the commercially most widely grown blueberry in the Mid-Atlantic, the Pacific Northwest, and the Midwestern United States. The information given here pertains primarily to highbush blueberry production.

While the highbush blueberry plant is indigenous to North America, it has been grown as a domesticated commercial fruit crop for only 80 years. The original breeding work and research was conducted by Miss Elizabeth White of Whitesbog, New Jersey, and Dr. Frederick Coville, USDA botanist, shortly after the turn of the century.

THE BLUEBERRY PLANT

The highbush blueberry originated in areas with acidic soils containing high levels of organic matter and with water abundantly available from a water table only 24 inches down. This caused the blueberry to develop features that make it well adapted to this type of environment, rather than to agricultural soils.

ANATOMY AND MORPHOLOGY

The blueberry plant is a perennial, consisting of a shallow root system and woody canes that originate from the crown. The root system is very fibrous with many fine feeder roots but no root hairs. Root hairs, which most crop plants have, increase the root’s surface area for water and nutrient uptake. The absence of root hairs on blueberry plants makes them very sensitive to changing soil-water conditions. In nature, blueberry plant roots are colonized by a fungal symbiont that forms mycorrhizae (“fungus roots”). This symbiotic relationship allows the plant to better absorb nutrients, particularly nitrogen, and occurs to a lesser extent when blueberry plants are conventionally cultivated. Whether this relationship occurs more frequently in organic culture is not known.

A mature cultivated blueberry bush usually has 15 to 18 canes. Growth habit varies among cultivars—some bushes grow very upright, while others have a more spreading growth habit. Fruit is borne on buds formed the previous growing season.

COLD-HARDINESS AND CHILLING REQUIREMENTS

Blueberries generally tolerate temperatures to -20°F, although some cultivar variation exists. Most highbush cultivars require 750 to 800 hours of chilling below 45°F as a prerequisite for breaking dormancy. In the Mid-Atlantic region, this requirement is usually met no later than early February. After the chilling requirement is met and temperatures begin to warm, water begins to move into plant tissues as a precursor to bud expansion. This increased water content makes the plants more susceptible to damage at low temperatures. Other types

of blueberry plants such as rabbiteye and southern highbush types have lower chilling requirements and can therefore come out of dormancy too early in the year when planted in northern areas. Blueberries, like most fruit crops, will bloom in the early spring, so choosing a site that is free of frost is important.

POLLINATION

A blueberry bush is capable of setting 100 percent of its flowers; a 70 to 80 percent set represents a commercially viable yield. Highbush varieties are moderately to highly self-fertile. However, most will benefit from cross-pollination, which can increase the number of seeds per berry, fruit size, and weight and hasten berry ripening, all of which improve yield. Therefore, abundant insect pollinators (bees) are needed to achieve optimal pollination, even in solid-block plantings of highly self-fertile varieties. Interplanting two or more highbush cultivars will often benefit fruiting characteristics.

No concrete data exist that indicate what the best arrangement of cultivars is for optimum pollination; however, alternating blocks of four rows of each cultivar is commonly suggested as a good middle ground for both pollination and cultural care considerations. Two cultivars that bloom at the same time are needed. Although cultivar-ripening periods vary, there is sufficient overlap of bloom periods to allow most cultivars to serve as pollen sources for each other.

Individual cultivars can bloom for a period of 7 to more than 20 days, depending on environmental conditions. Plants of early blooming cultivars tend to have a longer flowering period than later-blooming cultivars. The top four cultivars grown in the Mid-Atlantic region bloom in the following sequence: Weymouth (early season), Duke (early midseason), Bluecrop (midseason), and Elliott (late season). Pick-your-own farms, in particular, tend to have several cultivars to extend the blueberry-picking season.

Blueberry flowers have several characteristics that encourage cross-pollination. Inverted flowers with narrow corolla openings protect the reproductive structures from wind and rain, preventing excessive self-pollination.

The heavy, sticky pollen grains cannot be wind blown, and fragrant nectar is secreted explicitly to attract insect pollinators to the open blossoms. Individual blueberry flowers remain receptive to pollen for only a few days, and adequate pollination must occur in this time for proper fruit set to occur.

Blueberry pollen is most effectively dislodged from anthers by bees that have sonicating (“buzz-pollinating”) foraging behavior. These bees vibrate their wing muscles, which shakes the pollen free from the anther structures. Bumble bees (*Bombus* spp.) and the southeastern blueberry bee (*Habropoda laboriosa*), both of which are present in the Mid-Atlantic region, have this foraging behavior, while honey bees (*Apis mellifera*) do not.

Although honey bees are less efficient at pollinating blueberry flowers, they make up for this by having larger populations than non-*Apis* bees, whose populations fluctuate by year and are often inadequate for large plantings. As such, wild bees should not be relied upon as the sole source of pollination. Regardless of species, one rule of thumb is to have four to eight bees foraging on each blueberry plant at any given time during the warmest part of the day.

Some growers are interested in using commercial bumble bee colonies for blueberry pollination. However, not enough data are compiled to recommend this practice since commercial bumble bee colonies are currently more expensive to rent than honey bee colonies and have much smaller population sizes (fewer than 300 adults per colony).

Providing one or two strong honey bee colonies (i.e., those having 30,000 or more adult bees and six or more frames of brood) per acre of blueberries is usually sufficient. Beehives should be distributed throughout large fields to ensure adequate flower visitation. Hives should be introduced when about 5 percent of the flowers have opened, but no later than when 25 percent are at full bloom. If introduced too early, honey bees will find alternative plant sources and may prefer them over blueberry flowers until the competitive plants stop blooming. Eliminating blooming weed species in the field will help focus bee activity on blueberry plants. Pesticide

use during bloom should be avoided to prevent killing bees. Once petal drop has occurred, honey bee colonies should be removed from the field.

The use of bee attractants to increase the efficacy of honey bee pollination has been given minor attention. In one study, spraying a synthetic honey bee queen mandibular pheromone increased the yield of Bluecrop by at least 6 percent and farm gate revenue by \$364 per acre. Plant hormone sprays, such as gibberellic acid, have also been shown to increase fruit set in poorly pollinated blueberry fields; however, this hormone induces parthenocarpic fruit set (seedless berries), resulting in small, later-maturing berries.

A bumble bee look alike, the carpenter bee (*Xylocopa* spp.), is not a good blueberry pollinator. These bees rarely visit blueberry flowers legitimately and instead pierce the flower base with their tongues to steal nectar. Such illegitimate floral visits provide little or no pollination. Compounding this problem is the fact that honey bees learn to utilize the holes made by carpenter bees, and research has shown that 80 to 90 percent of foraging honey bees may switch to flower-robbing behavior if enough carpenter bee damage to blueberry flowers has occurred. No recommendations exist for ridding a blueberry field of carpenter bees since any chemical measures taken would likely have negative impacts on legitimate pollinators as well. While actual yield loss due to carpenter bee damage has not been documented, excessive carpenter bee activity could interfere with optimal fruit set. Providing enough honey bee colonies to overcome this potential problem would be the best solution to ensure profitable blueberry yields.

GENERAL CONSIDERATIONS IN CHOOSING A SITE

Consult considerations for crops as discussed in introductory chapters. Additional points that apply specifically to blueberries are given below.

TOPOGRAPHY

Blueberries, like most fruit crops, will bloom in the early spring, so choosing a site that is free of frost, or being

prepared to provide frost protection, is important. When blueberries are in full bloom, the flowers can be injured by temperatures slightly below freezing (30°F). The earliest flowering varieties are most susceptible to frost injury, so avoid planting these on frost-prone sites.

PREVIOUS CROPS AND FIELD BORDERS

As with small fruit crops in general, avoid planting following sod since white grubs can be especially injurious to young roots. Green manure crops grown for one or two years before planting are extremely valuable for new blueberry plantings, which require a high organic matter content (5 percent is preferred). Buckwheat is a good cover crop to precede blueberries because of its ability to tolerate a low soil pH.

Frequently, wild blueberries may be found in surrounding woods or uncultivated areas. These plants can be sources of viruses and other diseases, so keep new plantings at least 500 feet from wild plants.

See Chapter 1 and later information on specific blueberry pests for more information on these subjects.

SOIL CHARACTERISTICS

Blueberry roots will not tolerate extremely dry or excessively wet soils. Blueberries will thrive in light soils that are high in organic matter and have a relatively low native pH. Blueberries fall into the category of plants known as “calcifuges,” which means “lime-fleeing.” While heavy (clay or clay loam) soils can be amended with organic matter to improve aeration, and high pH soils can be amended with sulfur to lower the soil pH, nutritional problems are likely to be a continual concern and plant productivity is likely to be lower than in soils that are better suited for blueberry production. When a soil too high in calcium is used for blueberry production, magnesium deficiency is a recurring problem due to competition of the nutrients for uptake. When lowering the pH of a high-pH soil, the same chemical processes that change desirable nutrients, such as iron and zinc, into plant-available forms also change elements that can be toxic, such

as aluminum and manganese, into more available forms as well. In addition, blueberries are extremely sensitive to high salt concentrations. The NRAES *Highbush Blueberry Production Guide* has an excellent in-depth discussion on calcium levels and suitability of soils for blueberry production and should be consulted for further information (see Appendix E for ordering information).

IRRIGATION AVAILABILITY

Blueberries are very sensitive to fluctuating soil moisture levels due to their shallow root systems and fine roots. Long-term damage to the plants’ fine root system is possible when roots die off during dry spells. Therefore, installing trickle irrigation is highly recommended in plantings. While overhead irrigation for frost protection is not needed in every year, having it available is prudent.

CULTURE

SOILS AND SOIL PREPARATION

When choosing a site for blueberry production, begin soil testing and soil preparation one to two years before you plan to plant (see Appendix B for a listing of laboratories in the region). Few areas in the Mid-Atlantic region can support blueberries without a considerable amount of soil amending prior to planting. The best soils for blueberries are sandy loams that are moist, porous, and acidic. Soil pH should be between 4.5 and 5.0. A lower soil pH can result in manganese or aluminum toxicity; a

higher pH results in the unavailability of certain nutrients, most notably iron. In southern New Jersey where highbush blueberries originally grew, soils are usually sandy loams, the water table is shallow, organic matter is high, and the soil pH is naturally between 4.3 and 5.0. Most areas outside of southern New Jersey do not have these soil characteristics, so soil must be amended and plantings must be mulched and irrigated. Even the best of soils will often have no more than 2 percent organic matter and common limestone and clay soils tend to be more alkaline than is needed for blueberries. Because most blueberry cultivars are not well adapted to heavy upland soils, most soils will require considerable amendment with organic matter if plants are to thrive. Organic matter content can be increased by growing cover crops for two or more successive years prior to planting the blueberries on the site intended. Crops such as sudan-grass, hairy vetch, and rapeseed will all contribute needed organic matter if plowed under when green. For a complete discussion of preplant cover crops, see Chapter 2. Manure can be applied, but it should be composted or applied well ahead of planting to allow time for salts to be leached.

Added sulfur is generally recommended to lower soil pH, but sulfur needs to be incorporated thoroughly to be effective throughout the rooting zone. Even after incorporating sulfur, the full effects may not be realized for at least 6 months. This, along with the benefits of building organic matter for one or two years, is why early site selection prior to planting is important. See Table 7.1 for

Table 7.1. Amount of sulfur required to lower the soil pH.*

Present pH of Soil	Target pH of Soil					
	4.5			5.0		
	Sand	Loam (lbs/acre)	Clay	Sand	Loam (lbs/acre)	Clay
4.5	0	0	0	—	—	—
5.0	175	520	610	0	0	0
5.5	350	1,050	1,130	175	520	610
6.0	520	1,520	1,610	350	1,050	1,130
6.5	650	2,000	2,090	520	1,520	1,610
7.0	830	2,530	2,610	650	2,000	2,090
7.5	1,000	3,010	3,090	830	2,530	2,610

*Iron sulfate may be used at eight times the above rates.

the amount of sulfur required to adjust your soil pH levels. Iron sulfate may also be used at eight times the rate in the table for sulfur. Do not use aluminum sulfate to lower the soil pH because aluminum is toxic to blueberries and is already present in many soils in the region in quantities that can negatively impact blueberry plants once the pH is lowered. Sulfur is most frequently available in a powdered form, but it is difficult to work with in this state, so some growers apply it as a slurry. Pelletized sulfur is relatively easy to manage. Because sulfur does not move through the soil readily, surface sulfur applications after the plants are in place are relatively ineffective for lowering the pH. Lowering the soil pH only in the plant row is also inadvisable because soil interactions with the high-pH soil in the row middles will make maintaining the proper pH within the row difficult. Thus, incorporating sulfur throughout the blueberry field is recommended.

For organic production, select a site that has a soil pH as close to the ideal range (between 4.5 and 5.0) as possible. Fewer options may exist for lowering the soil pH as compared to conventional production. Options may include peat moss, pine bark, organic cottonseed meal, and sulfur. Working closely with your certifying agency when considering options is best to ensure organic certification is not compromised.

At least one year before planting, eliminate all noxious weeds (see “Controlling Weeds”). Phosphorus (if needed) should be added the fall before planting. Potassium can be added either in the fall or spring.

OBTAINING PLANTS

Blueberries may be purchased as one-year-old cuttings, as two- or three-year-old bare-root plants, or as potted plants.

Generally, two-year-old plants are the best buy. One-year-old cuttings require very close management or mortality will be high, and the larger size of the three-year-old plants is often not worth the extra cost. Potted plants are often more expensive as well, but many growers find that the plants establish much more quickly. As long as plants are not pot bound and effort is made to ensure good root-soil contact at planting, potted plants are a reasonable though expensive alternative. If the plant is pot bound, the root ball must be cut so that the roots will branch once the plant is placed in the hole. Remove the pot and place the plant on its side. Then, cut through the perimeter of the root mass four to six times, rotating the root ball between each cut. Cuts should be evenly spaced around the perimeter of the root mass.

For organic production, planting stock does not need to be organically produced since blueberries are perennial crops. However, the planting must be managed organically on a certified organic area for one year before harvested berries can be marketed as organic. Since harvesting newly planted blueberries the first year after planting is not recommended, this generally does not affect marketing.

The number of plants required per acre at various spacings is given in Table 7.2. For a list of nurseries from which to order blueberry plants, consult Appendix C.

VARIETIES

Appropriate cultivar selection is crucial for any perennial crop. Blueberry cultivars can be selected so they can be harvested from July through mid-September, if so desired. Cultivars are discussed below in order of ripening and are subgrouped as “standard cultivars” and “recent cultivars.” Standard culti-

vars are those on which long-term data on production are available. “Recent” cultivars may have been available for many years, but because of the longevity of blueberry plantings and the time it takes to evaluate new cultivars or plant availability, there still is not much information on their performance. However, some truly are recent—released in the last few years as of this writing. All of the cultivars in the “recent” category are currently recommended for trial only.

Early Season

Standard Cultivars

BLUETTA

- Bush is short, compact, low growing, spreading, and of medium vigor.
- Fruit is medium sized, soft, and blue black with fair flavor.
- Stem scars tend to be broad; fruit can hang for a long time.
- Consistent production may be a problem.
- Winters well and does not break dormancy too early.
- Moderately resistant to mummy berry disease; highly susceptible to anthracnose and red ringspot virus.

EARLIBLUE

- Bush is vigorous, upright.
- Fruit is large, firm, and light blue with fair flavor.
- Not recommended commercially in many areas because of erratic fruit set.
- Fruit does not drop easily when ripe.
- Plants have some resistance to powdery mildew.
- Especially susceptible to phomopsis twig blight and fusococcum canker.

WEYMOUTH

- Old variety (from 1936) that has been widely grown.
- Fruit is a bit soft, of average size, and has a mild, sweet flavor.
- Resistant to many diseases, except phomopsis.

Table 7.2. Number of blueberry plants required per acre at various spacings.

In Rows	Between Rows				
	8 feet	9 feet	10 feet	11 feet	12 feet
4 feet	1,361	1,210	1,089	990	908
5 feet	1,089	968	870	792	726
6 feet	908	807	726	660	605

Example: At a spacing of 5 feet x 10 feet, 870 plants are needed per acre.

Recent Releases**CHANTICLEER**

- Released in 1997.
- Very early, but the early bloom time can increase susceptibility to spring frosts.
- Yields tend to be biennial.
- Very good flavor.
- Early plantings not deemed successful by growers.
- Needs a well-drained soil.
- Highly susceptible to anthracnose.

HANNAH'S CHOICE

- Vigorous, upright bush.
- Released in 2000.
- Fruit has superior firmness, sweetness, and flavor with peachy overtones.
- Large first-pick berries, with some size decrease in later picks.
- Relatively resistant to anthracnose.
- Less productive in some areas than others.

POLARIS

- A cold-hardy half-high release from Minnesota (1996).
- Moderate productivity and average berry size, but has very good flavor and aroma.
- Not self-pollinating.

Early Midseason**Standard Cultivars****BLUEHAVEN**

- Bush is upright and productive but not sufficiently hardy for northern areas.
- Berry is large, light blue, and exceptionally flavorful.
- Scar is small and dry.

BLUEJAY

- Bush is vigorous, upright, and open.
- Berries are long stemmed and hang in loose clusters; they hold on to the bush without losing their quality and until most are ripe.
- Fruit is of medium size.
- Berries are firm and light blue with a small stem scar.
- Wood and buds are resistant to low winter temperatures.

- Flowers are less resistant to frost than Bluecrop.
- Moderately resistant to mummy berry and field resistant to shoestring virus.
- Production is sometimes erratic.

BLUERAY

- Plant is vigorous and propagates easily.
- Fruit is borne on small, tight clusters and canes tend to bend over, making it difficult to harvest mechanically; tight clusters can cause berries to drop, especially in hot weather.
- Berries are large, dark blue, and firm with medium scar and excellent flavor.
- Consistently productive, but may overproduce if not pruned properly.
- Upright habit; very hardy.
- Highly susceptible to mummy berry disease and anthracnose; also susceptible to red ringspot virus.

COLLINS

- Ripens about 5 to 7 days after Earliblue.
- Susceptible to winter injury.
- Bush is vigorous and upright with some spreading canes.
- May not sucker freely.
- Fruit is large, firm, light blue, and has very good flavor and a small scar.
- Has narrow soil adaptation and produces only moderately.

DUKE

- A vigorous, upright bush bearing medium-sized, light-blue, firm fruit with a small dry scar.
- Blooms late, avoiding early frosts, but ripens relatively early, slightly after Bluetta.
- Plant has numerous canes that are stocky and moderately branched.
- Buds and wood tolerate fluctuating winter temperatures well.
- Harvest can be completed in two or three pickings.
- Flavor is mild but is said to improve in storage.
- Moderately susceptible to mummy berry and anthracnose; stem blight problems have been documented.

IVANHOE

- Vigorous, upright bush with numerous stocky, moderately branched canes.
- Medium-sized light-blue fruit with good to excellent flavor.
- Buds and wood tolerate fluctuating winter temperatures well.
- Moderately resistant to anthracnose; good resistance to mummy blight (primary shoot infection); moderately susceptible to mummy berry fruit infection.
- Consistent yields in small-scale New Jersey test plot.

PATRIOT

- Plant is upright and vigorous, though only small to medium in height.
- Fruit is large and firm with a small dry scar and excellent flavor.
- Developed in Maine and has excellent cold hardiness, but blooms early and is subject to frost.
- Resistant to root rot.

SPARTAN

- Plants are vigorous, upright, and open.
- Fruits are large, firm, light blue, and highly flavored.
- Plant performs poorly on amended upland soils.
- Blooms late, but harvests relatively early; late bloom date helps prevent frost injury.
- Highly susceptible to anthracnose; partially resistant to mummy berry.

Recent Releases**DRAPER**

- Released in 2004 from the breeding program at Michigan State.
- Ripens with Duke, but with better flavor.

NUI

- Produces a very high-quality, large berry.
- Winter hardiness is questionable and growth is slow.

REKA

- An introduction from New Zealand.
- Upright, very vigorous habit that has been very productive where grown.
- Trial results in PA indicate potential for high yields.
- Berries are small with a spicy flavor.
- This cultivar's outstanding characteristic is that it appears to be very adaptable to a wide range of soil types.
- Moderately susceptible to anthracnose.

SUNRISE

- Moderately vigorous bush with taller, easily managed structure.
- Fruit is similar to that of Bluetta in size and color, but scar and firmness are superior.
- Very good flavor.
- Preliminary data from PA trial indicate potential.
- Suitable for commercial packing and pick-your-own.
- Resistant to red ringspot virus.

Midseason**Standard Cultivars****BLUECROP**

- Best midseason variety presently available.
- Bush is vigorous and upright, but canes tend to be slender and whippy, which may make fruit difficult to harvest mechanically.
- Is reluctant to send up new canes on upland soils.
- Fruit is medium and numerous, firm, small scarred, good flavored, and resistant to cracking.
- Consistently high production and good winter hardiness; season tends to be prolonged, making the crop impossible to harvest in one picking.
- Berries appear to be ripe (completely blue) well before full sweetness is achieved, so they need to be picked 5 to 7 days after the full blue color is present.
- Field resistant to shoestring and red ringspot virus; moderately resistant to

mummy berry and powdery mildew; very susceptible to anthracnose.

ELIZABETH

- Extremely flavorful, with medium to large berries.
- No longer commercially important because of inconsistent productivity, but of interest to home gardeners because of excellent flavor.

NORTHLAND

- Fruit is of average quality and soft, so it tends not to store well.
- Plants are bushy.
- Consistently productive.
- Resistant to mummy berry.

Recent Releases**BLUEGOLD**

- Very productive and cold hardy within the region.
- Has a very vigorous bushy growth habit.
- Ripening is concentrated.
- Below-average to very good flavor, depending on location.
- Primary downside to cultivar is that the stem sometimes remains, or when removed, the skin tears.
- Entire clusters may come off at one time.
- New growth is a golden color.

CARA'S CHOICE

- Released in 2000 as a specialty cultivar for exceptional fruit quality.
- Low- to moderate-sized spreading plants.
- Exceptionally firm, sweet, and flavorful.
- Medium-sized fruit.
- Moderate yield; about half that of Bluecrop.
- Moderately susceptible to anthracnose; resistant to mummy blight; average for mummy fruit infection.

CHIPPEWA

- A cold-hardy half-high release from Minnesota (1996).
- Compact bushes with medium to large, light-blue, firm, sweet fruit.

- For trial in areas where cold tolerance is needed.

LEGACY

- Has some *V. darrowi* (an evergreen blueberry native to Florida) in its background and holds its leaves through much of the winter, so its winter hardiness is suspect.
- Outstanding characteristic is extremely high yields due to a long harvest season while maintaining superior flavor and quality.
- Medium to large fruit.
- For trial only in milder or protected locations.
- Resistant to anthracnose.

PURU

- Purported to have excellent flavor and fruit quality.
- Upright, moderately vigorous bushes with light-blue, medium to large fruit.
- Winter hardiness is uncertain.

TORO

- Vigorous, upright bush that is consistently productive.
- Fruit is large with small, dry scars and good color and flavor.
- Begins ripening with Bluecrop but has a concentrated ripening, and harvest can be completed in two pickings.
- Tolerates fluctuating winter temperatures well.
- Not very self-fertile, so should be planted with another cultivar.

Mid to Late Season**Standard Cultivars****BERKELEY**

- Bush is tall, open, and spreading but tends to drop fruit, affecting the efficiency of mechanical harvesting.
- Berries are very large, light blue, firm, and store well in spite of a large stem scar.
- Flavor is only fair but sweet.
- Clusters tend to be hidden by heavy foliage, which slows hand-picking.
- Ships poorly unless picked early in ripening period.
- Production can be inconsistent.

- Winter hardiness is limited.
- Canes are very stout, sometimes making pruning difficult.
- Slow to produce new canes.
- Tends to be susceptible to fungal diseases during wet seasons; also especially susceptible to some viral diseases.

DARROW

- Very large fruit on vigorous, upright plants.
- Fruit is firm with excellent flavor and can be slightly acidic.

RUBEL

- A wild selection with small, firm fruit.
- Bush is erect and very productive.
- Flavor is fair.
- Fruit retains stems during drought or if harvest is delayed.
- Has higher concentrations of antioxidants than larger-fruited cultivars.
- Susceptible to stunt and resistant to red ringspot virus.

Recent Releases**BONUS**

- Large fruited.
- Very little testing has been done on this cultivar.

BRIGITTA BLUE

- Upright, vigorous, cold-hardy bush with moderate productivity.
- Fruit is large, very light blue, and firm with a small dry scar.
- Plant with other cultivars to ensure good pollination.
- Clusters are loose and ripening is concentrated.
- Excellent fruit quality and shelf life.
- Slow to “shut down” in the fall, so don’t fertilize after early season.
- Resistant to anthracnose and mummy berry.

CHANDLER

- Extremely large fruit ripens over a long harvest season, so this cultivar has good potential, especially for pick-your-own operations.
- Winter hardy in Northeastern PA, so far.

- Very good “true blueberry” flavor.

NELSON

- A vigorous, upright bush.
- Fruit is large, of size similar to Spartan, firm, and light blue with very good flavor.
- Initial tests show it to tolerate cold temperatures well.
- Test-plot yields in New Jersey and Michigan have been high.

OZARKBLUE

- Very late flowering.
- Slow to produce new canes.
- Quality is similar to that of Bluecrop.

SIERRA

- A vigorous, upright, productive bush.
- Fruit is medium sized with a small dry scar, good color, and excellent flavor and firmness.
- Because Sierra is an interspecific hybrid of four species, its cold hardiness is unknown.

Late Season**Standard Cultivars****COVILLE**

- Bush has very vigorous spreading habit.
- Has open fruit clusters; excellent for machine harvest.
- Needs high bee concentration for best pollination.
- Berry is large, medium blue, highly aromatic, and rated highly for strong blueberry flavor.
- Does not set fruit well on occasion, which can limit its productivity.
- Narrow soil adaptation and produces only moderately.
- Fruit is susceptible to anthracnose.

ELLIOTT

- Last to fruit of all standard cultivars.
- Bush is vigorous and upright; plants very productive, hardy, and resistant to mummy berry.
- Berry size is small and berries are light blue with firm flesh and only fair flavor.

- Fruit can be tart and berry can be fully blue when not fully ripe, so fruit should be allowed to remain on bush after coloring.
- Interplanting with another late-blooming variety has provided cross-pollination and improved size and flavor.
- Stores well.
- Resistant to anthracnose.

JERSEY

- Bush is vigorous and erect with open fruit clusters and is very good for machine harvesting.
- Medium-sized, firm fruit with good color and good flavor.
- May have fruit set problems; tends to set fruit without undergoing pollination, so fruit does not size.
- Considered by some to have the sweetest flavor.
- Resistant to anthracnose.
- Susceptible to fusiform canker.

LATEBLUE

- Bush is erect, vigorous, and very productive.
- Berries are firm, light blue in color, have small stem scars, and are fine flavored but tart.
- High temperature during harvest may lead to excessive stemminess.

Recent Releases**AURORA**

- Released in 2004 from the breeding program at Michigan State.
- Ripens very late; slightly later than Elliott.
- Huge berries with excellent flavor.

LIBERTY

- Released in 2004 from the breeding program at Michigan State.
- In PA trial, is producing more foliage than fruit.
- Berries are nice size.
- Ripens with Elliott, but with better flavor than Elliott.

PLANTING AND ESTABLISHMENT

Plants are typically planted in the spring as soon as soil can be worked. Traditionally, moistened peat moss is added at the rate of one gallon per plant to each planting hole; however, the high cost of peat moss has resulted in the use of alternative sources of organic matter. Composted sawdust, cranberry leaves, or woodchips can also be worked into the planting hole, replacing about one-half of the original soil with the organic material. Note: Do not use mushroom compost because the pH of this compost is not conducive to blueberry plant growth. Plants should be watered immediately after planting. Newly set plants will leaf out and will show a second flush of growth approximately 2 weeks later. This is an indication that the root system has begun to take up water and nutrients from the soil. The first application of fertilizer should be made at this time. Plants should be fertilized with 10 pounds of actual nitrogen per acre in the form of ammonium sulfate at 48 pounds per acre. Soils that are not naturally within the pH range of 4.5 to 5.0 should use ammonium sulfate as the first application and for the life of the planting because it helps to maintain the correct pH range and provides needed nitrogen. After this first application of fertilizer, plants should be heavily mulched along the length of the row with about 4 inches of composted sawdust or other organic matter. Avoid using fresh sawdust since it may burn the tender green stems and because it competes with the plants for nitrogen. The second application of fertilizer should be made in mid-June to supply an additional 5 to 10 pounds per acre of actual nitrogen to the planting. Ammonium sulfate can once again be used as the nitrogen source.

Immediately after planting, prune back 25 percent of the wood and rub off all the flower buds. Also, completely remove the flowers from plants during their second year so plants become well-established. Sacrificing this small amount of fruit is well worth the dividend of establishing a planting that will fruit for 50 years or more if well-maintained. Some of the crop should also be removed the third year, again encouraging sound establishment.

Table 7.3. Relevant characteristics of various cover crops for row middles.

Cover Crop	Water Use	Establishment	Vigor	Durability ^a
Creeping red fescue	M ^c	VG ^b	L ^c	VG ^b
Chewings fescues	M	G	L	VG
Hard fescues	M	F	L	E
White (ladino) clover	H	F	M	F
Tall fescue	MH	G	H	E
Sudangrass hybrids	H	VG	VH	P
Kentucky bluegrass	M	G	M	G
Perennial ryegrass	M	G	M	G
Annual ryegrass	M	G	M	P
Rye (<i>Secale cereale</i>)	H	VG	H	P
Buckwheat	H	VG	H	P
Oats	H	VG	H	P

a. Tolerance to foot traffic or equipment operations.

b. E = excellent; VG = very good; G = good; F = fair; P = poor

c. VH = very high; H = high; MH = moderately high; M = moderate; L = low

Table 7.4. Seeding rates and requirements for various seasonal and permanent cover crops for row middles.

Cover Crop	Seeding Rate (lb/A)	Seeding Time (mo)	Nutrient and pH Required ^a (N-P-K lbs/A) & pH
Creeping red fescues	70	Apr–May or Aug–Sept	60-80-40 & 6–7
Chewings fescues	75	Apr–May or Aug–Sept	60-80-40 & 6–7
Hard fescues	80	Apr–May or Aug–Sept	60-80-40 & 6–7
White (ladino) clover	15	Apr–May	10-80-60 & 6–7
Tall fescue	75	Apr–May or Aug–Sept	50-60-40 & 5–7
Sudangrass hybrids	80	June–Aug	80-40-40 & 5–7
Kentucky bluegrass	75	Apr–May or Aug–Sept	60-80-40 & 6–7
Perennial ryegrass	85	Apr–May or Aug–Sept	60-80-40 & 6–7
Annual ryegrass	60	Apr–May or Aug–Sept	60-80-40 & 6–7
Rye (<i>Secale cereale</i>)	110	May–Sept	30-60-30 & 5–7
Buckwheat	75	May–Aug	30-40-30 & 5–7
Oats	100	April or Aug	30-60-30 & 6–7

a. Nutrient requirements may be satisfied by some soils without amendments. Consult a soil test before applying fertilizers and avoid balanced fertilizers high in chloride.

Table 7.5. Postplant nitrogen recommendations for blueberries.

Age of Planting	Actual Nitrogen/A (lbs)	A.S./A ^a (lbs)	Urea/A (lbs)	A.S./plant ^b (grams)	A.S./plant ^b (oz)
0 (planting year)	see text	see text	see text	see text	see text
1	20	100	45	50	1.5
2	30	150	65	70	2.5
3	40	200	85	90	3.0
4	50	250	110	110	4.0
5	60	300	130	140	5.0
6+	65	325	140	150	5.5

a. A.S. = ammonium sulfate. If pH is equal to or higher than 5.0, ammonium sulfate should be used. If pH is lower than 5.0, urea can be used.

b. Assumes 5 x 9 foot spacing.

Fall planting (mid- to late October) may also be done if growers wish to plant at a less busy time of the year. Success will vary depending on fall temperatures, and growers may find that some plants become heaved out of the ground. Mulching once plants are in minimizes this problem. Nitrogen fertilization should not take place until the following spring, using the rates for first and second applications given above, applied at bud break and 6 weeks later. Otherwise, follow recommendations below for care during the establishment year.

Establishing permanent sod middles between the blueberry rows is a standard recommendation. However, note that sod middles increase the incidence of disease and insect problems. Many plantings are clean cultivated to avoid these problems. Characteristics of various permanent cover crops are listed in Table 7.3 and seeding rates and nutrient and pH requirements are listed in Table 7.4. Experimentation at Penn State has shown that hard fescues perform extremely well as permanent sod covers, being slow growing, relatively noncompetitive, and tough enough to withstand traffic. Planting in the fall rather than the spring has aided in establishment. Additional tips for successfully establishing sod middles are covered under “Practices for Minimizing Weeds Between the Rows” in the weed control section.

FERTILITY

Urea and ammonium sulfate are the recommended nitrogen fertilizers. Urea can be used when the soil pH is in the target range of 4.5 to 5.0, while ammonium sulfate should be used when the pH needs to be lowered or in locations where the soil pH tends to rise. Research has shown that blueberry plants prefer the ammonium form of nitrogen. Also, blueberry plants are sensitive to nitrates, which can cause root damage at high levels. Fertilization practices recommended for the planting year are outlined in the “Planting and Establishment” section. As a rule of thumb, nonbearing plants require 20 pounds of nitrogen per acre per year, which should be split into 2 applications of 10 pounds each. Depending on soil type and growing conditions, this requirement may be

as much as 30 pounds of nitrogen per season. After the plants begin bearing, tissue analysis should be used for nutrient recommendations. Fully bearing mature plants, depending on soil type and plant condition, will need about 65 pounds of nitrogen per acre. The prior season’s tissue analysis (see Appendix B for a listing of labs and interpretation levels) is the best method to fine-tune your blueberry fertility program. Table 7.5 shows recommended starting points for nitrogen application rates for a blueberry planting. After the first year, nitrogen should be applied annually using half of the recommended amount per acre during bloom and the other half approximately 6 weeks later. Split application encourages efficient uptake of nutrients and produces equivalent growth to that of higher rates applied at one time early in the season. Dormant applications of fertilizer to blueberries are not recommended since very little fertilizer is taken up into the plant before the leaves are present—a greater proportion of fertilizer is more likely to be leached into the groundwater.

MULCHING

Because the blueberry plant is very sensitive to fluctuating soil moisture, mulching is essential for a healthy planting and consistent yields. Hardwood bark mulch (such as that used for landscaping), rotted sawdust, and chopped corncobs are good mulches. Mixtures of sawdust and bark mulch have been used successfully, providing better infiltration of rain than sawdust alone. Apply mulches to a depth of 4 inches and replenish whenever necessary. As previously mentioned, avoid mulches with a high pH, such as mushroom compost. Also avoid uncomposted leaves, which may be high in natural toxins. Applying uncomposted sawdust or woodchips may tie up nitrogen as the mulch decomposes. Increased amounts of nitrogen fertilizer will be required to compensate; however, predicting how much is impossible due to differences in soil type, microorganism activity, temperature, and other variables. Only leaf analysis accurately depicts nitrogen status.

IRRIGATION

Blueberry plants require at least 1 inch of water per week. Although either overhead or trickle irrigation can be used on blueberries, trickle both conserves moisture and supplies the plant with adequate water while avoiding an increase in the amount of foliar disease. The trickle line can be placed under the mulch so it is out of the way and, in some cases, semipermanent. Because the small emitter holes in trickle irrigation components clog easily, the water source must be very clean (such as municipal water or clean spring), or water should be passed through a sand filter. Overhead irrigation has the advantage of cooling plants and berries when temperatures are very high. In addition, overhead irrigation can be used for frost protection.

FROST PROTECTION

Damage due to freezes and frost increases after bud break in the spring until flowering or fruit set. When blueberries are in full bloom, temperatures slightly below freezing (30°F) can injure the flowers. The exact temperature that damages flowers depends on the rate of temperature change, wind speed, humidity, sugar content of nectar, flower orientation, and so forth. Under certain conditions, open blueberry flowers can tolerate temperatures as low as 23°F. The earliest flowering varieties are most susceptible to frost injury, so avoid planting these on frost-prone sites. See Appendix A for additional general information on frost protection.

PRUNING

Understanding how a blueberry plant grows is important in order to prune correctly. Each year, canes are initiated from the base of the plant. Each succeeding year, a cane produces laterals, which produce laterals the next year and so on. Each year the lateral production on any individual cane decreases in diameter—in other words, the wood becomes progressively twiggy. As the wood becomes smaller, fruit size decreases. This is why we detail prune (remove small twiggy growth) to increase fruit size. In addition, pruning controls crop load, thus increasing fruit

quality. It also invigorates plants, forcing essential new growth from the plant's base. The philosophy behind pruning is to constantly renew the older, decreasingly productive canes by cutting them out and forcing new canes. Plants are continually replacing old canes with new canes while most canes are in a productive, intermediate stage.

Pruning is best done toward the end of the dormant season, usually sometime in March. Fall pruning is not recommended because it can force plants to produce new shoots that will be killed by winter cold. In March, flower buds are easily recognizable because they are plumper than vegetative buds (Figure 7.1). For the first two growing seasons, remove all flower buds to force vegetative growth in the plant.

Keep these five basic steps in mind when approaching a bush to be pruned:

1. Assess the plant's overall vigor. Is the cane production adequate? Mature plants should produce at least three to five new canes per year. If they are not, check your fertilizer program, the pH, or for soil insects or diseases.
2. Prune out all dead wood.
3. Keep the three best one-year-old canes and remove the rest.

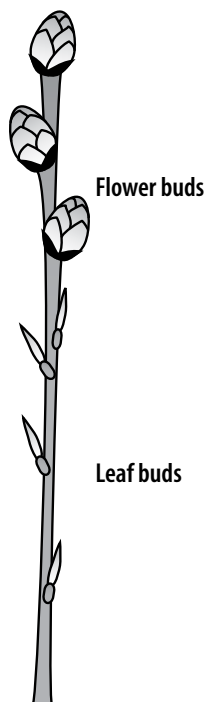


Figure 7.1. Types of buds on blueberry.

4. Locate the oldest canes and prune out one of every six canes, starting with the oldest. For example, if the plant has 12 canes, remove two of the oldest.
5. Prune out all low branches that will never be picked and are a source of disease.
6. Detail prune (i.e., remove as much twiggy wood as time allows).

Figure 7.2 shows a mature blueberry plant before and after pruning. New shoot production is somewhat cultivar dependent, and some cultivars may not respond as well as others. Pruning with this method will produce a plant that has two to three canes each of one-, two-, three-, four-, and five-year-old canes, or ten to fifteen canes. As in any biological system, this is an optimal range and many plants will deviate from this ideal. Which canes are pruned will also need to be adjusted depending on the growth habit of the plant.

Spreading or Open Growth Habit

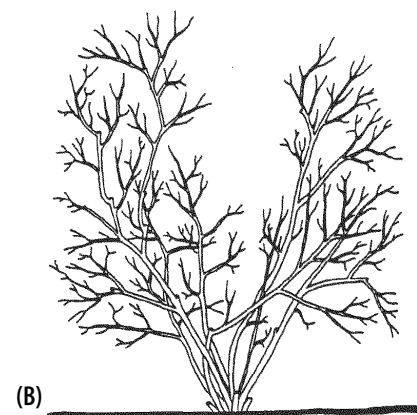
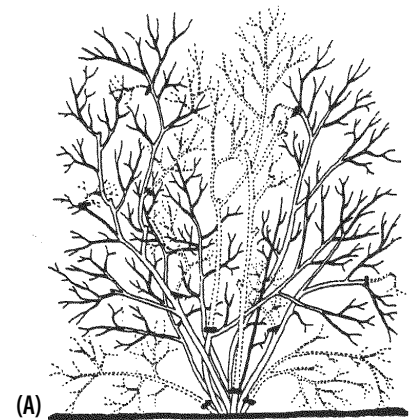
Most pruning of plants in this category should be directed to the outer edge of the bush. Keeping the growth habit pruned to a more erect form makes cultural operations and harvesting easier. Plants with this growth habit include Berkeley, Bluetta, Coville, Patriot, and Weymouth.

Weak or Slow-Growing Varieties

These varieties usually produce many short, weak shoots that lack productivity. Detail pruning improves overall berry quality on remaining shoots. Systematically removing thin shoots (less than $\frac{1}{8}$ inch in diameter) and those less than 6 inches long improves fruit quality. This is of special importance when pruning Bluetta and Weymouth.

Special Case: Neglected Plantings

If plants have not been pruned for many years, they can be rejuvenated by cutting back all of the canes and allowing re-



Upright or Erect Habit

Plants in this category become dense in the center. The denseness causes shading, which reduces both shoot formation and flower bud initiation. Remove the older central canes to produce a better growth situation. Bluecrop, Blueray, Collins, Darrow, Earliblue, Elliott, Herbert, Jersey, and Lateblue fall into this category.

Vigorous Varieties

These varieties yield better when "thinned out" rather than "detail" pruned (removing twiggy, one-year growth). Entirely removing older canes (six years and older) is beneficial for yield and growth, especially in Blueray, Collins, Coville, Earliblue, and Herbert.

Figure 7.2. Blueberry bush before and after pruning.

(A) = mature bush showing typical annual pruning cuts (solid bars) and wood to be removed. (B) = mature bush after pruning.

Courtesy Virginia Polytechnic Institute and State University

growth, or by cutting back half the canes in one year and half the following year. Commercial growers may prefer the latter method since it prevents a lapse in cropping.

HARVEST AND POSTHARVEST HANDLING

A well-managed mature blueberry plant can produce 6 to 10 pounds (7 to 10 pints) of fruit per year. Harvest begins in June with cultivars such as Duke, Earliblue, and Weymouth, and may continue through mid September with Lateblue. Berries turn blue 3 to 4 days before attaining maximum sweetness and flavor. Pick every 7 to 10 days. Do not pick berries with a reddish tinge because they are underripe.

Blueberries, like other fruits, should be picked in the morning after the dew has evaporated. If picked in the afternoon, the berries will more likely contain field heat, which needs to be removed in cooling. Field heat is not only expensive to remove, but the berry's heated condition makes it more susceptible to postharvest breakdown. In addition, berries should not be harvested when they are wet since the incidence of fungal problems will drastically increase.

After harvest, store at 32°F in 90 to 95 percent relative humidity. Under these conditions blueberries will keep for about 14 days.

ECONOMICS

The blueberry budgets given here were prepared to provide general information and do not apply to any specific operation. Use them, with appropriate modifications, as guides for preparing budgets for individual situations. Budgets can be used:

- for general farm business planning purposes
- as a basis for obtaining credit
- to project cash flows
- to assess profitability

Using these sample budgets as guides should help ensure that all costs and receipts are included in budgets you

prepare for your farm. Costs are often difficult to estimate in budget preparation because they are numerous and variable. Therefore, you should think of these budgets as a first approximation and then make appropriate adjustments using the "Your Farm" column to add, delete, and adjust items to reflect your specific growing conditions and resource situation.

The sample cost-of-production budgets were developed using a computerized budget generator. Input data reflect recommended production practices and current input costs. Major subheadings in the budgets are variable costs, fixed costs, and total specified costs. They are defined as follows:

Variable costs are costs that vary depending on the level of production. These include such inputs as fertilizer, herbicides, insecticides, fungicides, and labor.

Fixed costs are costs that do not vary by level of production and are incurred by virtue of owning assets such as machinery and land. Depreciation and taxes are examples.

Total specified costs are the sum of variable and fixed costs. Most land-preparation activities are assumed to be custom hired in these budgets because the small acreages for many berry farms do not justify the ownership of these implements. If you use your own tillage equipment, the variable costs for custom hire should be subtracted from the budgets and your labor variable costs and machinery fixed costs should be substituted.

Cost-of-production budgets are presented for the year of land preparation (Table 7.6), year of planting (Table 7.7), year after planting (Table 7.8) and for a mature planting (Table 7.9).

Returns to risk and management is the estimated profit attributable to the acceptance of risk and the contribution of management expertise by the grower (Table 7.10). The table estimates the return to the grower for a range of prices and yields. Because yields, grades, and prices are so variable, growers should use representative values for their operation. It is important to account for cash

flows over the life of the investment when assessing the overall profitability of the enterprise, so prorated land preparation and planting costs are subtracted from the estimates. Breakeven prices and yields are shown in the tables. Breakeven price is an estimate of the unit price required to cover all costs at a given yield; it is also the average cost per unit of production. Breakeven yield is an estimate of the yield required to cover all costs at a given price.

Berry production involves large initial investments and can be very risky; weather and animal related crop losses are common and crop prices can be highly variable. Use of whole-farm risk management tools such as AGR-Lite crop insurance can help you reduce these risks.

A land charge of \$150/acre has been included in the budgets, but this charge can vary greatly from location to location. If you own the land, you could include your principal, interest payments, and property taxes as a fixed cost. If you lease the land, then the annual rental cost could be included as a variable cost.

Production assumptions used in generating the budgets include the following:

- Fumigation is not used.
- Trickle irrigation is used and water is applied to 5 acres.
- Fungicides are rotated to reduce the likelihood of disease resistance.
- The numbers of pesticide and irrigation applications are average. In any given year or location, growers will need to adjust these for their particular set of circumstances.
- Both green manure and cover crops are used to increase organic matter.
- Plants are spaced at 5 feet within the row and 10 feet between rows (870 plants per acre).
- Two-year-old (12- to 18-inch) bare-root plants are used for establishment.
- Sawdust is used as a mulch.
- Hard fescue is planted in the aisles to reduce the need for mowing.
- Berries are hand-harvested and sold retail as ready-picked berries in pint clamshells.

Table 7.6. Summary of estimated costs per acre, 2009: year of land preparation for blueberries.

Item	Unit	Price (\$)	Quantity	Amount (\$)	Your Farm (\$)
Variable Cost					
Custom					
Soil test	each	10.00	1.00	10.00	_____
Chisel plowing	acre	16.80	1.00	16.80	_____
Grain drilling	acre	17.90	1.00	17.90	_____
Moldboard plowing	acre	19.10	1.00	19.10	_____
Disking	acre	18.50	3.00	55.50	_____
Spread dry fertilizer	acre	9.20	2.00	18.40	_____
Broadcast seeding	acre	11.90	1.00	11.90	_____
Fertilizer					
Urea	lb	0.48	150.00	73.35	_____
Sulfur 90%	ton	650.00	0.50	325.00	_____
Seed					
Oat seed	bu	8.20	3.00	24.60	_____
Annual ryegrass seed	lb	0.35	30.00	10.50	_____
Labor					
Labor	hour	13.50	0.50	6.75	_____
Interest on Operating Capital					
Interest on Operating Capital				6.60	_____
<i>Total Variable Cost</i>				596.40	_____
Fixed Cost*					
<i>Total Fixed Cost</i>				0.00	_____
Land Charge					
Land Charge	acre	150.00	1.00	150.00	_____
Total Specified Costs				746.40	_____

*Fixed costs are zero in this budget because it is assumed that all field operations for land preparation are done by custom operators. Ownership of tillage equipment, grain drills, and grass seeders is not economically justified for growers engaged solely in small fruit production.

Table 7.7. Summary of estimated costs per acre, 2009: planting year for blueberries.

Item	Unit	Price (\$)	Quantity	Amount (\$)	Your Farm (\$)
Variable Cost					
Custom					
Spread dry fertilizer	acre	7.25	2.00	14.50	_____
Moldboard plowing	acre	19.10	1.00	19.10	_____
Disking	acre	18.50	1.00	18.50	_____
Grass seeding	acre	11.90	1.00	11.90	_____
Fertilizer					
Ammonium sulfate	lb	0.17	100.00	17.50	_____
Herbicides					
Devrinol 50DF	lb	11.20	4.00	44.80	_____
Solicam 80DF	lb	24.90	2.50	62.25	_____
Princep 90WDG	lb	4.70	2.20	10.34	_____
Insecticides					
Provado 1.6F	oz	1.66	8.00	13.28	_____
Sevin 80S	lb	8.85	2.00	17.70	_____
Other					
Blueberry plants	each	6.25	870.00	5,437.50	_____
Hard fescue seed	lb	2.85	30.00	85.50	_____
Sawdust mulch	acre	250.00	1.00	250.00	_____
Trickle irrigation	acre	800.00	1.00	800.00	_____
Trickle operating	inch	20.00	20.00	400.00	_____
Labor					
Hired	hour	13.50	70.00	945.00	_____
Operator	hour	15.00	1.68	25.28	_____
Diesel Fuel					
	gal	3.25	4.09	13.30	_____
Repairs and Maintenance					
Tractors	acre	4.24	1.00	4.24	_____
Implements	acre	2.90	1.00	2.90	_____
Interest on Operating Capital					
				261.58	_____
<i>Total Variable Cost</i>				8,459.07	_____
Fixed Cost					
Tractors	acre	8.76	1.00	8.76	_____
Implements	acre	7.44	1.00	7.44	_____
<i>Total Fixed Cost</i>				16.20	_____
Land Charge					
	acre	150.00	1.00	150.00	_____
Total Specified Cost				8,625.27	_____

Table 7.8. Summary of estimated costs per acre, 2009: year after planting for blueberries.

Item	Unit	Price (\$)	Quantity	Amount (\$)	Your Farm (\$)
Variable Cost					
Custom					
Fertilizer	Spread dry fertilizer	acre	1.00	9.20	9.20
Fertilizer	Ammonium sulfate	lb	100.00	17.50	
Fungicides	Lime sulfur	gal	5.00	39.50	
Herbicides	Devrinol 50DF	lb	8.00	89.60	
Herbicides	Poast	gal	0.25	22.30	
Herbicides	Princep 90WDG	lb	4.40	20.68	
Insecticides	Provado 1.6F	oz	8.00	13.28	
Insecticides	Sevin 80S	lb	2.00	17.70	
Other	Blueberry plants	each	20.00	125.00	
Other	Plant analysis kit	each	1.00	24.00	
Other	Trickle operating	inch	20.00	400.00	
Labor	Hired	hour	24.50	330.75	
Labor	Operator	hour	3.28	49.22	
Diesel Fuel		gal	9.74	31.64	
Repairs and Maintenance	Tractors	acre	1.00	9.63	
Repairs and Maintenance	Implements	acre	1.00	10.52	
Interest on Operating Capital				37.45	
<i>Total Variable Cost</i>				1,247.97	
Fixed Cost*					
Tractors		acre	1.00	19.91	
Implements		acre	1.00	17.05	
<i>Total Fixed Cost</i>				36.96	
Land Charge		acre	1.00	150.00	
Total Specified Costs				1,434.93	

*Fixed costs are zero in this budget because it is assumed that all field operations for land preparation are done by custom operators. Ownership of tillage equipment, grain drills, and grass seeders is not economically justified for growers engaged solely in small fruit production.

Table 7.9. Summary of estimated costs per acre, 2009: mature planting for blueberries.

Item	Unit	Price (\$)	Quantity	Amount (\$)	Your Farm (\$)
Variable Cost					
Custom					
Spread dry fertilizer	acre	9.20	1.00	9.20	_____
Bee rental	acre	65.00	1.00	65.00	_____
Fertilizer					
Ammonium sulfate	lb	0.17	325.00	56.87	_____
Fungicides					
Captan 80W	lb	6.29	3.00	18.87	_____
Indar 75WSP	lb	120.50	0.13	15.06	_____
Lime sulfur	gal	7.90	5.00	39.50	_____
Pristine 38WDG	oz	3.45	40.00	138.00	_____
Herbicides					
Princep 90WDG	lb	4.70	2.20	10.34	_____
Devrinol 50DF	lb	11.20	8.00	89.60	_____
Sinbar 80W	lb	39.41	2.00	78.82	_____
Surflan AS	gal	56.35	0.75	42.26	_____
Insecticides					
Confirm 2F	oz	1.36	16.00	21.76	_____
Imidan 70WSP	lb	9.45	1.30	12.29	_____
Malathion 8F	gal	37.50	0.63	23.44	_____
Sevin 80S	lb	8.85	2.00	17.70	_____
Other					
Plant analysis kit	each	24.00	1.00	24.00	_____
Trickle operating	inch	20.00	20.00	400.00	_____
Clamshell, 1 pint	each	0.13	6,000.00	780.00	_____
Flats, 1 pint	each	2.10	250.00	525.00	_____
Labor					
Hired	hour	13.50	41.50	560.25	_____
Operator	hour	15.00	6.35	95.23	_____
Blueberry harvest	pt	0.80	6,000.00	4,800.00	_____
Diesel Fuel	gal	3.25	20.22	65.70	_____
Repairs and Maintenance					
Tractors	acre	19.74	1.00	19.71	_____
Implements	acre	18.29	1.00	18.29	_____
Interest on Operating Capital				202.43	_____
<i>Total Variable Cost</i>				8,129.32	_____
Fixed Cost					
Tractors	acre	40.75	1.00	40.75	_____
Implements	acre	35.22	1.00	35.22	_____
<i>Total Fixed Cost</i>				75.97	_____
Land Charge	acre	150.00	1.00	150.00	_____
Total Specified Costs				8,355.29	_____

Table 7.10. Returns to risk and management for blueberries, 2009.

Price (\$/pint)	Yield (pt/A)					Breakeven Yield
	4,000	5,000	6,000	7,000	8,000	
\$2.00	\$1,305	\$2,287	\$3,270	\$4,252	\$5,235	2,672
\$2.50	\$3,305	\$4,787	\$6,270	\$7,752	\$9,235	1,771
\$3.00	\$5,305	\$7,287	\$9,270	\$11,252	\$13,235	1,324
\$3.50	\$7,305	\$9,787	\$12,270	\$14,752	\$17,235	1,057
\$4.00	\$9,305	\$12,287	\$15,270	\$18,252	\$21,235	880
Breakeven price	\$1.67	\$1.54	\$1.46	\$1.39	\$1.35	

Prorated land preparation and planting costs included based on a productive life of 25 years.

One-pint clamshell of blueberries weighs 17 ounces.

PESTS

Pest control involves many aspects of production, and pesticide application is only one. All available practices to reduce the potential for disease and insect problems should be used. Consider site selection, crop rotation, variety selection, soil treatment, and planting stock in relation to disease and insect control before you plant.

Information on individual diseases and insects is presented below, with cultural controls discussed. Pesticide information including activity groups, efficacy, labeled uses, and restrictions are presented in tables that follow. Because avoiding buildup of resistant strains of fungi and insects is important, activity groups (for rotational use to avoid buildup of resistant strains) of fungicides and their efficacy on common diseases are presented in Table 7.11, and activity groups and efficacy of insecticides are listed in Table 7.12. Fungicides, insecticides, and miticides that can be used to assist in management are given in Table 7.13, arranged by various growth stages during the year for the crop. Pests are listed at the stages where they are most likely to be problematic or when treatment is most effective. Information in Table 7.13 should be supplemented with the reading below. Table 7.14 presents additional restrictions beyond preharvest intervals and reentry intervals that appear on the label.

FUNGAL AND BACTERIAL DISEASES

Alternaria Leaf Spot and Fruit Rot

Symptoms: Light-brown to gray spots surrounded by a reddish margin primarily on lower leaves of the plant unless infection is severe. Spots may enlarge up to $\frac{3}{16}$ inch in diameter under conditions of high humidity. On the fruit, black or dark-green moldy growth on the blossom end of the berry appears shortly before harvest. Fruit stored at room temperature may become leaky.

Causal Agent: The fungus *Alternaria tenuissima*.

Epidemiology: The fungus overwinters on twigs and in debris on the ground. Its growth is favored by wet or humid conditions. Leaf infection is more severe during springs with prolonged periods of cool wet weather and may result in a high incidence of fruit infection. Development of fruit infections is poorly understood, but it is presumed that over-ripe and injured berries are particularly susceptible to decay.

Controls: Do not allow fruit to become overripe. Harvest at regular intervals (7 to 10 days). No specific control programs are recommended for this disease although a regular fungicide program using a broad-spectrum material will help. Rapidly cooling the fruit after harvest is recommended.

Anthraxnose Fruit Rot

Symptoms: A slightly sunken area on the fruit surface where orange to salmon-colored ooze, which contains

spores, develops. These are the most diagnostic signs of an anthracnose infection. During wet or very humid conditions, spores are dispersed in water droplets to nearby surfaces. Fruit infections often do not become apparent until after harvest and may result in rejection or greatly reduced quality and shelf life at the marketplace. The disease organism may rarely cause a blossom blight as well as brown to black leaf and stem lesions of various sizes and shapes.

Causal Agent: The fungus *Colletotrichum acutatum*.

Epidemiology: Anthracnose overwinters primarily under bud sales. Spores are produced during wet periods throughout the growing season and are distributed by splashing rains. Fruit are susceptible to infection at any time during their development. Infections that occur are not immediately apparent but remain dormant until the fruit begins to ripen.

Controls: Fungicide sprays are needed during bloom and also prior to periods of wet, warm weather from bloom until harvest. The varieties Berkeley, Bluecrop, and Coville are the most susceptible, but the disease can occur on any cultivar when conditions are favorable. Use of overhead irrigation should be minimized. Heavy nitrogen fertilization and failure to harvest ripe fruit promptly may also increase the incidence of anthracnose.

Botryosphaeria Stem Blight

Symptoms: Sudden yellowing and reddening of leaves followed by death of individual canes and eventually entire plants. Cutting a cross-section through the cane or cutting away the bark below the area with outward symptoms reveals brown dead tissue, often on just one side of the cane for as little as an inch or two, or possibly along the entire cane. Young plants are much more susceptible than older, more mature plants. In new plantings, the first symptoms include scattered plants with dead symptomatic branches. The disease is most serious in young plantings where widespread infection can kill many plants if infection takes place near the crown.

Causal Agent: The fungus *Botryosphaeria dothidea*.

Epidemiology: Infection takes place through wounds, which may be made mechanically or by another disease organism. Symptoms begin showing 4 to 6 weeks after infection. Inoculum is spread mainly by rainfall, with most infections taking place in late spring and early summer, though inoculum is present anytime. Young tissue and plants are most susceptible.

Controls: Plants that are fertilized in August are likely to be more susceptible to winter injury as a result of not hardening off properly. This condition will lead to higher infection levels during the following growing season. Unlike phomopsis, fungicides are generally ineffective against botryosphaeria diseases, making the prompt removal of infected branches and, sometimes, whole plants the best approach. Most cultivars are susceptible; however, within the region, this disease has been observed primarily on Duke.

Botryosphaeria Stem Canker

Symptoms: Small, red lesions on green stems in the late spring that slowly grow into swollen lesions over the next 6 months. After 2 to 3 years, lesions are large, swollen, and have deep cracks. Entire stems or plants may be killed. On less susceptible cultivars, swelling may not occur and lesions are restricted in size and to the epidermis of the stem. On susceptible cultivars, cankers can girdle and kill stems as tissue is invaded.

Causal Agent: At least eight races of the fungus *Botryosphaeria corticis*, which affect different cultivars to different degrees.

Epidemiology: Only current season's growth can be infected, though progression of the disease continues within the tissue. The initial infection takes place in late spring with warm temperatures optimum for fungal growth and sporulation. Inoculum is released during wet weather and spread by wind.

Controls: Clean planting stock, isolation from infected plantings, and removal of cankers during pruning are necessary. Fungicides have not been effective in control.

Botrytis Blight

Symptoms: Green tissue, blossoms, fruit, and leaves can become infected. Tips of shoots die back and turn brown to black, eventually bleaching to a lighter tan or gray, which can be confused with winter injury. Infected blossoms appear water soaked and turn brown. This blossom blight causes the most loss. Infected immature fruits shrivel and turn bluish purple, whereas ripe, mature fruits become tan. In damp weather, all infected plant parts become covered with this fungus's characteristic "gray mold."

Causal Agent: The fungus *Botrytis cinerea*.

Epidemiology: *Botrytis cinerea* overwinters on infected plants and plant debris and is favored by cool, humid weather. Fungal spores are disseminated primarily by wind. The disease does not occur every year, instead occurring in years when conditions are favorable.

Controls: Any practice that minimizes leaf wetness such as keeping plantings pruned and weeded, and using trickle instead of overhead irrigation, will help. Refer to Table 7.13 for fungicide recommendations.

Leaf Rust

Symptoms: Yellow spots appear on the upper leaf surface in early summer that turn reddish brown. Yellow orange pustules develop on the leaf undersides in midsummer directly under these spots.

Causal Agent: The fungus *Naohidomyces vaccinii*, formerly referred to as *Pucciniastrum vaccinii*.

Epidemiology: This disease requires the presence of hemlock as an alternate host in order to complete its life cycle in northern locations. Evergreen blueberries in the South also serve in this role. Spores released from hemlocks infect blueberry leaves in late spring or early summer. Additional infections of other blueberry leaves take place within the planting during the summer. The disease survives the winter on infected blueberry leaves on the ground. Spores released from these leaves infect hemlocks in ear-

ly spring, which then release the spores that infect the blueberries.

Controls: Controls are not typically needed, as yields are not reduced unless defoliation is severe. Any practices that minimize leaf wetness such as using trickle irrigation rather than overhead and keeping plantings well pruned and weed free will help. In small plantings, removal and destruction of leaves soon after they fall may help as long as the planting is isolated from other blueberries. If only a few hemlocks are nearby, their removal may be a viable option. The current recommended distance from hemlocks for protection is 1/3 mile. Indar, Cabrio, and Pristine are labeled for control of blueberry rust, but efficacy is unknown and timing of application for effective control could be problematic.

Mummy Berry

Symptoms: In the spring, brown, cup-shaped structures (mummy cups), 1/4 inch in diameter can be found on the soil surface. About 2 weeks later, new shoots and leaves suddenly wilt. Brown discoloration develops along the upper surface of the wilted shoots and along midribs and veins of affected leaves (referred to as "strikes"). Flower buds can also be affected. All affected parts become covered with a powdery mass of fungal spores and eventually fall off of the plant. No other symptoms are apparent until the berries begin to ripen, when infected berries lighten in color and at first become soft, then shrivel, dry, and drop from the plant, usually before harvest.

Causal Agent: The fungus *Monilinia vaccinii-corymbosi*

Epidemiology: The fungus overwinters on shriveled, infected berries called "mummies." In the spring, cup-shaped fruiting bodies are produced on the mummies and release spores that infect new growth, causing a shoot blight. Spores from blighted shoots are carried by insects to open flowers along with the pollen. The fungus colonizes the developing fruit by growing into and colonizing flower ovaries. Mummy berry is most serious and widespread in the north after moist spring weather.

Controls: Several practices may help control mummy berry. Remove and dispose of fallen leaves and old berries. Cover old berries with at least 2 inches of soil by disking between rows or adding 2 inches of new mulch. An application of urea fertilizer, or a shallow cultivation of the ground between rows and beneath infected bushes before bud break, kills the exposed mushroom-like apothecia (mummy cups). Bluetta, Collins, Coville, and Darrow may have some resistance. Susceptible varieties include Berkeley, Bluecrop, Blueray, Earliblue, Jersey, and Weymouth. Wet sites are especially problematic. Fungicide applications made at bud break and followed up at 7- to 10-day intervals through bloom will control the disease effectively. Once the flowers have been pollinated, no further infection can take place.

Phomopsis Twig Blight and Canker

Symptoms: Usually consist of a tip die-back of about 2 to 6 inches on current-year wood and are very similar to those of winter injury. This disease can also cause cankers on stems or in the crown area that girdle and kill stems with the infection site appearing as an elongated flattened area, usually near the base of the cane. The pith appears discolored. Small, black dots, the spore-containing bodies (pycnidia) of the phomopsis fungus, can sometimes be seen within this flattened area and also on blighted twigs. As in other canker diseases, the most conspicuous symptom is “flagging” or wilting and death of individual stems during the summer with leaves turning reddish and remaining attached. Under severe disease conditions, several individual canes may be affected on a single bush. The disease also can cause a fruit rot, turning infected tissue reddish brown and soft.

Causal Agent: The fungus *Phomopsis vaccinii*.

Epidemiology: *Phomopsis vaccini* overwinters in infected plant parts. Pycnidia produce spores that are released during rainy periods and spread primarily by splashing rain. The disease infects opening buds and grows into the twigs, enters canes through wounds, or penetrates directly into the fruit. Infection can take

place anytime from blossom bud swell through late summer.

Controls: Remove and burn all blighted or discolored wood during dormant pruning and whenever blighted tips appear in the summer; cut shoots back to the point that pith appears normal. Avoid planting sites that are prone to spring frosts and use fertilization, irrigation, and weed control practices that discourage late-season growth and that promote early hardening off. Certain sprays for mummy berry and botrytis may help, particularly during flowering. Fungicides active against mummy berry and botrytis may not be active against phomopsis canker and vice versa. Consult Table 7.11 for efficacy ratings.

Phytophthora Root Rot

See discussion in Chapter 8: Brambles. Causes and management are similar.

VIRUSES AND PHYTOPLASMAS

There is no cure for plants infected with viral and phytoplasma diseases. Viruses and phytoplasmas are quite different, but they are often grouped together in discussions of plant pathogens. Viruses consist only of protein and genetic material (DNA or RNA) and cannot replicate (reproduce) on their own, instead needing to infect living cells to complete the process. Phytoplasmas are essentially a type of bacteria without cell walls. Both become systemic throughout the plant. Controls can only prevent or delay the movement of viruses and phytoplasmas into the planting and will slow further spread of the disease in infected plantings.

Blueberry Scorch Virus (BBSV)

Symptoms: This virus can cause severe flower and leaf necrosis in highbush blueberry. Symptoms first appear during bloom and consist primarily of a blossom blight with necrotic leaves near blighted flower clusters. Blighted clusters fail to develop into fruit and remain on the bush through the summer. Only one or a few branches are initially affected. Bushes appear to recover as the season progresses; however, yield is reduced or eliminated. Symptoms reappear in following years with more

branches affected. Plants can be killed in 3 to 6 years with all plants eventually infected. Tolerant cultivars may not show symptoms but still serve as sources of inoculum.

Epidemiology: This disease is spread by aphids; transmission from infected to uninfected plants takes place quickly (in a matter of minutes or hours). Aphid control is the best method available to stop the infection of the entire field. Virus spreads outward from the first plants infected.

Controls: Only virus-free stock should be utilized when setting out new plantings. Affected plants should be removed and burned. Aphids should be controlled to prevent spread. Bluetta, Blueray, Chanticleer, Duke, Elliott, and Weymouth are susceptible; Jersey is tolerant; and Bluecrop is intermediate.

Blueberry Stunt

Symptoms: Overall dwarfing of the bush is the primary symptom. Leaves are small, cupped downward, and often chlorotic. Stem internodes become shortened and growth of normally dormant buds causes twiggy branching. Infected bushes appear dense and bushy. The leaves of stunted bushes turn a bright red in early fall before normal plants begin to turn color. Fruit set is decreased. Symptoms are most noticeable after the initial flush of vegetative growth in early summer and when plants begin to turn color in the fall.

Epidemiology: This disease is caused by a phytoplasma rather than a virus, but it is often grouped under viruses. Stunt is spread by sharp-nosed leafhopper nymphs or adults. Once the leafhopper acquires the phytoplasma, the insect retains it for its entire life.

Controls: Using phytoplasma-free stock, controlling leafhoppers, and removing infected bushes are critical to control stunt. Treat bushes to be removed with an insecticide before removal. Otherwise, leafhoppers on infected bushes will only migrate to other bushes when disturbed, spreading infection further.

Red Ringspot Virus

Symptoms: Reddish-brown spots with green centers on leaves and stems. The spots, $\frac{1}{8}$ to $\frac{1}{4}$ inch in diameter, are found on the upper surface of the leaf. Plants with this disease exhibit a loss of crop—the amount varies with variety. Powdery mildew fungus can cause similar symptoms that appear on both sides of the leaf.

Epidemiology: Unknown; however, mealybugs may be involved in transmitting this virus.

Controls: The primary form of control is to use virus-free stock and remove infected bushes. Blue-ray and Blue-tta are especially susceptible.

Shoestring Virus

Symptoms: Elongated, reddish streaks about $\frac{1}{8}$ by $\frac{1}{2}$ to $\frac{3}{4}$ inch on current-year and one-year-old stems, especially on the side exposed to the sun. During blossoming, the flowers on infected bushes will exhibit pinkish to reddish petals. Infected leaves are often straplike, hence the name shoestring. Many leaves on a bush may appear this way, although in some cases just a few clumps near the crown will show this symptom.

Epidemiology: Shoestring is spread by the blueberry aphid. A latent period of four years occurs between infection of the plant and expression of symptoms.

Controls: Aphid control is critical to prevent the spread of shoestring. The long latent period makes identifying infected bushes before they serve as sources of inoculum impossible, so roguing is not feasible or effective. Clean planting stock is critical. Bluecrop shows resistance.

Tomato Ringspot Virus

Symptoms: Leaves are often malformed and have circular chlorotic spots on them, $\frac{1}{16}$ to $\frac{1}{8}$ inch in diameter. In addition, stems, twigs, and branches may exhibit circular, brownish necrotic spots of similar size. Younger terminal leaves tend to be strap shaped and have a mottled pattern. Fruit production may be reduced, and infected plants may eventually die.

Epidemiology: The vector for tomato ringspot virus is the dagger nematode. This virus can infect many different species of plants, including other fruit crops such as apples, peaches, and raspberries and weeds such as chickweed and dandelion. Infection spreads slowly.

Controls: The best control for this virus is to test the soil for this nematode before planting, eliminating the nematodes through chemical fumigation or biofumigation if present, and avoiding following fruit crops. Weeds should be controlled.

NEMATODES

Numerous species of nematodes have been found in association with blueberry plantings, but yield reductions in mature plantings have not been well documented. Highbush blueberries appear to have some resistance to root-lesion nematodes (*Pratylenchus penetrans*). As vectors of the tomato ringspot and tobacco ringspot viruses, dagger nematodes (*Xiphinema* spp.) merit watching. Two years of a grass crop with excellent weed control before blueberries are planted will decrease virus inocula so that nematodes, if present, are more likely to be virus free.

INSECT AND MITE PESTS

More than 300 species of insects and mites can attack blueberries, but only a few are commercially important in the Mid-Atlantic area. Pests may be divided into two groups: those affecting the fruit (direct pests) and those affecting parts of the plant other than the fruit (indirect pests). Direct pests must be kept at very low populations because even a few can cost the grower a great deal of return on the crop. Indirect pests, on the other hand, can be tolerated to some degree because a healthy plant can withstand some feeding damage and the fruit is not directly damaged.

Managing blueberry insects and mites can be keyed to the various growth stages of the plants because insect life cycles respond to many of the same environmental cues as the plants.

In this section, blueberry insects and mites are discussed as members of either the direct or the indirect pest group.

Management is discussed in terms of plant growth stages or phenology.

Direct Pests

Blueberry Maggot, Rhagoletis mendax (Diptera: Tephritidae)

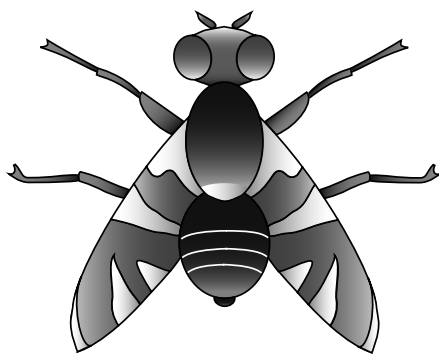
Symptoms of Damage: The blueberry maggot is the major blueberry pest in the northeast and Mid-Atlantic area, but populations may vary a great deal from farm to farm. Small upland areas may not be as susceptible to injury as are those in southern New Jersey. The presence of infested fruit at harvest can bring about the condemnation of whole fields of harvested fruit. Attacked fruit is soft and mushy with a maggot inside.

Identification: The female fly is about $\frac{3}{16}$ inch long, just slightly smaller than a housefly (Figure 7.3). It has a black body and one pair of clear wings marked with heavy black bands in the shape of an upside-down W. Its abdomen is black with white cross bands. Several other species of fruit flies can be confused with blueberry maggots if not inspected carefully. The larvae (maggot) is legless, has no head capsule, and starts out transparent but becomes white as it grows, reaching a length of 6 to 7 millimeters ($\frac{1}{4}$ inch). The puparia in which they overwinter are ovoid, light brown, and about 3 millimeters ($\frac{1}{8}$ inch) in length.

Life Cycle: Overwintering as pupae buried in the top inch of the soil below bushes, flies first emerge from the soil in early to mid-June and continue through July and the first half of August. After emerging, adult females take about 10 days to sexually mature but live for about 30 days. During the time just after emergence, they feed on nectar, dew, and honeydew. Toward the end of this period, mating takes place and females seek large, ripened berries in which to lay eggs. The female pierces the skin of fruit with her egg-laying apparatus and deposits a single egg in each berry. Each fly may lay up to 100 eggs in a 2- to 3-week period. Upon leaving the berry, the female deposits a chemical that deters other flies from laying eggs in that berry. The eggs hatch in 2 to 7 days, and the legless larva burrows into the berry and feeds on the pulp for about 2 weeks. The mature larva then drops to the soil where

it pupates and overwinters. Only one generation occurs per year, but a few pupae may remain in the soil for 2 or 3 years.

Monitoring and Controls: The potential for infestations of blueberry maggots can be assessed by trapping adults before their numbers reach damaging levels. Traps are yellow, sticky boards placed in the field and hung in the top 6 inches of the bush canopy. Traps should be hung from poles, folded, and hung in a “V” position with the yellow surface facing down. Traps should be placed at least a week before the first flies are expected to emerge (early June) and be placed at a density of 3 traps per 5 acres, though this depends on the size of the farm. For larger plantings, 1 trap per 9 to 10 acres may be sufficient. Boards are baited with a feeding attractant, either ammonium acetate or protein hydrolysates (see Appendix D for sources). Since most maggot flies will come from wild hosts outside the field, traps should be placed on field borders near wooded areas, with a few traps in the field interior. Continue trapping through harvest, replacing traps every 3 weeks or when they become clogged with insects. Each week count the flies on each trap and then remove them. Several other fly species will be trapped on the boards, along with other insects. Make sure only blueberry maggot flies are counted. If identifying species is difficult, consult an extension educator. If control is necessary, use a relatively nontoxic, short



Actual length
I
($\frac{3}{16}$ inch)

Figure 7.3. Blueberry maggot adult.

residual insecticide that does not interfere with harvest. Always check the preharvest interval for the pesticide being used. If ripe berries are present, harvest before the spray is applied. Sprays should be initiated within 10 days after the first adult catch. If using a calendar approach, continue with an application every 7 to 10 days until all unharvested fruit has dropped. Alternatively, if you use yellow sticky boards throughout the season, continue on a 7- to 10-day schedule only as long as at least one fly is caught in any trap per week. Planting early maturing cultivars that may escape blueberry maggot attack may help to minimize damage, especially for organic producers.

Cherry Fruitworm, *Grapholita packardii*
(*Lepidoptera: Tortricidae*)

Symptoms of Damage: Unlike cranberry fruitworms, cherry fruitworms seal entrance holes with silk so that frass is not visible outside the berries. An infestation is only evidenced by prematurely blue, shrunken berries that drop to the ground. Berries are not webbed together.

Identification: Eggs are greenish white, flat, and are laid on the undersurfaces of leaves or on fruit starting in late spring. Newly hatched larvae are white with black heads, become pink with brown heads when mature, and reach $\frac{1}{4}$ inch in length. Adult moths have a wingspan of $\frac{3}{8}$ inch and are dark gray with brown-banded wings (Figure 7.4).

Life Cycle: Cherry fruitworms overwinter as mature larvae in old pruning stubs on the bush. The moths emerge in late spring. After hatching, the larvae enter the berries. The larvae usually feed on one berry at a time and then penetrate and feed on another. Larvae require one to three berries to complete development. When feeding is complete, the larvae leave the berry to seek hibernation quarters. One generation occurs per year.

Monitoring and Controls: See cranberry fruitworm—monitoring and controls are similar, except that since webbing is not present, ascertaining presence of the pest is more difficult. Cherry fruitworm is usually less of a problem since fewer berries are required to complete development.

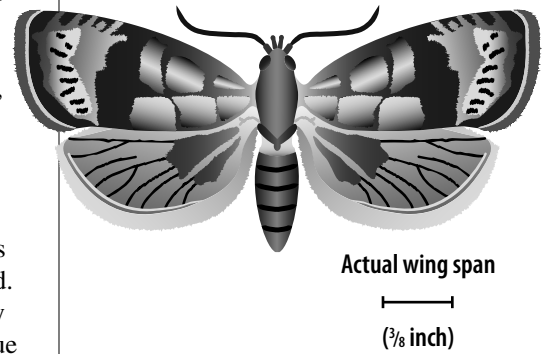


Figure 7.4. Cherry fruitworm adult.

Cranberry Fruitworm, *Acrobasis vaccinii*
(*Lepidoptera: Pyralidae*)

Symptoms of Damage: Characterized by berries tied together with webbing and masses of brown frass (excrement). Larvae can be found feeding in berries through late June or early July.

Identification: Adults are $\frac{1}{2}$ -inch-long moths with grayish-brown wings with white, triangular patches on each wing (Figure 7.5). Newly emerged moths have two white spots on each forewing. Eggs are raised and white when deposited, laid singly inside the calyx cup on the end of the berry. The larva, $\frac{1}{2}$ inch long when mature, has a green body with a reddish tinge on its back and a yellowish to light-brown head.

Life Cycle: This pest overwinters as a fully grown larva in a cocoon under litter within the top $\frac{1}{2}$ inch of soil under bushes. The adult moths emerge at bloom and begin laying eggs along the rim of the calyx cup. After hatching, the larva bores into the fruit at the stem end and eventually webs together several berries with silk, moving between and feeding inside as many as four berries. One generation occurs per year.

Monitoring and Controls: Because this pest is widespread in native blueberry populations, symptoms of damage are more common on rows near woods. Cranberry fruitworm infestations may be difficult to detect early. Look for a pin-sized entry hole near the stem of any small, shrunken berries that have turned blue and open adjacent berries to find the larva. The distinctive frass and

webbing do not appear until later in the larva's lifetime when it begins to move between berries. In small plantings, one method of control for this pest is to pick and destroy infested berry clusters showing evidence of webbing. Repeated disking to eliminate weeds and trash also helps in control. Both cranberry and cherry fruitworms can be controlled with one to two insecticide sprays. Use pheromone traps to monitor adult emergence and place the traps when berries first come into bloom. Insecticides can be applied just after the flight peak. Another spray should be made about 10 days later if needed.

Cranberry Weevil, also known as the Blueberry Blossom Weevil, *Anthonomus musculus* (Say) (Coleoptera: Curculionidae)

Symptoms of Damage: Adults feed on developing leaf and flower buds. Feeding signs include the chewing of expanding buds and holes chewed in the sides of flowers. Infested flowers turn purplish, fail to open, and eventually fall to the ground.

Identification: Adults are $\frac{1}{16}$ inch long and brown with a few white markings on the wing. The snout is about one-third as long as the body. Grubs are small, C-shaped, and have brown heads.

Life Cycle: Overwintering adults disperse into fields from wooded areas, hedgerows, weedy areas, or debris early in the spring. Like plum curculio, the cranberry weevil is active on warm, sunny days. Females lay eggs singly through the feeding holes into the developing flower somewhere along the style or anther filaments. The grubs feed throughout their growth within the flower bud in which they hatched. Pupation occurs within infested flowers and adults begin to emerge again in late May to June. The cranberry weevil has one generation per year in most of New Jersey, but a partial second generation in parts of southern New Jersey also occurs.

Monitoring and Controls: Most feeding and egg-laying activity occurs near field edges that are bordered by woodlands. Therefore, monitoring should concentrate on fields that border wooded areas. If weevils or weevil injury is

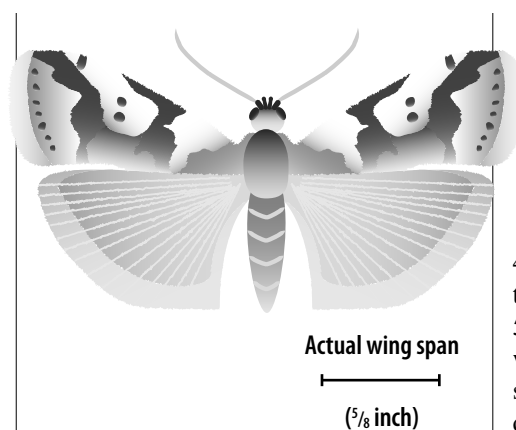


Figure 7.5. Cranberry fruitworm adult.

found on field edges, sampling should continue into the interior of the field to define the area of weevil activity. Monitoring should start at bud swell and continue through bloom, particularly on warm, sunny days. If monitoring on a cloudy day, concentrate on weevil injury. If the day is warm and sunny, look for both injury and adult weevils. Bud injury or the presence of adults prior to bloom is particularly important to catch since insecticides cannot be applied during bloom. Treatment can be initiated anytime weevils reach a threshold of five adults per bush. Monitor with a 1 square yard beating tray and knock the bush three times; examine the tray; knock the bush three times from the other side and examine the tray again. A more reliable threshold is to scan the number of blossom clusters showing damage. Use a treatment threshold of 20 percent of blossom clusters showing damage.

Japanese Beetle, *Popillia japonica* Newman (Coleoptera: Scarabaeidae)

Symptoms of Damage: Adults will feed on leaves and fruit. A well-known pest of fruits and ornamentals, Japanese beetles feed on more than 275 host plants. Adults can also fall into picking buckets and can be found as nuisance insects in the sold product. Larvae cause damage to roots as part of the white grub complex (see "Oriental Beetle").

Identification: Adults are just under $\frac{1}{2}$ inch long and metallic green to bronze with some coppery red color on the

wings. Larvae are C-shaped, white grubs that feed on the root system.

Life Cycle: One generation occurs per year. Grubs that overwinter in the soil pupate in late May with adults emerging from mid-June through mid-July. Adults will live for 30 to 45 days and can be found throughout the summer. Females lay approximately 50 eggs in the soil, which hatch after 2 weeks. Larvae feed on roots until the soil temperatures cool and then remain dormant until spring.

Monitoring and Controls: When numerous, adults can be controlled with the use of broad-spectrum insecticides. Eliminating row-middle sods is helpful, especially in large plantings. Entomopathogenic nematodes are effective for larvae, but they have a limited shelf life and must be applied strictly according to directions.

Obliquebanded Leafroller, *Choristoneura rosaceana* (Harris) (Lepidoptera: Tortricidae)

Symptoms of Damage: Overwintered larvae feed on developing buds, leaves, and berry clusters. Summer larvae feed on both foliage and fruit.

Identification: Larvae are easily recognized. They are up to $\frac{7}{8}$ inch long and robust with a green body and dark-brown to black head capsule, legs, and prothoracic shield (just behind the head capsule). Obliquebanded leafroller adults are larger than redbanded leafroller adults and are tan with a darker band of tan to brown on each front wing.

Life Cycle: Half-grown larvae overwinter under bark scales, around the crown, and in other protected places. Larvae feed for several weeks before pupating at the feeding site. Two generations occur per year. The first adults usually start to emerge by mid- to late May but may appear by late April. Eggs are laid on the foliage and hatch after 1 to 2 weeks, depending on the temperature. Summer larvae are usually found from late June through July. Second-flight adults start to appear in late July to mid-August, with larvae feeding briefly before finding overwintering sites.

Monitoring and Controls: Where first-hatch larvae are numerous, an

insecticide application of a *Bacillus thuringiensis* (Bt) product, Intrepid, or Confirm may be applied during mid-bloom since these products do not have activity against bees. No other insecticides should be used at this time. Treatments are justified only when the combined number of lepidopteran pests (worms) exceeds 1 larva per 100 blossom clusters.

Plum Curculio, *Conotrachelus nenuphar* (Herbst) (Coleoptera: Curculionidae)

Symptoms of Damage: Detected by examining berries for crescent-shaped scars, starting when the berries are green. The scar develops and remains for the life of the fruit. Most infested fruit will drop off of the bush before they are harvested. However, because early season varieties like Bluetta and Weymouth are ready to harvest before the grubs are fully mature, these varieties may be picked while still infested with grubs.

Identification: The adult weevil (a type of beetle) is dark brown, ¼ inch long, and has four humps on its back and a wrinkled surface with black and white flecks. It has a long snout (one-third the body length) that projects forward and downward from its head. The larva is a legless white grub, ¼ inch long when mature, with a distinct brown head capsule.

Life Cycle: Beetles overwinter as adults under debris in woods or field margins and disperse into fields around petal fall. They disperse more heavily when temperatures exceed 70°F and slow significantly when the weather is damp and cool (below 70°F). Plum curculios are usually more prevalent on plants adjacent to woods, fence rows, and trashy fields. The females gouge out crescent-shaped depressions with their snouts when the berries are green and oviposit one egg per berry. Upon hatching, larvae burrow into the fruit where they feed on the pulp for about 2 weeks, often causing the fruit to drop. Fully grown larvae leave the fruit, burrow into the soil, and pupate within an earthen chamber. The adult emerges about 4 weeks later, from midsummer to fall. Most adults enter diapause after several weeks of feeding, but if green berries are still present,

a few will mate and produce a second generation in southern regions of the Mid-Atlantic area.

Monitoring and Controls: Adult curculios are cryptic and may be difficult to see, but they can be found early in the morning or late in the evening by shaking the branches of a bush over a white cloth placed on the ground. Adults disturbed in this manner drop onto the sheet and feign death—they fold their legs tightly against the body and then remain motionless. They can easily be mistaken for debris. Because the weevil spends much of its life cycle on the ground under the bushes, frequent cultivation can aid in control. Infestations are more common in weedy fields. Some monitoring can be accomplished by using tedder traps, which are pyramid-shaped, wooden traps that attract the adult plum curculio beetle. The most reliable method of monitoring, however, is to sample newly set berries for the presence of egg scars. Early season varieties, especially if planted near wooded areas, should be monitored starting at the end of bloom. Effective control is reached through postpollination applications of insecticides. Make sure flowers have dropped in treated blocks so bees are not killed. Bluetta, Duke, Earliblue, and Weymouth are among varieties heavily attacked.

Redbanded Leafroller, *Argyrotaenia velutinana* Walker (Lepidoptera: Tortricidae)

Symptoms of Damage: First-generation larvae feed on leaves and the surfaces of young berries. Like other leafrollers, redbanded leafroller larvae produce a shelter made of leaf pieces spun together. During the early part of the season, these may be found on the tips of growing shoots and around developing blossoms or fruit clusters.

Identification: Adults have a wingspan of about ½ inch and have silver, gray, and orange markings with a prominent cinnamon-colored band across each wing. Larvae are green with a green head and prothoracic shield and are about ⅝ inch long when mature.

Life Cycle: Redbanded leafroller pupae overwinter in leaf litter and trash. Adults emerge during the early spring before flowering and deposit egg masses on

bark and leaf surfaces. Three generations occur per year. The first flight can start in early April, with a second flight starting in mid-June and peaking by the end of June to early July. The third flight usually peaks by early to mid-August. Egg-laying periods occur at roughly the same times as peak trap catches.

Monitoring and Controls: Where first-hatch larvae are numerous, an insecticide application of a Bt product, Intrepid, or Confirm may be applied during mid-bloom since these products do not have activity against bees. No other insecticides should be used at this time. Treatments are justified only when the combined number of lepidopteran pests (worms) exceeds 1 larva per 100 blossom clusters.

Indirect Pests

Aphids, *Illinoia pepperi*, *Ericaphis* spp., *Myzus persicae* (Sulzer) and Others

Symptoms of Damage: Aphids suck sap out of tender new growth and plants are devitalized. Honeydew is secreted as a waste product, which acts as a substrate for sooty mold. However, it takes heavy populations to create a honeydew film and resulting sooty mold. Six species of aphids are found in New Jersey blueberries. Of primary importance is the fact that three species are known to act as vectors for blueberry scorch virus (BBScV). One aphid (*Illinoia pepperi*) can also transmit shoestring virus.

Since aphids may serve as a disease vector, they should not be tolerated in any significant numbers where BBScV is known to occur. Virus transmission under field conditions can occur from early May to mid-August when aphid populations are common.

Identification: Aphids are slow-moving insects, usually 1 to 2 millimeters long, that are usually similar in color to that of the foliage on which they feed. They have sucking mouthparts and cornicles (tubes) extending backward from their posterior. Winged forms are found in the fall.

Life Cycle: Aphids overwinter as eggs deposited on stems, small shoots, and bud scales. After the eggs hatch in the spring, females find new growth and mature into “stem mothers,” giving live

birth to more females. Males and egg-laying females are produced in the fall and mate. Females then lay overwintering eggs.

Monitoring and Controls: Scouting should begin during bloom and continue through the remainder of the season. Recording the percent of new growth infested with aphid colonies is one way to track aphid populations. In scorch-infested areas, only one to two aphids should define an infested leaf or terminal, and sampling should be heavily biased toward new growth. New terminal growth should be scouted as soon as bees are removed. If significant populations of aphids are present, control can be initiated with Provado at 3 to 4 ounces per acre. Treating fields with Admire for Oriental beetle will also give several weeks of aphid control. Lannate can also be used for aphid control, but it is effective only at a full 1 pound per acre, which is higher than the labeled rate for aphids. Other materials that can keep low populations in check or be used as aphid suppressants include Asana, Diazinon, and Malathion. Controlling aphids combined with removing and destroying infested bushes over a 2- to 3-year period can reduce the spread of the virus.

Blueberry Bud Mite, *Acalitus vaccinni* (Keifer) (Acari: Eriophyidae)

Symptoms of Damage: Heavily infested buds become reddish and roughened with bumps on the outer scales. In severe cases, buds become desiccated and fail to open. In less-severe cases, fruit may be set, but berries are ruined by roughening and blistering of the skin.

Identification: The white mites are extremely small ($\frac{1}{125}$ inch) with four legs bunched toward the “head end.” They are carrot shaped with the head end being the wider portion. They are confined to the buds and blossoms and are difficult to see except with a dissecting scope. Symptoms of injury are noticed first.

Life Cycle: This mite is a sporadic pest; however, it may be more likely to be a problem following mild winters. Mites spend the winter under bud scales. All stages of the life cycle are present throughout the year.

Monitoring and Controls: Pruning out old canes helps to reduce mite populations. An insecticide and/or oil application will give control. A high water volume (400 gallons per acre) and high pressure (200 pounds per acre) are needed during application.

Blueberry Gall Midge, also called the Cranberry Tipworm, *Dasineura oxycoccana* (Johnson) (Diptera: Cecidomyiidae)

Symptoms of Damage: Small holes and feeding areas around the terminal bud and developing leaves are evident when larvae are feeding. As the larvae mature, infested bud and leaf tissue will dry up, leaving a very small and blackened terminal shoot.

Identification: This is a small fly in the gall midge (Cecidomyiidae) family. The adult is just over $1\frac{1}{2}$ millimeters long with a wingspread of about 3 millimeters. Larvae are tapered at both ends and legless. They mature from clear to white to yellow orange. Fully grown larvae are only 1.6 millimeters ($\frac{1}{16}$ inch) long.

Life Cycle: The insect overwinters as a pupa and emerges as an adult in early May. Eggs are laid on swelling buds and developing leaf petioles. Larvae feed deep within the terminal growth in developing terminal buds and leaf tissue. Three larval instars occur, which can mature in as little as 9 days. A generation takes from 2 to 4 weeks to mature, depending on temperature. Therefore, four to five or more generations may occur per year in the Mid-Atlantic area.

Monitoring and Controls: Suspected damage and buds can be collected in plastic bags and watched for emerging larvae. Larvae, if present, will emerge in about 2 days. Most organophosphate materials have some effect on this insect. Recommendations for best timing of application are under investigation.

Blueberry Stem Borer, *Oberea* sp. (Coleoptera: Cerambycidae)

Symptoms of Damage: The main symptom of this beetle’s damage is wilting at the tip of the shoots. As the grub bores down into the cane, the whole cane may be affected, with leaves turn-

ing red, dropping off, and then the entire cane dying.

Identification: The blueberry stem borer adult is a slender, elongated, light brown beetle. Inspection of a damaged cane may show pinholes down its length with light-yellow frass extruding from the holes. A yellowish grub will be found if the stem is split at the end of its long tunnel.

Life Cycle: This beetle deposits eggs in current season’s growth near the shoot tip in June or July. The girdling of the shoot is associated with egg laying and causes the tips to wilt. The grub bores down through the shoot toward the crown of the plant, then moves to adjacent stems and continues feeding. Larvae complete their development by the spring of the third year.

Monitoring and Controls: Remove and destroy wilted tips as soon as they appear.

Blueberry Tip Borer, *Hendecaneura shawiana* (Kft.) (Lepidoptera: Tortricidae)

Symptoms of Damage: Feeding results in shoot dieback and often resembles a primary infection of mummy berry.

Identification: These tiny moths emerge in early June and deposit eggs on the undersides of tip leaves. The larvae hatch and bore several inches into the soft tissue of terminal blueberry shoots.

Life Cycle: The blueberry tip borer overwinters as mature larvae inside stems.

Monitoring and Controls: The insecticides applied against fruitworms usually also control this pest.

Oriental Beetle, *Exomala (Anomla) orientalis* (Waterhouse) (Coleoptera: Scarabaeidae)

As part of the white grub complex along with Japanese beetles, the Asiatic garden beetle, and several June beetles, the Oriental beetle is the most important as a pest in New Jersey and the Mid-Atlantic area.

Symptoms of Damage: Grubs feed on roots. Large populations will retard growth and contribute to plant death. Damage is more severe on young plantings.

Identification: Oriental beetle adults are straw colored with black markings to varying extents, though completely black or completely straw-colored beetles are also found.

Life Cycle: Oriental beetles overwinter as grubs deep enough in the soil to avoid freezing. As soil temperatures warm in the spring, the grubs move upward and resume feeding on roots. Pupation occurs in May, and adults begin emerging in early June. Peak emergence is near the end of June. Female adults lay an average of 25 eggs each. Eggs hatch into larvae (grubs) from early July through mid-August, which feed on the roots, then move downward for winter. The Oriental beetle, Asiatic garden beetle, and Japanese beetle all have one-year life cycles.

Monitoring and Controls: Beetle populations should be monitored with Japanese beetle “can traps,” which are placed on the soil surface and baited with the Oriental beetle pheromone. In infested areas, traps will fill up in only a few days. Root systems that are excavated in infested areas may yield up to a dozen or more grubs per plant. Admire is currently the only insecticide that gives adequate control. Since Admire works only on first- and second-instar grubs, the applications must be made shortly after the eggs are laid and grubs are close to the soil surface. This means that applications should be made by late June to early July for mid- to late-season varieties and immediately after harvest for early season varieties. Additional controls currently being worked on include the use of pheromone-based mating disruption and entomopathogenic nematodes.

Scales Including Putnam Scale, *Aspidiotus ancylus* (Homoptera: Diaspididae), and Terrapin Scale, *Lecanium nigrofasciatum* (Homoptera: Coccidae)

Symptoms of Damage: Decreased vigor and yields and plant decline if in high numbers. The scale insects feed on sap and secrete honeydew on which black sooty mold develops. Infested berries are undersized and unmarketable.

Identification: These insects may be common in blueberry plantings if pruning has been neglected for several years and

older canes are not removed, especially if the scales’ parasites and predators have been destroyed by insecticide sprays. They spend most of their lives as legless, sedentary individuals. Putnam scales, which are the scale most commonly attacking blueberry, appear as gray, waxy dots about 1/16 inch in diameter. Most are under loose bark on older canes, but they can also be found on leaves and fruit. An immobile yellow insect can be seen if the scale covering is removed. Terrapin scales are brown or reddish brown, are shaped like a half-sphere about 1/2 inch in diameter, and are marked with black bands like the shell of a turtle. They are present primarily on the canes.

Life Cycle: Depending on location, there may be one or two generations of Putnam scale per year with varying life cycles for other species. In general, eggs are laid in the spring. Crawlers emerge in spring to early summer, thereby helping the insects disperse.

Monitoring and Controls: Good scale control is accomplished first by good pruning practices. Removing and destroying old wood during pruning often does much to reduce scale populations. The second approach is to use dormant oils to smother the overwintering scales. Oil should be applied early in spring after the bud scales start to expand but before the first leaf stands out from the cluster. Cover sprays during the growing season are usually ineffective because the scales are protected by their secreted “shell.” However, sprays timed to coincide with crawler emergence can be effective. Crawlers can be detected by wrapping black electricians’ tape covered by double-sided sticky tape around twigs. Use a hand lens to see the active crawlers on the edge of the sticky tape.

Sharp-Nosed Leafhoppers (three species), *Scaphytopius magdalenis*, *Scaphytopius frontalis*, and *Scaphytopius acutus* (Homoptera: Cicadellidae)

Symptoms of Damage: All three species of sharp-nosed leafhopper, while causing little outright injury to blueberry plants, are important in blueberry culture because they can transmit the phytoplasma that causes blueberry stunt disease, for which there is no control.

Identification: The adults are brownish gray, wedge shaped, and approximately 3/16 inch long with a distinctly sloped and pointed extension of the head in both the nymphal and adult stages. Both *S. frontalis* and *S. acutus* have a yellowish white marking on the front of the head. This marking is missing from *S. magdalenis*. The nymphs are 1/16 inch long and brownish black with a white or cream hourglass-shaped mark on their backs. Leafhoppers acquire the stunt pathogen by feeding on infected plants. Only the motile adults transmit the disease to healthy plants by subsequent feeding activity. Once leafhoppers have acquired the virus, they have it for life.

Life Cycle: The leafhopper overwinters as an egg inside fallen leaves. Eggs hatch in mid- to late spring, with first-generation adults appearing by late May to early June. In the northeast and Mid-Atlantic area, two generations occur per year. Large populations often emerge in abandoned blueberry fields and in wooded habitats where blueberries and huckleberries are common in the ground cover. Adults can fly long distances and tend to disperse from the woods during the spring generation and back into the woods during the fall generation. The stunt pathogen is probably carried back and forth between commercial fields and wild reservoirs by the annual cycle of leafhopper dispersal.

Monitoring and Controls: Control of first-generation leafhoppers is usually accomplished by a petal fall cover spray for plum curculio and fruitworms. Blueberry maggot traps can be used to monitor leafhoppers and to help time an insecticide spray, if necessary. Traps should be hung vertically, yellow side out, with the bottom about 18 inches above the ground. The yellow sticky traps used for leafhoppers do not have to be baited as they are for blueberry maggot. Apply an insecticide if the leafhopper population increases sharply between one week and the next. Make sure to apply at least one insecticide for the second generation just prior to flight peak. This will normally occur shortly after the last berries have been picked, or mid to late August to early September.

Thrips, *Frankliniella* spp.

Symptoms of Damage: Thrips can significantly damage blossoms, affect fruit set, and cause curling and malformation of leaves.

Identification: Very small, cigar-shaped insects. The adults are slender, winged, about 1/25 inch long, and orange or yellow. Young thrips are smaller, wingless, yellowish, and active.

Life Cycle: Several species of thrips are present in blueberries. The biology and damage potential is not well understood. The flower thrips has been the most common over the last several years.

Monitoring and Controls: Thrips can be monitored with a small beating tray just prior to, during, and shortly after bloom. If treatment is justified, then Spintor (spinosad) is the material of choice. Provado will also control thrips. Lannate and Diazinon will control

thrips to a much lesser extent. Of these choices, only Spintor may be used during bloom, but it is highly toxic to bees exposed to the spray before it has dried. Do not apply within 3 hours of bee activity, and if used during bloom, then apply the product in the evening after bees have stopped foraging for the day.

VERTEBRATE PESTS

With blueberries, birds are frequent vertebrate pests, as are voles. However, deer can also cause damage to young plantings, and miscellaneous other rodents cause occasional damage. Chapter 5 contains a complete discussion of vertebrate pests, including information on identification of various species of pests, diagnosis of damage when the culprit is not seen, and management/control measures.

WEEDS

Blueberry root systems are shallow and lack root hairs, which put them at a disadvantage when competing with weeds for water and nutrients. Weeds also compete with blueberry plants for light and space. They act as hosts for insects, diseases, and nematodes; provide cover for undesirable animals; reduce quality and yield; and impede harvest. Thus, good weed control is essential if optimum growth and yields are to be realized. Weeds may be controlled by a number of different methods or combinations of methods, but an integrated approach including the following methods is the most effective:

1. Avoid sites infested with persistent perennial weeds such as quackgrass, nutsedge, and wild brambles.
2. If such sites must be used, eradicate weeds in the years before planting. Cover crops such as sudangrass or rye are very effective in “outcompeting”

Table 7.11. Activity groups and effectiveness of fungicides for blueberry disease control.

Not all fungicides listed below are labeled for all the diseases listed. This table is intended to provide information on effectiveness for diseases that appear on the label and additional diseases that may be controlled from application. See Table 7.13 for labeled uses.

Fungicide	Activity Group ^a	Anthraco- se Fruit Rot	Mummy Berry	Alternaria Fruit Rot	Botrytis Blight	Phomopsis Twig Blight	Phytophthora Root Rot
Abound	11	+++ ^b	++	++	++	++	0
Aliette	33	+ ^c	0	—	0	++	+++
Bravo	M	++	+	+	+	0	0
Cabrio	11	+++	0	++	++	++	0
Captan	M	++	0	+	++	++	0
Captevate	17, M	++	0	+	+++	++	0
Elevate	17	0	0	+	+++	+	0
Indar	3	0	+++	—	—	+++	—
Lime sulfur	M	0	0	0	0	++	0
Messenger	—	0	0	0	0	0	0
Omega	29	+++	—	—	—	—	—
Orbit, Tilt	3	0	+++	—	0	0	0
Phosphorous Acid ^d	33	0 ^c	0	0	0	0	+++
Pristine	7, 11	+++	++	+	+++	+++	0
Ridomil Gold	4	0	0	0	0	0	+++
Switch	9, 12	++	++	+++	+++	0	0
Ziram	M	+++	0	0	++	++	0

a. Chemistry of fungicides by activity groups: 3 = demethylation inhibitors (includes triazoles); 4 = acylalanines; 7 = carboxamides; 9 = anilino-pyrimidines; 11 = strobilurins; 12 = phenylpyrroles; 17 = hydroxylanilides; 29 = activity group not named, chemical group = 2,6-dinitroanilines; 33 = unknown (phosphonates); M = chemical groups with multisite activity. Fungicides with two activity groups listed contain active ingredients from two activity groups.

b. 0 = not effective; + = slight effectiveness; ++ = moderate effectiveness; +++ = very effective; — = insufficient data

c. Aliette and the phosphorous acid fungicides are not effective for prevention of anthracnose fruit rot; however, they can be used to improve storage.

d. Phosphorous acid fungicides have the same active ingredient as Aliette. These include Phostrol, Prophyte, and Rampart.

Table 7.12. Activity groups and effectiveness of insecticides and miticides on blueberry pests.

Not all insecticides listed below are labeled for all the insects listed. This table is intended to provide information on effectiveness for insects that appear on the label plus additional insects that may be controlled from application. See Table 7.13 for labeled uses.

	Activity ^a Group	Aphids	Blueberry Maggot	Bud Mite	Cranberry Weevil	Fruit- worms	Japanese Beetle Adults	Leaf- hoppers	Leaf- rollers	Plum Curculio	Scales	Thrips	White Grubs
Actara	4A	+++ ^b	+	0	+++	0	++	+++	—	+	—	0	—
Admire	4A	+++	+	0	—	0	++	++	—	—	—	0	+++
Asana	3	++	++	0	+++	++	++	++	—	++	—	—	—
Assail	4A	++	+++	—	—	+	++	++	—	0	—	+	—
Avaunt	22	—	—	—	—	++	—	—	—	++	—	—	—
Aza-Direct	un	—	+	—	—	—	+	—	—	—	—	—	—
Brigade	3	+++	—	—	—	—	—	++	—	—	—	—	—
Bt Products	11	—	—	—	—	—	0	—	++	—	—	—	—
Confirm	18	—	—	—	—	++	0	—	+++	—	—	—	—
Danitol	3	++	—	—	—	—	+++	++	+++	—	—	—	—
Delegate	5	—	—	—	—	+++	—	0	—	—	—	++	—
Diazinon	1B	++	++	0	++	++	0	+++	++	+++	+++	+	+
Esteem	7	—	—	—	—	—	0	+	—	—	+++	—	—
Guthion (NJ only)	1B	—	+++	0	+++	+++	++	+++	+++	+++	++	—	—
Imidan	1B	—	+++	—	+++	+++	++	+++	+++	+++	++	0	—
Intrepid	18	—	—	—	—	—	—	—	—	—	—	—	—
Lannate	1A	++	++	—	++	+++	—	++	++	+	—	+	—
Malathion	1B	+	+++	—	+	+	+	+	—	++	—	++	—
M-Pede	—	++	—	—	—	—	—	+	—	—	—	—	—
Mustang Max	3	—	+	—	—	++	++	++	++	++	—	—	—
Platinum	4A	+++	—	0	—	0	—	++	—	+	—	0	—
Provado	4A	+++	+++	—	—	—	+++	+++	—	—	—	+++	—
Pyganic	3	+	+	—	—	—	+	—	—	—	—	—	—
Pyrellin	3, 21	—	+	—	+	+	++	—	++	+	—	—	—
Sevin	1A	—	+	—	+	+	+++	++	+	+	—	—	—
Spintor, Success, Entrust	5	—	+++	0	—	+++	0	+++	+++	0	0	+++	—
Superior Oil	—	++ ^c	0	+	—	—	0	—	—	—	+++	—	—
Surround	—	—	+	—	—	—	—	—	—	++	—	—	—
Thionex	2A	++	0	+++	—	+	—	0	—	+	0	—	—

a. Chemistry of insecticides by activity groups: 1A = carbamates; 1B = organophosphates; 2A = chlorinated cyclodienes; 3 = pyrethrins and synthetic pyrethroids; 4A = neonicotinoids; 5 = spinosyns; 7 = juvenile hormone mimics; 11 = Bt microbials; 18 = ecdysone agonists/molting disruptors; 21 = botanical (Site I electron transport inhibitors); 22 = voltage-dependent sodium channel blocker

b. — indicates insufficient data; +++ = good control; ++ = moderate control; + = some control; 0 = little or no control

c. Dormant to delayed dormant only; effective on eggs.

Table 7.13. Pesticides for blueberry disease and insect control.

Note: The recommendations below are correct to the best of our knowledge. Other formulations with the same active ingredient as some of the products listed below may exist and may or may not be labeled for the same uses. Always consult the label before making pesticide applications. Read the text for information on cultural practices to minimize pest incidence. If control cannot be achieved with a particular material, it is possible that resistant populations exist. Use a material in a different activity group, which will have a different mode of action. See Table 3.2 for use status, chemical names of active ingredients, and reentry intervals. See Table 3.1 for toxicity to nontarget organisms, and Tables 7.11 and 7.12 for activity groups and efficacy ratings to help determine products that best suit your situation. See Table 7.14 for other use restrictions such as quantity allowable per season, etc. Information was current as of October 1, 2009.

Pest	Timing of Treatment/Comments	Product ^a Labeled Rate/A (Days to Harvest)
DORMANT TO DELAYED DORMANT		
Note: The severity of many diseases such as botrytis blight, phomopsis twig blight, and anthracnose and some insects such as scale and bud mite can be decreased by thoroughly pruning out old canes and/or diseased twiggy growth. Avoid excessive nitrogen fertilization, which results in succulent growth that is more subject to infection.		
Diseases		
Phytophthora root rot	Before plants begin active growth, apply to soil in a 3-foot-wide band. Make either this application, or a soil application at green tip to pink bud stage (see Budbreak through Prebloom). Ridomil is at risk for resistance development, so have an accurate diagnosis made of the need for this treatment before applying.	Ridomil Gold SL, 3.6 pt (0)
Phomopsis twig blight ^b	When dormant, prune out diseased canes and burn. Continue to remove and burn blighted wood during the season. Apply lime sulfur at sufficient volume to achieve coverage of the canes. Do not use within 14 days of an oil spray or when temperature is above 75°F. Do not mix with other insecticides or fungicides. Will also aid in control of scale insects.	Lime sulfur, 5–6 gal in 100–150 gal of diluted spray/A (—)
Mummy berry	Bury old mummies by disking before mummy cup formation. Burial of mummies (infected berries) a least 1 inch deep, and 2 inches preferably, will greatly reduce germination of mummy cups.	
Insects		
Scale	Apply oil only if scales are present and there is no danger of freezing temperatures for 24 hours. Apply when buds have swollen but no green tissue is present. Good coverage is essential. Lime sulfur applied in the dormant stage for phomopsis will also aid in control of scale insects. Pruning out old canes prevents heavy infestations.	Superior oil, 3.0 gal. Apply 250–300 gal water/A at a pressure of 300–400 psi, or follow manufacturer's recommendations for water volume and pressure to be used. Esteem 35WP at 5 oz/A may be added to the oil for increased scale control.
BUD BREAK THROUGH PREBLOOM		
Diseases		
Phytophthora root rot	Make the first soil application of Ridomil now, unless used when dormant in spring (see above). Ridomil is at risk for resistance development, so have an accurate diagnosis made of the need for this treatment before applying.	Ridomil Gold SL, 3.6 pt (0), or
	Phosphorous acid products (Aliette, Phostrol, Prophyte, and Rampart) can be used as a soil application at this time, or as a foliar application if leaves are developed.	Phosphorous acid, see individual product labels

Table 7.13. Pesticides for blueberry disease and insect control, continued.

Pest	Timing of Treatment/Comments	Product^a Labeled Rate/A (Days to Harvest)
Mummy berry (primary infection)	Rake, sweep, or hoe under plants to disturb mummy cups through blossom period. Limited success has been achieved by applying 200 lb of 50% urea mix as a ground application as first mummy cups are formed (burns only open cups). Apply a fungicide when leaf buds show green, repeating once in 10 days. For resistance management, do not make more than two sequential applications of strobilurin (group 11) fungicides before rotating to a fungicide in a different chemical class. Indar, Orbit, and Tilt are in the same fungicide group and cannot be rotated with each other for resistance management.	Indar 75WSP, 2.0 oz or 2F, 6 fl oz (30), or Orbit, 6 fl oz (30), or Tilt, 6 fl oz (30), or Pristine, 18.5–23.0 oz (0), or Switch 62.5 WDG, 11–14 oz (0), or Abound F, 6.2–15.4 oz (0)—see note in Table 7.14 about severe toxicity of Abound to McIntosh, Gala, and related apple cultivars.
Anthracnose	Make this application immediately before bloom. Apply in sufficient water to cover emerging flowers and bud scales, in which anthracnose inoculum overwinters.	Omega 500F, 1.25 pt (30)
Insects		
Cranberry weevil	When leaf buds show green and blossom buds show white and are separating in the cluster. Do not apply within 7 days of pollination, as Asana repels bees.	Asana XL, 4.8–9.6 fl oz (14)
Leafrollers	Confirm is a selective insecticide effective against most caterpillar pests (larvae only). Confirm, Bt products, Delegate, and Intrepid are effective only on early instars.	Confirm 2F, 16.0 fl oz (14), or Bt products, var. kurstaki (0), or Mustang, 4.3 oz (1), or Mustang Max, 4.0 oz (1), or Delegate WG, 3–6 oz (3), or Intrepid 2F, 16 oz (7)
Spanworms	Confirm is a selective insecticide effective against most caterpillar pests (larvae only). Apply these products to early instars.	Confirm 2F, 16.0 fl oz (14), or Dipel DF, 0.5–1.0 lb (0), or Intrepid 2F, 16 oz (7)
Gypsy moth	Confirm is a selective insecticide effective against most caterpillar pests (larvae only). Apply these products to early instars.	Confirm 2F, 4.0–8.0 fl oz (14), or Dipel DF, 0.5–1.0 lb (0), or Intrepid 2F, 4–8 oz (7)

BLOOM**Diseases**

Mummy berry (secondary infection)	At 7- to 10-day intervals through petal fall. This spray is designed to prevent flower infections and is necessary if primary mummy berry (shoot blight) infections were not controlled previously. For resistance management, do not make more than two sequential applications of strobilurin (group 11) fungicides before rotating to a fungicide in a different chemical class.	Indar 75WSP, 2 oz or 2F, 6 fl oz (30), or Orbit, 6 fl oz (30), or Tilt, 6 fl oz (30), or Abound F, 6.2–15.4 oz (0)—see note in Table 7.14 about severe toxicity of Abound to McIntosh, Gala, and related apple cultivars, or Switch 62.5WG, 11.0–14.0 oz (0), or Pristine, 18.5–23.0 oz (0)
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Table 7.13. Pesticides for blueberry disease and insect control, continued.

Pest	Timing of Treatment/Comments	Product ^a Labeled Rate/A (Days to Harvest)
Botrytis	Begin application at early bloom. Combine treatments with anthracnose controls. Spray at 7- to 10-day intervals through petal fall. For resistance management, do not make more than two sequential applications of strobilurin (group 11) fungicides before rotating to a fungicide in a different chemical class. Note that although captan has a 0-day PHI, it has a longer REI for blueberries, and Captevate has a 48-hr REI.	Pristine, 18.5–23.0 oz (0), or Captan 50W, 5 lb or 80WDG, 3.125 lb (0), or Captec 4L, 2.5 qt, or Captevate 68WDG, 3.5–4.7 lb (0), or Switch 62.5WG, 11.0–14.0 oz (0), or Elevate, 1.5 lb (0)
Anthracnose	Apply at mid-bloom and repeat in 7 to 10 days. For resistance management, do not make more than two sequential applications of strobilurin (group 11) fungicides before rotating to a fungicide in a different chemical class. Captevate has a 48-hr REI.	Abound F, 6.2–15.4 oz (0)—see note in Table 7.14 about severe toxicity of Abound to McIntosh, Gala, and related apple cultivars, or Switch 62.5WG, 11.0–14.0 oz (0), or Cabrio EG, 14 oz (0), or Pristine, 18.5–23 oz (0), or Captevate 68WDG, 4.7 lb (0), or Ziram 76DF, 3 lb (—)—see special local needs label (24C) allowing 4 lb/acre rate and 14-day PHI in NJ
Insects		
Leafrollers, spanworms, fruitworms	Only insecticides nonharmful to bees (e.g., Bt, Confirm, Intrepid) can be applied during bloom. Confirm is a selective insecticide effective against most caterpillar pests (larvae only).	Confirm 2F, 16 oz (14), or Dipel DF, 0.5–1.0 lb (0), or Intrepid 2F, 16 oz (7)
Gypsy moths	Only insecticides nonharmful to bees (e.g., Bt, Confirm, Intrepid) can be applied during bloom. Confirm is a selective insecticide effective against most caterpillar pests (larvae only). Apply products to early instars.	Confirm 2F, 4.0–8.0 fl oz (14), or Dipel DF, 0.5–1.0 lb (0), or Intrepid 2F, 4–8 oz (7)
Thrips	Spintor is toxic to bees exposed to the spray before it has dried. Apply in the evening after bees have stopped foraging for the day.	Spintor 2SC, 4.0–6.0 fl oz (3)
AT PETAL FALL		
Diseases		
Anthracnose	This is intended to be the follow-up spray for the one applied at mid-bloom. For resistance management, do not make more than two sequential applications of strobilurin (group 11) fungicides before rotating to a fungicide in a different chemical class. Captevate has a 48-hr REI.	Abound F, 6.2–15.4 oz (0)—see note in Table 7.14 about severe toxicity of Abound to McIntosh, Gala, and related apple cultivars, or Cabrio EG, 14 oz (0), or Captevate 68WDG, 4.7 lb (0), or Pristine, 18.5–23.0 oz (0), or Switch 62.5 WG, 11.0–14.0 oz (0), or Ziram 76DF, 3 lb (—)—see special local needs label (24C) allowing 4 lb/acre rate and 14-day PHI in NJ

Table 7.13. Pesticides for blueberry disease and insect control, continued.

Pest	Timing of Treatment/Comments	Product ^a Labeled Rate/A (Days to Harvest)
Insects		
Cranberry or cherry fruitworm	At petal fall (May 25 to June 7 in NJ) and again 10 days later. Sprays for insects at this time will also give control of spanworms and gypsy moth. Confirm is a selective insecticide effective against most caterpillar pests (larvae only). Growers using Guthion should be aware of restrictions on use and long re-entry intervals for the general public. Guthion use on blueberries is prohibited after Sept. 30, 2012. A yearly maximum amount of 0.75 lb ai/a applies for 2010, 2011, and 2012.	Diazinon 50W, 1 lb or AG500, 1 pt (7), or Malathion 57EC, 1.6 pt or 8F, 1.5–2.5 pt (1), or Imidan 70W, 1.33 lb (3), or Asana XL, 4.8–9.6 oz (14), or Lannate SP, 0.5–1.0 lb or LV, 1.5–3.0 pt (3), or Assail 70WP, 1.9–2.3 oz/a, or 30SG, 4.5–5.3 oz (1), or Avaunt, 3.5–6.0 oz (7) Danitol 2.4EC, 10.67–16 fl oz (3), or Intrepid 2F, 16 oz (7), or Delegate WG, 3–6 oz (3), or Confirm 2F, 16 oz (14), or Esteem 35WP, 5 oz (7), or NJ only^c: Guthion 50WP, 1.0–1.5 lb
Leafrollers	At petal fall (May 25 to June 7 in NJ). Danitol is labeled for obliquebanded leafroller only. Confirm is a selective insecticide effective against most caterpillar pests (larvae only). In NJ, leafroller resistance to malathion has been noted.	Imidan 70W, 1.33 lb (3), or Lannate SP, 1 lb or LV, 3 pt (3), or Confirm 2F, 16 oz (14), or Dipel DF, 0.5–1.0 lb (0), or Malathion 8F, 1.5–2.5 pt (1), or Intrepid 2F, 16 oz (7), or Spintor 2SC, 4.0–6.0 fl oz (3), or Danitol 2.4EC, 10.67–16 fl oz (3), or Mustang, 4.3 oz (1), or Mustang Max, 4.0 oz (1), or Delegate WG, 3–6 oz (3)
Plum curculio	At petal fall (May 25 to June 7 in NJ). Apply if there is a history of this pest, or oviposition scars are seen on earliest forming green berries. Growers using Guthion should be aware of restrictions on use and long reentry intervals for the general public. Guthion use on blueberries is prohibited after Sept. 30, 2012. A yearly maximum amount of 0.75 lb ai/a applies for 2010, 2011, and 2012.	Malathion 57EC, 2.8–3.2 pt or 8F, 1.5–2.5 pt (1), or Imidan 70W, 1.33 lb (3), or Surround 95WP, 25.0–50.0 lb (0), or Danitol, 10.67–16 fl oz (3), or NJ only^c: Guthion 50WP, 1.0–1.5 lb (7)
Thrips		Assail 70WP, 1.9–2.3 oz, or 30SG, 4.5–5.3 oz (1), or Provado 1.6F, 6.0–8.0 fl oz (3), or Spintor 2SC, 4.0–6.0 fl oz (3)
Lecanium scale crawlers	As crawlers are detected.	Esteem 35WP, 5 oz (7)

1–2 WEEKS AFTER PETAL FALL**Diseases**

Anthracnose	Early to mid-June, especially when weather is warm and rainy. For resistance management, do not make more than two sequential applications of strobilurin (group 11) fungicides before rotating to a fungicide in a different chemical class. Ziram has a 14-day PHI in NJ; however, applications should be avoided within 28 days prior to harvest due to the visibility of white residues. Captevate has a 48-hr REI.	Abound F, 6.2–15.4 oz (0)—see note in Table 7.14 about severe toxicity of Abound to McIntosh, Gala, and related apple cultivars, or Pristine, 18.5–23.0 oz (0), or Cabrio EG, 14 oz (0), or Captevate 68WDG, 4.7 lb (0), or Ziram 76DF, 3 lb (—)—see special needs label (24C) allowing 4 lb/acre rate and 14-day PHI in NJ
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Table 7.13. Pesticides for blueberry disease and insect control, continued.

Pest	Timing of Treatment/Comments	Product ^a Labeled Rate/A (Days to Harvest)
Insects		
Sharpnosed leafhopper	Early to mid-June. As necessary. Sharpnosed leafhoppers transmit stunt, which is lethal to blueberries. Rogue out affected plants (refer to text discussion) and apply an insecticide when sharpnosed leafhoppers appear on yellow sticky traps.	Lannate SP, 0.5 lb or LV, 1.5 pt (3), or Asana XL, 4.8–9.6 oz (14), or Provado 1.6F, 3.0–4.0 fl oz (3), or Malathion 57EC, 2.8–3.2 pt or 8F, 1.5–2.5 pt (1), or Actara, 3.0–4.0 oz (3), or Brigade WSB, 5.3–16 oz (1), or Assail 70WP, 1.0–2.3 oz, or 30SG 2.5–5.3 oz (1)
Blueberry aphids	Early to mid-June.	Lannate SP, 0.5 lb or LV, 1.5 pt (3), or Diazinon 50W, 1 lb or AG500, 1 pt (7), or Provado 1.6F, 3.0–4.0 fl oz (3), or Malathion 8F, 1.5–2.5 pt (1), or M-Pede, 1–2% v/v (0), or Actara, 3.0–4.0 oz (3), or Brigade WSB, 5.3–16 oz (1), or Assail 70WP, 1.0–2.3 oz, or 30SG 2.5–5.3 oz (1), or NJ only^d : Asana XL, 4.8–9.6 oz (14)
Scale crawlers	As crawlers are detected.	Esteem 35WP, 5 oz (7)
LATER POSTPOLLINATION SPRAYS		
Diseases		
Anthracnose	For resistance management, do not make more than two sequential applications of strobilurin (group 11) fungicides per crop year. Captevate has a 48-hr REI.	Abound F, 6.2–15.4 oz (0)—see note in Table 7.14 about severe toxicity of Abound to McIntosh, Gala, and related apple cultivars, or Cabrio EG, 14 oz (0), or Switch 62.5 WDG, 11.0–14.0 oz (0), or Captevate 68WDG, 4.7 lb (0)
Phytophthora root rot	Several phosphorous acid products can be used. Product names include Aliette, Phostrol, Prophyte, and Rampart.	Phosphorous acid, see individual product labels
Insects		
Cranberry and/or cherry fruitworms	Confirm is a selective insecticide effective against most caterpillar pests (larvae only). Growers using Guthion should be aware of restrictions on use and long reentry intervals for the general public. Guthion use on blueberries is prohibited after Sept. 30, 2012. A yearly maximum amount of 0.75 lb ai/a applies for 2010, 2011, and 2012.	Diazinon 50W, 1 lb or AG500, 1 pt (7), or Malathion 57EC, 1.6 pt or 8F, 1.5–2.5 pt (1), or Sevin 80S, 1 7/8–2.5 lb or 4F, 1.5–2.0 qt (7), or Imidan 70W, 1.33 lb (3), or Asana XL, 4.8–9.6 oz (14), or Lannate SP, 0.5–1.0 lb or LV, 1.5–3.0 pt (3), or Assail 70WP, 1.9–2.3 oz, or 30SG, 4.5–5.3 oz (1), or Avaunt, 3.5–6.0 oz (7), or Danitol, 10.67–16 fl oz (3), or Confirm 2F, 16 oz (14), or Esteem 35WP, 5 oz (7), or Spintor 2SC, 4–6 fl oz (3), or NJ only^d : Guthion 50WP, 1.0–1.5 lb (7)

Table 7.13. Pesticides for blueberry disease and insect control, continued.

Pest	Timing of Treatment/Comments	Product ^a Labeled Rate/A (Days to Harvest)
Leafrollers	When populations are high. Danitol is labeled for obliquebanded leafroller only. Confirm is a selective insecticide effective against most caterpillar pests (larvae only). In NJ, leafroller resistance to malathion has been noted.	Imidan 70W, 1.33 lb (3), or Lannate SP, 1 lb or LV, 3 pt (3), or Confirm 2F, 16 oz (14), or Dipel DF, 0.5–1.0 lb (0), or Malathion 8F, 1.5–2.5 pt (1), or Spintor 2SC, 4–6 fl oz (3), or Sevin 80S, 2.5 lb or 4F, 2.0 qt (7), or Danitol 2.4 EC, 10.67–16 fl oz (3), or Mustang, 4.3 oz (1), or Mustang Max, 4.0 oz (1), or Delegate WG, 3–6 oz (3)
Sharponosed leafhopper	As necessary. Sharponosed leafhoppers transmit stunt, which is lethal to blueberries. Rogue out affected plants (refer to text discussion) and apply an insecticide when sharponosed leafhoppers appear on yellow sticky traps.	Lannate SP, 0.5 lb or LV, 1.5 pt (3), or Provado 1.6F, 3.0–4.0 fl oz (3), or Asana XL, 4.8–9.6 oz (14), or Actara, 3.0–4.0 oz (3), or Malathion 57EC, 2.8–3.2 pt or 8F, 1.5–2.5 pt (1), or Brigade WSB, 5.3–16 oz (1), or Assail 70WP, 1.0–2.3 oz, or 30SG 2.5–5.3 oz (1)
Aphids		Lannate SP, 0.5 lb or LV, 1.5 pt (3), or Provado 1.6F, 3.0–4.0 fl oz (3), or Malathion 8F, 1.5–2.5 pt (1), or M-Pede, 1–2% v/v (0), or Actara, 3.0–4.0 oz (3), or Brigade WSB, 5.3–16 oz (1), or Assail 70WP, 1.0–2.3 oz, or 30SG 2.5–5.3 oz (1)
Blueberry tip borers	Insecticides applied for fruitworms usually also control this pest.	Malathion 8F, 1.5–2.5 pt (1)

FRUIT MATURATION**Diseases**

Anthracnose	For resistance management, do not make more than two sequential applications of strobilurin (group 11) fungicides per crop year. Captevate has a 48-hr REI. Aliette is not effective for the prevention of anthracnose fruit rot; however, it can be used to improve storage.	Abound F, 6.2–15.4 oz (0)—see note in Table 7.14 about severe toxicity of Abound to McIntosh, Gala, and related apple cultivars, or Cabrio EG, 14 oz (0), or Switch 62.5 WDG, 11.0–14.0 oz (0), or Captevate 68WDG, 4.7 lb (0), or Aliette WDG, 5.0 lb (0.5)
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Insects

Blueberry maggots	Begin treatments 10 days after the first maggot adult catch in monitoring traps. Repeat every 10 days through harvest. If traps are not used and maggots are a problem, begin sprays when berries first turn blue. Adding a bait to the spray mixture will enhance its activity. Watch days-to-harvest limitations. Surround is for suppression and is recommended for application only within the first three weeks after fruit set due to likelihood of visible residues.	Sevin 80S 1.87–2.5 lb or 4F, 1.5–2.0 qt (7), or Lannate SP, 0.25–0.5 lb or LV, 0.75–1.5 pt (3), or Imidan 70W, 1.3 lb (3), or Malathion 8F, 1.5–2.5 pt (1), or Asana XL, 9.6 oz (14), or Danitol 2.4 EC, 10.67–16 fl oz (3), or Surround 95WP, 12.5–50 lb (0), or Provado 1.6F, 6.0–8.0 fl oz (3), or Assail 70WP, 1.9–2.3 oz, or 30SG, 4.5–5.3 oz (1)
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Table 7.13. Pesticides for blueberry disease and insect control, continued.

Pest	Timing of Treatment/Comments	Product ^a Labeled Rate/A (Days to Harvest)
Leafrollers	When populations are high. Danitol is labeled for obliquebanded leafroller only. In NJ, leafroller resistance to malathion has been noted.	Imidan 70W, 1.33 lb (3), or Lannate SP, 1 lb or LV, 3 pt (3), or Malathion 8F, 1.5–2.5 pt (1), or Danitol 2.4 EC, 10.67–16 fl oz (3), or Mustang, 4.3 oz (1), or Mustang Max, 4.0 oz (1)
Japanese beetle adults and other scarab beetles as listed on label	As necessary if adults are a pest.	Sevin 80S, 1.25–2.5 lb or 4F, 1–2 qt (7), or Imidan 70W, 1.33 lb (3), or Provado 1.6F, 6.0–8.0 fl oz (3), or Actara, 4.0 oz (3), or Assail 70WP, 1.9–2.3 oz or 30SG, 4.5–5.3 oz (1), or Danitol 2.4 EC, 10.67–16 fl oz (3)
Fall webworm	No pesticides are currently labeled for this pest. However, broad-spectrum pesticides applied for other pests will give control.	
Oriental beetle larvae and other white grubs	Admire works well on young larvae as they hatch from eggs but has little effect if applied later in the summer. Apply from June to mid-July at least 7 days before harvest begins for most varieties and right after harvest for the earliest varieties. Material should be applied to moist soil and watered in with 0.5 to 1 inch of water. The active ingredient is broken down by sunlight, so evening applications are best. Once in the soil, the insecticide will remain present for several months.	Admire Pro, 7–14 oz (7)
POSTHARVEST		
Diseases		
Anthracnose	As soon as possible after harvest. Make this application August 1 to 20 in NJ. See Special Local Needs label for NJ.	Ziram 76DF, 3 lb (—), or NJ only: Ziram 76DF, 4 lb (14)
Phomopsis twig blight	Late fall through early winter. This spray will also help with controlling black shadow, a recently identified disease that causes a blackened appearance to twigs and a decline of affected plants.	Lime sulfur, 5–6 gal in 100–150 gal of diluted spray/A (—)
Powdery mildew	Not often a problem.	Indar 75WSP, 2.0 oz or 2F, 6 fl oz (30), or Orbit, 6 fl oz (30), or Tilt, 6 fl oz (30)

CONTINUED

Table 7.13. Pesticides for blueberry disease and insect control, continued.

Pest	Timing of Treatment/Comments	Product^a Labeled Rate/A (Days to Harvest)
Insects		
Sharpnosed leafhopper	As necessary. Sharpnosed leafhoppers transmit stunt, which is lethal to blueberries. Rogue out affected plants (refer to text discussion) and apply an insecticide when sharpnosed leafhoppers appear on yellow sticky traps. Actara and Platinum contain the same active ingredient. Actara is for foliar applications, while Platinum is applied to the soil.	Malathion 57EC, 2.8–3.2 pt or 8F, 1.5–2.5 pt (1), or Asana XL, 4.8–9.6 oz (14), or Lannate LV, 1.5 pt or SP, 0.5 lb (3), or Provado 1.6F, 3.0–4.0 fl oz (3), or Brigade WSB, 5.3–16 oz (1), or Assail 70WP, 1.0–2.3 oz, or 30SG, 2.5–5.3 oz (1), or Actara, 3.0–4.0 oz (3), or Platinum, 5.0–12.0 fl oz (75)
White grub complex	This includes larvae of Japanese beetle, Oriental beetle, and Asiatic garden beetle. Earlier applications, prior to the end of July, are more effective. Postharvest application may be of value only on the earliest cultivars.	Admire Pro, 7–14 oz (7), or Platinum, 5.0–12.0 fl oz (75)
Blueberry bud mite	Immediately after harvest and 6–8 weeks later. Use oil when Putnam scale is also a problem. In NJ, make applications between September 15 and 30.	Thionex 3EC ^c , 2 qt or 50WP, 3 lb (—), or Superior oil, 3 gal

a. Some pesticides may be phytotoxic to plants. If in doubt, test a small area of the field first. This is especially important when new formulations are being used or tank-mixed. Be sure sprayer is calibrated properly. Diazinon and captan should not be tank-mixed as the combination may be phytotoxic. Liquid formulations of captan have caused phytotoxicity to blueberries under conditions of high humidity and cloudiness, when the leaf cuticle may be thinner than usual.

b. Berkeley, Coville, Jersey, and Weymouth cultivars are particularly susceptible to phomopsis twig blight.

c. Guthion is labeled for blueberries in the states of AL, AR, FL, GA, IN, MI, NC, NJ, and NY only.

d. Asana is labeled for use against aphids only in NJ.

e. Do not apply after buds are well formed. Do not make more than two applications per year.

Table 7.14. Additional restrictions on blueberry pesticides.

The information below is correct to the best of our knowledge. Other formulations with the same active ingredient as some of the products listed below may exist and may be labeled for the same uses. Always consult the label before making pesticide applications. Information was current as of October 1, 2009.

Abound	For resistance management, do not apply more than 2 sequential applications of Abound or any other strobilurin (group 11) fungicide before alternating with a fungicide with a different mode of action. See label for several additional resistance management strategies. See Table 7.11 for chemical activity groups of fungicides labeled for use on blueberries. Do not allow to drift to McIntosh, Gala or related apple cultivars (Bancroft, Bromley, Cortland, Cox, Discover, Empire, Jonamac, Kent, Spartan, and Summared). Do not use the same spray equipment for other materials that will be applied to these cultivars, even if thoroughly cleaned.
Actara	Do not apply more than three consecutive applications of Actara or other Group 4A insecticides before rotating to products with a different mode of action. Foliar applications of Actara should not be used on crops previously treated with long-residual or soil applied Group 4A insecticides. Do not use more than 12 oz of Actara per acre per growing season. The minimum interval between applications of Actara is 7 days.
Admire Pro	Do not apply more than 14 fl oz (0.5 lb ai) of Admire Pro per acre per season. Do not apply more than a total of 0.5 lb active ingredient per acre of Admire or Provado, or a combination of Admire and Provado per season.
Aliette WDG	Do not exceed 20 lbs of product per acre per season. Do not exceed 4 applications per year. Do not apply in less than 10 gallons per acre.
Asana	Do not apply more than 38.4 oz of product of Asana per acre per season.
Assail	Do not make more than 5 applications per season or apply more often than once every 7 days. Do not exceed 0.5 lbs of active ingredient per acre per growing season.
Avaunt	Make no more than 4 applications per season, or apply more than 24 oz per acre per crop. Minimum interval between treatments is 7 days.
Brigade	Do not make applications less than 7 days apart or apply more than 0.5 lbs of active ingredient per acre per season.
Cabrio EG	For resistance management, do not apply more than 2 sequential applications of Cabrio or any other strobilurin (group 11) fungicide before alternating with a fungicide with a different mode of action. See label for several additional resistance management strategies. See Table 7.11 for chemical activity groups of fungicides labeled for use on blueberries.
Captan	Do not apply more than 43.75 lb of 80WDG, or equivalent of a different formulation, per acre per season.
Captevate 68WDG	Do not make more than two consecutive applications of Captevate or Elevate, or any product containing the active ingredient fenhexamid, before alternating with a fungicide with a different mode of action. Do not apply more than 21.0 lb per acre per season.
Confirm 2F	Do not apply more than 64 fl oz of product per acre per season.
Danitol 2.4EC	Do not exceed 2 pts total application of Danitol per acre per season.
Delegate WG	To reduce the potential for resistance development in target pest species, do not make more than 2 consecutive applications of group 5 insecticides (active ingredients of spinetoram or spinosad). If additional treatments are required, rotate to another class of effective insecticides for at least one application. Do not apply more than a total of 19.5 oz of Delegate WG per acre per crop. Do not make more than 6 applications per calendar year or applications less than 6 days apart.
Diazinon	Do not apply more than one in-season foliar application per year.
Elevate	Do not make more than two consecutive applications of Captevate or Elevate. Do not apply more than 6 lb/a/season of Elevate.
Esteem 35WP	Do not make more than 2 Esteem 35 WP applications per growing season. Do not exceed 10 oz per acre per season. Do not apply earlier than 14 days after last Esteem 35WP treatment.
Indar 75WSP or 2F	Do not make more than 4 applications or apply more than 8 oz of Indar 75WSP or 24 fl oz of Indar 2F per acre per year.
Guthion (NJ only)	Do not allow persons not covered by the Worker Protection Standard, such as members of the general public involved in pick-your-own operations, to enter a treated area for 30, 35, or 42 days after application depending on rate used. Guthion use on blueberries is prohibited after September 30, 2012. A yearly maximum amount of 0.75 lb ai/a applies for 2010, 2011, and 2012.
Imidan 70W	Do not apply more than 7½ lb of Imidan 70W per acre per year or make more than 5 applications per year.

Table 7.14. Additional restrictions on blueberry pesticides, continued.

<i>Intrepid</i>	Do not apply more than 64 fl oz of Intrepid 2F per acre per calendar year. Do not make more than 3 applications per year or apply more often than once every 7 days.
<i>Lannate</i>	Do not apply more than 3.6 lb ai per acre per crop. Do not make more than 4 applications per crop.
<i>Lime sulfur</i>	Do not use within 14 days of an oil spray or when temperatures are above 75°F.
<i>Mustang</i>	Do not apply more than 0.3 lb of active ingredient (25.8 oz of product) per acre per season. Do not make applications less than 7 days apart.
<i>Mustang Max</i>	Do not apply more than 0.15 lb of active ingredient (24 oz of product) per acre per season. Do not make applications less than 7 days apart.
<i>Omega 500F</i>	Do not use more than 7.5 pints per acre per growing season.
<i>Orbit, Tilt</i>	Orbit and Tilt both contain the same active ingredient, propiconazole. Do not apply more than 30 fl oz (0.84 lb of propiconazole) in total of Orbit and Tilt per season. Apply these products in minimum spray volumes of 5 gal/A for ground application and 15 gal/A for aerial application.
<i>Platinum</i>	Only a single soil application of Platinum should be made per growing season. Foliar applications of other Group 4A insecticides should not be made following an application of Platinum.
<i>Pristine</i>	Do not apply more than two sequential applications before alternating with a fungicide with a different mode of action. See label for several additional resistance management strategies. See Table 7.11 for chemical activity groups of fungicides labeled for use on blueberries. Pristine may cause injury to foliage of Concord or related grape varieties such as Worden and Fredonia. Do not use Pristine on these varieties and use special care when applying to prevent contact with these sensitive varieties. Thoroughly rinse spray equipment, including the inside of the tank, hoses, and nozzles after use and before using the same equipment on these sensitive grape varieties.
<i>Provado</i>	Do not apply more than 40 fluid ounces of Provado 1.6F per year. Do not apply more than 5 applications of Provado per crop season.
<i>Sevin 80S</i>	Do not apply more than 5 times, or more often than once every 7 days.
<i>Spintor, Success, Entrust</i>	Do not apply more than a total of 0.45 lb ai of spinosad per acre per crop. Do not make more than 6 applications per year. Do not make applications less than 6 days apart. Do not apply more than 3 times per crop. When applied two times in succession, rotate to another insecticide class for at least one application.
<i>Switch</i>	Do not exceed 56 oz of Switch per acre per year. Do not make more than 2 applications before using a fungicide in another resistance management group.
<i>Thionex</i>	Do not make more than 2 applications per year. Do not exceed 1.5 lb ai per acre per year.
<i>Ziram 76DF</i>	Ziram applications should be avoided within 28 days prior to harvest due to the visibility of white residues.

noxious weeds; they also help build up soil organic matter if plowed under at the end of the season. For a more complete discussion of cover crops, see Chapter 2. Weeds can also be controlled the year before planting with glyphosate (Roundup), Touchdown, and selective broadleaf herbicides in grass crops. For a general discussion of weed control practices that will aid in minimizing weed pressure, see Chapter 4.

3. Control weeds in crops that precede blueberries on the site.
4. Control weeds in fencerows and adjacent fields.
5. Correctly identify the weeds that are in your planting so you can implement measures that will be effective for the weeds that you have.
6. Minimize weeds between the rows through the use of cultivation or establishment of a weed-free sod.
7. Use weed-free mulching materials within the row.
8. If cultivation is required, do so only shallowly since the blueberry root system is easily damaged.
9. In conventional systems, use recommended herbicides properly (see Table 7.18).

Practices 5, 6, 7, and 9 are discussed below.

In organic production, cultural practices that successfully manage weeds take on increased importance. Weed management strategies include planting permanent sod between rows of blueberries, mulching along the length of the row of blueberries, and using mechanical or hand cultivation. Placing a wide and deep mulch (6 inches deep and 4 feet wide) or fabric weed barrier around blueberry plants are also weed management strategies to consider.

WEED IDENTIFICATION

Knowing what the weed is and its life cycle (whether a summer annual, winter annual, biennial, or perennial) is a critical first step in implementing effective control measures. General information on the above terms is provided in Chapter 4 and in Table 4.1. Resources for weed identification are provided in Appendix E.

PRACTICES FOR MINIMIZING WEEDS BETWEEN THE ROWS

Between the rows, use cultivation and/or herbicides to control weeds, or establish a perennial grass sod such as tall or hard fescue to suppress weeds. It is essential to integrate the vegetation management program with insect and disease control programs.

Cultivation

When cultivation is used between the rows, it should be shallow and frequent during the growing season. Annual weeds are easily controlled by cultivation when they are less than one inch tall. Weeds that are more than two inches tall are more difficult to control and may have already competed with the blueberries.

Using Sod Row Middles

Sod between the rows prevents soil erosion, provides traction for equipment and people, increases soil organic matter, improves soil structure and water permeability, and furnishes shelter for beneficial insects. Sod also creates a more friendly environment for pick-your-own fields. The sod should not include plants that are an alternate host for insect pests, or diseases and nematodes that attack the crop. In addition, the sod should be easily maintained, tolerant to drought, low pH, require little or no fertilization, and compete very little with the blueberries.

Tall fescue or hard fescue perennial grass sods are recommended for *row middles*. Both types of fescue are tolerant to disease, drought, low pH, and low fertility. They compete effectively with weeds, do not spread or creep into the row by rhizome or stolon growth, and are semidormant during the hot, dry summer months. Tall fescue is more vigorous and is more easily established but requires more frequent mowing. Newly developed “turf type” tall fescue varieties are vigorous and have a lower mowing requirement than the traditional ‘Kentucky 31’ tall fescue, but they have not been evaluated in blueberries. Hard fescue grows more slowly and close to the ground and has a minimal mowing

requirement, but it is moderately slow and difficult to establish. The addition of clover or other legumes is not recommended.

Prepare for sod establishment before the blueberries are planted. Control perennial weeds and nematodes and correct soil pH and nutrient deficiencies first. Complete primary tillage operations the summer before planting. If building gently sloping raised ridges for blueberry rows to improve drainage, do so *before* sowing grass or planting blueberries.

The success of a sod planting will depend on accurate seeding and timing. Sow tall or hard fescue in late summer into a well-prepared seedbed. Use 50 to 75 pounds of seed per broadcast acre to establish tall fescue, or 25 to 50 pounds of seed per broadcast acre to establish hard fescue. Blend up to 5 pounds of perennial ryegrass per 100 pounds of hard fescue seed to provide a fast, thin cover while the hard fescue gets established. The perennial ryegrass will be eliminated from the stand by disease and drought in a few years. If perennial ryegrass is not used, a significantly greater amount of hard fescue seed should be used. See Tables 7.3 and 7.4 for additional information on cover crop characteristics and rates.

Use a seeder that will ensure good seed placement in a firm seedbed with good seed and soil contact. Failure to use adequate equipment for seeding frequently results in poor establishment. In an area like New Jersey, complete seeding by September 1 in the northern counties of New Jersey and by September 20 in the southern counties. Apply 50 pounds of nitrogen (N) per acre at seeding and repeat in late fall or early spring to encourage rapid establishment.

Establishment of a dense sod that is competitive with weeds will require 15 to 20 months. Some additional effort during this period will ensure success.

Broadleaf weeds are undesirable in a sod growing between blueberry rows. Competition with the crop and mowing requirements may be increased. Many weeds may be alternate hosts for diseases, insects, or nematode pests. The flowers of dandelion, clover, mustard species, and other weeds may coincide with bloom and are preferred by pol-

linating insects. The same weeds—and others—may also bloom before or after the crop blooms and attract bees into the field when insecticides must be sprayed. The seedheads of dandelion clog tractor radiators and cause overheating, which can interfere with crop maintenance operations.

Apply Gallery 75DF to the sod early each spring after the sod is at least 6 months old and while the field is non-bearing to control large crabgrass and other summer annuals. Use 1.0 pound of Gallery (0.75 pounds of active ingredient) per acre. This is the same rate of Gallery recommended for use in the row on newly planted nonbearing blueberries.

Clover is difficult to control but can be suppressed or controlled in a sod with good management practices and herbicides. Manage fertilizer applications to favor grass rather than the clover. Nitrogen fertilizer stimulates grass growth, and phosphorus and potassium stimulate clover growth in a mixed grass and legume sod. Do not apply fertilizer containing phosphorous or potassium to sod if clover control is a problem. Apply fertilizer for blueberry growth in the vegetation free strip only. Mowing height also influences the composition of a mixed grass and clover sod. Close mowing favors the clover. Taller sod will favor the grass. Mow no closer than 4 inches if clover control is a problem in the sod.

PRACTICES FOR MINIMIZING WEEDS IN THE ROWS

In the row, a weed free zone should be maintained where weed competition with the crop is severe. Control in-row weeds with mulches and/or herbicides. The use of mechanical cultivation equipment in the row is seldom recommended due to risk of damaging the shallow roots of the blueberries.

The width of the weed-free zone should be about 36 to 48 inches wide, or about 18 to 24 inches on each side of the row. This weed free strip should be about 40 percent of the distance between the rows. The width may vary, however, depending on soil fertility, water-holding capacity and exposure to erosion. Do *not* reduce the width of the weed-free zone in young nonbearing fields. Maintain the

full width of the vegetation-free zone in new plantings to achieve maximum growth of the blueberries.

In-Row Sod before Planting

Excellent results have been obtained by seeding perennial grass in the row as well as between the rows. Use perennial ryegrass rather than fescue. Rapid establishment and growth and susceptibility to herbicides make perennial ryegrass a better choice than fescue for seeding in the row. Kill the sod in the row before the blueberries are planted and no-till the plants into the dead sod. Use recommended herbicides to control weeds. The sod's roots increase soil organic matter and improve soil structure and water permeability, and the sod acts as a mulch to conserve water and prevent erosion during the establishment year. By fall, the dead sod deteriorates and is not attractive to rodents.

Mulching

Mulches control annual weeds and provide additional horticultural benefits in many fields. When using mulch for weed control, apply the mulch 3 to 4 inches thick when the rows are weed free. Thinner layers of mulch may not smother emerging weeds. Organic mulches may tie up important nutrients as they break down, so the use of mulch may require additional fertilizer. Reapply mulches annually or when needed to maintain weed suppression. Choose mulch products such as sawdust or wood chips, or a mixture of the two for improved infiltration of water over sawdust alone. Avoid mulches such as straw that provide a favorable environment for rodents such as field mice and voles that may damage blueberries, materials that are not already decomposed, or those that have a high pH such as mushroom compost.

HERBICIDES

Choose herbicides for use in the row that are labeled, have adequate crop safety (Table 7.15), and control the weeds in your field (see Table 4.1). The use of a single herbicide repeatedly will lead to an increase in resistant weeds. Use her-

bicide combinations, herbicide rotations, and sequential or spot treatments in a well-managed weed control program to eliminate or minimize problems. The recommended herbicides covered below have been evaluated for crop safety and effectiveness. Information on all varieties is incomplete. Use herbicides with care on new varieties.

Remember that weeds also compete with each other besides competing with your crop. Thus, controlling a particular weed or group of weeds may allow other weed species to take over. A combination of two preemergence herbicides gives better weed control than a single herbicide. Combining a "grass herbicide" with a "broadleaf herbicide" results in wider-spectrum control. Consult the label and Table 7.18 for compatible tank mixes.

Terminology

Herbicide terminology may not be everyone's cup of tea, but it is important to understand in order to effectively use herbicides and to avoid undesirable consequences from herbicide application.

Residual herbicides remain in the soil and kill weeds for up to several months. They are applied before weeds germinate. Weeds begin to compete with most crops within 2 to 4 weeks. Some products are effective only on germinating seeds. If weeds are present, a postemergence herbicide can be combined with a residual herbicide. Residual herbicides are applied incorporated or preemergence.

Incorporated herbicides are mechanically mixed with the soil. This application method is *not* well suited to blueberries. It is difficult or impossible to incorporate herbicides near the crown of the blueberry plant, and shallow roots may be pruned by the incorporation equipment.

Preemergence herbicides are applied to the soil surface and are used to prevent weeds from establishing before they emerge from the soil, not to prevent weeds from germinating. Labels often state that preemergence herbicides must be "activated by cultivation or irrigation." As mentioned above, cultivation is not a recommended practice for incorporating herbicides in blueberries.

However, rainfall or overhead irrigation is needed to move the herbicide into the soil before the weeds emerge and, ideally, just into the zone of weed seed germination. Use a preemergence herbicide in combination with a postemergence herbicide if weeds have emerged, unless the preemergence herbicide also controls weeds postemergence. Of preemergence herbicides labeled for blueberries, Devrinol, Kerb, and Surflan work by inhibiting cell division. Solicam and Callisto inhibit pigment synthesis. Casoron inhibits cellulose biosynthesis and Chateau disrupts cell membranes. Princep and Sinbar work by inhibiting photosynthesis. Sinbar, besides having this effect on germinating weeds, kills small emerged annual weeds. Casoron, Kerb, Chateau, and Callisto also control emerged plants of certain weed species. Repeatedly using herbicides that act on weeds with the same mode of action may lead to weed populations that are resistant to those herbicide(s).

Postemergence herbicides are used after weeds have emerged from the soil and kill weeds through the leaves. They are used by carefully applying the herbicide to the weeds without allowing it to contact desirable plants that could be affected, such as blueberries or sod row middles. The best time to apply postemergence herbicides is when weeds are growing rapidly. Do not treat weeds that are dormant or under stress. Most herbicides that enter the plant through the leaves need a minimum rain-free period of at least 1 to 8 hours after application for maximum effectiveness. Postemergence herbicides may be selective or nonselective.

Selective postemergence herbicides kill only certain susceptible weeds. Poast, Select, and Fusilade DX are examples that kill only grasses and will not control broadleaf weeds or harm the blueberries.

Nonselective postemergence herbicides kill or injure any treated plant. They may be *contact* or *translocated*. *Contact* herbicides (Gramoxone Inteon, Scythe) affect only the plant tissue with which they come in contact. Thorough spray coverage is essential for good results. Roots of established annual weeds and perennial weeds often survive. *Translocated* herbicides (glyphosate, Fu-

silade, Poast, Select) move systemically in the weed (or crop plant if contacted) after treatment. Application at the proper growth stage will often result in good control of the roots as well as tops of established annuals and perennial weeds. Results of translocated herbicides may not be evident for several days or weeks.

Herbicides have no activity after application for one of two reasons. Some herbicides are too tightly bound to the soil to be available to plants after application. Care must be exercised in soilless growing environments, where surprising residual activity can be observed from these herbicides. Other herbicides are highly soluble in water and are not bound to soil particles. Residual activity from these herbicides can be observed in the soil, but it often lasts only a few days. They are rapidly leached out of the zone of weed seed germination and degraded by soil microorganisms. Table 7.16 lists the solubility and soil adsorption characteristics of herbicides labeled for use on blueberries. A complete discussion of the effects that trickle

irrigation can have on increasing weed growth under the trickle line is included in Chapter 4: Weed Management.

Glyphosate products—including Roundup products, Touchdown products, Glyphomax Plus and others—and paraquat products, including Gramoxone Inteon, Firestorm, and others are too tightly bound to the soil to have residual activity. These herbicides are completely unavailable to plants after application. They remain tightly bound to the soil until broken down. Glyphosate can be degraded or digested by soil microorganisms. Residual activity from glyphosate has been observed when used in greenhouses, on plastic mulch, and near hydroponic growing systems. Paraquat is degraded by sunlight and is less likely to cause problems when used on plastic mulch, in greenhouses, or near soilless growing systems.

On coarse-textured sandy soils low in organic matter, Surflan (oryzalin) and Princep (simazine), respectively, are the best choices for annual grass and annual broadleaf weed management based

Table 7.15. Crop safety of blueberry herbicides.

	New (Nonbearing)	Established (Bearing)
Preemergence, Residual		
Callisto	G	G
Casoron/Norosac	?	G
Chateau	F	G
Devrinol	G	G
Gallery	G	—
Karmex (NJ and MD only)	—	F/G
Princep	—	F/G
Sinbar	—	F
Snapshot	?	—
Solicam	F/G	G
Surflan	G	G
Velpar	P	P/F
Postemergence, Selective		
Fusilade DX	G	—
Kerb (also preemergence)	—	G
Poast	G	G
Select/Select Max	G	—
Postemergence, Nonselective		
Paraquat products	G	G
Glyphosate products*	G	G

G = good; F = fair (use with care; recommended); P = poor (not recommended); ? = labeled but data insufficient; — = not labeled (do not use)

*Do *not* allow spray to contact young or green (living) bark or leaves.

on very low water solubility of both herbicides. On fine-textured soils and soils higher in organic matter, Surflan (oryzalin) and Karmex (diuron; New Jersey and Maryland only), respectively, are the best choices for annual grass and annual broadleaf weed control based on their low and very low water solubility and strong adsorption to the soil. Unfortunately, certain weeds, including yellow nutsedge, escape this herbicide combination.

Rate Control

Strict rate control is necessary. Improperly applied herbicides or herbicides applied above recommended rates may cause damage to blueberries. Using rates that are too low will result in a lack of efficacy or short duration of control. Residual herbicide rates must be matched with soil type and percentage of organic matter to obtain good weed control and crop safety. Determine type and percentage of organic matter for each soil on the farm with a separate soil test.

Be aware that most herbicide labels are written for “typical agricultural soils” and that many common blueberry fields are not “typical.” Most coarse-textured soils, such as loamy sands and sandy loams, are low in organic matter, often less than 2 percent. Medium-textured soils, such as loams, may have 2 to 4 percent organic matter. Many traditional “black” blueberry soils may be classified as loamy sands but may have organic matter contents over 8 percent. Have your soil analyzed for percent organic matter. This is a separate test that must be requested from most soils laboratories. If your soil has an organic matter content higher than the choices listed on the herbicide label for your soil texture, choosing the correct rate may be difficult. See Table 7.17 for recommended rates of specific herbicides for various soil types and organic matter levels. Consult your Cooperative Extension service for assistance in determining the correct herbicide rate to use on your soil if needed. Adjust by changing tractor speed and maintaining pressure when spraying a field with soil that requires different herbicide rates. Herbicide application and equipment are discussed in Chapter 4.

Herbicide Use in New (Nonbearing) Plantings

Weed control in a newly planted field should be planned to provide a maximum margin of crop safety. Tillage and/or herbicides prior to planting should control established biennial and perennial weeds. Apply a combination of herbicides to control annual grasses and broadleaf weeds. Surflan plus Gallery 75DF has been a safe and effective residual herbicide combination for newly planted blueberries. Apply in early spring after 1 to 2 inches of rainfall or irrigation has settled the soil around the roots of the new plants but before weeds emerge or the blueberry buds break. Waxed paper “milk cartons” are effective and recommended shields. The use of shields adds an additional margin of safety when installed prior to herbicide application.

An alternative to shields is the use of granular formulations when available. Granular formulations fall through the blueberry canopy to the soil surface, provided applications are made when the foliage and shoots are dry. The use of nonselective postemergence herbicides

such as a paraquat or glyphosate product should be avoided during the year of planting unless shields are in place. Avoiding contact of these products with the plant is critical.

Herbicide Use in Established (Bearing) Plantings

Apply herbicides to the blueberry row in established fields in late fall and also in late spring. Herbicides are applied in late fall or when the soil temperature has dropped to between 40 and 50°F to control winter annuals, certain perennials, and early season summer annuals. The spring herbicide application extends summer annual weed control through harvest.

Late fall herbicide applications should all include a residual broadleaf herbicide. Use Princep in fields that are not irrigated or are watered with overhead irrigation. If trickle irrigation is used, apply Karmex (New Jersey and Maryland only) in the fall. Small seedling annual broadleaf weeds will be controlled by the residual herbicide, but if well established annuals are present, add a postemergence herbicide such as

Table 7.16. Herbicide water solubility and soil adsorption characteristics.

	Solubility	Soil Adsorption
Residual Herbicides		
Callisto (mesotrione)	Moderate	Moderate/strong
Casoron/Norosac (dichlobenil)	Low	Moderate
Chateau (flumioxazin)	Very low	Not available
Devrinol (napropamide)	Moderate	Strong
Gallery (isoxaben)	Very low	Strong
Karmex (diuron)	Low	Strong
Kerb (pronamide)	Low to moderate	Strong
Princep (simazine)	Very low	Moderate
Sinbar (terbacil)	Moderate	Weak
Solicam (norflurazon)	Low to moderate	Strong
Surflan (oryzalin)	Very low	Strong
Velpar (hexazinone)	High	Weak
Nonresidual Herbicides		
Fusilade DX (fluzifop-P-butyl)	Very low	Very strong
glyphosate products	Very high	Very strong
paraquat products	Very high	Very strong
Poast (sethoxydim)	Moderate to very high ^a	Moderate
Select products (clethodim)	Not available	Weak

Source: Weed Science Society of America (2002), *Herbicide Handbook*, 8th ed. *Controlling Weeds in Nursery and Landscape Plantings*. 2007. Penn State College of Agricultural Sciences.

a. pH dependent

Table 7.17. Per-acre rates per application for preemergence (residual) herbicides for common soil types for blueberries.

Rates for each active ingredient are followed by the corresponding rates of a commonly available product containing the active ingredient listed.

Herbicide	Soil Type / % Organic Matter												
	Sand		Loamy Sand		Sandy Loam			Loam		Silt Loam		Clay Loam	
	0–1	1–2	0–1	1–2	0–1	1–2	2–4	1–2	2–4	1–2	2–4	1–2	2–4
Napropamide (lb ai) ^a	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4
Devrinol 50DF (lb) ^a	4–8	4–8	4–8	4–8	4–8	4–8	4–8	4–8	4–8	4–8	4–8	4–8	4–8
Mesotrione (oz ai) ^a	1.5–.3	1.5–.3	1.5–.3	1.5–.3	1.5–.3	1.5–.3	1.5–.3	1.5–.3	1.5–.3	1.5–.3	1.5–.3	1.5–.3	1.5–.3
Callisto 4F (fl oz) ^a	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6
Flumioxazin (oz ai) ^a	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6	3–6
Chateau 51WDG (oz) ^a	6–12	6–12	6–12	6–12	6–12	6–12	6–12	6–12	6–12	6–12	6–12	6–12	6–12
Isoxaben (lb ai) ^b	0.75	0.75	0.75	0.75	0.75	0.75	1	0.75	1	1	1	1	1
Gallery 75DF (lb) ^b	1.0	1.0	1.0	1.0	1.0	1.0	1.33	1.0	1.33	1.33	1.33	1.33	1.33
Pronamide (lb ai) ^b	2	2	2	2	2	2	2	2	2	2	2	2	2
Kerb 50WP (lb) ^b	4	4	4	4	4	4	4	4	4	4	4	4	4
Diclobenil (lb ai) ^a	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4
Casoron CS (gal) ^a	1.4–2.8	1.4–2.8	1.4–2.8	1.4–2.8	1.4–2.8	1.4–2.8	1.4–2.8	1.4–2.8	1.4–2.8	1.4–2.8	1.4–2.8	1.4–2.8	1.4–2.8
Simazine (lb ai) ^b	—	—	—	—	—	2	2	2	3	2	3	3	4
Princep 90DF (lb) ^b	—	—	—	—	—	2.2	2.2	2.2	3.3	2.2	3.3	3.3	4.4
Terbacil (lb ai) ^b	—	—	—	—	—	1	1.6	1.6	1.6	1.6	1.6	2.4	2.4
Sinbar 80WP (lb) ^b	—	—	—	—	—	1.25	2	2	2	2	2	3	3
Norflurazon (lb ai) ^b	—	—	—	2	—	2	2.5	2.5	2.5	2.5	3	3	4
Solicam 80DF (lb) ^b	—	—	—	2.5	—	2.5	3.0	3.0	3.0	3.0	3.75	3.75	5
Oryzalin (lb ai) ^a	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4
Surflan 4AS (qt) ^a	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4	2–4
Hexazinone (lb ai) ^b	—	—	—	—	—	—	—	—	0.5	0.5	0.75	0.75	1.0
Velpar L (pt) ^b	—	—	—	—	—	—	—	—	2.0	2.0	3.0	3.0	4.0
NJ and MD only:													
Diuron (lb ai)	—	—	—	1.0	—	1.5	1.5	1.5	2.0	2.0	2.0	2.0	2.0
Karmex DF (lb)	—	—	—	1.25	—	1.9	1.9	1.9	2.5	2.5	2.5	2.5	2.5

a. Use the lower recommended rate when tank-mixing with another preemergence herbicide, unless annual grass pressure is severe.

b. Use one-half the recommended rate when tank-mixing with another preemergence herbicide.

— = not labeled or not recommended (do not use).

a paraquat product to the tank. In recent years, Princep and Karmex have not performed as reliably as in previous years at some sites. Reasons may include weed species shifts to annual broadleaf weeds, such as groundsel, that are less susceptible to these herbicides, the development of triazine-resistant biotypes, or the establishment of perennial broadleaf weeds. If this is the case on your farm, an alternative is to apply Casoron in the late fall at rates given in Table 7.18 to control these weeds. Casoron will control early season annual grasses, but a residual annual grass herbicide should be applied in the spring for full-season grass control.

The use of a grass herbicide in the fall depends on the product chosen. Kerb 50WP is the only grass herbicide that *must* be applied in the fall. Choose Kerb to control cool season perennial grasses such as quackgrass. An additional residual annual grass herbicide is needed in the spring to provide full season summer annual grass control following a fall application of Kerb 50WP. Solicam 90DF, Surflan 80WP, and Devrinol 50DF are annual grass herbicides that should be applied in late fall or as a split application, half in the fall and the second half in the spring. Use the split application when grass pressure is heavy for best results. The use of these herbicides in spring only has resulted in inconsistent weed control when dry weather followed the application. Sinbar 80WP applications should be applied only in the spring. The relatively high solubility of Sinbar 80WP results in leaching when applied in the fall. Increased risk of crop injury and poor weed control can result.

Consider spot treating with a labeled glyphosate product if perennial weeds are present; treatment is recommended in the fall. Application by use of a wick applicator is a safer option in order to avoid contact of the herbicide with the blueberry plants.

Follow-up late spring applications should include a different residual broadleaf weed herbicide and a residual grass herbicide. Add a postemergence herbicide only if needed. Use Karmex 80DF (New Jersey and Maryland only) for residual broadleaf weed control if Princep was used in the fall, or use Princep if Karmex was used in the fall.

Apply Sinbar 80WP or the second half of a split herbicide treatment of Solicam 80DF, Surflan 80WP, or Devrinol 50DF for annual grass control. Include a paraquat product if seedling annual weeds are observed.

As mentioned above under “Late Fall Herbicide Applications,” Princep and Karmex have recently not performed reliably at some sites. This has also been the case with the spring application of Princep and Karmex, as well as Sinbar. Reasons for failure at this time of the year may be the same as those listed above, plus the possibility that biotypes may exist that germinate later in the summer when these herbicides are less effective. In these cases, add Callisto or Chateau to your spring tank mixture to improve control of summer annual broadleaf weeds.

Spot treat with a labeled glyphosate product to control established perennial grasses and broadleaf weeds. Sinbar 80DF is also effective for seedling weed control postemergence. No other postemergence herbicide may be needed if no established weeds are present and seedling annual weeds are sprayed with Sinbar before they exceed 1 inch in height.

See Table 7.18 for recommended herbicides and timings at which they can be used.

PROBLEM PERENNIAL WEEDS

Especially in perennial crops such as blueberries, certain problem weeds can become well established since the field is not worked after crop establishment, and herbicides may have limited or no effectiveness at this point. Many of the weeds that are likely to become problematic are discussed below, along with their life cycle and cultural and chemical means for management.

Yellow Nutsedge

Yellow nutsedge, a perennial, may be the most serious weed in agriculture worldwide. Yellow nutsedge is sometimes referred to a “nutgrass,” even though it is not a grass. Although yellow nutsedge can reproduce from seed, where it is established, annual reinfestation is primarily due to dormant nutlets

in the soil. Nutlets are small, about the size of a pea, and are tan to reddish brown in color. They sprout in the spring and establish a plant about 8 to 12 inches tall with narrow leaves and parallel veins. At a glance the plant may appear to be a grass, but close inspection of the plant reveals that the leaves are not divided into two parts, a blade and a sheath. Further inspection reveals that just below the soil, the triangular stem could be detected by rolling the shoot between two fingers. Nutlets can resprout six to eight times if cultivation kills the shoot. After the plant becomes established, rhizomes, which are horizontal underground stems, begin to grow in late spring or early summer. By early to midsummer, the rhizomes curve upward and produce additional plants. The vegetative spread of the weed continues until late summer. By August in most locations, the weed can sense the approach of fall by the longer nights, and a burst of rhizome growth follows. These rhizomes do not curve up and produce more daughter plants. They grow out and down. By early fall, a pronounced swelling can be observed at the tip of each rhizome, which matures into a new dormant nutlet. Later in the fall, the still longer night signals that it is time for the mother plant to enter dormancy, effectively separating the nutlets from the mother plant and each other.

Yellow nutsedge can be managed and eventually eliminated from a field by preventing new nutlet production. This can be done by persistent management of nutsedge from late summer through early fall (see below). The results of the effort will not be evident after one year. Too many “old” nutlets remain dormant in the soil for several years before they sprout, but after several years, success will be evident.

Cultural Management

Avoid spreading nutsedge into clean fields from infested soils with equipment or in mulches such as straw and manure. Nutsedge is intolerant of shade. Using close row spacing can result in shading and minimize yellow nutsedge growth. Mulches, including plastic, straw, and cover crop residues can also provide shade as well as provide a physical barrier that reduces plant emergence.

Nutsedge is also a poor competitor with vigorous crops. Use management practices that promote crop health. Also, include vigorous cover crops in your rotation, and include corn and soybeans in the rotation to shade nutsedge and allow the use of herbicides that are effective against nutsedge. Repeated mowing prevents seed production and helps with depleting root reserves. While seeds are not the primary method for spreading yellow nutsedge, they are important for spreading the plant greater distances. Preventing seed production by mowing prior to flowering and seed set will prevent the formation of seeds. Mowing can exhaust the energy reserves of nutlets; however, it can take seven or more mowings until reserves are depleted. Tilling in fall can directly destroy small nutlets and expose larger nutlets to killing cold temperatures. In the fall, chisel plowing or using tillage tools that bring vegetative structures to the soil surface are better than tools that invert soil (moldboard plow) and bury the nutsedge. Tillage in the spring, however, can help spread yellow nutsedge. This is particularly a problem when using more shallow types of tillage. Yellow nutsedge tends to be a larger problem on low or wet areas in a field. Using raised beds in areas with poor drainage can help to manage yellow nutsedge.

Chemical Management

Glyphosate products. Apply initial application at higher labeled rate when plants are more than 6 inches tall but before going to seed. Repeated subsequent applications at lower rates will be needed for control. Use lower gallonages of water to allow a greater amount of glyphosate to remain on the foliage, as nutsedge foliage will not retain much spray solution. *Broadcast:* 2.25 lb ae (acid equivalent)/A. *Spot Treatment:* See your product's label for rate. Wet the weed foliage as thoroughly as possible. Use the highest labeled percent solution rate when only partial wetting of the weed foliage is possible. Wet a minimum of 50 percent of the weed foliage for effectiveness. *Ropewick Applicator:* Wipe twice; travel in opposite directions for each wipe.

Bindweed Species (Hedge and Field)

These perennial weeds have deep vertical roots for food storage and horizontal roots that spread the weed vegetatively. Shoots emerge from this extensive root system in the spring. Flowers appear in late spring and throughout the summer. They are distinctively trumpet shaped, white, or lightly tinted with lavender. Hedge bindweed flowers are larger than field bindweed flowers. Bindweed species are often confused with annual morningglories, which have larger bright blue flowers, simple shallower roots, and are easier to manage. The leaves of bindweed species are triangular or arrow-head shaped. Hedge bindweed leaves are pointed, while field bindweed leaves have a blunt tip. The shoots grow as a vine across the ground or twining up the shoots of other plants for support. Management can be difficult due to the deep and extensive root system bindweed develops.

Cultural Management

Bindweed is sensitive to shading. However, because roots store significant reserves, shading is ineffective after bindweed is well established. Cultivation is effective only if repeated frequently. Regrown shoots begin to replenish root reserves in as little as 2 weeks after shoot emergence.

Chemical Management

Casoron/Norosac (dichlobenil, 4–6 lb ai/A). Use 100 to 150 pounds of Casoron/Norosac 4G or 2.8 gallons of Casoron CS per acre. Apply between November 15 and March 15 to control labeled annual, biennial, and perennial weeds. Late-fall treatments, after November 15 but before the soil freezes, have had a more consistent effect on susceptible perennial weeds than late winter applications. Treat before weed growth begins and when daily high temperatures do not exceed 50°F. Casoron/Norosac is volatile in warm temperatures and must be irrigated or incorporated after application if applied in warm weather to prevent significant loss of the herbicide. This product is for established (bearing) fields.

Glyphosate products. Apply in fall when plants are translocating photo-

synthates to their roots. A follow-up application in spring may be needed. Applications made in late spring and early summer when bindweed is actively growing will have little effect. *Broadcast:* 2.25 lb ae (acid equivalent)/A. *Spot Treatment:* See your product's label for rate. Wet the weed foliage as thoroughly as possible. Use the highest labeled percent solution rate when only partial wetting of the weed foliage is possible. Wet a minimum of 50 percent of the weed foliage for effectiveness. *Ropewick Applicator:* Wipe twice; travel in opposite directions for each wipe.

Canada Thistle

This perennial weed has deep vertical roots for food storage and horizontal roots that spread the weed vegetatively. Shoots emerge from this extensive root system in the spring. Flowers appear in late June, and seed is dispersed in July. The shoots die after the seed is dispersed. New shoots appear in late summer and grow vegetatively until frost. These fall shoots make food for the roots and do not flower.

Cultural Management

Mowing in spring at bud to bloom time will assist with depleting root reserves, as plant reserves are already at a low point, and mowing (either physically, or chemically with a burndown material) will force the plant to use additional root reserves for regrowth. Repeated frequent tillage will be effective prior to planting and between rows; however, if tillage is infrequent, this plant may become the dominant weeds as other more easily controlled weeds become less numerous. Only extremely shallow tillage can be used near blueberry plants in order to avoid damaging their root systems.

Chemical Management

Casoron/Norosac (dichlobenil, 4–6 lb ai/A). Use 100 to 150 pounds of Casoron/Norosac 4G or 2.8 gallons of Casoron CS per acre. See paragraph on use of this product under “Bindweed Species.”

Glyphosate products. Apply in late June when Canada thistle has flower buds or flowers, or in the fall after the shoots are 6 to 8 inches tall but before

frost. Roundup translocates into the vertical roots of the plant well but in less quantity into the horizontal roots. Follow-up spot treatments may be needed to control regrowth from pieces of horizontal roots that were not killed by the initial application. *Broadcast*: 2.25 lb ae (acid equivalent)/A. *Spot Treatment*: See your product's label for rate. Wet the weed foliage as thoroughly as possible. Use the highest labeled percent solution rate when only partial wetting of the weed foliage is possible. Wet a minimum of 50 percent of the weed foliage for maximum effectiveness. *Ropewick Applicator*: Wipe twice; travel in opposite directions for each wipe.

Dandelion

This perennial plant grows actively during the spring and fall and forms a robust tap root that may resprout several new tops when the plant top is broken off.

Cultural Management

Hoing or hand removal is typically ineffective since removing the entire tap root is difficult, and since cultivation in blueberry fields must be done shallowly, a significant portion of the root system is not likely to be destroyed. Mowing before flower heads bloom can aid in reducing the number of seeds produced.

Chemical Management

Norosac/Casoron (dichlobenil, 4–6 lb ai/A). Use 100 to 150 pounds of Norosac/Casoron 4G or 2.8 gallons of Casoron CS per acre. Apply between November 15 and March 15 to control labeled annual, biennial, and perennial weeds. Late-fall treatments—after November 15 but before the soil freezes—have controlled susceptible perennial weeds more consistently than late-winter applications. Treat before weed growth begins and when daily high temperatures do not exceed 50°F. Norosac/Casoron is volatile in warm temperatures and must be irrigated or incorporated after application if applied in warm weather to prevent significant loss of the herbicide.

Glyphosate products. Apply when the weed is growing actively and has flower buds. Spring or fall applications are more effective than applications made in midsummer. (See warnings in

Table 7.18.) *Broadcast*: 2.25 lb ae (acid equivalent)/A. *Spot Treatment*: See your product's label for rate. Wet weed foliage as thoroughly as possible. Use the highest labeled percent solution rate when only partial wetting of the weed foliage is possible. Wet a minimum of 50 percent of the weed foliage for effective control. *Ropewick Applicator*: Wipe twice; travel in opposite directions for each wipe.

Goldenrod Species

These closely related weeds are perennials that begin growth in April from rosettes or rootstocks. Typically, yellow blooms appear in late summer and the stems die in the fall. Some regrowth, as short stems or rosettes, often occurs before winter. Strong root systems overwinter and resume growth in the spring. The weeds spread using underground horizontal roots. Once established, management of this weed is difficult since it is tolerant to most herbicides and the roots can be spread by cultivation or other tillage practices.

Cultural Management

Best options are shallow tillage or removal when first plants to invade field are small, and mowing of any nearby goldenrod infested areas to avoid spread of the weed into cultivated fields.

Chemical Management

Casoron/Norosac (dichlobenil, 4–6 lb ai/A). Use 100 to 150 pounds of Casoron/Norosac 4G or 2.8 gallons of Casoron CS per acre. See paragraph on use of this product under “Bindweed species.”

Glyphosate products. Apply in late spring after spring growth is 8 to 10 inches tall, but before the shoots become too tall for good coverage with the spray solution. Generally, banded or broadcast sprays must be applied earlier in the spring, while spot treatments and ropewick applications can be applied later in the spring. *Broadcast*: 1.5 to 3 pounds ae (acid equivalent)/A. *Spot Treatment*: See your product's label for rate. Wet weed foliage as thoroughly as possible. Use the highest labeled percent solution rate when only partial wetting of the weed foliage is possible. Wet a minimum of 50 percent of the weed foliage

for maximum effectiveness. *Ropewick Applicator*: Wipe twice; travel in opposite direction for each wipe.

Horseweed

Horseweed is a biennial plant with seed that usually germinates in late summer or early fall. Though biennial, it usually behaves like a winter annual in that the seedling grows as a rosette during the fall and early spring. The plant bolts during the summer, flowers, sets seed, and dies during its second late summer and fall season. It may also behave like a typical spring-germinating biennial or summer annual as well. The weed produces a large number of wind-distributed seed in late summer and early fall. Some people refer to horseweed as “marestail” which is a misnomer. Herbicide labels that state “marestail control” may be referring to another weed.

Note: *Glyphosate-resistant horseweed*, also called marestail or stickweed locally, has been identified in the Mid-Atlantic Region, including New Jersey. Due to the windborne distribution of the seed, it is likely that glyphosate-resistant biotypes will spread to your farm despite good integrated weed management by individual growers. Therefore, all horseweed populations should be considered potentially glyphosate resistant. Glyphosate, formulated as Roundup Ultra Max, Touchdown, Glyphomax Plus, and other generic formulations, were recommended for horseweed control prior to 2003 but have been removed from the recommendations for horseweed control due to the resistance development.

Cultural Management

Best options are shallow tillage or removal when first plants to invade field are small, and mowing of any nearby horseweed infested areas to avoid spread of the weed into cultivated fields.

Chemical Management

Casoron/Norosac (dichlobenil, 4–6 lb ai/A). Use 100 to 150 pounds of Casoron/Norosac 4G or 2.8 gallons of Casoron CS per acre. See paragraph on use of this product under “Bindweed Species.”

Karmex (diuron, 1.0–3.2 lb ai/A), New Jersey and Maryland only. Use 1.25 to

2.5 pounds/A Karmex 80DF, depending on soil texture and organic matter. Apply in late fall to weed-free soil, or tank-mix with a paraquat product to kill existing vegetation. This product is for established (bearing) fields.

Princep (simazine, 1–4 lb ai/A). Use 1.1 to 4.4 pounds/A Princep 90DF (or other labeled formulations), depending of soil texture and organic matter. Apply in late fall to weed-free soil, or add a paraquat product to kill existing vegetation. This product is for established (bearing) fields.

Paraquat (Gramoxone Inteon, Firestorm, or other labeled formulations, 0.6–1.0 lb ai/A). Use 2.4 to 4.0 pints/A Gramoxone Inteon or 1.7 to 2.7 pints/A Firestorm 3SC (or other labeled formulations). Contact killer only; has no translocation or residual activity. Best results occur when horseweed seedlings are treated in late fall or are less than 1 inch in diameter. Two applications two weeks apart are more effective than a single application. Regrowth may occur from the root systems of established weeds. Use a surfactant to be 0.25 percent of the spray solution (1 quart per 100 gallons of spray solution). Combine with recommended preemergence herbicide(s) for residual effectiveness. Do not allow spray or drift to contact green bark, leaves, or fruit. Crop damage may result. The use of shields, such as grow tubes or paper milk cartons, greatly reduces the risk of injury in young plantings. This product is for newly planted (nonbearing) fields and for established (bearing) fields. *DANGER: Do not breathe spray mist. Read safety precautions on the label.*

Poison Ivy

This woody perennial vine or shrub is capable of climbing a trellis. Contact with any part of the plant may result in an itching, blistering skin rash. Nonselective postemergence herbicides must be used to control this weed. Take measures to eradicate before the vine grows up into the plants or trellis.

Cultural Management

No cultural controls recommended.

Chemical Management

Glyphosate products. Apply in mid- to late summer after the weed flowers in late June or early July, or in early fall before fall colors appear. Results of the fall application may not become evident until the following spring. Best results have been obtained in late summer after the fruit has formed. *Broadcast:* 3 to 3.75 pounds ae (acid equivalent)/A. *Spot Treatment:* See your product's label for rate. Wet weed foliage as thoroughly as possible. Use the highest labeled percent solution rate when only partial wetting of the weed foliage is possible. Wet a minimum of 50 percent of the weed foliage for maximum effectiveness. *Ropewick Applicator:* Not recommended. *“Cut Stump” Treatment:* See your product's label for rate. Apply to the cambium (inner bark area) of the stump of woody plants *immediately* after cutting. Cut and treat stumps only when the target is actively growing and not under stress. Best results are often obtained in late summer and early fall before fall color is observed in the foliage. *Warning:* Injury due to root grafting may occur in adjacent plants. Do not treat cut stumps if there is a possibility of root grafting to desirable vegetation.

Quackgrass

This perennial plant grows actively in the late spring and early fall when daily high temperatures range between 65 and 80°F (18.3 and 26.7°C). High midsummer temperatures, above 85°F (29.4°C), and/or low soil moisture cause the weed to become dormant or semidormant until moisture and cooler weather return. The weed reproduces by seed and vegetatively by rhizomes, horizontal underground stems that eventually curve upward and make new shoots. The seedhead, which appears in June, resembles ryegrass, except each floret is rotated one quarter turn compared to ryegrass. The rhizomes are about 1/8 inch in diameter and may grow horizontally for up to several feet in length before curving upward and making a new shoot. Ryegrass does not have rhizomes.

Cultural Management

Prior to planting, plowing followed by disking or repeated disking chops

rhizomes into small pieces that are more susceptible to herbicides and additional cultivation. Repeated cultivation forces plants to use rhizome reserves. Cultivation during hot dry spells causes rhizomes to dry out. Failure to follow initial cultivations with control measures will only result in propagation of rhizomes.

Chemical Management

Glyphosate products. Apply in late spring (May or June) or in the fall (October or November) when the weed has vigorous healthy foliage, a minimum of 4 to 6 leaves, and has begun to tiller. Do *not* till the field or otherwise disrupt the root and rhizome system of the weeds in the soil for a minimum of 8 months before treatment. *Broadcast:* 1.5 lb ae (acid equivalent)/A. *Spot Treatment:* See your product's label for rate. Wet weed foliage as thoroughly as possible. Use the highest labeled percent solution rate when only partial wetting of the weed foliage is possible. Wet weed foliage as thoroughly as possible. *Ropewick Applicator:* Wipe in late May or June after the weed is at least one foot tall. Not recommended in the fall due to the more prostrate growth habit of the weed.

Kerb (pronamide), 1–2 lb ai/A. Use 2 to 4 pounds/A Kerb 50WP. Apply in November when soil temperatures are between 35 and 55°F (1.7 and 12.8°C). Primarily effective against perennial grasses, including quackgrass, bluegrass, ryegrass sp., and fescue sp., and also provides early management of annual grasses the following spring. Apply Surflan, Prowl (nonbearing only), Solicam, or Sinbar the following May or June for full season annual grass control. Tank-mix Kerb with Gramoxone Inteon or a glyphosate product and with Princep for postemergence and residual broadleaf weed control. This product is for established (bearing) fields.

Fusilade (nonbearing fields only), Poast, and Select. Provide partial control. Repeat applications needed for additional control.

Virginia Creeper

Virginia Creeper is a woody perennial vine capable of climbing a trellis and smothering a plant.

Cultural Management

No effective cultural controls have been identified.

Chemical Management

Nonselective postemergence herbicides must be used to suppress or control this weed. Remove the vine from the trellis during winter pruning and put it on the ground or plan a “cut stump” treatment during the growing season. Do *not* “prune out” the vine during the dormant season. Good growth and maximum leaf area are needed at the time of herbicide application during the summer.

Glyphosate products. Apply in mid- to late summer after the vine flowers in early July but before fall color appears in the foliage. Applications in spring or early summer, before flowering, have been less effective. Repeat applications may be needed. One application may merely suppress Virginia Creeper. *Broadcast:* 3 to 3.75 pounds ae (acid equivalent)/A. *Spot Treatment:* See your product’s label for rate. Wet weed foliage as thoroughly as possible. Use the highest labeled percent solution rate when only partial wetting of the weed foliage is possible. Wet a minimum of 50 percent of the weed foliage for maximum effectiveness. *Ropewick Applicator:* Not recommended; the creeping nature of plant is difficult to wipe. *“Cut Stump” Treatment:* See your product’s label for rate. Apply to the cambium (inner bark area) of the stump of woody plants *immediately* after cutting. Cut and treat stumps only when the target is actively growing and not under stress. Best results are often obtained in late summer and early fall before fall color is observed in the foliage. Warning: Injury due to root grafting may occur in adjacent plants. Do not treat cut stumps if there is a possibility of root grafting to desirable vegetation.

White Heath Aster and Other Aster Species

White heath aster is a perennial that begins growth in April from rosettes or rootstocks. (Other asters may be annuals or biennials.) Typically, blooms are about ½ inch in diameter. The flowers have white or slightly tinted purple petals with yellow centers. They appear in late summer, set seed, and the stems die in the fall. Some regrowth, as short stems or rosettes, often occurs before winter. The weed spreads using underground horizontal roots.

Cultural Management

Once established, management of this weed is difficult since it is tolerant to most herbicides and the roots can be spread by cultivation or other tillage practices.

Chemical Management

Casoron/Norosac (dichlobenil, 4–6 lb ai/A). Use 100 to 150 pounds of Casoron/Norosac 4G or 2.8 gallons of Casoron CS per acre. See paragraph on use of this product under “Bindweed Species.”

Glyphosate products. Apply in May or June after spring growth is 8 to 10 inches tall, but before the shoots become too tall for good coverage with the spray solution. Generally, broadcast sprays must be applied in May, while spot treatments and ropewick applications can be delayed until June. *Broadcast:* 1.5–3 lb ae (acid equivalent)/A. *Spot Treatment:* See your product’s label for rate. Wet weed foliage as thoroughly as possible. Use the highest labeled percent solution rate when only partial wetting of the weed foliage is possible. Wet a minimum of 50 percent of the weed foliage for maximum effectiveness. *Ropewick Applicator:* Wipe twice; travel in opposite direction for each wipe.

Table 7.18. Herbicides for blueberry weed control.

Note: See text discussion for additional discussion on timing and use of various herbicides in this chapter and Chapter 4. See Table 4.1 for efficacy ratings of herbicides on various weeds. See Table 3.2 for limits on states in which these cannot be used, use status (general vs. restricted), days-to-harvest limitations, and reentry intervals. The information below is correct to the best of our knowledge. Other formulations with the same active ingredient as some of the products listed below may exist that may or may not be labeled for the same uses. Always consult the label before making pesticide applications. Information was current as of October 1, 2009.

Weeds	Timing of Treatment/Comments	Active Ingredient Rate/A ^a	Product Rate/A (Days to Harvest) ^b
NEW (NONBEARING) PLANTINGS			
Preemergence			
Primarily for annual broadleaf weeds	Add nonionic surfactant to be 0.25% of the spray volume, or 1 qt per acre crop oil concentrate. Apply in the late fall after leaf drop and/or in early spring before bud break as a spray directed toward the base of the bush. Broadleaf weeds controlled include horseweed and common lambsquarter. Tank-mix with an appropriate postemergence herbicide for broad-spectrum control of emerged weeds. Tank-mix with a residual grass herbicide to improved annual grass control. Do not apply more than 6 fl oz of Callisto per acre within one year.	Mesotrione, 1.5–3.0 oz	Callisto 4F, 3–6 fl oz (prebloom)
Annual broadleaf weeds; also controls or suppresses annual grasses	Only if plants established less than 2 years are protected from spray contact by nonporous wrap, grow tubes, or waxed containers. Add crop oil concentrate to be 1% of spray volume. Apply in late fall after leaf drop or in early spring before bud break. Tank-mix with an appropriate postemergence herbicide for broad-spectrum control of emerged weeds. Tank-mix with a residual grass herbicide to improve annual grass control. Do not allow spray to contact foliage or new green bark. Do not use more than 6 oz/a of product where the soil contains more than 80% sand until the plants have been in the field for more than 3 years. Follow instructions on label for tank clean-out if any part of the sprayer will be used to spray other crops; otherwise, crop injury may occur. See label for other cautions and restrictions, as even contact with treated residue can cause phytotoxicity.	Flumioxazin, 3.0–6.0 oz	With protection for first 2 years: Chateau 51WDG, 6–12 oz (pre-budbreak)
Primarily for annual broadleaf weeds	Apply in late fall or early spring to weed-free soil to control many broadleaf weeds. If newly planted, allow the soil to settle and fill any depressions around the plant before application. Add a postemergence herbicide to improve the control of emerged weeds. Gallery primarily controls annual broadleaf weeds. Tank-mix with Surflan to control annual grasses. <i>Note: Gallery is not labeled for bearing blueberries.</i>	Isoxaben, 0.75–1.0 lb	Gallery 75DF, 1.0–1.33 lb (365)
Primarily for annual grasses	Apply in late fall and/or early spring to weed-free soil, or add an appropriate postemergence herbicide to kill existing vegetation. Use the high rate for long-term control (4 to 8 months) and the low rate for short-term control (2 to 4 months). Tank-mix with Princep plus a postemergence herbicide in late fall or with Karmex (New Jersey and Maryland only), or Sinbar in the spring if the planting has been established for at least one year, to control annual broadleaf weeds.	Oryzalin, 2.0–4.0 lb	Surflan 4AS, 2.0–4.0 qt (—)

Table 7.18. Herbicides for blueberry weed control, continued.

Weeds	Timing of Treatment/Comments	Active Ingredient Rate/A ^a	Product Rate/A (Days to Harvest) ^b
Primarily for annual grasses; suppresses or controls certain annual broadleaf weeds	Apply in late fall and/or early spring to weed-free soil, or add an appropriate postemergence herbicide to kill existing vegetation. Use the high rate for long-term control (4 to 8 months) and the low rate for short-term control (2 to 4 months). Tank-mix with Princep plus a postemergence herbicide in late fall or reduced rates of Princep, Karmex (New Jersey and Maryland only), or Sinbar in the spring, if planting has been established for at least one year, to control annual broadleaf weeds. Activate with one-half-inch sprinkler irrigation within 24 hours after application. If left on the soil surface, napropamide (Devrinol) is broken down by sunlight. Irrigation moves the herbicide into the soil and prevents breakdown by the sun.	Napropamide, 2.0–4.0 lb	Devrinol 50DF, 4.0–8.0 lb (—)
Primarily for annual grass control; may provide partial control of many broadleaf weeds	Apply in late fall or spring to weed-free soil, or add an appropriate postemergence herbicide to kill existing vegetation. Tank-mix with Princep plus a postemergence herbicide in late fall, or with Karmex (New Jersey and Maryland only), or Sinbar in the spring if the planting has been established for at least one year, to improve the control of broadleaf weeds. Planting must have been in the ground for at least 6 months before application.	Norflurazon, 2.0–4.0 lb	Solicam 80DF, 2.5–5.0 lb (60)
Postemergence—Selective			
Emerged annual grasses and perennial grasses, depending on rate (see information in column to right)	Add 2 pints crop oil concentrate or nonionic surfactant to be 0.25% of the spray solution (1 qt. per 100 gallons of spray solution). Use the lower rate on most annual grasses less than 6 inches tall and to control johnsongrass. Use the higher rate to control other perennial grasses, crabgrass, and annual grasses more than 6 inches tall. Do <i>not</i> tank-mix Fusilade DX 2EC with any other pesticide. Do <i>not</i> apply within 1 hour of rainfall. Do <i>not</i> apply to grasses suffering from drought, heat, cold, or any other stress condition.	Fluazifop-P-butyl, 0.18–0.38 lb	Fusilade DX 2EC, 12.0–24.0 fl oz (365)
Emerged annual grasses	Use the lower rate to control annual grasses less than 6 inches tall. Use the higher rate to control annual grass 6 to 12 inches tall and to control perennial grasses. Do <i>not</i> tank-mix Poast with any other pesticide. Do <i>not</i> apply within 1 hour of rainfall. Do <i>not</i> apply to grasses suffering from drought, heat, cold, or any other stress condition.	Sethoxydim, 0.2–0.5 lb	Poast 1.5EC, 1.0–2.5 pt, plus 2.0 pints crop oil concentrate per acre (30)
Most grass weed species, including certain hard-to-control grass weeds, such as small grain volunteers and cover crops, and perennials, such as hard fescue, tall fescue, Bermudagrass, orchardgrass, quackgrass, Johnsongrass, and wirestem muhly	Use the lower rate to control annual grasses and the perennial grasses listed to the left. Repeat the application if regrowth occurs. Always add oil concentrate to be 1% of the spray solution, or a minimum of 1 pint per acre, to Select 2EC. Always add oil concentrate to be 1% of the spray solution, or a minimum of 1 pint per acre, or nonionic surfactant to be 0.25% of the spray solution to Select Max. Do <i>not</i> tank-mix with any other pesticide unless labeled. Do <i>not</i> apply within 1 hour of rainfall. Do <i>not</i> apply to grasses suffering from drought, heat, cold, or any other stress condition. <i>Select is currently labeled for nonbearing fields only. Do not apply within 12 months of harvest.</i>	Clethodim, 0.1–0.125 lb	Select 2EC, 6.0–8.0 fl oz (365), or Select Max, 12.0–16.0 fl oz (365)

CONTINUED

Table 7.18. Herbicides for blueberry weed control, continued.

Weeds	Timing of Treatment/Comments	Active Ingredient Rate/A ^a	Product Rate/A (Days to Harvest) ^b
Postemergence—Nonselective			
Annual weeds	Contact killer only; no translocation or residual activity. Best results occur when weeds are 2 inches tall or less. Regrowth may occur from the root systems of established weeds. Use a surfactant to be 0.25% of the spray solution (1 qt. per 100 gallons of spray solution). Combine with recommended preemergence herbicide(s) for residual weed control. Do not allow spray or drift to contact green bark, leaves, or fruit. Crop damage may result. The use of shields, such as grow tubes or paper milk cartons greatly reduces the risk of injury in young plantings. <i>DANGER: Do not breathe spray mist. Read safety precautions on the label.</i>	Paraquat, 0.5–1.0 lb	Gramoxone Inteon, 2.0–4.0 pt (—), or Firestorm 3SC, 1.3–2.7 pt (—)
Annual and perennial weeds	Glyphosate is a translocated, slow-acting herbicide with no soil or residual activity. Results will become evident 1 to 3 weeks after application. Apply lower rates to control seedlings and annual weeds and to suppress established perennial weeds. Use shields and do not allow glyphosate to contact the foliage or green shoots. Optimum rate and time of application depend on weed species and growth stage. Weeds should be growing vigorously when treated. Do not treat weeds that are under stress from drought, extreme heat, cold, or other adverse growing conditions. When using a ropewick applicator, fill the pipe only half full to avoid excessive dripping. Repeated wiping may be needed to provide control equal to broadcast or spot applications. A ropewick applicator offers significant herbicide cost savings. <i>Warnings:</i> (1) Do not allow glyphosate to contact the leaves, young green bark, fresh trunk wounds, or root suckers, or severe crop injury may occur. (2) Do not allow glyphosate to contact any immature part of blueberry plants. (3) Do not use galvanized containers—glyphosate may react with the container to produce explosive hydrogen gas.	Glyphosate <i>Broadcast:</i> 0.56–3.0 lb ae (acid equivalent). <i>Spot treatment:</i> See label; wet foliage thoroughly. <i>Ropewick applicator:</i> See label for product/water ratio. One gallon of product will treat 10–100 acres depending on weed density.	Roundup, or Touchdown, or other labeled formulations (14)
BEARING FIELDS			
Preemergence			
Primarily for annual grasses; suppresses or controls certain annual broadleaf weeds	Apply in late fall and/or early spring to weed-free soil, or add an appropriate postemergence herbicide to kill existing vegetation. Use the high rate for long-term control (4 to 8 months) and the low rate for short-term control (2 to 4 months). Tank-mix with Princep plus a postemergence herbicide in late fall or reduced rates of Princep, Karmex (New Jersey and Maryland only), or Sinbar in the spring, if planting has been established for at least one year, to control annual broadleaf weeds. Activate with one-half inch sprinkler irrigation within 24 hours after application. If left on the soil surface, napropamide (Devrinol) is broken down by sunlight. Irrigation moves the herbicide into the soil and prevents breakdown by the sun.	Napropamide, 2.0–4.0 lb	Devrinol 50DF, 4.0–8.0 lb (—)

Table 7.18. Herbicides for blueberry weed control, continued.

Weeds	Timing of Treatment/Comments	Active Ingredient Rate/A ^a	Product Rate/A (Days to Harvest) ^b
Primarily controls perennial grasses, including quackgrass, bluegrass, ryegrass species, fescue species	Apply in late fall when soil temperatures are between 35 and 55°F. Spring transplants should be at least six months in the field, and fall transplants should be in the field for twelve months prior to treatment. When applied in the fall, also provides early control of annual grasses the following spring. Apply Surflan, Solicam, or Sinbar the following spring for full season annual grass control. Tank-mix Kerb with Princep for residual broadleaf weed control.	Pronamide, 1.0–2.0 lb	Kerb 50WP, 2.0–4.0 lb (—)
Primarily for annual broadleaf weeds	Apply in late fall or spring to weed-free soil, or add an appropriate postemergence herbicide to kill existing vegetation. Tank-mix with Surflan, Solicam, Devrinol, or a reduced rate of Sinbar. This rate is one-half the labeled Karmex rate for use alone for the soil type. Tank-mixing will improve crop safety and the range of weeds controlled. In recent years, Karmex has not performed as reliably as in the past in some locations. For fall applications, using Casoron in the fall plus a residual annual grass herbicide applied in the spring may be a suitable alternative. For spring applications, adding Callisto or Chateau to your spring tank-mix will improve control of summer annual broadleaf weeds..	NJ and MD only: Diuron, 1.0–2.0 lb	NJ and MD only: Karmex DF 1.25–2.5 lb (—)
Labeled perennial, biennial, and annual weeds	Apply in late fall/early winter to control labeled perennial, biennial, and annual weeds, or in late winter/early spring before weed growth begins and daily high temperatures exceed 50°F. Perennial weed control following late winter/early spring applications has been less consistent than late fall applications. Casoron/Norosac is volatile in warm temperatures and must be irrigated or mechanically incorporated after application. Significant herbicide loss may occur if applied in warm weather.	Diclobenil, 4.0–6.0 lb	Casoron/Norosac 4G, 100–150 lb (—), or Casoron CS, 2.8 gal (—)
Primarily for annual broadleaf weed control	Apply in late fall or spring to weed-free soil, or add an appropriate postemergence herbicide to kill existing vegetation. Tank-mix at 1.0–2.0 lb ai (1.1–2.2 lb of Princep 90DF), depending on soil texture and organic matter, with Surflan, Solicam, or Devrinol. This rate is one-half the labeled Princep rate for use alone for each soil type. Tank-mixing will improve crop safety and the range of weeds controlled. In recent years, Princep has not performed as reliably as in the past in some locations. For fall applications, using Casoron in the fall plus a residual annual grass herbicide applied in the spring may be a suitable alternative. For spring applications, adding Callisto or Chateau to your spring tank-mix will improve control of summer annual broadleaf weeds.	Simazine, 1.0–4.0 lb	Princep 90DF, 1.1–4.4 lb (—)
Primarily for annual broadleaf weeds	Add nonionic surfactant to be 0.25% of the spray volume, or 1 qt per acre crop oil concentrate. Apply in the late fall after leaf drop and/or in early spring before bud break as a spray directed toward the base of the bush. If applying in the fall, use a 3 fl oz rate and repeat with 3 fl oz prebloom for longer control. If applying in the spring, up to 6 fl oz can be used. Broadleaf weeds controlled include horseweed and common lambsquarter. Tank-mix with an appropriate postemergence herbicide for broad-spectrum control of emerged weeds. Tank-mix with a residual grass herbicide to improved annual grass control. Do not apply more than 6 fl oz of Callisto per acre within one year.	Mesotrione, 1.5–3.0 oz	Callisto 4F, 3–6 fl oz (prebloom)

Table 7.18. Herbicides for blueberry weed control, continued.

Weeds	Timing of Treatment/Comments	Active Ingredient Rate/A ^a	Product Rate/A (Days to Harvest) ^b
Primarily for annual broadleaf weeds; also controls or suppresses annual grasses	Add crop oil concentrate to be 1% of spray volume. Apply in late fall after leaf drop or in early spring before bud break. Tank-mix with an appropriate postemergence herbicide for broad-spectrum control of emerged weeds. Tank-mix with a residual grass herbicide to improve annual grass control. Do not allow spray to contact foliage or new green bark. Do not use more than 6 oz/a of product where soil contains more than 80% sand until plants have been in the field for more than 3 years. Follow instructions on label for tank clean-out if any part of the sprayer will be used to spray other crops; otherwise, crop injury may occur. See label for other cautions and restrictions, as even contact with treated residue can cause phytotoxicity.	Flumioxazin, 3.0–6.0 oz	Chateau 51WDG, 6–12 oz (pre-budbreak)
Controls many annual broadleaf weed species but may be weak on pigweed species	Apply in the spring to weed-free soil, or add an appropriate postemergence herbicide to kill existing vegetation. Tank-mix using terbacil at 0.5 to 1 lb ai/A (Sinbar 80WP at 0.63–1.25 lb/a), depending on soil texture and organic matter, with Surflan, Devrinol, or a reduced rate of Karmex (New Jersey and Maryland only). This rate is reduced from the labeled Sinbar rate for use alone for the soil type. Tank-mixing will improve crop safety and the range of weeds controlled. In recent years, Sinbar has not performed as reliably as in the past in some locations. Add Callisto or Chateau to your spring tank-mix to improve control of summer annual broadleaf weeds in these situations.	Terbacil, 1.0–2.4 lb	Sinbar 80WP, 1.25–3.0 lb (—)
Primarily for annual grass control; may provide partial control of many broadleaf weeds	Apply in late fall or spring to weed-free soil, or add an appropriate postemergence herbicide to kill existing vegetation. Tank-mix with Princep plus a postemergence herbicide in late fall, or with Karmex (New Jersey and Maryland only), or Sinbar in the spring if the planting has been established for at least one year to improve the control of broadleaf weeds.	Norflurazon, 2.0–4.0 lb	Solicam 80DF, 2.5–5.0 lb (60)
Primarily for annual grasses	Apply in late fall and/or early spring to weed-free soil, or add an appropriate postemergence herbicide to kill existing vegetation. Use the high rate for long-term control (4 to 8 months) and the low rate for short-term control (2 to 4 months). Tank-mix with Princep plus a postemergence herbicide in late fall or with Karmex (New Jersey and Maryland only), or Sinbar in the spring if the planting has been established for at least one year to control annual broadleaf weeds.	Oryzalin, 2.0–4.0 lb	Surflan 4AS, 2.0–4.0 qt (—)
For briars, wild cherry, goldenrod, aster species, meadowsweet, red (sheep) sorrel, sheep-laurel, and other perennial broadleaf weeds	Velpar is not recommended in New Jersey because of a narrow margin of safety when applied to soil with a sandy mineral component, and caution is recommended for all states. Blueberry plants must have been established for at least 3 years. Apply to pruned blueberries in the early spring before leaf emergence. Velpar is also labeled for use in lowbush blueberries, but with a 450 day PHI. Warning: The effect of Velpar on blueberries varies with soils, plant vigor, uniformity of application, and rainfall. Most blueberries are resistant to Velpar, but some varieties are susceptible to injury. In some cases, productivity may be affected even when visible symptoms of phytotoxicity are not apparent. Use lower rates on poorly drained soils, but do not apply to standing water. Do not use on sands, loamy sand, or sandy loam soils. Do not apply to snow or frozen ground.	Hexazinone, 0.5–1.0 lb	Velpar L, 2.0–4.0 pt (90)

Table 7.18. Herbicides for blueberry weed control, continued.

Weeds	Timing of Treatment/Comments	Active Ingredient Rate/A ^a	Product Rate/A (Days to Harvest) ^b
Postemergence—Selective			
Emerged annual grasses	Use the lower rate to control annual grasses less than 6 inches tall. Use the higher rate to control annual grass 6 to 12 inches tall and to control perennial grasses. Do <i>not</i> tank-mix Poast with any other pesticide. Do <i>not</i> apply within 1 hour of rainfall. Do <i>not</i> apply to grasses suffering from drought, heat, cold, or any other stress condition.	Sethoxydim, 0.2–0.5 lb	Poast 1.5EC, 1.0–2.5 pt, plus 2.0 pints crop oil concentrate per acre (30)
Postemergence—Nonselective			
Annual weeds	Contact killer only; with no translocation or residual activity. Best results occur when weeds are 2 inches tall or less. Regrowth may occur from the root systems of established weeds. Use a surfactant to be 0.25% of the spray solution (1 qt per 100 gallons of spray solution). Combine with recommended preemergence herbicide(s) for residual weed control. Do not allow spray or drift to contact green bark, leaves, or fruit. Crop damage may result. The use of shields, such as grow tubes or paper milk cartons greatly reduces the risk of injury in young plantings. DANGER: Do not breathe spray mist. Read safety precautions on the label.	Paraquat, 0.5–1.0 lb	Gramoxone Inteon, 2.0–4.0 pt (—), or Firestorm 35C, 1.3–2.7 pt (—)
Annual and perennial weeds	Glyphosate is a translocated, slow-acting herbicide with no soil or residual activity. Results will become evident 1 to 3 weeks after application. Apply lower rates to control seedlings and annual weeds and to suppress established perennial weeds. Use shields and do not allow glyphosate to contact the foliage or green shoots. Optimum rate and time of application depend on weed species and growth stage. Weeds should be growing vigorously when treated. Do not treat weeds that are under stress from drought, extreme heat, cold, or other adverse growing conditions. When using a ropewick applicator, fill the pipe only half full to avoid excessive dripping. Repeated wiping may be needed to provide control equal to broadcast or spot applications. A ropewick applicator offers significant herbicide cost savings. Warnings: (1) Do <i>not</i> allow glyphosate to contact the leaves, young green bark, fresh trunk wounds, or root suckers, or severe crop injury may occur. (2) Do <i>not</i> allow glyphosate to contact any immature part of blueberry plants. (3) Do <i>not</i> use galvanized containers—glyphosate may react with the container to produce explosive hydrogen gas.	<i>Broadcast:</i> 0.56–3.0 lb ae. <i>Spot treatment:</i> See label; wet foliage thoroughly. <i>Ropewick applicator:</i> See label for product/water ratio. One gallon of product will treat 10–100 acres depending on weed density.	Roundup, or Touchdown, or other labeled formulations (14)

a. Adding a surfactant to these herbicides may improve their effectiveness (see labels).

b. No days-to-harvest limitation is specified on the label if days-to-harvest is listed as (—).

Additional Notes

- All the rates in this table are given on a full-acre basis. If the material is to be banded along or over the row, use the following formula to calculate the banding rate: rate/A banded = rate/A broadcast × (band width in inches ÷ row spacing in inches).
- With all chemicals, follow label instructions and warnings carefully.
- Use pesticides safely. Consult label for restriction.
- It is unlawful to use recommended chemicals for crops not covered on the label or to use chemicals not cleared for such use on blueberry plantings.
- Formulations other than those listed, with the same active ingredient, may be labeled for the same uses.