Blueberries: Organic Production

Horticulture Production Guide

Abstract: *Blueberries are the most widely grown fruit crop in the U.S. Blueberries are well-suited to organic culture, and good markets exist for organically grown blueberries. This production guide addresses key aspects of organic blueberry production, including soils and fertility, cultural considerations, pests, and diseases, as well as marketing. Additional resources are provided for further investigation.*

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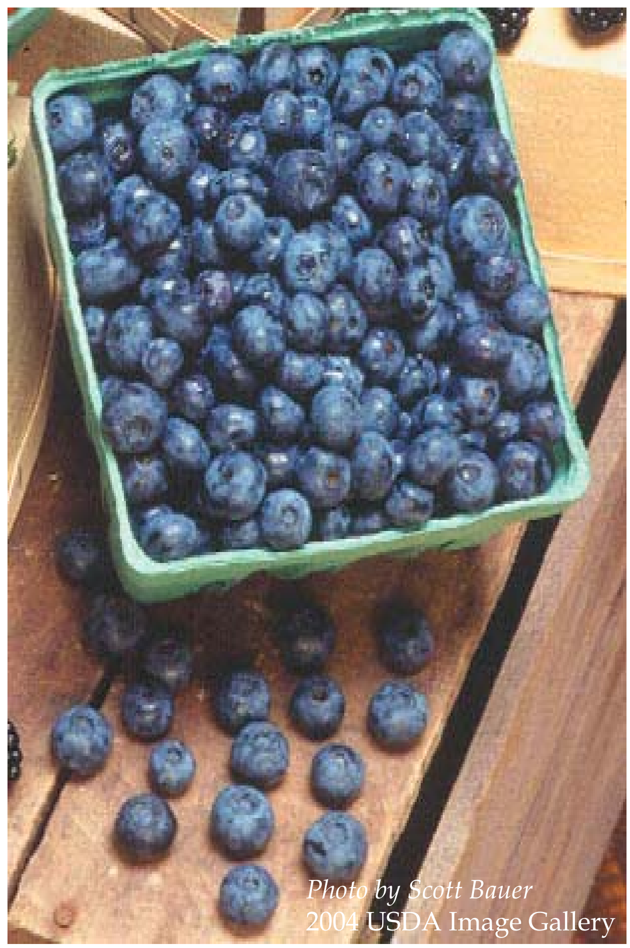

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Introduction

This publication focuses on organic blueberry production, specifically the highbush and rabbiteye species, and is most relevant to production conditions east of the Rocky Mountains. It does not go deeply into many of the basics of blueberry culture—variety choice, planting, pruning and training—which are largely the same under both organic and conventional management. Such general information is available from the Cooperative Extension Service and many horticulture books, periodicals, and bulletins. Nor does this publication address organic production of lowbush blueberries. The Maine Organic Farmers and Gardeners Association (MOFGA) and K-Ag Laboratories International in Wisconsin both have information on organic culture of native, unimproved lowbush blueberries. (See the **Electronic Resources** section of this publication for contact information.)

While anyone may choose to grow organically, the USDA National Organic Program (NOP) now regulates the labeling, marketing, and record-keeping procedures of ***all*** products labeled as organic. If you have a commercial farm and plan to market your produce as organic, you will need to be certified, unless your gross farm income is less than $5000. To learn about organic certification and the steps involved in it, read ATTRA's *Organic Farm Certification & the National Organic Program*.

Blueberries adapt well to organic culture. Production costs may be somewhat higher using organic methods, but this can be effectively counterbalanced by premium prices. Many cultural practices, such as the use of deep mulching and sodded row-middles, work for both conventional and organic blueberry production systems, offering a more sustainable approach to commercial horticulture.

Choosing a Variety

Blueberries are members of the genus *Vaccinium* and belong to the Rhododendron family (Ericaceae). The *Vaccinium* genus contains several species of economic importance. The highbush blueberry (*Vaccinium corymbosum*) is the most widely cultivated, grown from the Mid-Atlantic to California, Oregon, and Washington, and from the Upper Midwest to the Mid-South. The lowbush (wild) blueberry (*V. angustifolium*) is adapted to the far North and is commercially important in Maine, Eastern Canada, and parts of New Hampshire, Massachusetts, Michigan, and Wisconsin. Rabbiteye (*V. ashei*) is a large bush well-adapted to the South, in the region roughly south of Interstate 40. Southern highbush (*V. corymbosum x V. darrowi*), a new hybrid, is adapted to the southern rabbiteye zone as well as the coastal South. It has a lower chilling-hours requirement, and it flowers and fruits earlier than highbush or rabbiteye varieties.

Blueberries have fewer pest problems than most other fruits, offering an advantage for organic production. In some areas, most insect and disease problems can be controlled through cultural manipulation and proper cultivar selection. Weather fluctuations and geographic seasonal advantage are the major economic considerations for variety selection.

The National Organic Standard is unclear on the precise requirements for planting stock when establishing a perennial crop like blueberries. Historically, non-organic transplants could be used to establish perennial crops. However, if conventional planting stock were used, most certifiers required that the plants be grown at least 12 months under organic conditions after transplanting before any harvested product could be marketed as organic. It is likely, but not certain, that most certifiers are continuing that policy. Therefore, it is important that you discuss your plans with your certifier prior to making a purchase.

Soils and Fertility

The Importance of Soil pH

Blueberries are distinct among fruit crops in their soil and fertility requirements. As members of the Rhododendron family, blueberries require an acidic (low pH) soil, preferably in the 4.8 to 5.5 pH range. When soil pH is appreciably higher than 5.5, iron chlorosis often results; when soil pH drops below 4.8, the possibility of manganese toxicity arises. In either case, plants do not perform well.

Blueberries have a relatively low nitrogen requirement and thrive on organic fertilizers. Soil pH also plays a significant role in nitrogen management for blueberries. Research shows that blueberries prefer soil and fertilizer nitrogen in the ammonium form, absorbing and using it much more efficiently than nitrate nitrogen—the form preferred by most other commercial crop plants. Neutral and high-pH soils favor *nitrification*—the rapid conversion of ammonium nitrogen to nitrate through the activity of nitrifying microorganisms. In an acidic soil, however, the ammonium form of nitrogen predominates and is readily available to blueberries. For instance, when a slow-release organic fertilizer like fishmeal is applied, the nitrogen in the proteins is converted first into ammonium. This ammonium—which would rapidly convert to nitrate under neutral soil conditions and be leached out of the root zone—tends to remain in the desired, ammoniated form and thus be held in the soil for uptake.

Perhaps the most common method of lowering soil pH in organic culture is by applying sulfur. Pre-plant incorporation of sulfur to lower the pH to an optimal blueberry range of 4.8 to 5.5 should be based on a soil pH test. Because soil pH is subject to considerable seasonal fluctuation—especially on cropped soils—it is advisable to do soil sampling and testing in winter or very early spring, when biological activity is low. Table 1 provides guidelines for sulfur or lime to raise or lower pH on different types of soil.

Powdered sulfur takes about one year to oxidize and reduce soil pH. Prilled sulfur takes somewhat longer. Limestone, used to increase pH, requires several months to a year to effect changes in pH, and reactive time is highly dependent on the fineness of the grind.

Single applications of sulfur should not exceed 400 pounds per acre. Best results are obtained by applying up to 200 pounds in spring, followed by up to 200 in the fall, for as many applications as are required to deliver the total amount. It is advisable to re-test the soil one year after each application to determine whether additional acidification is necessary.(Pritts and Hancock, 1992)

Organic growers should be conservative in the application of soil sulfur. Sulfur has both fungicidal and insecticidal action and can detrimentally affect soil biology if overused. Organic growers sometimes increase their applications of peat moss at planting time, since it too is a soil acidifier (pH 4.8), reducing the need for sulfur. The Ozark Organic Growers Association suggests as much as 5 to 10 gallons of peat moss per blueberry plant. While costly, peat is resistant to decomposition and provides the benefit of soil humus. Those seeking alternatives to sphagnum peat moss might consider pine bark or similar amendments incorporated in the planting rows or holes. While less desirable than sphagnum peat moss, pine bark often can be obtained locally at a much lower cost.

It is advisable to monitor soil pH over time because production practices can cause gradual changes to occur. Irrigation water often con-

Table 1. Approximate pounds per acre of sulfur or ground limestone to change soil pH one unit.(Whitworth, 1995)

Soil Texture	Pounds per acre of sulfur to lower	Pounds per acre of lime to raise
Sand (CEC=5)	435 to 650	1000
Loam	870 to 1300	2800
Clay (CEC=25)	1300 to 1750	4400

tains calcium and magnesium, which may cause soil pH to creep upwards, while repeated use of acidifying fertilizers, such as cottonseed meal, may lower pH.(Spiers and Braswell, 1992) Fortunately, the presence of abundant organic materials such as peat and the breakdown products of sawdust and woodchip mulches tend to buffer soil pH. Several organic growers have even observed that blueberries grown in high organic matter soils will perform well at a pH as high as 6.0 with few apparent problems. As a result, additional sulfur (or lime, for that matter) seldom is needed. When needed, sulfur is usually applied as a top dressing, but delivery of soluble sulfur through drip irrigation lines also is an option. Vinegar or citric acid solutions may also be applied through drip lines to provide acidity.

Blueberry Fertilization Practices

Soil-building practices prior to establishment can go a long way toward providing the fertility necessary for a healthy blueberry planting. High levels of soil organic matter are especially important in blueberry culture, contributing to the soil's ability to retain and supply moisture to the crop, buffering pH, and releasing nutrients through decay. Soils rich in organic matter are also a desirable environment for symbiotic mycorrhizal fungi that assist blueberry roots in absorbing water, nitrogen, phosphorus, and other minerals.(Yang et al., 2002) Green manures in advance of planting can play an important part in cycling organic matter into the soil system, as can applications of composts and livestock manures. ATTRA has several publications that can be useful in these areas, including *Overview of Cover Crops and Green Manures*, *Manures for Organic Crop Production*, and *Farm-Scale Composting Resource List*.

Once a blueberry planting is established, supplemental fertilization can be applied in a number of forms and by several means. Generally, supplemental nitrogen is the greatest concern, followed by potassium. Blueberries have a low phosphorus requirement and typically require little, if any, phosphorus fertilization. In fact, excessive phosphorus has been one of the factors linked to iron chlorosis in blueberries. High calcium levels are also undesirable.

Nitrogen fertilizer recommendations vary somewhat from region to region. As a general guideline, 100 to 120 pounds of nitrogen per acre are commonly recommended on mulched berries; a reduced rate of 50 to 60 pounds per acre is advised where little or no mulch is used.(Clark, 1987) In conventional production, nitrogen is often applied in three split applications—one at bud break, followed by two more at six-week intervals. Adjustments may be necessary for less-soluble organic fertilizers. One rule of thumb suggests that these fertilizers be applied from one to four weeks ahead of the recommended schedule for soluble fertilizers. This allows additional time for the decomposition processes to make nutrients available. Applications after mid-July are discouraged, as they tend to promote late growth that is particularly sensitive to freeze damage. Table 2 shows natural materials used by organic growers for supplementary fertilization.

Table 2. Natural materials for supplementary fertilization.(Penhallegon, 1992, and Nitron, no date)

Material	Estimated N-P-K	Characteristics
Alfalfa meal	3-1-2	Slow to medium N release Good micronutrient source
Blood meal	12-1.5-0.6	Medium N release, 6-8 weeks
Cottonseed meal	6-2.5-1.7	Slow N release, 4-6 months
Feather meal	13-0-0	Slow N release, 4-6 months
Fish meal	10-4-0	Slow N release, 4-6 months
Soybean meal	7-1.6-2.3	Slow N release, 4-6 months
Compost	Variable	Analysis depends on feed stock
Fortified compost	Variable	Analysis depends on materials added

Current fertilization practices among organic growers vary considerably. In one example (Moore et al., 1994), an organic blueberry grower in the Missouri Ozarks applied ½ pound of feather meal per mulched plant in late May of the establishment year, followed by a similar application four to six weeks later. In subsequent years, an additional (third) application of ½ pound of feather meal was made earlier, in mid- to late-March. As the feather meal products available in this region contain roughly 13% nitrogen, this grower was applying approximately 141 pounds of actual N per acre in the establishment year, and an annual total of 212 pounds per acre thereafter.

Using the same schedule of split applications, another organic grower in the Arkansas Ozarks, also growing mulched berries, applies cottonseed meal (estimated at 7% N) at 1 pound per plant each time—that's two times in the establishment year and three times in subsequent years. At these rates, this grower is applying roughly 152 pounds per acre in the establishment year and about 229 pounds per acre in subsequent years.(Watkins, 1988) However, it should be noted that many sources of cottonseed meal are contaminated and will not be allowed in organic production. Contact your certifier first.

Associate professor John Clark (1987) at the University of Arkansas believes the fertilization rates used by many organic growers are probably excessive. Despite the slower release of organic-based nitrogen, the carry-over from previous seasons probably results in roughly the same amount of nitrogen released each season as is being applied.

Clark suggests that the best way to determine whether fertilization rates are "on target" is to test foliar nitrogen levels annually. This testing is done in late July or early August (in Arkansas) by sampling leaves from the mid-shoot area on fruiting canes and sending them to an analytical laboratory. Lab results showing nitrogen levels below 1.6% indicate a nitrogen deficiency; a level above of 2.2% indicates excess nitrogen. This service is available through Cooperative Extension in Arkansas and other states. Several commercial laboratories also provide foliar analysis. ATTRA identifies laboratories that offer various soil and plant tissue-testing services in its publication *Alternative Soil Testing Laboratories*.

Potassium for blueberries is often adequately provided through decaying mulches. The need for further supplementation should be determined by soil and/or tissue testing. Where additional potassium is needed, it can be applied in a number of mineral forms—including sulfate-of-potash-magnesia or K-Mag,™ granite meal, and greensand. Some forms of potassium sulfate are also allowed in organic production. See your certifier before buying fertilizer.

High-quality compost is an all-around good blueberry fertilizer. Depending on the humus condition and biological activity in the soil, compost may provide all the fertility needs of the crop. Where compost is of average quality, it may still function as a good soil conditioner. Using aged animal manures in blueberry production also is possible, but less common.

Fertigation—the practice of injecting soluble fertilizers through drip irrigation lines—is a common practice in conventional blueberry production. Since fertigation is based on the complete solubility of fertilizers in water, there are limited options among organic fertilizers. Early attempts at fertigation with blood meal by Arkansas blueberry growers resulted in clogged emitters and algae growth. In the 1990s, however, researchers in California successfully demonstrated the use of spray-dried fish protein and poultry protein in drip systems.(Schwankl and McGourty, 1992) In addition, several organic liquid fertilizers—derived from fish emulsion, seeds, kelp, or seaweed—are available.

Unlike the roots of grapes and bramble fruits, which grow well into the inter-row area, blueberry roots are not very extensive. As a result, all fertilizers and acid-forming amendments must be applied under the plant canopy to assure that they reach the roots.

Foliar feeding of blueberries is practiced by some organic growers and is especially helpful when plants are stressed. Foliar fertilization programs usually employ seaweed and fish emulsion. The Ozark Organic Growers Association has recommended a seaweed-fish mix applied three times per growing season—at bud break, just prior to harvest, and just after harvest. More detailed information is available in ATTRA's *Foliar Fertilization* publication.

Cultural Considerations

Plant Spacing

Highbush blueberries are typically spaced 4 to 4½ feet in the row, with 8 to 12 feet between rows. As bushes can get quite large at maturity, many growers find that 10– to 12–foot row spacings—approximately 900 to 1090 plants per acre—are preferable for tractor operations (mowing, harvesting, and spraying). Rabbiteyes are typically spaced at 5 to 8 feet within a row, with 12 to 14 feet between the rows, or 388 to 726 plants per acre.

Dr. J.N. Moore and others at the University of Arkansas have experimented with denser within-row plant spacings for highbush blueberries, effectively doubling the number of plants per acre. Yields during the first five years after planting were found to be substantially higher (a boon to the overall economics of blueberry production—especially where growers have made high investments in drip irrigation and bird netting).

These researchers have been careful to point out, however, that beyond the fifth year, inter-plant competition may create problems, requiring removal of every other plant in the row.(Pritts and Hancock, 1992) Fortunately, highbush blueberries transplant easily, and removed bushes can be used to establish a new field.

Inter-row Management

Blueberries do not have extensive root systems. As a result, clean cultivation of row middles to control weeds and to incorporate cover crops is less damaging to blueberries than it is to bramble fruits. Still, it is wise to till no deeper than 3 inches. Similarly, inter-row living mulches—also called *sodded middles*—generally are not competitive with the crop unless the inter-row species are aggressive and invade the rows. Fescue is commonly used in the Mid-South for sodded middles, as are several other grass species.

Timely mowing—usually three to five times per year—is the common means of controlling weeds and other vegetation in sodded middles. It is most important that weeds not be allowed to produce seed that may be scattered into the rows and germinate later.

In a Texas study, researchers demonstrated that the inter-row area could be used to produce significant quantities of mulch for rabbiteye blueberries. Successful winter crops of rye, ryegrass, and crimson clover, and a summer crop of pearl millet, were grown, cut, and windrowed onto the blueberry rows. Nitrogen proved the major limiting factor for non-leguminous cover crops; low soil pH and browsing deer limited the biomass production of legumes. Pearl millet demonstrated the greatest level of allelopathic (natural production of plant chemicals by one plant that inhibit other plants growing nearby) weed suppression.(Patten et al., 1990)

In some systems that employ sodded middles, a weed-free strip 6 to 12 inches wide often is maintained between the edge of the mulch and the cover crop. The strip reduces competition between the cover crop and berry bushes, and lessens the chance that weeds or the cover crop itself will advance into the mulch. It has the added advantage of discouraging cutworms, an occasional pest in blueberries. In organic systems, this strip is maintained without the use of herbicides.

Organic growers typically employ mechanical cultivators of various types to maintain the weed-free strip. Gordon Watkins (1989) described two modified "off-the-shelf" cultivators used by growers in the Ozark region. One, referred to as the Vasluski Edger, uses a single disc from a rice levee plow in conjunction with two shanks from a spring-tooth chisel. These are mounted on a tool-bar that extends past the rear tractor tire. The disc cuts a strip along the row edge and throws soil towards the plants, while the shanks stir soil closer to the bed. The result is a weed-free strip about 6 to 8 inches wide. The drawback of this implement is the amount of dirt shifted by the disc and the resulting "ditch."

The second implement Watkins describes is the Lilliston Rolling Cultivator,™ with all the heads removed except the two extending beyond one rear tire. One head rolls in the ditch area that is (or would be) created by the Vasluski Edger. The second extends approximately 12 inches onto the side of the bed. Depth of penetration is set at 1 inch, and the implement is best operated at relatively high speeds. Since it cultivates about one-half of the bed surfaces, only about a 2-foot strip remains for hand pulling and hoeing. The tool works well on small weeds but does not control larger, well-established weeds.

Flame, steam, and infrared thermal weed-control systems are other options. In the 1980s and '90s, flame weeding made a rapid comeback as a non-chemical weed control technique, especially among organic farmers. However, this technique is not always practical or safe around flammable mulch materials. ATTRA can provide additional information on flame weeding.

In-row Weed Management and Mulching

Weeds are considered by many growers to be the number one problem in organic blueberry culture. It is especially important to control aggressive perennial weeds such as johnsongrass, bermudagrass, and quackgrass *prior to crop establishment*. Sites with these grasses should generally be avoided for blueberry establishment. Details of pre-plant and post-plant weed management for all fruit plants are provided in ATTRA's *Overview of Organic Fruit Production*. Some techniques, however, deserve additional elaboration.

In much of the country, blueberries are grown on mulched, raised beds. Rabbiteyes and old highbush plantings are commonly grown without mulch. Raised beds reduce the incidence of soil- and water-borne diseases. Thick organic mulches provide weed and disease suppression, soil temperature regulation, slow-release nutrients, organic matter, and moisture conservation. The latter is especially important because blueberry roots lack root hairs—the primary sites for water and mineral absorption on most plants. This characteristic makes water management of paramount concern and goes a long way toward explaining why irrigation and mulching are recommended practices.

The importance of maintaining a weed-free zone around blueberries was demonstrated in a Georgia study(NeSmith et al., 1995) using rabbiteye blueberries—which have a more vigorous root system than highbush. Researchers determined that an optimum vegetation-free zone during the first two to three years of growth extends roughly 1.5 to 2.5 feet from the plant. This translates to a 3- to 5-foot-wide, weed-free row bed.

Current recommendations suggest mulching a 3- to 4-foot-wide strip under the plants with 3 to 5 inches of sawdust, bark, wood chips, or wood shavings. Organic growers often prefer a deeper mulch of up to 6 inches over a strip at least 4 feet wide. Ideally, the mulch should be sufficiently coarse to minimize crusting, and the surface relatively flat to encourage water penetration and gas exchange.

While the mulch suppresses many weeds, the moist organic medium can also become a haven for annual weeds (annual ryegrass, stinging nettle, crabgrass) as well as perennial weeds (dandelion, horsetail, sheep sorrel) that find a niche in perennial plantings. Strategic attention to weed control, even in mulched fields, is a major cultural consideration. Tractor-drawn cultivation implements are impractical for in-row weed control on deep-mulched blueberries because blueberry roots often grow into the mulch, and significant plant damage can result from tillage. Shallow hoeing or hand-pulling weeds are two traditional options practiced by many organic growers.

Weeder geese can also eliminate most of the grass and many of the tender broadleaf weeds from a planting. They are prone to eating ripe fruit, however, and may damage some of the newly emerging canes, so their use should be timed accordingly. Obviously, goose stocking rates are much lower, and management easier, on clean cultivated plantings. Investigators at the Kerr Center for Sustainable Agriculture have used weeder geese for effective weed control in blueberries with sodded middles. The Center's strategy involves using movable electric fencing and intensive grazing. One possible drawback cited by Kerr Center researchers is the tendency of geese to compact the soil and mulch. ATTRA can supply further information on weeding with geese.

A promising alternative to organic mulching is the use of fabric weed barriers. While fabric mulches may not provide all the benefits of deep organic mulch, they are highly effective for weed control and allow water to pass through.

And, though the initial cost is high, it may prove reasonable when amortized over the fabric's expected lifetime of 10 to 12 years. All fabric mulches must be removed, however, before they deteriorate and decompose into the soil. Have a plan in place to deal with this eventuality. Available fabric mulches include Sunbelt by DeWitt Company (see **References**).

Non-porous black plastic mulches—commonly used in vegetable production—are not recommended for blueberries. Polyethylene plastic mulch encourages surface rooting—making the plants more susceptible to drought stress and winter injury—and the plastic does not allow water to pass through.

Pollination

Blueberries are insect-pollinated; thus, increasing the number of pollinators can be quite beneficial. Blueberry flowers vary greatly in size and shape, depending on species.(Lyrene, 1994) Therefore, having a variety of pollinators like horn-faced bees, mason bees, carpenter bees, bumblebees, orchard bees, and others is important for good fruit set.

Several varieties of blueberry require cross-pollination, and almost all varieties yield better as a result of it. In a pollination study, the variety Patriot, and possibly Northland, benefited from cross pollination, while the variety Bluecrop did not; therefore, highbush blueberry planting design must be based on the pollination requirements of the particular variety.(MacKenzie, 1997) Identify the pollinators that are most efficient for the variety and encourage them to remain in the area by creating insect habitats. Cover crops and adjacent vegetation may act as habitats for beneficial insects that provide pollination and help suppress pest insects and mites. When crops and field borders are managed with beneficials in mind, they often are referred to as *refugia*, and represent a new approach to attracting pollinators and natural enemies of pests, based on planned biodiversity. To learn more about refugia, request the ATTRA publication *Farmscaping to Enhance Biological Control*. Additional information on using various bees as pollinators can be found in ATTRA's *Alternative Pollinators: Native Bees*.

Insect Pests

Rabbiteye blueberries seem more tolerant of insect damage than highbush varieties. Although insect damage in blueberry plantings rarely reaches economic thresholds, regular monitoring by scouting and use of insect traps is advised. As discussed in the previous section, the use of beneficial insect habitats along crop field borders increases the presence of beneficial insects. If you are releasing purchased beneficial insects, these field-edge habitats will encourage them to remain and continue their life cycle in that location, helping reduce the pest populations. However, pests may also inhabit the field-edge habitats; therefore, these habitats should be monitored along with the crop field. For additional information, request ATTRA's publications *Biointensive Integrated Pest Management* and *Farmscaping to Enhance Biological Control.*

Depending on the locations of blueberry plantings and the insect pressure on them, sanitation, good cultural practices, vigorous plant growth, and natural biological control will handle most pests. However, when specific pests reach economically damaging levels, additional action is necessary. The following discussion identifies some common blueberry pests and allowed organic controls. This information was taken largely from Cornell University's *Crop Profiles: Blueberries in New York* (Harrington and Good, 2000), where more detailed information can be found.

Figure 1. Blueberry maggot adult fly. Used with permission. By G.J. Steck and J.A. Payne

The most common insect pest is the blueberry maggot, *Rhagoletis mendax*. It attacks the fruit in midsummer before harvest and feeds on all varieties of blueberries. It is found throughout the eastern U.S. and Canada. This pest overwinters in the pupae stage, buried 1 to 2 inches in the soil. The adult flies emerge over a period of a month or two during summer. They lay eggs in ripe berries, and the maggots eat the pulp of the fruits, causing many to drop, spoiling the sale of others, and creating difficulties in post-harvest care. Through degree-day calculations based on soil temperatures, one can predict the emergence of the flies—934.3 degree days at the low temperature threshold of 41°F (Teixeira and Polavarapu, 2001)—and implement appropriate measures to prevent or control maggot damage.

The choice of blueberry varieties can influence the severity of blueberry maggot damage. In a Rhode Island study, the early ripening varieties Earliblue and Bluetta were found to have fewer maggots than late maturing varieties whose ripening periods were synchronized with the fly's egg-laying period. Of the mid- to late-season varieties, Northland and Herbert stood out with less damage.(Liburd et al., 1998)

The botanical insecticides rotenone and pyrethrum can be effective in controlling blueberry maggots, but they can also be toxic to beneficial insects, fish, and swine. The spinosad-type insecticide Entrust™ (Dow AgroScience) is approved for use on organic crops including blueberries and has been reported effective against the blueberry maggot. Additionally, disking, cultivating, and off-season grazing by fowl can reduce pupa populations.

Blueberry stem borer

This beetle, *Oberea myops*, causes damage in two ways. First, egg deposits can cause the first 3 to 4 inches of the current season's growth to wilt or die. This is evidenced by girdling in two places, approximately ½ inch apart, on the injured twig. Secondly, grubs can cause canes to die. Leaves will turn from green to yellow and drop off, and the cane will die. Pinholes along the shoot with yellowish strings hanging from them are indicative of this problem.

This pest can be controlled by removing wilted tips below the insect damage and burning them.

Cranberry fruitworm

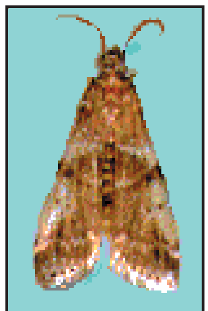

Figure 3. Photo used with permission By C.D. Armstrong. Cranberry fruitworm adult moth.

Particularly troublesome in the eastern U.S., the cranberry fruitworm, *Acrobasis vaccinii*, affects both cranberries and blueberries. It overwinters in the soil as a fully grown larva and completes development in the spring. Adult moths mate and lay eggs from bloom until late green fruit, usually on unripe fruit. The eggs are very small and difficult to see. Young larvae enter the stem end of the fruit and feed on the flesh. They often web berries together with silk. A Michigan study reports that many parasites attack the cranberry fruitworm. The most common larval parasitoid is *Campoletis* *patsuiketorum* (Hymenoptera: Ichneumonidae); the most common parasitoid recovered from the fruitworm's hibernating structure was *Villa*

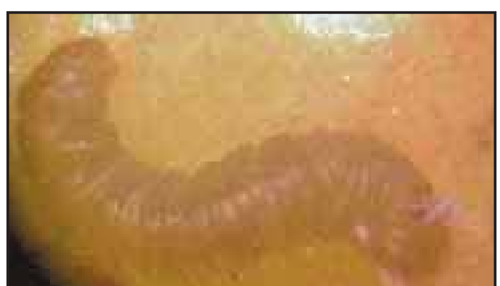

Figure 4. Cranberry fruitworm larva. By C.D. Armstrong. Photo used with permission.

lateralis (Diptera: Bombyliidae).(Murray et al., 1996) Therefore, maintaining refugia, by enhancing field borders for beneficial insects, and proper sanitation are especially important in controlling this pest. Additionally, eliminating weeds and vegetative litter around plants helps cut down on overwintering protection for fruitworm cocoons.

The biocontrol *Bacillus thuringiensis* (Bt) can effectively control cranberry fruitworm. Make sure to use a Bt product approved for organic production. The spinosad insecticide Entrust (Dow AgroScience) is registered for use against the cranberry fruitworm and cherry fruitworm on blueberries.

Cherry fruitworm

The cherry fruitworm, *Grapholitha packardi*, which bores into the fruit and feeds extensively below the surface, can be very damaging to blueberries. It causes injury within a few days of hatching. This pest overwinters as mature larvae in hibernating structures on the blueberry bushes, with larvae pupating in the spring. The adults appear in about a month (this varies by seasonal conditions). Adult moths mate and lay eggs on unripe fruit.

Pruning and burning the cut limbs helps control the cherry fruitworm, because the hibernating larvae are contained in these limbs. The cherry fruitworm is a lepidopteran pest, and organically approved control products include B.t. or the spinosad product Entrust.

Japanese beetle

Figure 5. Japanese beetle skeletonizing a leaf. Photo used with permission. University of Maryland Cooperative Extension Home and Garden Information Center.

The Japanese beetle larvae develop in pastures, lawns, and other types of turf, where they live in the soil. Adults emerge in early summer and feed on blueberry foliage and berries, causing injury to the berries, as well as decay from fruit-rotting pathogens.

Organic growers use a number of methods to control these pests. Hand picking, trapping, milky spore disease, and/or beneficial nematodes have all been used by growers with varying degrees of success. The key practices are the use of milky spore (which provides a long term approach to larvae reduction), trapping away from the crop, and regular emptying of the traps.

Clean harvesting prevents the accumulation of overripe fruit, reducing the attraction for beetles. In a Michigan study, fields with tilled row-middles had significantly fewer larvae than those with permanent sod, and larval abundance was significantly lower on the interiors of the fields compared to the perimeters.(Szendrei et al., 2001) Clean row middles may have fewer Japanese beetle larvae, but they also leave the soil open to erosion, so this option should be used only on level fields.

Some botanical insecticides—such as rotenone—can legally be used even on the day of harvest according to current label restrictions; however, none have proven adequate for Japanese beetle control. Kaolin clay, available in the product Surround, can be used for suppression of the Japanese beetle only on blueberries that will be processed.

Leafroller

Leafrollers are the caterpillars of a few species of small moths. These pests roll leaves (hence their name) to use as shelter during their metamorphosis. Adults emerge, mate, lay eggs, and then repeat the cycle at least twice each year. Larvae feed on green berries, ripe berries, and leaves. Small numbers of leafrollers (fewer than 15 per plant) usually will not cause significant losses, unless they are feeding on blossoms.(Elsner and Whalon, 1998)

The pesticide Bt *var kurstaki* can be applied when insects are feeding. Additional organically accepted strains of Bt can be effective at egg hatch, becoming less effective as larval size increases. Neemix, a product containing azadirachtin, acts as an insecticide and insect growth regulator affecting young (1^{st} and 2^{nd} instar) caterpillar pests. It is registered for leafrollers on organic blueberries with an "R" (regulated) status.

Leafhopper

Leafhoppers are small, mobile insects that are often found on stems or the undersides of leaves. They feed by piercing the plant surface to suck plant juices.(Elsner and Whalon, 1998) Leafhoppers transmit a microorganism that causes stunt disease. In areas where stunt disease is a known problem, leafhopper control is suggested. The botanical pesticide sabadilla, as well as insecticidal soap and diatomaceous earth, are reported to be effective against these pests. Surround (for processing blueberries) and Neemix are registered for leafhopper control on blueberries. Kaolin clay in Surround can be used for suppression of leafhoppers on processing blueberries only.

Aphids

Aphids, or plant lice, are related to the leafhopper. They feed on the undersides of the youngest leaves and on tender shoots, and reproduce very rapidly. Aphids transmit blueberry shoestring virus, which can be very damaging to commercial blueberry producers.(Elsner and Whalon, 1998)

Aphids have many natural enemies like ladybugs, lacewings, and parasitic wasps. Encouraging these natural enemies with habitat plantings can keep aphids and other pests on blueberries below economic thresholds. Remove the virus-infected plants, which will have bright red streaks or straplike leaves. Avoid overfertilization of the crop. Organic growers can also use insecticidal soap to control aphids.

Diseases

Diseases in plants occur when a pathogen is present, the host is susceptible, and the environment is favorable for the disease to develop. Changing one of these three factors may prevent the disease from occurring. Pathogens responsible for blueberry diseases include fungi, bacteria, nematodes, and viruses. If these pathogens are present, manipulation of the environment and the host, to make it less susceptible, help to manage diseases on blueberries in a more sustainable manner. Check with your nursery and local Extension office to see whether known diseases are prevalent in your area. Then, plant tolerant or resistant blueberry varieties.

Managing soil health is key for successful control of soil-borne diseases. A soil with adequate organic matter can house large numbers of organisms (e.g., beneficial bacteria, fungi, amoebas, nematodes, protozoa, arthropods, and earthworms) that in conjunction deter pathogenic fungi, bacteria, nematodes, and arthropods from attacking plants. These beneficial organisms also help foster a healthy plant that is able to resist pest attack. For more information, see the ATTRA publication *Sustainable Management of Soil-borne Plant Diseases.*

The plant's leaf surface can also host beneficial organisms that compete with pathogens for space. A disease spore landing on a leaf surface, for example, has to find a suitable niche for it to germinate, penetrate, and infect. The more beneficial organisms there are on the leaf, the greater the competition for the disease-causing spore trying to find a niche. Applying compost teas adds microorganisms to the plant's surface, making it more difficult for diseases to become established. Note, however, that there are restrictions on the use of compost tea prior to harvest. Be sure to consult your certifier. For more information on disease controls, see the ATTRA publications *Notes on Compost Teas* and *Use of Baking Soda as a Fungicide.*

A blueberry diagnostic tool from Cornell University has a step-by-step exercise that can aid a blueberry grower in determining what diseases may be affecting the crop. The diagnostic tool can be found at the following Web site: www.hort.cornell.edu/department/faculty/pritts/BerryDoc/blueberry/BBparts.htm

Diseases common to blueberries include mummy berry, Botrytis blight (gray mold), stem blight, stem canker, phytophthora root rot, blueberry

Figure 6. Mummy berry

Figure 7. Mummy berry with apothecia

Figure 8. Infected leaves and flower bud

Figures 6,7,8
Credits: Photos used with permission. Nova Scotia Agriculture and Fisheries Agriculture Center.

stunt, and several viral diseases. For proper disease identification, consult Cooperative Extension Service publications and related literature. Many states also have plant pathology laboratories associated with their land-grant university that can provide diagnosis.

Foliar diseases

Mummy Berry (*Monilinia vacinii-corymbosi*)

This fungus overwinters in mummified berries that have fallen to the ground. Sod or moss directly under the plant will contribute to spore production. To control this fungus, remove infested fruit ("mummies") from the plant, rake and burn mummified berries, or cover the fallen berries with at least two inches of mulch. Cultivation during moist spring weather will destroy the spore-forming bodies. Strategies that lead to early pollination of newly open flowers may be useful in managing mummy berry disease in the field, since studies show that newly opened flowers are the most susceptible to infection and that fruit disease incidence is reduced if pollination occurs at least one day before infection.(Ngugi et al., 2002)

The fungus survives the winter on dead twigs and in organic matter in the soil. The disease is more severe when excessive nitrogen has been used, where air circulation is poor, or when frost has injured blossoms. Varieties possessing tight fruit clusters are particularly susceptible to this disease. Remove dead berries, debris, and mulch from infected plants during the winter and compost or destroy it. Replace with new mulch, and do not place mulch against the trunk of the plant.

Highbush blueberry varieties are more resistant to mummy berry than are rabbiteye. Rabbiteye varieties that showed lower levels of infection were Coastal, Delite, Centurion, Walker, Callaway, and Garden Blue.(Ehlenfeldt et al., 2000) Highbush varieties that exhibited constant resistance to mummy berry were Northsky, Reka, Northblue, Cape Fear, Bluegold, Puru, and Bluejay.(Stretch and Ehlenfeldt, 2000)

This fungus overwinters in dead or diseased twigs, fruit spurs, and cankers. Spores are released in the spring and are spread by rain and wind. Varieties in which the ripe fruit hangs for a long time on the bush prior to picking are especially susceptible. Removal of infected

Botrytis Blight (*Botrytis cineria*)

Figure 9. Botrytis Blight

Figure 10. Infected flower clusters

Photos used with permission. Nova Scotia Agriculture and Fisheries, Agriculture Center. www.gov.ns.ca/nsaf/elibrary/archive/hort/wildblue/disease/botrybli.htm

Anthracnose (*Collectotrichum acutatum* and *C. gloeosporioides*)

Figure 11. Anthracnose infected fruit oozing out of berry.

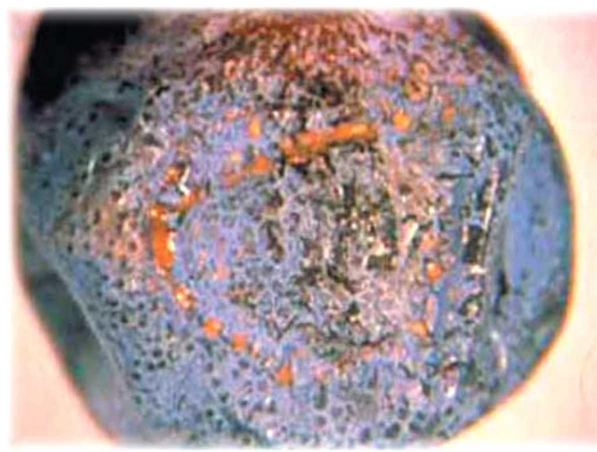

Figure 12. Orange Spores

Photos courtesy of Dr. P. Bristow, Washington State University, Puyallup, WA. www.agf.gov.bc.ca/cropprot/blueberry.htm twigs by pruning and frequent harvesting are beneficial to control. Old canes and small twiggy wood should be removed in order to increase air circulation around the fruit clusters. Immediate postharvest cooling will significantly reduce the incidence of this disease.

Stem Blight (*Botryosphaeria dothidea*)

Stem blight shows up as a wilting, browning, or reddening of the infected leaves, which frequently precedes the death of the plant. This is a vascular disease that most often starts from a wound infection site. The most typical symptom would be a flag (limbs killed by the disease that do not drop their leaves). The stems can be cut open to reveal a light-brown discoloration.

Removal of infected wood, pruning about 12 inches below the discolored part of the limb, is the only practical control for *Botryosphaeria* stem blight. Since infection can spread throughout the growing season, growers should prune during dormancy. Fertilizer management is necessary to prevent the formation of succulent shoots late in the season. Infection of cold-injured shoots around the base of the bush is a primary way for this fungus to enter the plant. The worst cases of stem blight occur on soils that are extremely sandy or on heavy peat soils that promote excessive growth. Clove oil inhibits fungal growth and spore germination of *Botryosphaeria dothidea* and could be effective in controlling this disease on several woody plant species such as blueberry. (Jacobs et al., 1995) Be certain any clove oil product you use is properly formulated and allowed in organic production.

Figure 13

Figure 14

Figures 13 and 14. Symptoms of Botryosphaeria Stem Blight

Photos used with permission. Bill Cline, Plant Pathology Extension, North Carolina State University.

Rust is a serious leaf-defoliating problem for southern highbush varieties. The first yellow leaf-spot symptoms appear in late spring to early summer. The yellow spots turn reddish-brown as yellow-to-orange pustules show up on the bottom sides of leaves. Finally the infected leaves turn brown and drop off prematurely. Remedial action includes removing and burning infected vegetation. Multiple reinfestations are possible during one growing season. Native evergreen berries (but not hemlock) are suspected as the overwintering source and a necessary alternative host for completion of the fungus life cycle. It may be beneficial to remove native species in the *Vaccinium* genus—which include sparkleberry, huckleberry, gooseberry, and bearberry—from areas adjacent to cultivated bushes.

Phytophthora Root Rot (*Phytophthora cinnamomi*)

Root rot occurs more often on southern highbush plants than on rabbiteyes. The first symptoms are general unthriftiness leading to yellowing and reddening of leaves. Necrosis will appear on small rootlets and progress to a discoloration on the main roots and crowns. Eventually the plants will drop their leaves and die. Controls include use of clean nursery stock and good field drainage. Heavy soils that become waterlogged or have a high water table should be avoided. Plants can be grown on raised beds to reduce risks. Varieties resistant to *Phytophthora* include the rabbiteye varieties Premier and Tifblue and the highbush variety Gulf Coast.(Smith and Hepp, 2000)

Blueberries' shallow roots may benefit from the soil-disease suppressive qualities of an organic mulch.

Phomopsis Twig Blight (*Phomopsis* species)

Tip browning and dieback are classic symptoms of this disease. Then elongated brownish cankers up to 4 inches long appear on stems. The fungus overwinters in infected plant parts. Spores are released from old cankers in the spring; rain is necessary for spore release. Temperatures ranging from 70 to 80°F encourage infections, and moisture stress predisposes the plant to infection. The disease is most severe after winters in which mild spells are interspersed with cold periods. Growers should prune and destroy infected plant parts. Avoid mechanical damage such as that caused by careless pruning and cultivating. Avoid moisture stress by using irrigation during dry periods. A fall application of lime sulfur after the leaves have dropped helps reduce disease spores. Spring application of lime sulfur should be made early before warm weather occurs, to avoid injury to plants. Refer to your state's spray guide for recommended rates and timing. Careful variety selection can greatly reduce the severity of twig blight. The varieties Elliott and Bluetta have proved resistant to *Phomopsis* twig blight. (Baker et al., 1995)

Figure 15

Figure 16

Figures 15 and 16. Phomopsis Twig Blight symptoms

Photos used with permission. Highbush Blueberry Production Guide, NRAES, Cooperative Extension, Ithaca, New York.

Fusicoccum Canker

Fusicoccum is a stem disease causing dieback and general plant decline. This fungus overwinters in cankers. Spores are largely disseminated by rainwater, and cold stress may play a part in increasing disease damage. Removal of infected plant parts is essential for control. Varieties differ in their resistance to this disease.

Figure 17. Fusicoccum Canker (*Fusicoccum* species)

Photo used with permission. Highbush Blueberry Production Guide, NRAES, Cooperative Extension, Ithaca, New York.

Viral diseases

Control of vectors, like aphids and leafhoppers, and sanitation of pruning and propagating materials are important steps in controlling viral diseases. Once a plant is infected, diagnosing it and culling it from the field is critical to prevent the virus from spreading.

Shoestring disease

Symptoms appear as red discoloration in the midvein of a leaf, which then develops abnormally into wavy, distorted, or crescent shapes. Other than buying disease–free plants, destroying wild plants near the planting, and removing diseased plants, control does not exist. Some cultivars possess genetic resistance or tolerance.

Stunt

With this disease, plants lose vigor and become yellowish and dwarfed. The yellow-tipped leaves remain small, rounded, and often puckered. The only known carrier is the sharp–nosed leafhopper, though other vectors probably exist. Diseased bushes cannot be cured. They must be removed from the field as soon as they are diagnosed. Agitation of the bush during removal will dislodge the leafhoppers, causing them to move to a neighboring healthy bush.

Scorch virus

This virus causes severe dieback, blossom blighting, and significant yield reduction on susceptible varieties, eventually killing its host. First, the flowers turn brown and fade to a greyish color before they fall off, though with the West Coast strain of the virus, the dried flowers can be retained on the bush for more than a year. Production drops off and the plants do not recover. The virus is spread by aphids or by planting infected stock. The first line of defense is to plant virus-free stock obtained from a nursery that undergoes regular virus testing. Otherwise, remove infected plants when symptoms appear and after the disease has been diagnosed by testing. Also, control aphids in the blueberry field. Replant with virus-free stock. Most University Extension Service State offices have a disease diagnostic service for plant samples.

Bacterial disease

Bacterial Crown Gall (*Agrobacterium tumefaciens*)

The crown gall bacterium does not grow well in an acidic environment, so this disease is uncommon where soil pH is maintained in the optimum range for blueberries.

Bird and Rodent Control

Birds are a common pest of blueberries. Their impact varies, depending on location and bird density. Oregon reported up to 60% crop loss from birds.(Main et al., circa 2000) In a Florida study (Main et al., circa 2000), blueberries protected with bird netting yielded the same as those unprotected. Various methods of control have been tried—including “scare-eye” balloons, Mylar reflective tape, and sonic devices—with varying levels of success. The problem with most repellents or scare tactics is that birds become habituated to the stimulus, rendering it ineffective after a short time. Sometimes, growers overcome this problem by changing the stimulus frequently—e.g., switching from balloons to Mylar tape, or moving the balloons from one site to another. Properly applied bird netting has provided consistent and predictable control, but it is expensive to purchase and set up. At the time of this writing (2004), the cost for ¾-inch bird netting 14 feet wide by 100 feet long is $85 plus shipping; 14 feet by 200 feet is $175, plus shipping; while a 5000 foot roll of 14-foot wide netting runs $1800 plus shipping. For a Web site that sells bird netting, see <www.bird-away.com/html/bird-netting.html>.

An Illinois study (Anon., 1991) found that the yield increase on net-protected blueberries paid 80% of the costs of installation at a problem site. As growers report a 10-year life expectancy for netting, the investment proved profitable by the second year.

Rodents, primarily voles, can be a problem in blueberries, because they inhabit mulches and feed on roots and bark. Several other soil dwellers such as moles and shrews may also be present. Shrews are carnivores that feed on grubs and worms; however, their tunneling can harm the plants. Rodent problems are largely confined to plantings that are mulched and those with permanently sodded middles. Clean cultivation provides little shelter and disturbs burrows, but it also creates an erosion hazard. Organic alternatives include trapping, encouraging predators (e.g., setting out perches to attract hawks, and owl boxes for barn owls), frequent mowing of sodded middles, and managing fencerows and adjacent areas to discourage migrants.(Hauschild, 1995)

For details on options for rodent control, please refer to ATTRA's *Overview of Organic Fruit Production*. This publication also discusses management of bird problems. Cooperative Extension and the U.S. Fish and Wildlife Service also have information on rodent and bird control.

Marketing

There are a number of marketing options for organic blueberries. Fresh blueberries can be marketed directly through roadside stands, U-Pick operations, on-farm sales, and farmers' markets. There are also well-established wholesale markets for both fresh and frozen blueberries.

While highbush blueberries are grown for both fresh fruit and processing markets, "nearly half of the cultivated blueberries grown are sold as fresh blueberries," according to the North American Blueberry Council.(Anon, no date) Since returns to the grower usually are higher for fresh berries, most organic growers choose that option.

As local retail markets become saturated, many growers will also sell their berries wholesale through growers' cooperatives. This is a common option for organic growers, especially where organic collectives have helped to identify premium markets. Some value-added processing options include frozen berries, jams, and juice.

A breakthrough in value-added marketing came in the late 1990s, when scientific research indicated special health benefits associated with blueberry consumption.(Staff, 2000; Anon, 1999; Lazarus and Schmitz, 2000) More farmers are now looking at marketing blueberries as a healthy "functional" food that contains flavonoids, vitamin C, anthocyanins, and phenolic acids.(Medders, 2001) Among the selling points are that blueberries are a good source of antioxidants and vitamin C, that the tannins in blueberries can help prevent urinary tract infections, and that ½ cup of blueberries contains only 40 calories.(Anon., 2002)

For more information about marketing options, see the ATTRA publications *Direct Marketing, Farmers' Markets,* and *Adding Value to Farm Products: An Overview*. On-farm, value-added blueberry products usually require setting up a rural enterprise besides farming, and may entail considerable additional planning, management, and start-up expense. Co-packers are an alternative to doing your own processing.

Blueberries are a popular "U-Pick" crop. When acreage exceeds the capacity of U-Pick customers, whether 5 or 15 acres, hired labor becomes necessary. One rule of thumb suggests that 10 to 15 pickers per acre are required during the height of the harvest season.

For a good article on marketing blueberries from a New Jersey blueberry farm, see <www.newfarm.org/features/0803/NJ%20blue/index.shtml>.

For more information, see *Blueberry Marketing Options*, from the Northwest Berry & Grape Information Network, available on-line at <http://berrygrape.orst.edu/fruitgrowing/berrycrops/blueberry/mopt.htm>.

Additionally, the Wild Blueberry Association of North America (WBANA) Web site, <www.wildblueberries.com>, promotes marketing and is an excellent source of information on production practices.

Economics

Organic blueberries typically sell for about 20% more than conventionally grown blueberries. Nationally, a survey conducted by the Organic Farming Research Foundation showed that organic blueberry growers received between $1.00 and $3.50 per pound for fresh berries in 1997 and that wholesale prices for fresh organic blueberries were 20% to 100% higher than for conventional blueberries, depending on supply and demand. (Krewer, 2001)

Highbush blueberries typically start producing in the third season, and yields increase annually for the next four years. At full capacity, blueberries yield about 3 tons per acre. As blueberries are expensive to establish and maintain, growers often do not realize a return on their capital investment until the seventh year. Well-maintained blueberry bushes remain productive for at least 15 to 20 years.

Blueberries ripen fairly predictably, according to the region in which they are grown. In heavy bearing years, market prices can drop dramatically, with early-bearing regions faring well and late-bearing regions doing poorly. Harvest patterns follow a sequence beginning with rabbiteyes from Georgia and Texas, followed by highbush berries from North Carolina and the Southern Interior Highlands (Arkansas, Tennessee, Kentucky, and Missouri). These are followed by the Northern Interior Highlands, New Jersey, and so on. In years of overproduction, harvest prices do not even cover the cost of picking. Therefore, factors affecting local supply (such as late spring frost and the number of blueberry farms in your area) can play a major role in profitability.

Blueberries are a highly perishable crop, and efficient post-harvest handling is critical. Berry flats should be quickly refrigerated following harvest. For the commercial grower, a walk-in cooler is a must, as is a grading and packing shed. The Mississippi State University Extension Service publication *Costs & Returns Associated with Producing Commercial Blueberries*, available on-line at <http://msucares.com/pubs/publications/p2159.html>, provides more detailed information on the economics of blueberry production, including costs for irrigation, fertilizer, yields based on plant age, labor requirements, field operation costs for establishment, and more. While cost and return estimates will vary by state, the publication can serve as a useful planning guide.

For a budget showing establishment and maintenance costs for blueberry production, see this highbush blueberry budget from Penn State: <http://agalternatives.aers.psu.edu/crops/highbush_blueberry/highbush_blueberry.pdf>. Below are two of their budgets for conventional highbush blueberries (Table 3 and 4).

Table 3. Per-acre Cost Estimates for Fresh-market Highbush Blueberries*						
Costs	**Land Preparation**	**Your Estimate**	**Planting year 0**	**Your Estimate**	**Mature year 4+**	**Your Estimate**
Variable						
Custom operations	74.60		34.80		6.00	
Fertilizer	311.00		16.00		32.00	
Weed control	0.00		129.64		212.10	
Insect control	0.00		10.88		74.85	
Disease control	0.00		0.00		103.24	
Seed	48.00		60.00		0.00	
Plants	0.00		2,001.00		0.00	
Irrigation	0.00		620.00		120.00	
Mulch	0.00		250.00		0.00	
Bee rental	0.00		0.00		25.00	
Labor	8.00		400.05		5,526.19	
Fuel	0.00		4.23		7.32	
Maintenance	0.00		3.12		8.07	
Interest	22.62		188.13		16.87	
Total Variable	464.23		3,717.84		6,131.63	
Fixed						
Equipment	0.00		6.22		14.71	
Land	100.00		100.00		100.00	
Total Fixed	100.00		106.22		114.71	
Total Costs	564.23		3,824.06		6,246.35	

*Demchak, K., J.K. Harper, and G.L. Greaser. 2001. Highbush Blueberry Production. Agricultural Alternatives. Pennsylvania State University College of Agricultural Sciences.

Table 4. Returns above total costs for various prices and yields*				
Price	Yield - pounds/acre			
	4000	6000	8000	10,000
Dollars/pound	$	$	$	$
0.75	-646	-446	-246	-46
1.00	354	1054	1754	2454
1.25	1354	2554	3754	4954
1.50	2354	4054	5754	7454
1.75	3354	5554	7754	9954
2.00	4354	7054	9754	12,454
2.25	5354	8554	11,754	14,954

*Demchak, K., J.K. Harper, and G.L. Greaser. 2001. Highbush Blueberry Production. Agricultural Alternatives. Pennsylvania State Univeristy College of Agricultural Sciences.

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Figure 17. Highbush Blueberry Production Guide, NRAES-55, published by NRAES, Cooperative Extension, P.O. Box 4557, Ithaca, New York. 14852-4557.
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Alternative Opportunities for Small Farms: Blueberry Production Review
http://edis.ifas.ufl.edu/pdffiles/AC/AC00800.pdf

The Berry Basket, its precursor, News from the Berry Patch, and Blueberry Times
http://library.smsu.edu/paulevans/berrybasket.shtml

Blueberry Bookmarks
Michigan State University
www.msue.msu.edu/msue/iac/agnic/blueberry2.html

The Blueberry Bulletin
Rutgers Cooperative Extension
www.rce.rutgers.edu/pubs/blueberrybulletin/

Blueberry Citation Database
Michigan State University Extension
www.msue.msu.edu/msue/imp/modbb/modbbb.html

The Berry Diagnostic Tool
By Dr. Marvin Pritts
Cornell University, Ithaca, NY 14853
www.hort.cornell.edu/department/faculty/pritts/BerryDoc/blueberry/BBparts.htm

A companion to the NRAES Production Guides for strawberries, raspberries and blueberries.

Blueberry gall midge, Featured Creatures
http://creatures.ifas.ufl.edu/fruit/blueberry_gall_midge.htm

Blueberry Gardener's Guide
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www.citygardening.net/blueberryinfo/

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Michigan State University
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Mississippi State University Extension Service
http://msucares.com/pubs/infosheets/is1448.htm

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http://agalternatives.aers.psu.edu/crops/highbush_blueberry/highbush_blueberry.pdf

Highbush Blueberry Council
www.ushbc.org/

The History of the Lowbush Blueberry Industry in Nova Scotia, 1880–1950
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www.nsac.ns.ca/wildblue/hist/kinsman5090/index.htm

Jammin' with Kentucky Blueberries
http://fp1.ca.uky.edu/robinsonstation/jammin.htm

K-Ag Laboratories International
2323 Jackson St.
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www.kaglab.com

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Maine Organic Farmers and Gardeners Association (MOFGA)
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Unity, ME 04988
207-568-4142
207-568-4141 FAX
mofga@mofga.org
www.mofga.org/

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Michigan State University Extension Blueberry Site
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Oregon State University
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By Paul Evans
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Chapter 9: Blueberries

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North Carolina State University
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University of California, Davis
http://fruitsandnuts.ucdavis.edu/

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University of Maine
www.wildblueberries.maine.edu/default.htm

University of Maryland Cooperative Extension Home and Garden Information Center
www.hgic.umd.edu/diagn/flow/jap_beetle.html

USDA Crop Profiles: Pest Management
http://pestdata.ncsu.edu/cropprofiles/cplist.cfm?org=crop

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http://edis.ifas.ufl.edu/WG016

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www.wildblueberries.com

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www.wildblueberries.maine.edu/TableofContents.htm

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www.nsac.ns.ca/wildblue/

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The electronic version of **Blueberries: Organic Production** is located at:
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