Virginia Cooperative Extension

PUBLICATION 438-103

# Specialty Crop Profile: Blueberries

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## Introduction

Blueberries are long-lived, woody perennial shrubs that produce an annual crop of one-quarter- to three-quarter-inch diameter berries (Figure 1). They are members of the Ericaceae family that includes plants adapted to acid soil such as azaleas and rhododendrons. Blueberries are naturally found in well-drained, but nutritionally poor organic sands. In some areas of the country (southern New Jersey, southwest Michigan, and the Carolina coastal plains) where these soils are prevalent, important commercial production exists. Blueberries can be successfully grown in mineral (clay, loam mix) soils, but can be a special challenge for growers out of the natural adaptation zones. Careful site and cultivar selection, site preparation, and proper cultural practices are critical to ensure success.

As are most small-fruit crops, blueberries are labor and management intensive. They also require a significant initial investment and careful production and market planning. Blueberries are a long-term crop that may be in the field for more than twenty years. Blueberries require several years to establish and the initial harvest does not begin until the third or fourth season. Full production is achieved by years six to eight. On a small scale, such as one to two acres, various field tasks can be done with hand-held equipment. As acreage increases, mechanization is recommended for fertilizer application and mulching and spraying operations. Appropriate fertility, irrigation, and weed, insect, and disease control are critical. Developing a sound knowledge of the crop, its biology, pests, and problems is essential for success.

Figure 1. Blueberries are sweet and nutritious. (Photo courtesy USDA ARS Image Library, *http://www.ars.usda.gov/is/graphics/photos/k5182-18.htm*)

## Market Potential

As a small-fruit crop, blueberries are a good fit for the diversified small farm and direct marketing operation as well as for wholesale markets. Interest in this nutritious and versatile berry is on the increase as consumers discover its flavor and uses as a fresh fruit or in baked goods. The berries are high in antioxidants and vitamins. They also have a long postharvest shelf life as compared to other small fruit and freeze well for future use. Additional value-added commercial uses include jams, jellies, and specialty wines.

Blueberries represent significant per acre income returns for the grower who pays attention to cultural details, is patient, and has access to a ready market. Mature plantings may yield up to 6,000 pounds per acre (or more), assuming good growing conditions and management. With the right marketing and sales strategies, gross returns can exceed $5,000 per acre, and net, $3,000 per acre or more. Marketing considerations and sample crop enterprise budgets are presented in the Blueberry Production Guide, NRAES Publication # 55, which is available through local Extension offices.

www.ext.vt.edu

Produced by Communications and Marketing, College of Agriculture and Life Sciences, Virginia Polytechnic Institute and State University, 2009

The primary market for small-scale blueberry producers is consumers from surrounding communities. Fruit is direct marketed, usually sold as a prepicked product on the farm or to restaurants and independent grocery stores. Most commonly, blueberries are sold in Pick-Your-Own (PYO) operations. PYO fruit usually is sold at 15 percent to 25 percent less than prepicked fruit. Fruit sold by weight (usually pounds, ounces) must be weighed with state inspected scales (Virginia Department of Agriculture and Consumer Services). Sales by volume (i.e. pints, quarts) do not have an oversight requirement.

The successful PYO marketer must be a savvy entrepreneur who plans ahead, orders supplies, trains workers, handles harvest logistics such as customer parking and flow, is people oriented, and develops a successful advertising program. The grower must have a feel for the potential PYO trade area, who the competitors are, and what the best advertising media/approach is. In general, it requires about 450 customers to harvest one acre (approximately 6,000 pounds) of blueberries. For a PYO, adequate insurance coverage is also necessary, because normal farm insurance plans may not be sufficient.

Wholesale markets also exist, and these usually have specific packing and shipping requirements. Growers need sufficient volume for sales contracts to produce brokers. Limited wholesale marketing can also be found with local restaurants, grocery stores, and to neighboring roadside markets and "tailgate" operators.

## Plant Species and Cultivar Selection

There are three types of commercially important blueberries that represent several species: (lowbush, *Vaccinium angustifolium*; highbush, *V. corymbosum*; and rabbiteye, *V. ashei*). The diversity of Virginia's climate offers suitable production areas for rabbiteye and highbush types (northern and southern), For the mountain regions of hardiness zones 6b to 5b (see the Hardiness Zone Map, Figure 2), northern highbush is the blueberry of choice as most cultivars (cultivated varieties) can tolerate low winter temperatures (-15°F). The southern highbush types are more adapted to the lower and mid-elevation Piedmont and coastal regions (zones 7a to 8a). Because they are hybrids of northern highbush and rabbiteye types, they are more soil adaptable and heat tolerant and thus, are faster growing and quicker to produce than northern highbush blueberries. However, their winter hardiness is generally not as good as the northern highbush; therefore, their potential use in the western mountain regions of the state is restricted. Exposure to cool temperatures or "chilling hours," is needed to satisfy plant dormancy. This is measured as the number of hours during the winter months that the plant is exposed to a specific temperature range (35° to 45°F). Southern highbush cultivars have a lower chilling requirement (200 to 600 hours), than northern highbush cultivars (600 to 1,000 hours) and have a tendency to break bud during false spring conditions in late winter, resulting in flower damage. Rabbiteye blueberries are the most adaptable of all the types and will tolerate a range of soil and warm climatic conditions. Due to their sensitivity to low winter temperatures, they are best suited for regions in hardiness zones 7a to 8a, which are found in the central to lower Piedmont to the Coastal Plain regions and the Eastern Shore. Temperatures below 0° to -10°F can damage rabbiteye canes and flower buds.

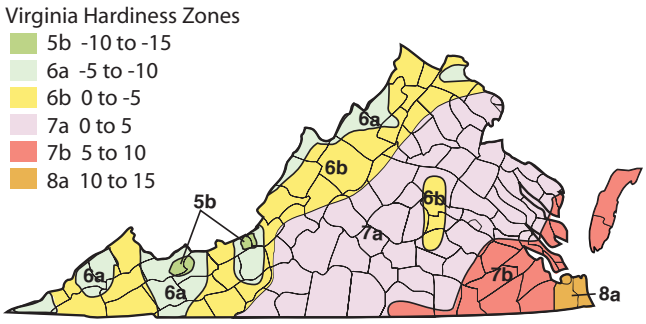

Figure 2. Virginia hardiness zone map.

Southern highbush performance is not well documented in the state, and growers should proceed on a trial-only basis. However, by all indications, southern highbush may be the blueberry of choice for many Virginia Piedmont microclimates. Southern highbush should not be confused with rabbiteye blueberries. Generally, southern highbush is intermediate between northern highbush and rabbiteye in soil and climate adaptation.

Cultivar selection and locating a reputable nursery source are important preplant tasks that should begin during the preparation year. Time spent adequately researching the characteristics of cultivars will pay off in the future. Plant growth and fruiting habits, fruit size, maturity period, flavor, and disease resistance are important characteristics to assess. Cultivar adaptation to specific sites can be variable. Good examples of proven, widely adapted highbush types planted in blueberry producing areas in the U.S. and around the world include: 'Bluecrop,' 'Blueray,' 'Jersey,' and 'Duke.'

Many newer southern highbush cultivars have been released and will require evaluation across the state before recommendations can be made. However, 'O'Neal' and 'Cape Fear' have been grown at the Southern Piedmont Agricultural Research and Extension Center at Blackstone since 1988 and observations suggest that these are suitable for this region. There also have been many rabbiteye cultivars released recently from the University of North Carolina breeding program and statewide adaptability will need to be assessed. Three rabbiteye cultivars ('Premier,' 'Tifblue,' and 'Powderblue') have also been grown successfully at the Blackstone location, proving to be suitable for commercial production.

Information about cultivars is available from a number of sources, and the local Extension agent may have information about local grower or home-garden experiences. Other growers and nurserymen may offer insight. A list of recommended cultivars is presented in Table 1.

## Plant Sources

Blueberry plants are sold either bare-root or containerized, most commonly as two-year-old plants. There are many retail and wholesale sources. For commercial production, growers are encouraged to source plants through nurseries that specialize in small-fruit plants. Depending on the planting date, orders should be booked in advance, as many nurseries have limited supplies and may sell out of specific cultivars quickly. Many growers opt for more expensive containerized plants, which offer increased survival and earlier production due to their intact and undisturbed root systems. However, bare-root stock if managed correctly also has high survival rates. The following nurseries are known to offer quality plants, have an active cultivar evaluation program, and/or specialize in blueberries:

**Table 1. Blueberry cultivar recommendations for Virginia.**

| Cultivar | Type[1] | Area[2] | Season | Comments |
|---|---|---|---|---|
| Duke | NHB | M, NP | Early | |
| Collins | NHB | M, NP | | |
| Patriot | NHB | M, NP | Early | |
| Blueray | NHB | M, NP | Mid | |
| Bluecrop | NHB | M, NP | Mid | |
| Chandler | NHB | All | Mid-late | |
| Darrow | NHB | All | Late-mid | |
| Jersey | NHB | M, NP | Late | |
| Elliot | NHB | M, NP | V.late | |
| O'Neal | SHB | N/SP, CP | Early | |
| Reville | SHB | N/SP, CP | Early | |
| Cape Fear | SHB | N/SP, CP | Early | |
| Pamlico | SHB | N/SP, CP | Early-mid | needs a pollinator |
| Sampson | SHB | N/SP, CP | Early-mid | |
| Duplin | SHB | N/SP, CP | Early-mid | |
| Blueridge | SHB | N/SP, CP | Mid | |
| Lenoir | SHB | N/SP, CP | Mid-late | needs a pollinator |
| Legacy | SHB x NHB | All | Late | |
| Premier | RE | SP, CP | Early | |
| Montgomery | RE | SP, CP | Early-mid | |
| Columbus | RE | SP, CP | Early-mid | needs a pollinator |
| Tifblue | RE | SP, CP | Mid | |
| Yadkin | RE | SP, CP | Mid | |
| Onslow | RE | SP, CP | Mid-late | |
| Powderblue | RE | SP, CP | Late | |

[1]NHB – Northern highbush, SHB – Southern highbush, RE – Rabbiteye

[2]M – Mountain, CP – Coastal Plain, SP – Southern Piedmont, NP – Northern Piedmont

**Nourse Farms, Inc.**
41 River Road
South Deerfield, MA 01373
Phone (413) 665-2658
*http://www.noursefarms.com/* : NHB

**Indiana Berry and Plant Co.**
5218 W. 500 S.
Huntington, IN 47542
Phone (800) 295-2226
*http://www.inberry.com/* : NHB, RE

**Finch Blueberry Nursery**
P.O. Box 669
Bailey, NC 27808
Phone (252) 235-4664
*http://www.danfinch.com/berrys.htm* : NHB, SHB, RE

**Fall Creek Farm & Nursery**
39318 Jasper-Lowell Rd.
Lowell, OR 97452
Phone (541) 937-2973
*http://www.fallcreeknursery.com/* : NHB, SHB, RE

## Site Selection and Preplant Preparations

The best planting sites include gentle slopes that provide good cold-air and surface-water drainage. Though blueberry flowers tolerate mild frosts, late spring frosts have the potential to damage blossoms. Sloped locations provide several degrees of frost protection as compared to lower areas, allowing cold air to flow away from the planting as it settles to low areas. Cold-air pockets can occur, especially where timber restricts air movement, and should be avoided when selecting a site. Early-flowering cultivars should not be planted in questionable sites.

Surface-water drainage is also important, and slopes allow excess rainwater to move away from the planting, not stand in the field. This is particularly important when internal drainage is slow due to heavy soil types (high clay percentage) and structure. Most farms do not have sufficient variation to allow a choice of soil type for a potential site, but where possible, significant clay content areas should be avoided. Ideal soils will range from silt loam to sandy in texture. A sandy soil with low native fertility and at least 2 percent to 3 percent organic matter is preferred. As a species, blueberries are intolerant of waterlogged soils, and internal drainage is critical regardless of soil type. Heavy soils with good internal drainage can be used, but sites where water stands for extended periods after rainfall should be avoided. Questionable drainage will be improved by planting on raised beds or by installing drainage tiles. Prior to planting, a cover crop, such as rye, vetch, or buckwheat can be planted to help build soil tilth and improve soil structure, as well as add well-composted organic matter to enhance drainage.

Of equal importance to soil type is the soil pH. As noted, blueberries require acidic soils, with an ideal range of 4.5 to 5.2 pH. Agricultural sulfur can be used to lower soil pH. The amount applied depends on the existing (native) pH level determined by a soil test, and the soil type (Table 2). Depending on the starting pH of the soil and its buffering capacity (resistance to change), this process usually takes time. In many cases, it is not economically feasible to drop pH in heavy soils with a naturally high pH. In this case, the cost of sulfur may be high enough to defray profits from the blueberries, especially considered over the life of the planting. In general, soils with a starting pH of 6.0 or less and without a limestone base, can be amended successfully. Sulfur application should be done at least a year ahead of planting, and requires thorough incorporation into the soil profile. Amounts greater than 400 pounds per acre should be split between a fall and a spring application. A second soil test should be done before planting to determine if the target pH was reached. Additional sulfur can be applied just before plants are set. Soils, depending on native pH and buffering capacity, will return to their original pH status over time. Thus soil pH should be monitored for the life of the planting. Maintaining pH in the proper range after planting is accomplished by judicious use of acidifying nitrogen fertilizers and timely topdressings of sulfur.

**Table 2. Approximate amount of sulfur (lbs/acre) to lower soil pH to 4.5***

| Current pH | Soil type | | |
|---|---|---|---|
| | Sand | Loam | Clay |
| 5.0 | 175 | 530 | 800 |
| 5.5 | 350 | 1,050 | 1,600 |
| 6.0 | 530 | 1,540 | 2,310 |
| 6.5 | 660 | 2,020 | 3,030 |

*taken from Highbush Blueberry Production Guide, NRAES

Based on a soil test, preplant phosphorus (P) and potassium (K) can be broadcast and incorporated as soil pH

amendments are made. Supplemental P and K should be added to bring soil fertility to "moderate" levels as indicated in most soil-testing formats. Even under optimal soil fertility conditions, a minimum starter application of 50 to 75 pounds P per acre (as $P_2O_5$) and 75 to 125 pounds K per acre (as $K_2O$) should be applied, with the higher end of this range for light soil types. A low preplant application of nitrogen (N) also should be incorporated with P and K (20 to 30 pounds per acre).

Additional preplant activities include site weed assessment and management. The field should be surveyed for perennial weeds that will become more problematic in the future. It is more economical and easier to eradicate weeds using nonselective herbicides prior to planting. In general, approved postplant herbicides for blueberries have poor activity on established perennial weeds. Planting the field with a grain crop such as corn, wheat, or soybeans will help to reduce future soil insect and weed problems. Restrict the use of herbicides with carryover potential, such as atrazine (used on corn), and consult replant restrictions on the label. If cover crops are planted, they should be plowed down at least three to four weeks prior to planting to allow for decomposition.

Two final considerations for site selection include water availability and customer access. Ideal sites are near a water source for irrigation or have the capacity to be developed for irrigation (drilling a well or digging a pond). Additionally, easy access for pick-your-own (PYO) customers is important. The PYO site also should provide ample parking near the field and have appropriate signage to direct customers during their harvest/purchase experience.

## Field Layout and Final Preparation

Following cultivation of the site, row locations should be marked and if needed, raised beds formed. Raised beds are usually eight to 12 inches high and four to five feet wide. Beds can be formed with a moldboard plow alternating in direction, or by using a bed shaping attachment (Figure 3). Ideally, rows should be oriented north and south for maximum light interception. In poorly drained sites, the perpendicular arrangement of beds across slopes may result in water pooling, so rows should be aligned with the slope. Seeding the drive rows with a permanent grass will help reduce erosion with this orientation. Row spacing of 10 to 14 feet on-center should be made to accommodate equipment and

Figure 3. Building of raised bed for blueberry planting using disc-hiller attachment. (Photo by A. Bratsch)

allow for mature plant size. Rows should not exceed 200 feet in length without a drive row or crosswalk for PYO customer convenience.

Increasing organic matter (OM) levels has been shown to have a positive impact on plant growth, especially when soils have less than 3 percent OM. Organic matter improves soil structure, holds moisture, and increases the availability of nutrients. Preplant additions should be made either as a directed application over the row and incorporated or in the planting hole as plants are set. Sphagnum peat moss, composted leaves, and well-decayed sawdust or bark mulch are good choices. Peat used directly in the planting hole or in a band under the planting row should be well wetted, or it may cause early moisture stress in the root zone.

### Pollination Notes

Most northern and southern highbush cultivars are self-fertile and will set fruit in monoculture plantings; however, cross-pollination has been shown to produce larger fruit, higher yields, and earlier ripening. Similarly maturing cultivars should be planted together in alternating blocks of two to four rows each for the best cross-pollination. Blocking cultivars by maturity period also keeps the harvest progressing in an orderly fashion and for PYO operations, makes directing customers an easier task.

Rabbiteye cultivars are partially to completely self-sterile and plantings consisting of at least two cultivars of the same season is essential for good fruit set. 'Premier,' 'Yadkin,' and 'Onslow' are a few that are self-fertile, an objective in current breeding programs. Like highbush types, fruit size and yield increase from cross-pollination.

Though wild bees such as bumblebees pollinate blueberries effectively (Figure 4), honeybee hives brought in during the pollination period improve cross-pollination. One to two hives per acre should be used, and set within 100 yards of the field. Hives can be rented for $40.00 to $75.00 each. The local Extension agent may have a list of beekeepers in the area who might be interested in leasing their hives. Hives should remain in place during the duration of the pollination period. The use of insecticides on the crop should be avoided at this time to prevent bee kill.

Figure 4. Bumblebee working new blueberry flower.
(Photo by H. Stiles)

## Planting

Planting bare-root stock should be scheduled for the early spring (February to March) as soon as soils are workable. Containerized plants can also be set in the fall (September to November) in all but the coldest elevation regions. Fall planting has the advantage of allowing good root development through the winter and earlier spring growth. Spring plantings often are delayed by wet conditions and tend to have smaller root systems by the end of the first growing season.

### Spacing

Highbush types should be set four to five feet apart in the row. Highbush cultivars can vary considerably in mature size, and less compact plants should have a wider spacing. Allow slightly more room for southern highbush and rabbiteye with six-foot in-row spacing. With a twelve-foot between-row spacing this would require 907 plants at five feet, or 605 plants at six feet on a per acre basis.

Plants should be set in holes at least twice the diameter of the root ball at the same depth as they were growing in the nursery. Holes can be dug by hand, with an auger, or a furrow can be made down the center of the row. As previously noted, moist peat can be mixed with the soil and used for backfill, using about one pound per plant. A peat band can also be used below the plants, but avoid planting into pure organic matter or peat.

During the planting operation, keep roots of bare-root plants moist. Containerized plants should be well watered prior to setting them out. For both bare-root and container-grown plants, irrigation soon after field setting is critical to success.

Row middles should be seeded with a permanent grass as soon as the planting operation is completed. This facilitates equipment access, decreases weed invasion into the planting, and helps to slow erosion. For most locations, turf-type fescues, perennial rye, or orchard grass are good choices.

## Mulching

Various studies show that mulching, even under irrigated conditions, results in larger plants and two to four times greater yields over time as compared to non-mulched plants (Figure 5). The primary benefits of mulching are better soil moisture retention and uniformity and better weed control. Mulched soils remain cooler during the summer and warmer during the winter and have reduced effects of frost heaving. By moderating early spring temperature fluctuations, mulching results in delayed spring growth (and crop maturity) as compared to no mulching. Mulching is not a replacement for irrigation, which is often necessary during low-precipitation periods. Mulching should be used with discretion on poorly drained, consistently wet or heavy soils common to some mountain regions. In areas where voles and other rodents are a problem, mulch applications should have less thickness and be applied more frequently. Steps should be taken to monitor and control the rodent population through trapping or chemical baiting.

Figure 5. Well-mulched blueberry planting using hardwood sawdust.
(Photo by A. Bratsch)

Almost any organic material will function as suitable mulch. Well-composted sawdust is the material of choice for many and is sometimes mixed with hardwood chips to decrease crusting. Pine or other softwoods have the advantage of a lower pH than hardwoods (3.5 to 4.5 vs. >5.0). A heavy layer of rotted leaves will also work, and is preferable to wheat straw, which can become weedy. Fabric mats have the advantage of better weed control, but they increase soil temperatures and do not supply needed organic matter. Most mulch is sold in bulk loads, usually fresh and non-decomposed, while decomposed mulch or compost is more expensive and difficult to find.

Following planting, three to six inches of material is mulched in the row centers or just around new plants. Mulch should be re-applied every two to three years, depending on its decomposition rate. A "once-mulched-always-mulched" policy should be used for the life of the planting. Older plantings losing mulch cover will experience root damage more readily than nonmulched plantings due to a more shallow root system and exposure to environmental stresses.

Mulching does add to the expense of growing blueberries, not only for the materials and the time it takes to spread and maintain, but also through increased fertilizer costs. Fresh mulches, such as sawdust, decay at the point of soil contact through microbe activity, which uses nitrogen in the decomposition process. To get enough nitrogen through the decaying mulch and into the soil, nitrogen rates need be increased, often by two to three times to compensate, depending on the state of mulch decay. Application of a well-decomposed mulch or compost will help to lessen nitrogen requirements.

## Irrigation

Supplemental irrigation of blueberries is considered essential in most areas. Blueberries are shallow-rooted plants with the majority of the root system in the top one and a half to two feet of soil (Figure 6). Blueberry rootlets are less efficient than those of other plants because of their limited root hairs (very fine roots) to absorb water and nutrients. Crop water use is significant: four to six gallons per day per plant or one acre-inch per week for a mature planting and two inches when plants have a full crop load. Blueberries thrive under constant, yet moderate soil moisture. While avoiding droughty conditions and fluctuations is important, it is equally important to avoid excess soil water that favors

Figure 6. Exposed blueberry root system. (Photo by J. Pattison)

soil-disease development and root rot. Irrigation needs are related to the use of mulch and its status; as mulch degrades water requirements will increase. Monitoring soil moisture is essential to determine the true moisture status. A tensiometer or other moisture evaluation tool is a minimal investment to ensure an adequate balance is maintained.

Drip irrigation is preferred to overhead irrigation due to increased efficiency and delivery where needed; it also allows concurrent field work activity and reduces the incidence of foliar disease (Figure 7). However, if the site is frost prone, overhead irrigation should be installed to provide frost protection and supplemental moisture. Micro-emitter systems are better than point-source drip systems because they wet a larger surface area, though over-wetting the crown area should be avoided with this system. Companies that sell irrigation equipment usually provide consultation and specific design services for customers using their products. The local Extension agent will be aware of local irrigation suppliers and other technical consulting services in the area.

Figure 7. Permanent drip irrigation system tubing with emitters on blueberry bed surface, (Photo by J. Pattison)

# Fertilization

Several factors affect the need for fertilization: age of the plants, soil pH and nitrogen source, use of and the condition of mulch, and the water applied.

## Age of Plants

Nitrogen (N) application levels are gradually increased each year from planting until a maximum is reached. A general rule of thumb is to apply 20 pounds of N per acre in the first year, and increase 20 pounds per year until 80 to 120 pounds of N per acre is applied annually (the fourth to the sixth years). The final amount is site and growth dependent; however, 80 pounds is considered a minimum rate on most soils. After planting, the first surface application of 10 pounds of N per acre should be made at four weeks. Then two more increments of five pounds each at six-week intervals should be made. For older plantings, the total should be spilt between an early spring application before bud break, and again six to eight weeks later. If growth is slow, an additional split may be helpful, but fertilizer should not be applied after July 1. Materials can be applied on a per-plant basis or banded or broadcast over the row.

## Soil pH and N Source

Nitrogen fertilizer is available in several forms. Blueberries have been shown to primarily utilize the ammonium ($NH_4^+$) rather than the nitrate ($NO_3^-$) form. The latter is absorbed, but not to the extent of ammonium. Using ammonium sulfate (21 percent N) serves two purposes. It is in a form most utilized by the plant, and the sulfate component helps to maintain a low (acidifying) pH. When the pH is 5.0 or below, other types of nitrogen such as urea (46 percent N, also released as ammonium) or a complete fertilizer such as 10-10-10 can be used. Soil pH should be monitored regularly, at least every two years. Elemental sulfur can be surface applied postplanting if significant pH change is needed. Plants exhibiting high pH sensitivity will have interveinal chlorosis (greenish yellow leaves with dark green veins, Figure 8). This is a sign of poor iron uptake, and can be corrected temporarily by a foliar iron spray; however, long-term steps should be taken to lower the soil pH with acidifying nitrogen sources and surface applied sulfur.

Figure 8. Interveinal chlorosis of blueberry leaves due to high soil pH.
(Photo by A. Bratsch)

## Supplemental Phosphorus and Potassium

Every two to three years a soil test should be done to monitor soil pH and potassium (K) levels. Generally, there will not be a response to surface applied phosphorus (P), as this element will be tied-up in the topsoil layers and not leach downward. In lighter soils, P has greater mobility and levels should be monitored. Soil K levels can decrease due to uptake and its moderate mobility in the soil. Supplemental K should be surface applied or injected in the irrigation system when a soil test indicates less than moderate status.

## Use of Mulch

The above nitrogen rates are determined by site conditions and plant growth response under specific conditions. For mature bushes, six to 12 inches of new growth per year is adequate; while generalized leaf yellowing and poor shoot growth is a sign of nitrogen deficiency. New applications of fresh mulch, or materials worked into the soil may lead to an N deficiency, and supplemental N should be added. Older and thinner mulches do not tie-up as much N, and the total annual rates may be decreased by one-third to one-half of the above rates (40 to 60 pounds N per acre), provided growth is maintained.

## Applied Water

Soil moisture influences nutrient release to plants; too little or too much water can reduce availability. Heavy rains and over irrigation lead to the leaching of fertilizers, particularly N and K, while at the same time cause these nutrients to be more available for plant uptake. This can occur when application rates are high or

not split over time. Thus water helps to make nutrients available to the plant, but it also is a factor in leaching loss below the root zone. Drought conditions restrict soil nutrient release, and excess application under dry conditions may cause root damage.

## Pruning

Unlike with many fruit crops such as grapes and peaches, failure to prune blueberries annually does not lead to immediate crop failure. However, mature bushes will respond to proper pruning with much higher yields and larger fruit sizes. Pruning should be done during the dormant season and late winter is preferable.

At planting, bare-root plants generally have one-third to two-thirds of the branches removed to balance top growth with the roots. The remaining one to three strong canes per plant are headed back 50 percent to a strong bud. Containerized plants need only weak and twiggy growth removed, along with moderate heading cuts. Any flower buds (round/plump) should be rubbed or clipped off (Figure 9). Early fruiting is stressful to young plants, and flower buds should be removed during the first two years after planting.

Figure 9. Blueberry flower buds beginning to swell.
(Photo by J. Pattison)

During the second year of establishment, pruning should consist of removing weak, damaged, or diseased wood and flower buds. In the third year, flower buds may be left on the most vigorous shoots. By the fourth season, a light crop may be harvested, but flower buds should be thinned to prevent over-fruiting and bending of the shoots. By the fifth to sixth year and later, annual pruning consists of:

1. Pruning small, twiggy growth at the base of the plant and removing dead or diseased wood.

2. Removing older canes at ground level: one cane of every six canes present should be taken out. This is the most important step in pruning a mature blueberry planting. It will help to stimulate new shoots and keep the bush productive. Old and new canes are easily distinguished by their color (Figure 10).

Figure 10. Canes of mature blueberry bush after pruning, note percentage of new canes (light green-brown) versus older canes (grey).
(Photo by A. Bratsch)

3. Heading back tall new shoots to encourage branch development at a lower level and to help control bush height.

4. Thinning dense growth in the upper part of the canopy by removing crossing and twiggy branches by as much as 50 percent. This is time consuming, but such "detail" pruning can increase fruit size significantly.

An excellent website has video and slide sets that take the grower through the steps of pruning and other blueberry management tasks. The "Fruit Advisory Online Workshops" are available through the Missouri State Mountain Grove Fruit Experiment Station at *http://mtngrv.missouristate.edu/workshops/default.htm*.

Failure to prune will result in a gradual decline in plant vigor and an increase in the number of small fruit. With the above pruning regimen, the canes will be renewed every six years, the age at which individual shoot productivity declines.

# Weed, Insect, and Disease Control

## Weeds

Weeds compete for water, nutrients, and in new plantings, for space and light with young plants. In well-mulched plantings, weed problems will be minimal, but can increase over time as the mulch degrades and weed seeds migrate in. Hand pulling or spot spraying with a contact herbicide such as Gramoxone™ generally is sufficient. Perennial weeds emerging in the row should be dug out by hand or spot treated with a translocated, systemic herbicide such as Roundup™ (avoid crop contact) or Poast™ (grasses only) that will help to eradicate regenerative underground plant parts. Row middles should be kept mowed to reduce grass invasion and seed drop into the mulched strip. A number of pre-emergent herbicides are available for use in blueberries, which can be applied to the mulch surface to prevent weed-seed germination. Label directions should be followed carefully to avoid damage to plants. Cultivation for weed removal should always be shallow to avoid damaging roots.

## Insects and Diseases

Insect and disease problems in blueberries are limited but present in Virginia. Maintaining adequate cultural conditions and healthy plants helps to prevent problems. Growers should be aware of potential pest problems in their area and understand their biology and life cycles to better target control measures. A number of excellent insecticides and fungicides are available for use on blueberries. Each material has specific one-time and seasonal application rates, re-entry and preharvest intervals to consider, as well as very specific target-pest activity.

Important insect problems for blueberries include various fruit-worm species, aphids, mites, and blueberry maggots. Control measures include well-timed cover sprays of selected pesticides at petal fall, ten days later, and again at preharvest. Materials applied will depend on the identified pest problem. An integrated approach to insect pest management, which only targets pests that are present or known to potentially be a problem in the area, as determined by thorough observation and field scouting, is the best approach.

Important disease problems for blueberries include mummy berry, twig blight, and fruit and leaf spots. As with insect control, the presence of these diseases should be confirmed by scouting and observation and an appropriate preventative spray program implemented.

As noted, there are various chemical compounds available for use in blueberries to control weeds and pests. It is beyond the scope of this publication to detail their use. Full recommendations for weed and pest control are provided in *Pest Management Guide, Horticultural and Forest Crops*, Virginia Cooperative Extension publication 456-017, *http://www.ext.vt.edu/pubs/pmg/index.html*. The "Mid-Atlantic Berry Production Guide" is also available for growers in the region and provides additional information on culture, as well as alternative pest-control measures. Both publications are available in print through the local Extension office. An excellent online site for pest-management information in blueberries and other fruit is the The Mid-Atlantic Regional Fruit Loop: The Virginia Fruit Page, which has continually updated information on pesticides as well as many useful production links, *http://www.ento.vt.edu/Fruitfiles/VAFS.html*

## Notes on Organic Production

Blueberries have potential as an organically grown fruit, and often can be grown with limited insecticide and fungicide inputs provided cultural control methods are also employed. A number of newer, organic spray materials are available. Manure and other organic fertilizers can be substituted for chemical fertilizers. A good online reference for organic production is found at the Applied Technology Transfer for Rural Areas (ATTRA), National Sustainable Agriculture Information Service website, Blueberries: Organic Production, *http://www.attra.org/attra-pub/blueberry.html*.

For growers interested in organic production, acquiring official certification of the operation and farm site is needed before the product can be labeled "organically grown." Early planning is needed to achieve timely certification and to avoid actions (such as herbicide application) that lead to delay. Organic certification is costly and can take several years to achieve. In Virginia, certification is conducted by private parties who follow government guidelines. Information about organic certification can be found at the Virginia Department of Agriculture and Consumer Services, Marketing Services, Certified Organic Growers Web page, *http://www.vdacs.virginia.gov/organic/index.html*, and the USDA Agricultural Marketing Service National Organic Program website, *http://www.ams.*

*usda.gov/nop/indexIE.htm*. The Virginia Association of Biological Farmers (VABF) is an organization that assists growers in this process, represents organic growers and their issues, and provides educational programs for members. The VABF can be contacted online at *http://www.vabf.org/*.

## Predator Control

Bird predation is the biggest pest problem faced by blueberry growers. Without protection, losses can exceed 75 percent of the crop in smaller plantings. Scare devices and exclusion by netting are the most common means to reduce these losses. Usually, one-inch mesh netting is draped over the rows or supported on a framework enclosure. This will eliminate most of the damage, though birds such as ground traversing robins often come through the open bottom. Newer scare devices that emit bird distress calls have provided some degree of protection. Loud propane canons and stationary scare balloons lose their effectiveness over time.

Deer may be a problem on some isolated plantings, though this damage is usually confined to winter twig browsing and not fruit feeding. Fencing and/or trained dogs are effective deterrents. As noted, voles and other rodents may invade mulched areas and cause significant chewing damage to roots and plant bark. Control measures should be taken when their activity is evident.

## Harvesting and Handling

Well-managed, mature highbush plants can yield up to 10 pounds per plant or more. Depending on cultivar, weather, and to some extent the level of detailed pruning done, the harvest can spread over several weeks (Figure 11). Fruit will hold well on the plant through varying degrees of maturity. The best quality is reached if picking is conducted every five to seven days, after the first ripe fruit develop. Southern highbush, like their rabbiteye parents, maximize flavor if seven to eight days are allowed between pickings.

Figure 11. Variable fruit ripening in blueberry fruit cluster.
(Photo by J. Pattison)

Berries should be picked into small buckets or shallow trays, and should not be placed more than four to five inches deep in a container (Figure 12). Though considerably firmer than other small fruit, over-ripe and soft berries can detract from the pack when they are crushed. The light waxy covering on blueberries should not be removed or washed, as this will decrease storage life.

Figure 12. Blueberries marketed in one-quart containers.
(Photo courtesy USDA Online Photography Center, *http://www.usda.gov/oc/photo/98cs0421.htm*)

Blueberries keep well, and pre-picked fruit can store up to two weeks under cold storage conditions of 33° to 35°F and 85 percent humidity. In an open market setting at 70°F expect two to three days of shelf life.

## Summary

Blueberries are a specialty small-fruit crop that can be grown successfully in most areas of Virginia. Cultivar choice, site selection, and preparation are important to meet specific cultural requirements. Blueberries have the greatest potential for direct marketing in roadside stands and Pick-Your-Own operations, as well as for selected wholesale markets. Consumer interest in this crop is on the rise due to increased awareness of its nutritional qualities, and the future for increased markets looks promising.

# Additional References

## In Print

Galletta, G.J. and Himelrick, D.G. (eds). 1990. *Small Fruit Crop Management*. Prentice Hall. Englewood Cliffs, N.J. (602 pages; 12 small fruit crops profiled). ISBN 0-13-814609-8

Funt, R.C., Ellis, M.A., and Welty, C. 1997. *Midwest Small Fruit Pest Management Handbook*. The Ohio State University, Bulletin 861. 173 pages. (Pritts, M.P., J.F. Hancock, and B. Strik (eds). 1992.)

*Highbush Blueberry Production Guide*. NRAES 55. Northeast Regional Agricultural Engineering Service. Ithaca, N.Y. 200 pages. (This publication can be ordered through local Extension offices.)

*The Mid-Atlantic Berry Guide for Commercial Growers*. 2006. Penn State University College of Agricultural Sciences. (This publication can be ordered through local Extension offices.)

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Pavlis, Gary C. (weekly newsletter; about four to six pages per issue). *The Blueberry Bulletin*. For subscription information, contact: Dr. Gary C. Pavlis, County Agricultural Agent, Rutgers Cooperative Extension of Atlantic County, 6260 Old Harding Highway, Mays Landing, NJ 08330. Phone: (609) 625-0056

## Online

Applied Technology Transfer for Rural Areas (ATTRA), the National Sustainable Agriculture Information Service (sustainable production), *http://www.attra.org/*

Cornell Fruit Resources, Berries, *http://www.fruit.cornell.edu/berry.html*

North Carolina Specialty Crops Program, *http://www.cals.ncsu.edu/specialty_crops/*

Northwest Berry & Grape Information Network, *http://berrygrape.oregonstate.edu/*

The Southern Region Small Fruits Consortium, *http://www.smallfruits.org/*

University of Kentucky College of Agriculture, New Crop Opportunity Center, *http://www.uky.edu/Ag/NewCrops/welcome.html*

The Virginia Fruit Web Site: Small Fruit, *http://www.ento.vt.edu/Fruitfiles/VirginiaSmallFruitSite.html*

# Acknowledgements

Special thanks to reviewers Jerry Williams, associate professor, Department of Horticulture, Virginia Tech; Cynthia Marston, Extension district program leader, Northwest District; and Jon Vest, Extension agent, Roanoke County.



*Reviewed by Allen Straw, Extension specialist, Southwest Agricultural Research and Extension Center*