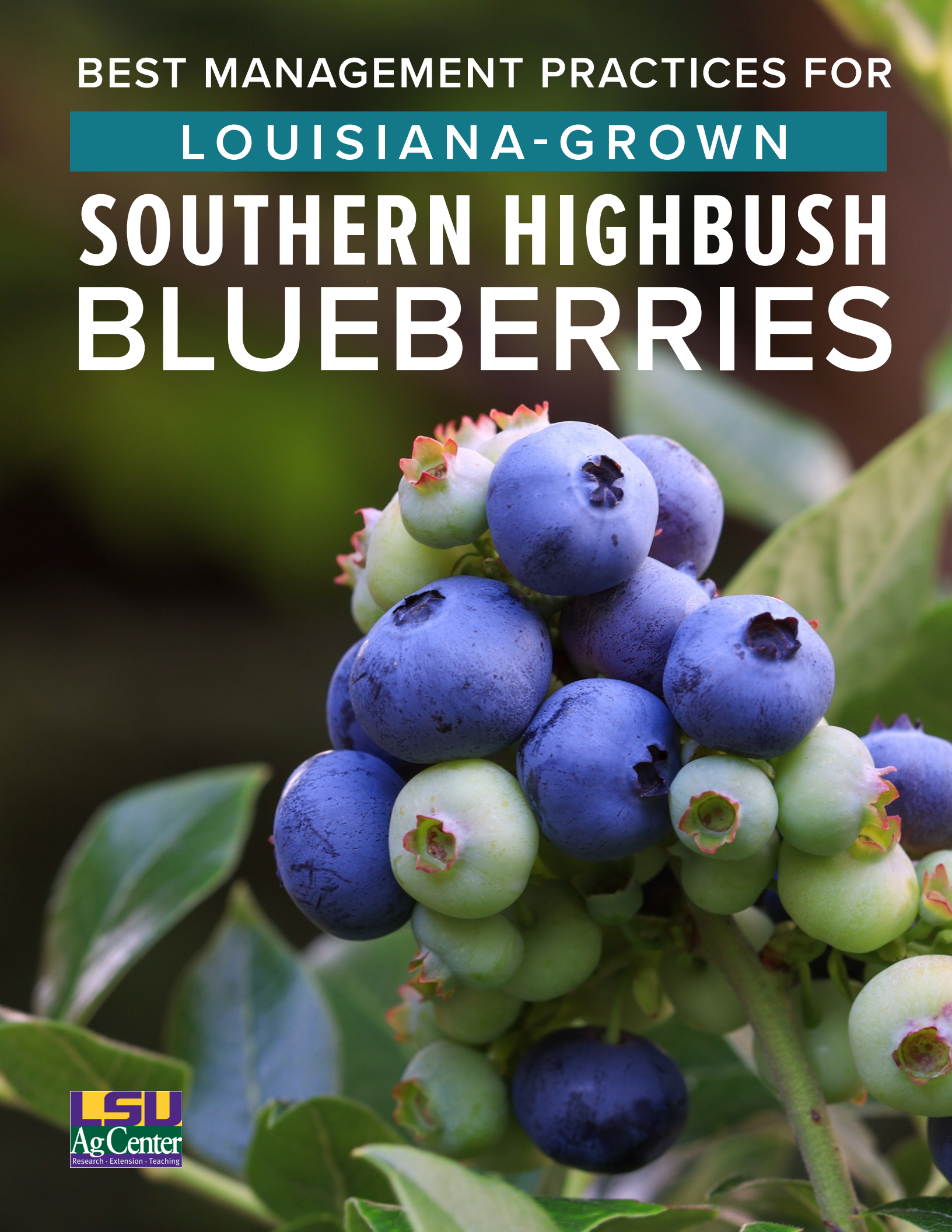
BEST MANAGEMENT PRACTICES FOR LOUISIANA-GROWN SOUTHERN HIGHBUSH BLUEBERRIES



LSU AgCenter
Research · Extension · Teaching

ABOUT BLUEBERRIES

What are blueberries?

Blueberry shrubs are members of the *Vaccinium* genus. The shrubs bear small delicate bell-shaped pink and white flowers from spring through summer that turn into tiny dark blue fruit that also emerge spring through summer. The harvest time is very species and cultivar dependent. The plants are native to North America ranging from the tip of Florida, west through Texas, and northward along the east coast. The simple fact that these shrubs are native should not convince any commercial producer to think that this plant will grow well in every condition throughout the state. Blueberry plants require acidic, well-drained soil. Like many temperate fruits, blueberry plants also require a certain degree of chill hours in the winter to break flower dormancy. These specificities will be discussed in this manual. Traditionally, Louisiana growers have produced Rabbiteye blueberries. Today, many types of blueberries exist. This publication will specifically focus on the production of Southern Highbush blueberries.

Blueberry shrubs bear small fruits that emerge spring through summer.

What's the difference between Rabbiteye and Southern Highbush blueberries?

Rabbiteye blueberries (*Vaccinium ashei*) are considered resistant to many diseases and are typically harvested in the late Spring through Summer season (May to July).

Southern Highbush blueberries (*Vaccinium corymbosum* interspecific hybrid) are crosses of Northern Highbush cultivars (*Vaccinium corymbosum*) with native blueberry plants found in Florida and the southeastern United States. They were specifically bred for a reduced need for chilling requirements. Based on recent Louisiana extension demonstrations, Table 1 compares the major differences between Rabbiteye and Southern Highbush blueberries growing in Louisiana.

Table 1. Notable differences in LSU AgCenter Extension demonstration plantings of Rabbiteye and Southern Highbush blueberries.

Rabbiteye Blueberries	Southern Highbush Blueberries
More disease tolerant*	Less disease tolerant*
Once established, plants will continue to produce fruit in a range of soils with a high preference towards acidic soils. Fruit production and vegetative growth will slow in neutral soils.	Plants need acidic soils to maintain fruit production and shrub vigor throughout their life span.
Plants are typically harvested May through July.	Plants can be harvested as early as March and typically finish bearing in June.
Plants can grow directly in the field or in containers.	Plants are typically but not always produced in containers. If grown directly in the field, the grower is advised to heavily amend the soil with organic matter.
The foliage naturally defoliates in the fall and winter. Before complete defoliation, the delicate, blue-green foliage typically turns red and orange in the late fall and bears white, umbrella-shaped flowers in the spring.	Plants maintain foliage longer into the fall. If a mild winter persists, the foliage will often turn deep red and purple and will fall off as the new growth emerges in the spring. Thus, some years these plants will have foliage year-round. Foliage is sparser in the fall and winter months. Plants also bear white, umbrella-shaped flowers in the late winter and early spring through mid-summer depending on the cultivar.
Named Rabbiteye because of the appearance of the fruit. The fruit displays a pink color prior to ripening into its characteristic blue, resembling the eye color of an albino rabbit.	Fruit ripens from a hard green color into a soft blue powder color and finally into a dark blue softer stage.

*Disease resistance notation is based on a study occurring in 2018-2023 where container-grown Rabbiteye and Southern Highbush blueberry plantings were grown in Baton Rouge, Louisiana. More Southern Highbush plants were lost to disease, specifically phytophthora, than Rabbiteye plants.

If the winter is mild, the foliage on some varieties of blueberries will turn purple.

Why grow blueberries?

Blueberries are easy to grow and one of the most nutritionally dense foods on Earth. They are a significant source of vitamins and secondary metabolites that are widely studied for pharmaceutical interests. Blueberry fruit is one of the richest sources of ascorbic acid and is an excellent source of antioxidants. Blueberries contain natural compounds called anthocyanins, procyanidins, chlorogenic acid and flavonoid compounds. Anthocyanin is the main antioxidant found in blueberries. All of these natural compounds can provide us with cancer-fighting power, help with cataracts and macular degeneration, have anti-diabetic properties, and have been shown to decrease both blood pressure and cholesterol, thereby reducing the incidence of atherosclerosis and cardiovascular disease risk. These benefits of course have the most effect if they are consumed on a regular basis.

United States production

According to the U.S. Department of Agriculture, blueberries rank as the United States' second-most produced berry, trailing only strawberries. Over the last decade, the availability of fresh blueberries for American consumers has surged, increasing fivefold and growing faster than that of strawberries. This rise is attributed to both heightened U.S. production and increased imports, fueled by year-round consumer demand. Initially, New Jersey, Georgia and Michigan led in fresh-market blueberry production in 2010, but by 2019, Georgia, California and Oregon became the top producers, each contributing around 17% to U.S. output. The U.S. blueberry production season has notably extended, beginning as early as March in Florida, and extending into October in states like Washington, Michigan and Oregon, thanks to newer cultivars and favorable growing conditions. Despite this domestic growth, there remains a lower supply from fall to early spring, encouraging increased production during these months both domestically and overseas (Kramer, 2020).

Louisiana farms

According to the 2022 Louisiana Summary: Agriculture and Natural Resources, Louisiana reported 103 blueberry producers with 430 harvested acres at a gross farm value of $9.1 million which is a small share of what is grown nationwide. Blueberry cultivation primarily takes place in the northern part of the state with Caddo, DeSoto and Morehouse parishes leading production.

Unlike many fruit crops that require hand harvesting, blueberries offer the flexibility of being harvested either by hand or through mechanical means. In Louisiana, the preference leans towards hand harvesting, although mechanically harvested blueberries are often directed to processing for the creation of value-added products. Like strawberries, blueberries can be field packed, cooled and shipped. Larger operations might harvest into big containers and employ assembly lines for sorting based on marketability. Most of Louisiana's farms sell direct market and are open to the public as you-pick operations.

Find a farm

If you are interested in visiting one of our local operations, simply use an internet browser search and type "pick your own" or visit www.pickyourown.org to find you-pick operations. Louisiana MarketMaker at la.foodmarketmaker.com is also a nice website to find local farms. Using MarketMaker you will also need to refine your search by filtering the data to blueberries. The Louisiana Department of Agriculture and Forestry also has a web-based listing of local farms. Simply visit www.louisianagrown.com/where-to-buy then click on "Fruit and Veggie Producers. No matter where you choose to purchase your berries, Louisiana's blueberries are known for their sweet and delectable taste.

Most of Louisiana's blueberry farms allow the public to pick their own berries.

Where can I find current budgeting information and wholesale prices?

The Agricultural Marketing Resource Center is a division of the USDA. The goal of this division is to provide U.S. producers with information related to marketing, value-added producer grants, economic tools and information related to all crops. Louisiana blueberries are mostly marketed to the direct end user at farmers markets, through community supported agriculture subscriptions, at you-pick operations and at roadside stands. The retail price varies throughout the state and time of season. Price is also very dependent on the weather, yields of the local crop, as well as U.S. and foreign supplies. Today's consumers demand year-round blueberry availability. Therefore, our local growers compete on a global level even in parts of rural and urban Louisiana. Knowing the most current wholesale prices can help you (in collaboration with your input costs) determine the price you should be using at the market of your choice.

- **For budget tools, to locate other blueberry farms and to gather information regarding producer grants** visit www.agmrc.org/commodities-products/fruits/blueberries
- **For the current prices of blueberries,** visit the USDA Agriculture Marketing Service at https://www.marketnews.usda.gov/mnp/fv-report-top-filters?locName=&commAbr=BLUBY&commName=BLUEBERRIES&className=FRUITS&rowDisplayMax=25&startIndex=1&navClass=FRUITS&navType=byComm&repType=termPriceDaily&type=termPrice

GROWING REQUIREMENTS

Ideal planting location

A producer must consider many factors in order to produce optimum yields of fresh blueberries.

Sunlight

Like most blueberries, Southern Highbush blueberries require full sun (direct sunlight for at least half of the day) for maximum berry production. While the plants do grow well in shade, fruit production will be reduced. As an example, a demonstration planting of blueberries was conducted at the Hill Farm Teaching Facility on LSU's main campus in Baton Rouge, Louisiana. The shrubs were planted in containers in three rows. Rows were oriented east to west. The plants located to the westernmost side of the rows were also closer to a five-story hotel and tree line. Those plants received less morning sun as compared to the rest of the rows and always had less fruit production than the other shrubs, simply by receiving less sunlight for a portion of the day.

Southern Highbush blueberries require full sun for maximum berry production.

Soil requirements – ground and container

Southern Highbush blueberries prefer acidic soils ranging in pH levels from 4.5-5.5. They also prefer soils with high organic matter which is why many Louisiana commercial producers use container production. Typically, Southern Highbush shrubs are grown in containers either filled with 100% pine bark fines or a soilless media containing mostly pine bark fines mixed with peat moss. Other soil amendments are used and will be discussed in the fertilizer section.

In the LSU AgCenter Extension demonstration plantings, Southern Highbush blueberries were directly transplanted from 38 count cell plug trays into 45-gallon containers. However, we believe a 20-25-gallon sized container will be adequate for commercial production. One benefit of the larger container size used in our plantings was the weight of the container. The LSU AgCenter container plantings never blew over in storms, but the roots did not reach the bottom of the pots in the six years they were studied.

If growing Southern Highbush blueberries directly in the field, the soil pH should naturally be between 4.5 and 5.5. If it is not in this range, we would not recommend growing Southern Highbush blueberry plants directly in the soil. While Rabbiteye blueberries can grow in higher pH soil, the plants will not produce as much fruit as if the soil were in the ideal pH range. Rabbiteye blueberry plants must be grown in acidic soils in the first few years of their lifespan and can become more tolerant of soils with a pH ranging upwards of 6.0, whereas Southern Highbush plants will not perform under these conditions. The native soil should also be loose with excellent drainage for Southern Highbush plants to thrive in the ground. If the soil is more compact, consider amending the soil with pine bark in a band at least 12-14 inches wide and deep.

Container production is not a guaranteed fix to poor drainage. Containers must be in a location such that they do not stand in waterlogged conditions for more than a few hours. Containers that are standing in even a few inches of water for several days can have reduced drainage. These waterlogged conditions will eventually cause root rot, decay and death. Container production in standing water is also susceptible to soil borne pathogens transferring into the drainage holes of the containers. The disease can then infiltrate the substrates and infect plants.

In the LSU AgCenter demonstration plantings, all containers rested on top of concrete pavers to ensure the containers were out of the water when 5- to 6-inch rain events occurred. In the third year of this demonstration planting, we lost an entire variety of Southern Highbush blueberries to phytophthora even though they were growing in clean media in containers because the containers sat in waterlogged conditions for several days.

Fertilization requirements

Fertilization of blueberries should be based on soil and foliar tests. Soil testing can be performed at any time, but foliar testing is best done within two weeks after harvest. Tissues collected should be mature leaves from the middle of the current season's growth. Blueberries grown in containers may be more prone to burning due to overfertilization

Placing blueberry containers on top of pavers can help improve drainage and ensure that the containers do not become waterlogged from sitting in standing water.

but are also easier to flush out excessive amounts. Overfertilization should also be avoided as it can push vegetative growth at the expense of fruiting.

In both in-ground and container systems, nitrate forms of nitrogen should be avoided. Blueberries do not process nitrates efficiently and large concentrations of them can lead to leaf burning. Ammonium forms of nitrogen should be used instead. One of the most common fertilizers to use with blueberries is ammonium sulfate as it also acidifies the growing conditions. Micronutrients should be added to the substrate before container production to ensure availability to the plant. Iron deficiency is common in blueberries grown in the upper range of their pH preference as their utilization of soil iron decreases significantly above a pH of 5.2.

Both field and container growing systems benefit from multiple split applications of fertilizer throughout the spring

and summer. Container production in particular benefits more from this strategy as it ensures uniform nutrient availability. Containers are more prone to nutrient loss in their substate due and leaching out of the system. Timing multiple, smaller fertilizer applications throughout the season reduces this nutrient loss.

Need foliage testing?

The LSU AgCenter Soils Testing and Plant Analysis Lab is capable of testing blueberry foliage for nutrient levels.

Blueberries in containers benefit from the installation of irrigation such as these spray stakes.

Irrigation

Ideally blueberries should receive 1 to 2 inches of water per week. Irrigation water can come from a number of sources such as rainfall, municipal water or well water. Open sources of water such as ponds, streams and rain barrel collection must be monitored for human pathogens as this fruit is often consumed raw. Rainfall is ideal for maintenance. But steady rainfall doesn't always occur. Installing trickle or drip irrigation near the base of the plant is best to reduce disease and water loss to evaporation. In the LSU AgCenter study, the containers were each fitted with two spray stakes aimed at the soil for irrigation. Water was pumped through a 1-inch poly tub header line that was attached to the side of pots with zip ties. Microtubing then took the water from the header line into each container. Containers were watered two to five minutes per day when rain did not occur.

CROP MANAGEMENT

Pruning

Regular and proper pruning is critical for both container and in-ground production systems. Pruning for container blueberry plantings is critical to ensure that the plants do not overgrow their environment, maintain harvestability and that there is not a reduction in production potential. If plants are allowed to get too large in container systems, they will struggle to have adequate water and be more likely to have crowding that reduces yields. In-ground planting will have similar crowding issues and reduction of yield but will be less likely to have water stress. Proper cane renewal and pruning for size will ensure consistent and easily harvestable yields.

There are many methods that can be used to prune Southern Highbush blueberries. Here are some suggestions.

Years 1-2

Little pruning occurs to blueberries in their first year or two. Many but not all growers will prune the first year to remove flower buds, allowing the plants to focus on vegetative and root growth prior to producing a crop. Any pruning conducted in the first year or two is to shape the plants into a more uniform row.

For growers wanting to produce many acres and machine harvest their crop, consider training plants to have a narrow base or less canes per plant to better allow machine harvesting to occur. A narrow base allows the machine harvester to catch more fruit than wide based plants. Strategies for reducing the base of the canopy can be found in the University of Florida, Institute of Food and Agricultural Sciences guide Pruning Southern Highbush Blueberry in Florida Pub #HS1359.

Pictured below is a commercial planting of Southern Highbush blueberries in Mississippi where cartons were used to restrict lower canopy growth. Having a narrower canopy will reduce the number of berries that drop to the ground when machine harvesting.

If your intention is to operate a you-pick operation or hand pick farm, a narrow base to the plant is not necessary.

Placing cartons at the base can restrict lower canopy growth to assist with machine harvesting.

Year 3 and beyond

Immediately after harvest ends in mid to late-June (variety dependent), growers should hedge the tops of the plants. Plant height should be reduced to 3.5 to 4.0 feet tall for field-grown plantings. This height is recommended if this practice is kept up annually. Use sharp blades. Blades can be tractor mounted for large operations. Gas powered handheld hedgers can be used for smaller operations. Make sure the blades are sharpened and cleaned between seasons to slow the spread of disease. Best management strategies would also recommend that growers remove all pruned materials from the field as soon as possible to reduce disease spread.

Hedging also occurs after harvest ends for container grown plants. The amount to remove depends on how vigorously the plant grew that year. Typically, we would recommend removing between 4 to 12 inches of growth.

Years 4-5 and beyond: Cane removal

Pruning blueberries is a lot like pruning any edible shrub. The main trunks or stems of a blueberry plant are referred to as canes, just like raspberry and blackberry plants. Thus, these fruits are often all referred to as “caneberries.” After four to five years of growth, a good management practice is to reduce the number of total canes by 10% to 20%. Removing canes has several benefits.

1. Removing old canes opens air flow in the shrub, reducing the chance of disease.
2. Cane removal provides more sunlight evenly distributed throughout the plant thus increasing fruit yield. Many growers have a challenging time removing enough canes or wood because they fear they will reduce overall yields. However, not pruning for many years will result in decreased fruit production.
3. In container culture, a top-heavy plant will easily blow over. Reduce labor costs by keeping container grown plants shorter and with less canes to allow air to pass through the plant rather than push it over in storms. Each time plants tip over, media and fertilizer that was top-dressed into the container spill out and cost you money and growth.

Cane removal typically occurs when the Southern Highbush blueberry shrubs slow in growth from November to December or cane removal can occur immediately after harvest ends.
Remove canes all the way back to the base of the plant that:

- Are the oldest or dead.
- Rub against another cane. Crossed canes will rub in wind and storms as cause opening for disease.
- Are lower, thin weak growth that hangs over containers or isn’t in an upright fashion in the field.

Rejuvenation pruning

Different pruning strategies are required if you have purchased an older orchard that hasn’t been pruned in many years to decades. Blueberry plants can become quite tall if left unmanaged. The fruit of unpruned plants will mostly occur at the top of the plant where it is extremely hard to harvest by machine or hand and is typically only enjoyed by birds.

If you have a blueberry orchard where the plants are 10 feet or taller, you may consider using a chain saw to completely cut the plant back to 2 to 3 feet tall. This strategy may remove every single green leaf but is very necessary. The shrub will send out new sprouts and can be trained into a more manageable shrub from that point. Rejuvenation pruning is best done in the spring. Remember you will not make any fruit the year that you pruned this drastically.

The blueberry shrubs in the foreground were pruned to a height of 3-4 feet, whereas the ones in the background are at a height that is not manageable.

Container versus in-ground planting tips

Both Rabbiteye and Southern Highbush blueberries can be grown in the ground and in containers.

Rabbiteye blueberry plants have been named a Louisiana Super Plant because of their reliability as an excellent performer in gardens and landscapes and their ability to grow well in containers. Rabbiteye blueberries, because of their disease tolerance, make a fantastic addition to edible landscapes and can be used as foundation shrub plantings. Additionally, they can be grown as a hedge or landscape feature. They tend to do best as younger plants if you maintain a low pH soil. As they age, they can tolerate a wider range of pH soils than Southern Highbush types.

Southern Highbush blueberries can grow directly in the ground if the ground is heavily amended with organic materials. Many southern states have found growing these less disease tolerant types of blueberries easier in container culture. Southern Highbush blueberries need to always be grown in low pH soils for optimum production and plant quality. If your soil is not naturally low in pH, we recommend considering only container production for Southern Highbush blueberries.

Containers must be a minimum of 15 to 20 gallons in volume for optimum production throughout the lifespan of the plants. Shrubs may be planted in smaller containers but will need to be transplanted into larger containers as they mature. We suggest purchasing plug plants, 1-quart plants or 1-gallon plants and bumping them straight into a 20-gallon container.

Ideal soil and amendments for container plantings

Blueberries can be grown in a wide range of soil types and substrates. Plantings in well-drained sandy loam soils tend to perform better than those in heavier clay. One advantage to Rabbiteye blueberries is that they have a much wider adaptability to more varied soil compositions and drought conditions than Southern Highbush.

Two soil factors that contribute to a successful field blueberry planting are soil pH and organic matter content. The ideal soil pH for blueberries is about 4.5. They can tolerate a wider pH range of 3.8 to 5.8 with adequate organic matter content. Before investing in in-ground planting, check your native soil type and pH range to ensure that it will be viable. Temporary changes can be induced though soil amendments and more long-term buffering can be accomplished through increasing the soil organic matter. Inducing and maintaining acidic growing conditions in soils that have a naturally high pH may not be practical or economically sustainable. A common and effective way to increase organic matter composition and percentage in in-ground plantings is through regular mulching.

Soil pH and organic matter content are easily modifiable in container production. Most substrates for containers are organic based so container production seldom needs any organic matter additions except to mediate substate loss due to microbial breakdown. Substrate pH should be monitored regularly as they do not have the pH buffering capacity that soils do. Microbial breakdown of the substrate and nutrient uptake by root systems contribute to acidification. Irrigation water sources can influence substrate pH long term. Most rainfall tends to be slightly acidic but municipal and well water can vary depending on location. Those with more alkaline water sources will need to mediate with sulfur or acidifying fertilizers. Electrical conductivity/ salinity of leachate water from containers should be maintained below 2.0 dS/m to prevent root damage.

Weed management strategies

Weed control in container blueberry production should initially be minimal considering the soilless mixes used for potting should be weed-free. However, many opportunities and ideal growing conditions await any seed that lands in the container. Pots can be top-dressed with coarse pine bark to suppress weed development. Once blueberry plants become established and begin to shade the container, weed pressure in the container should subside.

Out in the field, good weed control is a critical part of the establishment process. For the first couple of years after planting, blueberries compete poorly with weeds for water, nutrients, and sunlight. The process of reducing weed competition should begin six months to a year before planting using cultivation and herbicides. At the time of planting the site should be weed-free. A 4-foot strip of bare ground should be maintained for the life of the blueberry planting. Between the rows a permanent sod can be established. Centipede and carpetgrass are better suited to row middles than an aggressive growing Bermudagrass or bahiagrass.

Synthetic mulches like plastic and woven fabrics can aid in weed control but can reduce water and nutrient availability. These products will also not add to soil organic matter levels. Maintaining a 2-to-3-inch blanket of acid-forming mulch from sources like pine bark, pine straw and oak leaves will help to control weeds while acidifying the soil.

Pre- and postemergent herbicides can be used to control weeds. Preemergent herbicides work by forming

a protective barrier to weed emergence. However, if the growing medium is not bare soil the activity of the preemergent product will be poor. Organic mulches and heavy leaf litter partner poorly with preemergent products resulting in poor product performance. Postemergent herbicides work on actively growing weeds. Glufosinate ammonium is currently the most used post emerge product. This product should be applied with a shielded sprayer to prevent the herbicide from getting on the plants. The latest herbicide recommendations can be found in the Southeast Regional Blueberry Integrated Management Guide at www.smallfruits.org/ipm-production-guides and the LSU AgCenter Louisiana Suggested Chemical Weed Control Guide at www.lsuagcenter.com/portals/communications/publications/management_guides.

Southern Highbush blueberry diseases and their management

This section discusses major economical important diseases of Southern Highbush blueberries in Louisiana. The information is derived from the LSU AgCenter 2023 Plant Disease Management Guide (www.lsuagcenter.com/portals/communications/publications/management_guides/plant_disease_guide) and the 2024 Southeast Regional Blueberry Integrated Management Guide (www.smallfruits.org/ipm-production-guides)

Diseases

A blueberry twig exhibiting irregular necrosis of leaf tip and margins caused by Xylella fastidiosa. Photo by Raghuwinder Singh

Bacterial leaf scorch is caused by a xylem-inhabiting bacterium *Xylella fastidiosa*. Symptoms appear as brown, marginal necrosis along the edges of leaves. Affected leaves eventually drop off the plant, and young twigs and stems may turn yellow before plants die. Fruit production may decline over time in diseased blueberry plants. Infected plants may become more sensitive to environmental stresses such as heat, drought and wind. The bacterium inhabits and multiplies in the xylem channels resulting in interruption of water and nutrient flow. The pathogen is spread primarily by sharpshooter leafhoppers and other xylem-feeding insects such as spittlebugs. It is also known to be transmitted through propagation. Once a plant is infected, there is no cure. The use of cultural practices that reduce environmental stresses, particularly water stress, may help prolong the life of infected plants. Management of bacterial leaf scorch relies on the removal of declining plants and replanting with resistant varieties of Southern Highbush blueberries species. No chemicals are available for disease management. **Abiotic stresses including nutrient toxicity, and drought stress may produce similar symptoms to those caused by bacterial leaf scorch.** See the Southeast Regional Blueberry Integrated Management Guide at www.smallfruits.org/ipm-production-guides for insecticide recommendations for leafhoppers.

A blueberry twig exhibiting uniform marginal necrosis of leaves caused by accumulation of high sodium in the leaves. Photo by Raghuwinder Singh

Exobasidium leaf and fruit spot is a fungal disease caused by *Exobasidium maculosum*. Initial symptoms appear as irregular to circular whitish spots on the underside of leaves, with pale green spots on the upper sides. As the disease develops, spots turn brown. Severely infected leaves defoliate prematurely. Symptoms on berries include small, circular spots that remain green or pink resulting in uneven ripening and misshaped fruits. Galls usually do not form in blueberries. The pathogen overwinters on the surface of the plant and/or in bud scales or bark and infects the plant in the spring when leaves are young. Management of the disease includes planting in areas with good air movement and use of drip irrigation to keep humidity low. Additionally, an application of lime sulfur (calcium polysulfide) has been found to be very effective when applied two weeks before bud break.

Fruit rots in Highbush blueberries are caused by a variety of foliar fungal pathogens including *Alternaria* and *Colletotrichum* species. The pathogens colonize ripened berries and may cause significant fruit rot during storage. In case of Anthracnose fruit rot, berries shrivel on the bush. Fungal spores and mycelium develop on infected fruits if not properly stored at cooler temperatures. The fungi causing fruit rots survive from year to year on or in infected twigs, fruit pedicles, bud scales and for *Alternaria*, fallen debris. Fruit rots are best managed when ripened berries are harvested and kept cool immediately after harvest to minimize postharvest disease development. See the Southeast Regional Blueberry Integrated Management Guide at www.smallfruits.org/ipm-production-guides for a fungicide spray schedule, at the interval(s) directed on label(s), if needed.

A blueberry plant exhibiting girdling of infected twigs resulting in death of leaves, flowers, and fruit caused by Botrytis cinerea. Photo by Raghuwinder Singh

Gray mold is caused by *Botrytis cinerea*. The fungus attacks all above ground plant parts including tender young twigs, leaves, flowers, and fruit. Infected twigs initially appear brown to black and turn tan or gray as the disease develops. The pathogen girdles and kills twigs resulting in death of leaves, flowers, and fruit. Infected berries shrivel and decay after harvest and fungal spores are produced on berries. The fungus overwinters as dormant mycelium in or on the plant debris or sclerotia. Spores are wind dispersed. Highbush blueberry cultivars Elliot and Bluecrop are relatively resistant to gray mold. Rapid drying of plant canopy and improved air circulation help reduce disease incidence. Additionally, pruning out dead twigs and removing leaf debris from ground aid in reducing initial inoculum. Postharvest fruit rot can be reduced by cooling down harvested berries immediately. Follow a fungicide spray schedule, if needed, and visit www.smallfruits.org/ipm-production-guides for more information.

A blueberry leaf exhibiting leaf spots caused by Alternaria species. Photo by Raghuwinder Singh

Leaf spots in Highbush blueberries are caused by several fungal species *(Alternaria, Gloeosporium*, and *Septoria* species). Alternaria leaf spots occur on lower leaves during extended cool wet weather. Spots are small, irregular to circular in shape and appear brown to gray with a red border. Gloeosporium leaf spots appear as small reddish flecks. Septoria causes small, circular, light-colored lesions with a purple border on leaves, and sunken lesions on stems. The fungi survive from year to year in infected leaf debris and stems. Spores are windborne. Leaf spots are effectively managed by implementing cultural practices that promote healthy plant growth and use of fungicides. Follow a fungicide spray schedule, if needed and visit www.smallfruits.org/ipm-production-guides for more information.

Mummy berry disease is caused by a fungal pathogen called *Monilinia vaccinii-corymbosi*. The pathogen attacks and kills emerging leaf shoots, twigs, flowers, and fruit. The leaves on blighted leaf shoot produce a mass of ash-gray spores alongside the midrib as the disease develops. Infected fruit turn cream to pink as they begin to mature and then shrivel and harden into "mummies." Diseased fruits contain a hard fungal fruiting body (pseudothecium) whereas, a white fungal tissue can be seen inside infected asymptomatic green berries. The fungus overwinters in the mummified fruit and serves as a primary source of infection. The primary spores are wind-dispersed and infect new emerging leaf shoots. Pollinating insects transfer secondary fungal spores produced on blighted shoots to flowers resulting in infection of developing fruit. Management of mummy berry disease starts with planting disease-free dormant plants. Growers are recommended to rake and remove/bury (1-inch depth) mummified fruit from production areas. Mulching blueberry bushes up to 3-4 inches helps in avoiding mummified berries from producing initial source of infection in spring. Southern Highbush cultivars Legacy, O'Neal, and Star are considered resistance to mummy berry disease. Fungicide sprays applied at leaf emerging and blooming stages are effective in managing this disease. fungicide spray schedule should be followed. For fungicide spray schedule, selection and timing, visit www.smallfruits.org/ipm-production-guides.

Phytophthora root rot is caused by a fungal-like microorganism called *Phytophthora cinnamomi*. Early disease symptoms include yellowing of leaves and stunted plant growth. The pathogen causes brown discoloration of roots and crown. Diseased blueberry plants exhibit root rot resulting in wilting, defoliation, and death of the plants as the disease develops. The disease is more severe in low lying, poorly drained sections of the field. The pathogen survives as chlamydospores (resting spores) in the soil. Disease development is favored by saturated and compacted soil conditions. Phytophthora root rot is effectively managed by integrating cultural and chemical practices. Growers are recommended to plant disease-free plants in well-drained soil or raised beds. For fungicide selection and application timing, For fungicide spray schedule, selection and timing, visit www.smallfruits.org/ipm-production-guides. If plants are severely infected, chemicals are not likely to result in a return to healthy plant growth.

Stem blight of Southern Highbush blueberries is primarily caused by *Botryosphaeria* species. Symptoms of stem blight caused by *Botryosphaeria* species appear on new growth leading to browning or reddening of leaves (flagging) followed by wilting and death of the plant as

A blueberry plant showing twig dieback caused by Botryosphaeria species. Photo by Raghuwinder Singh

the pathogen spreads to the base of the plant through vascular system . The pathogen primarily enters the host tissue through wounds/injuries including freeze cracks. The fungus survives in dead diseased stems and has a wide host range including several woody ornamentals and trees that may serve as a source of primary infection. Fungal spores spread from diseased to healthy plants by irrigation water or wind-splashed rain. Management of stem blight includes planting disease-free healthy plants, avoiding mechanical injury to stems, removing diseased canes/shoots, and following a proper fertilizer program. Fungicides are not likely to be very effective for management of *Botryosphaeria*.

Table 2. Suggested seasonal fungicide spray schedule for blueberry*.

Season	Pesticide Application Timing	Disease
Early spring	At planting or, for established plants, while dormant, plus additional spray while conditions favorable for disease development prevail	Phytophthora root rot
Early spring	At bud swell	Exobasidium leaf and fruit spot
Prebloom	Green tip or, for mummy berry, when 1%-5% of blooms are open (whichever occurs first); repeat as directed on label	Mummy berry Exobasidium leaf and fruit spot
Bloom	10%-20% bloom through full bloom (2-3 applications, at interval specified on label)	Mummy berry Botrytis blight Fruit rots Exobasidium leaf and fruit spot
Petal fall and cover sprays	Immediately following bloom, followed by applications at 7- to 14-day intervals or as directed on label	Fruit Rots Exobasidium leaf and fruit spot
Summer	Preharvest and harvest	Fruit rots
Summer and fall	Postharvest	Leaf spots

*This table was originally produced in the 2023 Plant Disease Management Guide.

Integrated blueberry disease management

Successful management of blueberry diseases requires an integrated approach. Choosing appropriate varieties, a well-suited planting site and good soil preparation are all important for preventing blueberry disease problems. Well-drained soil is especially important for preventing Phytophthora root rot, one of the most significant blueberry diseases. For protection from both frost and disease problems, it also may be beneficial to choose a site from which air can easily drain (not low sites).

- **Select varieties appropriate for your region.** For variety recommendations as well as information on how to choose a suitable site and prepare the soil before planting, see LSU AgCenter publication 2363, Commercial Blueberry Production, and publication 1978, Home Blueberry Production in Louisiana.
- **Start clean and stay clean**. Use plants that have been propagated from clean (disease-free) planting material and check plants for disease symptoms before planting.
- **Use good cultural practices.** Pruning is recommended to remove dead, damaged or diseased limbs so that sunlight and pesticides can penetrate the plant canopy. Pruning recommendations are provided in the LSU AgCenter publication 2363, Commercial Blueberry Production. Applying 1 inch of mulch under plants each year may help minimize the effects of mummy berry disease. Avoid using equipment that has been in orchards infected with mummy berry.
- **Use of fungicides**. Prior to using chemicals, have the disease confirmed by a crop specialist You can visit the LSU AgCenter's Plant Diagnostic Center at www.lsuagcenter.com/plantdiagnostics for help. Once the disease has been confirmed, select a labeled product that has been shown to be effective in reducing disease, and apply the product at the correct stage of plant development. Chemicals with proven efficacy against a pathogen will not reduce disease if applied at the wrong time. Always rotate between products with different modes of action to prevent the development of fungicide resistance in the pathogen. If a pathogen becomes resistant to a product, the product will no longer be effective.

Insect management strategies

Integrated pest management, where chemical and nonchemical practices are employed is the most economical and environmentally sustainable option for controlling insects in blueberries. The inclusion of good cultural practices into a pest management strategy ensures that chemical applications will be more effective and may reduce the number of pesticide applications needed in a production season.

Proper pruning practices in blueberries should encourage airflow and sunlight through the canopy. One added benefit of this openness is the increased efficacy of chemical sprays and reduction of dense vegetation that can be a habitat for insect pests. Reduction of and management of weeds on the orchard floor also reduces potential habitats for problem pests. Additionally, it is prudent to consider the habits of beneficial and pollinator insects when timing or considering applications. If possible, it is best to avoid applications when pollinators are active. Chemical applications can still be made during pollination windows but should be timed outside of bee activity or use modes of action that are not harmful to them.

Scouting should be an integral part of an insect management plan. Traps or threshold counts should be employed to determine if chemical controls are needed. Historical orchard data is useful in determining/timing spray schedules too as it may take several years to reduce the population of certain insect pests.

There are multiple insect pests that can be of concern in commercial blueberry production but three that are likely to be need some forms of control are spotted-wing drosophila (*Drosophila suzukii*), blueberry maggot (*Rhagoletis mendax*) and fire ants (*Solenopsis Invicta*). Fire ants can be a major concern for you-pick operations as they can be a hazard to customers. Not all fire ant control chemicals are labeled for crop use so make sure to use a formulation that is. The key issues with spotted-wing drosophila and blueberry maggots are the reduction of postharvest quality and consumer appeal. Both pests can manifest as small maggots in the final product which is unsatisfactory to retail consumers. There is an overlap in chemical control methods of the two. Consult your local extension staff and up to date specialized integrated pest management guides to employ the most effective control strategies for these and other insects.

Pollinator insects are needed for adequate blueberry production.

Cold protection measures

When selecting blueberries you need to consider how many chill hours your farming area typically receives. Chill hours are easily defined as hours below 45 F that occur after the plant has gone dormant. In Southern Highbush culture this idea is still largely not understood., as the plants can remain vegetative year-round depending on how cold the winter gets. Some Southern Highbush varieties have zero chill hours and others range as high as needing 400-500 chill hours.

If you select a shrub that requires fewer chill hours than you typically receive, the flowers and fruit will begin to form early and will be in danger of frost and freezing events. Therefore, you must select varieties that match your typical chill hour range. Even doing so, freeze events can occur early and late in the year. Growers must be ready to deploy some sort of mechanism to protect those early blooms if you want your yield to be as high as possible.

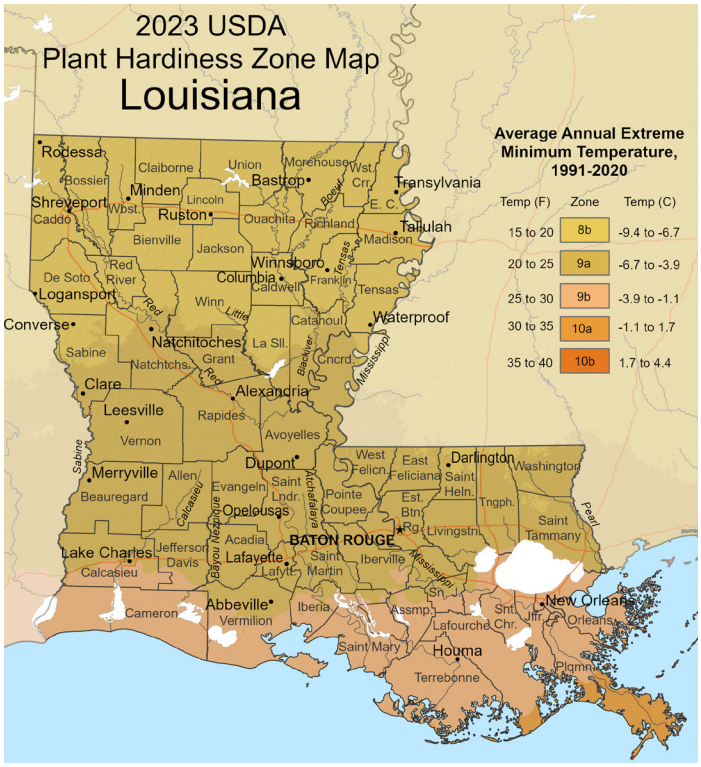
Southern Highbush blueberry plants can be hardy to the mid-teens.

The blooms are hardy depending on the stage they are in and other weather conditions such as wind speed, humidity levels, and dew point. The temperatures provided below are a reference point please note other environmental factors weigh in heavily to these ranges.

- Closed bud stage flowers are hardy to 21-23 F.
- Open bud stage flowers are hardy to 29 F.
- Fruits are hardy to 30 F but expect reduced quality for the fresh market. Fruit exposed to 30 F will be more of a processed fruit quality berry.

Protection measures for blooms and fruit when temperatures are too low

- Water the soil in the containers or in the field at the base of the plants. Wet soil helps conduct heat upwards from lower warmer portions of the soil as compared to dry soil.
- Consider installing an overhead irrigation system for frost protection. Consult an irrigation firm when doing so.
- On smaller plantings cover with frost protection cloth. The cloth must come in contact with the ground, not just cover the foliage.



The USDA Plant Hardiness Zone Map is the standard by which gardeners and growers can determine which perennial plants are most likely to thrive at a location. View an interactive map online at https://planthardiness.ars.usda.gov/

Use frost protection cloth to prevent damage to flowers and fruit in freezing temperatures

High tunnel production thoughts

The thoughts below are solely based on our experience growing Southern Highbush blueberries under the high tunnel conditions in Baton Rouge, Louisiana, in 2023.

- Early fruit production is heavily cultivar dependent. Our earliest yielding blueberry in outdoor conditions was Snowchaser. However, we lost so many Snowchaser shrubs to disease that we did not have enough to place into the high tunnel. However, some of our no-chill-required cultivars did produce earlier in the high tunnel as compared to when they were in the field.
- High tunnels require a lot of maintenance. Temperature regulation is as important in the summer as it is in the winter. For optimal results remove all plastic covering from the roof, side walls and end walls in the summer months after fruit has completely been harvested to maintain good airflow and lower temperatures.
- Warmer conditions in high tunnels promote weed growth around the shrubs. Install a gravel floor or be willing to mechanically or chemically remove weeds weekly from around the base of containers in the high tunnel.
- Blueberries need insect pollinators for optimal production. You must install bird netting on the sidewalls of the high tunnels so that in the late winter and early spring you can allow insects into the tunnels during the day but not birds. You must remember to close the tunnels at night when temperatures dip.
- High tunnels prevent natural rain from falling into the containers. In areas where the municipal or well water sources are neutral to high in pH, high tunnels are not a viable option unless rain catchment water is used or the grower installs an acid injection system into the water to maintain a low soil pH.
- High tunnels were excellent protection for the berries from birds.
- High tunnels were excellent for maintaining warmth in the winter freezes, but those temperature benefits did not outweigh the tremendous heat they held in the summer months.

1.) Adding bird netting to the sides of high tunnels can help protect blueberries.

2.) High tunnels are excellent for maintaining warmth during freezes but hold tremendous heat during summer months.

3.) Blueberries are well-protected from birds when kept in high tunnels.

4.) In order to control the temperature within a high tunnel, close the sidewalls during freezes and open the sidewalls on warm and hot days to alleviate heat.

1.

2.

3.

4.

VARIETIES & POST HARVEST

Recommended cultivars/varieties

A Southern Highbush blueberry trial was conducted at the LSU AgCenter in Baton Rouge, Louisiana. Ten cultivars were planted in 2018 from 38 count plug trays into 40-gallon containers filled with pine bark mulch and amended with nursery special fertilizer and Ironite fertilizer. The blueberry containers were on automatic irrigation set between three to five minutes a day depending on the season. Irrigation was completely turned off in rainy periods. Fertilizers were applied each spring and again at the end of harvest, typically in June. Containers were drenched once a year starting in 2020 with Ridomil gold because of phytophthora infestation. It is hypothesized that this occurred after a heavy rain period where the containers sat in 2-3 inches of water for four days. We lifted all containers onto concrete blocks to prevent future saturation. The shrubs grew quickly, and harvest took place in 2020 and 2021. The first two harvests were conducted when the shrubs were growing in outdoor conditions. In 2023, nine of the 10 cultivars were moved into a high tunnel that was completely enclosed with side and end walls. The side walls had a bird netted lining and in warmer temperatures side walls were raised to cool the house. The end walls were fitted with doors and both doors were also opened to move air through the house. Harvest data was collected in 2023 in hopes that the extra layer of protection (the enclosed high tunnel) would promote earlier berry production and thus higher yields so we would not lose fruit to cold.

Table 4. Yield data comparing outdoor production and high tunnel production of Southern Highbush blueberries.

Variety	2020 Outdoor Average Weight (g)/Shrub	2021 Outdoor Average Weight (g)/Shrub	2023 High Tunnel Average Weight (g)/Shrub
Arcadia	1,163	1,316	263
Atlas Blue	1,648	435	87
Bianca Blue	474	70	14
Endura	871	866	173
Jewel	1,177	981	196
Jupiter Blue	407	85	17
Kestrel	1,033	685	137
Star	815	882	176
Ventura	748	559	112
Average	**926**	**570**	**131**

Arcadia, Jewel, Endura and Star were some of the top performers in terms of total fruit production in this study.

Table 5. Average berry size comparing outdoor production and high tunnel production of Southern Highbush blueberries.

Variety	2020 Outdoor Average Berry Diameter (mm) Throughout the Entire Season March-June	2021 Outdoor Average Berry Diameter (mm) Throughout the Entire Season March-June	2023 High Tunnel Average Berry Diameter (mm) Throughout the Entire Season March-June
Arcadia	15.3	15.6	13.7
Atlas Blue	15.6	13.8	12.7
Bianca Blue	14.2	12.9	13.1
Endura	14.9	14.8	15.5
Jewel	14.9	13.8	13.5
Jupiter Blue	14.6	13.5	15.1
Kestrel	14.3	14.5	11.8
Star	15.5	15.2	8.9
Ventura	16.5	15.9	9.9
Average	**15.1**	**14.4**	**12.7**

Ventura produced the largest blueberries in the outdoor conditions. However, this single variety was planted closest to a tall building on campus that shaded it more than all other cultivars. We believe this lack of afternoon sunlight is the reason for the lower outdoor fruit production and larger overall berry size when planted outdoors. Star and Ventura were the only berries to lose significant size when grown under high tunnel conditions.

Data indicates production under high tunnels did not provide enough fruit to warrant their usage. Several factors play into the poor production in 2023.

- Heavy pruning occurred in 2022 which may have results in fewer fruit in 2023. The heavy pruning was to reduce disease and cold damaged canes.
- Bee activity was occurring in the high tunnel however, we noticed the bees remained at the west side of the tunnel more so than other locations. The high tunnel location was several miles from our outdoor location but next to a bee facility which should have strengthened our insect activity.
- Increased heat into the late spring early summer and no cloud cover from the 2023 drought stressed plants incredibly. Without natural rainfall (due to drought), we weren't able to catch and use any rainwater for irrigation. The plants were solely relying on 100% municipal water which in Baton Rouge ranges in pH between 8.0 to 8.3. This took a heavy toll on the plants.

The original hypothesis that the Southern Highbush blueberries being able to flower and fruit earlier in the season would benefit from extreme cold protection did not provide the results (obtaining earlier harvest and protection from both cold and birds) that we expected.

Results indicate farmers in south Louisiana will save money and have better yields planting Southern Highbush blueberries outdoors. When planted outside, covering the berries with frost protection cloth when temperatures dipped below 28F (data 2020 and 2021) resulted in better yields than when berries were grown under high tunnels (2023).

Postharvest management and care

Managing good postharvest care is critical to the success of your operation. Follow these key steps to ensure the best product for your customer.

1. Only harvest completely blue blueberries. This fruit does not continue to ripen after harvested.
2. Blueberries should be 1-3 grams in size.
3. Only touch the fruit once. Harvest with care and place directly into container you will sell the fruit in.
4. Remove field heat as soon as possible. Do not leave harvested berries in the field. Place them in a cooler immediately. Ideally store the fruit between 32-34 F.
5. Maintain the temperature of fruit between 32-34 F during transportation from the farm to the final place of sale.

Blueberry Muffin Recipe

Blueberries are delicious to eat fresh or prepared in dishes. Enjoy this muffin recipe modified by Mandy Armentor, an LSU AgCenter Nutrition and Community Health agent.

Ingredients

1/2 cup low-fat milk
1/4 cup canola oil
1 large egg, slightly beaten
1 1/2 cups all-purpose flour
1/2 cup sugar
2 teaspoons baking powder
1/2 teaspoon salt
1 cup fresh or frozen blueberries, rinsed and drained*
*If using frozen blueberries, do not thaw before adding to the batter.

Instructions

1. Wash hands with warm soapy water before any food preparation.
2. Preheat oven to 400 F. While the oven is preheating, spray a muffin tin with nonstick cooking spray or line with baking paper cups and set pan aside.
3. In a mixing bowl, mix milk, oil and slightly beaten egg together.
4. Measure out all the dry ingredients in a separate bowl.
5. Add dry ingredients to the egg, milk and oil mixture and blend until the flour is moistened.
6. Fold in the blueberries and stir until mixed, about 4-5 times.
7. Using a liquid measuring cup, fill the muffin tin about 3/4 full (this is approximately 1/2 cup of batter).
8. Bake for 20-25 minutes or until the muffin springs back if lightly touched or a toothpick inserted in the center comes out clean.

Makes 12 muffins. Recipe adapted from University of Nebraska at Lincoln Extension Service, www.lancaster.unl.edu/food

Because blueberries do not continue to ripen after being picked, they should be harvested when they are fully blue in color and at least 1-3 grams in weight.

Literature cited

D.A. Phillips, J.G. Williamson, P.M. Lyrene and P.R. Munoz. Southern Highbush blueberry cultivars from the University of Florida. Publication #HS1245. https://edis.ifas.ufl.edu/publication/HS1245

David Himelrick. Home Blueberry Production in Louisiana. LSU AgCenter Pub 1978. https://www.lsuagcenter.com/NR/rdonlyres/D30270C0-F2DC-4B33-8AB7-036865AB6AAE/43117/pub1978HomeBlueberryProductionLOWRES.pdf

Doug Phillips and Jeffrey Williamson. Nutrition and Fertilizer Practices for Southern Highbush blueberry in Florida. IFAS University of Florida. Publication #HS1356. https://edis.ifas.ufl.edu/publication/HS1356

Doug Phillips and Jeffrey Williamson. Pruning Southern Highbush Blueberry in Florida Publication #HS1359. https://edis.ifas.ufl.edu/publication/HS1359

E. Stafne, R. Melancon, B. Layton, J. Silva, D.E. Canales Medina. Establishment and Maintenance of Blueberries. Mississippi State Extension. Publication #P1758. http://extension.msstate.edu/publications/publications/establishment-and-maintenance-blueberries

Kramer, Jaclyn. 2020. Fresh Blueberry Supplies Expand as U.S. Consumers Develop a Taste for Year-Round Blueberries. Amber Waves Journal. United States Department of Agriculture, Economic Research Service. https://www.ers.usda.gov/amber-waves/2020/december/fresh-blueberry-supplies-expand-as-us-consumers-develop-a-taste-for-year-round-blueberries/ (Accessed 3-13-24).

Louisiana Summary Agricultural and Natural Resources. 2022 https://www.lsuagcenter.com/articles/page1710451756369 (Accessed, March 14, 2024).

LSU Agriculture Center. 2023 Louisiana Plant Disease Management Guide. LSU AgCenter Pub 1802. https://www.lsuagcenter.com/portals/communications/publications/management_guides/plant_disease_guide

Authors

Kathryn Fontenot, Professor and Southwest Region Director, LSU AgCenter.
Heather Kirk-Ballard; Assistant Professor; School of Plant, Environmental and Soil Sciences, LSU AgCenter.
Stuart Gauthier, Agriculture and Natural Resource Extension Agent, Southwest Region, LSU AgCenter.
Raghuwinder (Raj) Singh, Professor and Director of the Plant Diagnostic Center, LSU AgCenter
Michael Polozola, Assistant Professor, Statewide Fruit Specialist, LSU AgCenter
Mandy Armentor, Nutrition and Community Health Regional Coordinator, Southwest Region, LSU AgCenter
David Picha, Professor and Director of the School of Plant, Environmental and Soil Sciences

Photos

All photos by Kathryn Fontenot unless noted otherwise.

Funding for the project entitled “Intensive protective structure production and fruit quality evaluation of southern highbush blueberries and primocane blackberries and raspberries for development as high-value Louisiana fruit crops” was made possible by the U.S. Department of Agriculture’s (USDA) Agricultural Marketing Service through grant 21SCBPLA1040-00.

Its contents are solely the responsibility of the authors and do not necessarily represent the views of the USDA.

Visit our website: www.LSUAgCenter.com

Pub. 3935 (online) 7/24