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Fertilizing Highbush Blueberries in Pine Bark Beds

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Physical Properties of Pine Bark

Grower experiences have proven milled pine bark to be an excellent growing substrate for southern highbush blueberries. Although milled pine bark shares many characteristics with good blueberry soil, fundamental differences exist and need to be understood for rapid growth of young plants and high blueberry yields.

Why has milled pine bark proven to be a successful substrate (medium) for growing southern highbush blueberries?

Internal pore space makes up 40-45 percent of a pine bark particle and assists in holding both water, fertilizer and maintaining air space in the substrate. Another 40 percent of the pine bark substrate is intraparticle pore space which also holds water, fertilizer and air. Approximately 20 percent of the substrate is solid matter. In one study, fresh pine bark had a water holding capacity of about 13 percent by volume, while aged pine bark held 21 percent water by volume. Many pine bark substrates contain a significant amount of sand from handling operations and this can be beneficial in maintaining long term integrity of the substrate. Water holding capacity is improved and water infiltration rates are reduced by sand in the pine bark, which promotes better wetting of the substrate. Air space equal to 20 to 30 percent of the volume provides adequate aeration and the drainage needed for an extended rainy period.

Pine bark is high in lignin, an organic (carbon) substance which is much more resistant to decay than cellulose. Materials with a high cellulose (carbon) to nitrogen content will be decomposed rapidly by microorganisms once nitrogen is applied. Particle size decreases and nitrogen is tied up by microorganisms breaking down the cellulose. Rapid decay of organic matter in a blueberry substrate can result in shrinkage which decreases aeration of the substrate. Sawdust has a C:N ratio of about 1000:1, while pine bark has a ratio of about 300:1. Both are considered to have a high C:N ratio, but the saw dust is much more susceptible to rapid break down once nitrogen is added. This means that pine sawdust is best used as a blueberry amendment mixed with sandy soil and not as a substrate for high-density blueberry plantings. As the sawdust breaks down, the sandy soil provides aeration. Pine bark also decomposes, but at a slower rate. Typically, a loss of 1 inch per year is seen in pine bark beds in south Georgia.

pH of Pine Bark

Pine bark should have a natural pH between 4.0 and 5.0, ideal for blueberries. Several sources disagree whether the pH goes up or down slightly with decomposition. High pH irrigation water can raise the pH and may require action by the grower. If the pH of pine bark increases above 5.0, use ammonium sulfate as a nitrogen source. Acidification of the irrigation water is another option. Sulfuric acid is normally used for pH control of irrigation water. Many Georgia greenhouse growers and longleaf pine nursery growers are acidifying the irrigation water for their crops. Elemental sulfur can also be used to lower the pH, but apply a modest amount (200 pounds per treated acre) and wait several months to determine the extent of the pH change before applying more, if needed. At the 200 pound per acre rate, sulfur can be applied over the top

on plants in the field. However, do not apply when the leaves are wet. Iron sulfate can also be used to lower the pH of the pine bark and supply iron. On plants already set in the field, use a maximum of ½ pound per cubic yard of pine bark substrate or ½ pound per 54 square feet. This is equivalent to 400 pounds per treated acre if the pine bark is 6 inches deep. If the pH of the pine bark is below 4.0 use urea as a nitrogen source. It is less acid-forming than ammonium sulfate. Liming with dolomitic limestone can be conducted if necessary, but has not been needed since most of the deep well irrigation water in the South Georgia blueberry belt is alkaline (pH above 7).

Pine Bark Problems

Although pine bark has proven to be an excellent substrate for southern highbush blueberries, there are a few odd problems for which growers need to be aware.

1. **Contamination of the bark with lime rock.** This has been a significant problem in Georgia. Lime rock is often used to firm up the mud at saw mills. As pine bark is scooped up, some lime rock becomes mixed with the pine bark, raising the pH into the range where iron chlorosis occurs on blueberries (above 5.3).
2. **High manganese levels.** Several growers have experienced manganese levels in the blueberry plants as high as 2,000 ppm. When very high levels of manganese accumulate in the plant, the leaves may turn red and yellow and defoliate. Pine bark contains some manganese and manganese is more available at low pH. Another source of manganese is premium grade fertilizers and some fungicides. Monitor manganese levels by tissue analysis. Do not apply manganese containing fertilizers and fungicides if manganese levels are excessive.
3. **Weed seeds.** Some pine bark (especially old weed-covered piles) and pine bark which is contaminated with dirt may contain weed seeds. This has been an occasional problem in Georgia.
4. **Fire in pine bark storage piles.** This is can be a problem with finely milled pine bark if piled too high. If temperatures reach over 150 degrees F, turn and moisten the pile. Don't stack piles over 8 feet in height.
5. **Low oxygen composting of pine bark (anaerobic respiration) causing very low pH.** This can occur in pine bark when mold (mycelia) develops in a band 24 to 30 inches below the surface of the pile. This creates a cap that seals off oxygen. Anaerobic respiration can occur producing acetic acid (vinegar), phenolic and alkaloid compounds toxic to plants. The pH may drop as low as 2.0, which causes nutrients (fertilizer salts) to be flushed from the pine bark. These can also be toxic. Check the pH before planting. If low pH is a problem, wet and aerate the pine bark. After three weeks the pH should return to about 4.0.
6. **Mold in the bark thatrepels water.** Pine bark in **dry** piles may develop high fungal populations recognized by clouds of spores when disturbed. Once spread out and irrigated, a mold (mycelia) grows rapidly which repels water. Newly set plants may dry out and die. Frequent irrigation (5-6 times per day) may be needed to keep plant alive. Directing high pressure jets of water from a hose end nozzle may break up the mycelial masses enough to get water to the small plants. A surfactant can also be sprayed on the surface of the bark to assist with wetting. Wet pine bark before storing to avoid this problem.

Pine Bark Particle Size and Cation/Anion Exchange Capacity

Milled pine bark with 70 to 80 percent of the particles by volume within a range of 1/42 to 3/8 inch (0.6 to 9.5 mm) in diameter, with the remaining particles less than 1/42 (0.6 mm) is a good potting substrate. The need for small particles is to provide better water and nutrient holding capacity by creating a large surface area which provides cation exchange capacity. Cation exchange capacity or CEC is a term used to describe the attraction of cations (positively charged ions) in the soil or pine bark to negatively charged sites on soil or pine bark particles. Many nutrients required by plants are positively charged and thus are attracted by these negatively charged sites. Pine bark has a cation exchange capacity in the range of 10-13 milliequivalents per 100 cubic centimeters. As a comparison, course sandy soils have a CEC of 5-15, silts soils 8-30 and clay soils 25-50. Cations in the soil solution such as calcium, magnesium, ammonium nitrogen and potassium will be attracted to the surface of the pine bark substrate and exchanged with other cations. The significance of CEC in practical terms is that it slows the rate of leaching of cations applied as fertilization occurs.

Anion exchange capacity or AEC of pine bark is poor. Pine bark has little ability to hold anions such as

nitrates, phosphates or sulfates. Phosphates are normally retained well in Georgia soils, but in pine bark they leach out rapidly.

Initial Conditioning of the Pine Bark Substrate with Nitrogen

Because of the ability of fresh pine bark to absorb ammonium nitrogen and the fact that most milled pine bark contains some wood which requires nitrogen for microbial degradation, growers should consider applying nitrogen to fresh bark beds before planting. Aged, composted pine bark will need less nitrogen applied than fresh bark. Suggested amounts are ¼ pound per cubic yard for high quality, milled bark to up 1 pound of nitrogen per cubic yard for pine bark containing a significant amount of wood.

If pine bark beds are 6 inches deep, then ¼ pound of nitrogen per cubic yard equals ¼ pound of nitrogen per 54 square feet of bed or 200 pounds per acre if broadcast. Since most high density systems have 75 percent to 85 percent of the land area covered with pine bark, then 150 to 170 pounds of nitrogen should be applied to the beds. The nitrogen used should be ammonium or urea based. If the pine bark has a marginally high pH, above 5.0, use ammonium sulfate. Below 5.0 use urea since it is less acid forming. The nitrogen should be applied at least three months before planting and the beds kept moist. If the nitrogen is applied a month before planting, use 50 pounds per acre. If high rates (600 pounds per acre) of nitrogen are needed to break down the wood in the very woody substrate, apply the nitrogen at least three months in advance of planting and keep moist. Test the substrate for high salt levels before planting (see section on monitoring).

Fertilizer Sources for Blueberries in Pine Bark

Nitrogen: Blueberries generally grow best with the ammonium or slow release form of nitrogen. Urea is rapidly converted to the ammonium form of nitrogen and can be used. Nitrate nitrogen can be used in small amounts, but iron uptake and low pH maintenance is assisted by the use of ammonium nitrogen.

Phosphorus: Many types can be used. Diammonium phosphate is a very good source and available at low pH. Phosphorus leaches out of pine bark, but try to maintain at least 4 ppm of phosphorus in the pine bark solution.

Potassium: Blueberries do not tolerate high levels of chloride, so do not apply high levels of potassium chloride. However, potassium chloride can be used as part of a maintenance fertilizer program. The chloride will leach out with rainfall. Try to maintain at least 50 ppm of potassium in the pine bark solution.

Calcium: If you are using alkaline deep well water for irrigation, use a fertilizer with low calcium content. Calcium fertilizers are rarely needed in blueberry production, but monitor via leaf and substrate samples.

Magnesium: This is a common deficiency in blueberries. Calcium and magnesium should be found in a ratio of not more than 2 to1 in the pine bark solution since they are in competition to enter the plant. High calcium irrigation water combined with rapid leaching of magnesium often causes magnesium deficiency in blueberries. Dry fertilizers should contain a minimum of one and preferably two percent magnesium.

Micronutrients: Dry fertilizers for blueberries should generally contain a micronutrient package. Monitor the micronutrient levels via leaf samples and adjust your fertilizer accordingly. There have been serious problems with excessive manganese levels on some farms (see section above on pine bark problems). Use fertilizers without manganese if levels are too high. Iron chelate and iron sulfate are good sources of iron for blueberries.

Dry Fertilizer Types

Three types of dry fertilizer are used on blueberries in pine bark beds: granular soluble, slow release and controlled release. In addition, liquid fertilizer for fertigation and foliar feeding are used. Each has advantages and disadvantages.

Regular granular fertilizer is inexpensive, but must be applied every two to three weeks for best growth response. If applied too close to the plant in too large an amount, soluble granular fertilizer can cause burning. Materials containing slow release fertilizers are medium in price and reduce the number of fertilizer applications to about four to eight per year in pine bark. There is a reduced chance of causing fertilizer burn to young plants if improperly applied. Controlled release materials are expensive, but reduce the number of fertilizer applications to two or three per year. Combinations of dry fertilizers and liquid can also be used to with great success.

Table 1. Characteristics of dry fertilizer types used in blueberries

Type	Examples	Longevity in Pine Bark	Applications per Season	Approx. Cost	Comments
Granular soluble (regular fertilizer)	8-8-8 10-10-10 (Super Rainbow, FFF, etc.) 12-4-8 (Big Buck, Gold Kist)	Shot (2-4 weeks)	6-8	$.12-.24 lb	Read label; some do not contain micro or secondary nutrients. Monitor nutrient levels by leaf analysis. If manganese or other micronutrient levels are becoming too high, use one without manganese or certain micronutrients.
Slow release or partially slow release	Blends containing ureaformaldehyde (UF) or isobutylidenediurea (IDBU) or sulfur-coated urea (SCU) or organic nitrogen as part nitrogen source Tristate 12-6-6 Growers Fert. 18-6-12 Graco 13-6-6 (blueberry special)	Medium (2-3 months)	4	$.14-.50 lb	Read label; some do not contain micro or secondary nutrients. Monitor nutrient levels by leaf analysis. If manganese or other micronutrient levels are too high, use one without manganese or certain micronutrients.
Controlled release (polymer or resin coating)	Meister 15-5-10 Sierrablen 18-7-10 Osmocote 18-6-12 Plus	Long – varies with type (2-6 months in Georgia)	2-4	$.75-$1.00 lb	Usually contains micro or secondary nutrients but many may not be listed; check with supplier. Monitor nutrient levels by leaf analysis. If manganese or other micronutrients are becoming too high, use a fertilizer without manganese or certain micronutrients.

Fertilizing Young Highbush Plants

First year of planting

Young blueberry plants are easily burned by excess fertilizer salts. For this reason, extreme caution must be exercised if you are using a regular dry granular fertilizer on young blueberry plants, especially rooted cuttings. Slow release or controlled release fertilizers are recommended for this phase of production. Follow manufacturer's directions. Use the "low" or "medium" rate for salt sensitive plants.

Rooted cuttings with controlled release and slow release fertilizer

If rooted cuttings or plug plants are set, typically about 1 teaspoon to 1 tablespoon of fertilizer per plant is applied at each application, with two to four applications per year depending on if controlled release or slow release fertilizer is used. This is based on manufacturer's recommendations for a 1-gallon container. Some growers are using several applications of controlled release fertilizer per year with regular fertilizer applied monthly. Scatter the fertilizer evenly over a circle about 12 inches in diameter the plant in the center. Increase amount of fertilizer as plants grow.

Regular fertilizer in year one

If you plant rooted cuttings or plug plants and decide to use regular fertilizer, evenly apply about ½ teaspoon of premium grade (contains micronutrient) 10-10-10 in a circle 12 inches in diameter, starting at bud break and continuing every two to three weeks during the early part of the summer. This is equivalent to 30 pounds of nitrogen per acre if broadcast. As the rooted cuttings grow to about a foot in height or if 1-gallon size plants are set, the rate can be increased to a teaspoon per application and the diameter of the

circle increased to 18 inches. Apply every two to three weeks. This is equivalent to 27 pounds of nitrogen per acre if broadcast.

Gallon size plants with controlled release and slow release fertilizer

If gallon size plants are set, use the recommendations for a 3- to 5-gallon container. A typical program might be 1.5 ounces of 13-6-6 slow release fertilizer applied four times per year or 2-2.5 ounces of controlled release "8-9 month" 18-6-12 applied once. Additional fertilizer from a regular, slow release or shorter term controlled release material may be needed to finish the season, since "8-9 month" controlled release fertilizer is based on an average 70 degree F temperature and normally only lasts about five months in Georgia. Apply evenly in a circle about 24 inches in diameter with the plant in the center.

Fertilizing two-year-old bushes in pine bark beds

If gallon plants were set and growing conditions were favorable, a plant height of about 3 feet may be obtained by the start of year two. If you are using slow release or controlled release fertilizer, spread the fertilizer over an area about 2 feet in diameter with the plant in the center. The area of the circle in this case would be 7 square feet or 3.5 cubic feet (24 gallons) if the pine bark is 6 inches deep. **Follow manufacturer's directions.** A typical program may be 4 ounces of a slow release material (such as 13-6-6) applied three times per year or 8 ounces of a 8-9 month controlled release material (such as 18-6-12) applied once a year. In late summer an additional application of regular fertilizer may be needed.

Based on recent research from Florida by Wilber and Williamson (2002), if you are using regular fertilizer, second year plants should receive about 2 teaspoons (10.5 grams) of premium grade 10-10-10 or 12-4-8 applied to a circle 24 inches in diameter. This is equivalent to 30 pounds of nitrogen at each application per acre if broadcast. Apply every two weeks during the period growth is desired.

Fertilizing bushes three years and older

In most high density southern highbush planting situations, bushes 3 years and older are considered mature and have filled their allotted space. Normally a severe rooftop hedging program is practiced, where the bushes are cut back to about 3 feet immediately after the harvest is finished (about June 1 in South Georgia). This creates a higher demand for fertilization than plants growing in soil where moderate winter pruning is often the only pruning conducted. Also, since pine bark does not hold anions such as phosphate well, there is a need to apply phosphorus throughout the growing season.

Research on fertilizing mature bushes in pine bark is very limited, but there is a large body of grower experience. One grower observation is the significant release of nitrogen from old pine bark beds. After the pine bark has been fertilized and aged for a number of years, plants may not require as much nitrogen as expected late in the season. Leaf nutrient levels and growth should be monitored.

Many growers in Georgia and Florida are using a premium grade (contains micronutrient and secondary nutrients) 10-10-10, 12-4-8, or 18-6-12. Micronutrients (boron, iron, manganese, zinc, etc.) and secondary nutrients (sulfur, magnesium, etc.) may be needed but some micronutrients such as boron and manganese may reach toxic levels in some situations. Leaf nutrient levels should be monitored and fertilizer blends adjusted as needed.

Typically about 100 to 220 pounds of actual nitrogen is applied per year, divided into six to eight applications. A typical program with **regular** fertilizer would be 150-200 pounds per acre of 10-10-10 or 120-135 pounds per acre of 18-6-12 applied in mid-February, mid-March and early April in south Georgia. Avoid application of nitrogen during harvest if the plants look healthy and have adequate nitrogen in the leaves based on leaf analysis. Make sure that plants have adequate potassium in the leaves at harvest. This is an important element for fruit quality. However, excessive application of potassium will induce magnesium deficiency. Starting at hedging June 1, another 150-200 pounds of 10-10-10 or 120-135 pounds per acre of 18-6-12 is applied every three to four weeks until early September in south Georgia. Allow the plants to set terminal buds and harden off before winter or freeze injury may occur. Freeze injury can allow entry points for diseases such as stem blight. Some growers use foliar fertilizer or fertigation applied on an as needed basis in the fall, based on plant appearance and weather. It can also be used as the sole method of fertilizer application if the watering system is even.

Fertigation

Fertigation can be used to supply all or part of the blueberry fertilizer requirement. Fertigation is an efficient system in a high density planting, but wasteful in a low density system with overhead irrigation, since only about 50 percent of the area has blueberry roots. Also note that your fertilization via fertigation will only be as even as your watering system. **Typically about 5 pounds of nitrogen per acre plus phosphorus and potassium (if needed) are injected each week.**

Avoid application of fertilizer during harvest in most cases. Since blueberries are a salt sensitive plant, determine the electrical conductivity of your fertilizer solution and dilute the fertilizer in enough water to create the proper solution. Your fertilizer supplier should have this information or we can obtain it for you. A maximum electrical conductivity of 0.75 mMhos/cm (pronounced *millimoles*) is suggested for salt sensitive plants such as blueberries. Typically this means the fertilizer should be diluted so that no more than 100 to 150 ppm of nitrogen is applied in the irrigation water at one time. This is calculated by the following equation:

$$\text{lbs of fertilizer mixture to add to 100 gal of water} = \frac{100 \times \text{desired ppm (usu. 150 ppm)}}{(\%\ \text{nitrogen concen. of fer.} \times 1205}$$

As an example, if a 32% liquid nitrogen solution is used:

$$\frac{100 \times 150\ \text{ppm}}{32\% \times 1205} = \frac{15{,}000}{38{,}560} = 0.39\ \text{lbs of 32\% nitro-gen fertilizer solution/ 100 gal. of irrigation water to form a 150 ppm nitrogen solution}$$

To determine the amount of liquid to use:

Since 32 percent nitrogen weighs 10.5 pounds per gallon, then divide 0.39 pounds of fertilizer by 10.5. The answer is 0.037 gallons of 32 percent nitrogen per 100 gallons of irrigation water to equal 150 ppm of nitrogen.

Each gallon of 32 percent nitrogen contains 3.36 pounds of nitrogen (10.5 pounds per gallon x .32 nitrogen). If we want to apply 5 pounds of nitrogen per acre, divide 5 by 3.36 (number of pounds of nitrogen in a gallon of 32 percent nitrogen) = 1.49 gallons of 32 percent nitrogen. To make a 150 ppm solution of the 32 percent nitrogen, divide 1.49 gallons by 0.037 gallons = 40.27. Multiply times 100 gallons to get the number of gallons of irrigation water to add. **The answer is 1.49 gallons of nitrogen diluted in 4,027 gallons of water will give 5 pounds of nitrogen in a 150 ppm solution.**

If your sprinklers apply 0.33 inches per hour, this is about 9,000 gallons per hour. Dilute and inject the fertilizer over a period of about ½ hour. Irrigate with clear water for a few minutes after injection to wash off the plants, but do not flush out the fertilizer from the pine bark. Repeat weekly as needed, but use a balanced fertilizer if needed to phosphorus, potassium and micronutrients.

Contact the University of Georgia Extension Service via a county agent if you would like some help with the calculations. We will be glad to assist you.

Monitoring the Fertilizer in the Pine Bark Substrate

Several methods can be used to check your fertilizer salt levels (electrical conductivity) in the pine bark. If too low, growth will be reduced, if too high, root burn can occur. Samples can be collected and sent to the University of Georgia lab or a private lab as a "greenhouse/nursery" sample. This will give you nutrient levels and soluble salt levels in the pine bark. The following is a chart used in woody ornamental production.

Table 2. Range of nutrient concentration in saturation extraction method for soil-less media for optimal production of woody ornamentals during the growing season. [Method used by UGA lab]

	Parts per million (ppm)		
Element	**Insufficient**	**Sufficient**	**Excessive**
Nitrogen (nitrate)	<39	40-139	>140
Phosphorus	<3	4-13	>14
Potassium	<49	50-179	>180
Calcium	<69	70-219	>220
Magnesium	<29	30-99	>100

Electrical conductivity is a general measure of the amount of fertilizer salts in the pine bark substrate. You can purchase your own electrical conductivity (EC) meter and use the "pour through" method to determine if the fertilizer salts are present in the substrate. (See http://pubs.caes.uga.edu/caespubs/horticulture/solublesalts.html) Suggested EC levels for blueberry pine bark substrate are .50-.75 mMhos/cm.

Monitoring Leaf Nutrient Levels

Growers should monitor leaf nutrient levels at least once a year. Traditionally this has been done in July and early August on rabbiteyes, but a better time for southern highbush would be just prior to hedging in late May or early June. In this way, fertilization could be adjusted for the main summer and fall growth flushes. Collect a double fist full of leaves from the mid-portion of the 20 shoots on 20 plants and place in a paper bag. Take to your county extension office. Recently, high levels of manganese have been found in some high density plantings in Georgia. It is suspected that the source of the manganese is the fertilizer. If so, change to a fertilizer with little or no manganese.

Suggested foliar nutrient levels for highbush blueberry leaves.

Element	Deficient (below)	Min.	Max.	Excessive (above)
Nitrogen	1.70%	1.80	2.10	2.50
Phosphorus	0.10	0.12	0.40	0.80
Potassium	0.30	0.35	0.65	0.95
Calcium	0.13	0.40	0.80	1.00
Magnesium	0.08	0.12	0.25	0.45
Sulfur	0.10	0.12	0.20	NA
Manganese	23 ppm	50	350	450
Iron	60	60	200	400
Zinc	8	8	30	80
Copper	5	5	20	100

Summary

Growing southern highbush blueberries in pine bark has been a successful and increasingly important method of production. Fertilizing blueberries in pine bark is similar to fertilizing in soil, but major differences are present that growers need to understand.

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