# Growth and Yield of Southern Highbush Blueberry in Pine Bark Culture under Varying Fertilizer Regimes

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**Southern highbush blueberry (*Vaccinium corymbosum* hybrid) plants were grown on pine bark beds using several rates of granular or liquid fertilizers. Canopy volume and berry yield per plant increased linearly with increasing fertilizer rate up to the highest rate included in the study. Berry yields per plant were closely correlated with canopy size. No consistent differences in plant growth or yield were observed between granular or liquid fertilizer; however, 'Star' mean berry weight was slightly greater for granular fertilizer treatments than for liquid fertilizer treatments. Visual examination of excavated plants at the conclusion of the study indicated that roots of plants grown on pine bark beds were largely restricted to the pine bark layer and only a few roots were located in the native soil. Frequent irrigations required for shallow-rooted blueberries in pine bark beds, and the limited water and nutrient holding characteristics of pine bark, probably resulted in some fertilizer leaching below the root zone, which in turn may have resulted in a higher than expected fertilizer requirement.**

Harvested blueberry acreage in Florida has more than doubled between 2000 and 2008 from 1200 acres to more than 3000 acres (U.S. Department of Agriculture, 2008). During the same period, statewide blueberry production approximately tripled from about 3.3 million pounds to nearly 10 million pounds. The industry's value continues to grow rapidly, increasing by more than $12 million between 2007 and 2008 (U.S. Department of Agriculture, 2008). Further growth of this industry is anticipated for the foreseeable future as new plantings continue to be established. Despite the rapid increase in acreage and production, prices for Florida blueberries have remained high, usually averaging between $4.00 and $5.00 per pound (U.S. Department of Agriculture, 2008). Southern highbush blueberry (SHB) is the principal blueberry grown for the commercial market in Florida because of its early harvest period in April and May (Williamson and Lyrene, 2004a, 2004b). SHB are usually grown in Florida using a system known as pine bark culture or pine bark bed production. With this production system, plants are planted directly in 6 to 8 inches of pine bark on top of native soil. The bark is usually arranged in beds about 3 ft wide centered on row middles about 9 or 10 inches apart. Plants grow vigorously in this system provided they receive adequate irrigation and fertilization. However, this system usually results in shallow roots that are restricted to the pine bark layer. Pine bark is reported to have marginal water and nutrient holding capacities (Krewer and Ruter, 2006). With pine bark bed production, frequent irrigations are needed during warm weather in Florida in the absence of rain. This study was conducted to determine the effects of varying fertilizer rate applied as granular or liquid (fertigation) on growth and yield of SHB grown in pine bark culture.

## Materials and Methods

The experimental site was a blueberry farm in southeastern Alachua County, FL. Pine bark screened to 1 inch or smaller was used to create double row beds approximately 8 inches deep and 10 ft wide on top of Lochloosa fine sand. 'Misty' and 'Star' SHB plants were planted in a double row configuration with a 3-ft in-row spacing and 5 ft between rows. Although the planting was established in Spring 2000, the present experiment began in 2003. Prior to the emergence of spring growth during 2003, there were no differences in canopy volume among the plants used in the study. The treatments consisted of three fertilizer rates applied either as granular fertilizer (eight applications per season spaced 4 weeks apart beginning 1 Mar. and ending 1 Oct.), or as liquid fertilizer (16 applications spaced 2 weeks apart beginning 1 Mar. and ending 15 Oct.). The analysis and composition of the granular fertilizer were 12N–1.75P–6.6K with N consisting of 3.5% nitrate, 3.5% ammonium, and 5% urea. The analysis and composition of the liquid fertilizer was proportionally similar to the granular fertilizer: 24N–3.5P–13.2K with 7% nitrate, 7% ammonium, and 10% urea nitrogen. Since plant canopy volume responded linearly to fertilizer rate during 2003, fertilizer rates were increased in 2004 and 2005 in an attempt to reach the rate needed for maximum growth in this production system.

The annual fertilizer rates for 2003 were: Low = 175 g/plant (granular) and 87.5 g/plant (liquid); Medium = 258 g/plant (granular) and 129 g/plant (liquid); and High = 417g/plant (granular) and 208.5 g/plant (liquid). For the 2004 and 2005 seasons the fertilizer rates were increased to: Low = 400 g/plant (granular) and 200 g/plant (liquid); Medium = 525 g/plant (granular) and 263 g/plant (liquid); and High = 675 g/plant (granular) and 338 g/plant (liquid). Granular fertilizer was applied at twice the amount of the liquid fertilizer so that equivalent amounts of N, P, and K were applied for both fertilizer types. A peristaltic pump (MasterFlex LS ®, Cole-Palmer Instrument Co., Vernon Hills, IL) was used for fertilizer injections.

Spot-Spitters® (Roberts Irrigation Products, San Marcos, CA) microsprinkler emitters, which delivered 9.6 gal/h at 15 psi to a 7.3-ft² surface area, were used for all irrigation except for cold protection. The microirrigation system applied approximately 1 inch of water per week during March and April, and about 1.7 inches of water per week during June through September in the absence of rain.

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Plant canopy volumes were determined by measuring plant height and width parallel and perpendicular to the row. All ripe fruit were harvested at 2- to 3-d intervals throughout the commercial harvest season. Mean berry weights were determined from 10-fruit subsamples collected and weighed from each plot for four consecutive harvest dates corresponding with the middle of the harvest season for each cultivar.

Guard plants separated all plots and were fertilized by hand with granular fertilizer at the medium fertilizer rate. Since cultivars and fertilizer type responded similarly to fertilizer rates during 2003 and 2004, only data for 'Star' fertilized with granular fertilizer were collected during the third and final year of the study. A randomized complete-block design with single-plant plots and 8 replications with a two (cultivar) × two (fertilizer type) × three (fertilizer rate) factorial arrangement was used.

At the conclusion of the study, eight 'Star' plants were excavated by hand with their root systems intact for a visual assessment of root distribution. Data were analyzed using the General Linear Models (GLM) procedure of SAS (version 9.1; SAS Institute, Cary, NC). Regression analysis was used to evaluate fertilizer rates and fertilizer types (liquid vs. granular) were compared using *t*-tests.

## Results and Discussion

A strong positive linear relationship was found between canopy volume and fertilizer rate during all three years of the study (Table 1). During 2003, plants fertilized at the low fertilizer rate had canopy volumes about half as large as plants receiving the high rate of fertilizer. During 2004 and 2005 plants receiving the low fertilizer treatment were about 75% to 80% the size of plants receiving the high fertilizer rate. A slight difference was noted for mean plant size in response to granular vs. liquid fertilizer during the first year of the study with granular fertilizer plants being slightly larger. However, these differences were small compared to the differences among fertilizer rates and did not persist throughout the study.

The high fertilizer rate consistently resulted in the greatest berry yield through the duration of the study (Table 2). Berry yields for both cultivars were strongly correlated with canopy volumes ($r = 0.747$ and 0.739 for 'Misty' and 'Star', respectively, 2004; $r = 0.810$ for 'Star', 2005). When berry yield was adjusted for canopy volume, there was no effect of fertilizer treatment on berry yield. Neither fertilizer rate nor form affected the timing of fruit harvest.

Optimum fertilizer rates for southern highbush blueberry appear to be significantly higher in pine bark than in soil. Berry yields increased during all three years as fertilizer rates increased up to the highest fertilizer rate included in the study. The increased berry yields from the high fertilizer rates can be primarily attributed to larger canopy volumes of the plants receiving the higher fertilizer rates since no differences in berry yield were found when yields were adjusted for canopy size. In the present study, the high fertilizer rate during 2004 and 2005 was over two times the suggested rate for traditional soil culture in the southeastern U.S. (Krewer and NeSmith, 2006; Williamson et al., 2006).

Excavation of eight 'Star' plants and examination of their root systems revealed that the roots were predominately located in the pine bark layer with very few roots located in the non-amended soil beneath the pine bark (Figs. 1–2). Pine bark is an excellent medium for growing blueberry plants provided adequate water is available. The water holding capacity of pine bark is generally thought to range from about 13% to 21% (by volume) (Krewer and Ruter, 2006). A 4-inch-deep bed of pine bark with a 15% water-holding capacity will retain only slightly over one-half inch of water at field capacity. Moreover, pine bark has low anion and only moderate cation exchange properties compared to many soil types. The relatively low water and nutrient holding capacities

Table 1. Effect of fertilizer rate and type on canopy volume ($ft^3$) of 'Misty' and 'Star' southern highbush blueberry grown in pine bark bed culture.

| | Date | | |
|---|---|---|---|
| Treatment | 3 June 2003 | 7 June 2004 | 2 June 2005$^z$ |
| Annual fertilizer rate$^y$ | | | |
| Low | 18.75 | 39.48 | 44.32 |
| Medium | 24.93 | 44.46 | 49.90 |
| High | 36.73 | 52.48 | 56.72 |
| Significance | *** (L) | *** (L) | * (L) |
| Fertilizer type | | | |
| Liquid | 25.29 | 39.69 | --- |
| Granular | 29.21 | 44.32 | 50.31 |
| Significance | * | NS | |
| Cultivar | | | |
| 'Misty' | 26.56 | 42.02 | --- |
| 'Star' | 28.07 | 48.95 | 50.31 |
| Significance | NS | ** | |

$^z$2005 data for 'Star" only.

$^y$Low = 175 g/plant (granular) or 87.5 g/plant (liquid) for 2003 and 400 g/plant (granular) or 200 g/plant (liquid) for 2004 and 2005. Medium = 258 g/plant (granular) or 129 g/plant (liquid) for 2003 and 525 g/plant (granular) or 263 g/plant (liquid) for 2004 and 2005. High = 417g/plant (granular) or 208.5 g/plant (liquid) for 2003 and 675 g/plant (granular) or 338 g/plant (liquid) for 2004 and 2005. (Adapted from HortTechnology 19:152–157).

$^{NS, *, **, ***}$Nonsignificant or significant at $P \leq 0.05$, 0.01, and 0.001, respectively.

Table 2. Effect of fertilizer rate and type on berry yield of 'Misty' and 'Star' southern highbush blueberry grown in pine bark bed culture.

| | Berry yield (g/plant) | | |
|---|---|---|---|
| Treatment | 2003 | 2004 | 2005$^z$ |
| Annual fertilizer rate$^y$ | | | |
| Low | 581 | 2827 | 3591 |
| Medium | 700 | 1060 | 4280 |
| High | 1120 | 3909 | 5238 |
| Significance | 0.001 (L) | 0.001 (L) | 0.007 (L) |
| Fertilizer type | | | |
| Liquid | 705 | 3089 | --- |
| Granular | 896 | 3528 | 4370 |
| Significance | 0.011 | 0.026 | |
| Cultivar | | | |
| 'Misty' | 998 | 3994 | --- |
| 'Star' | 602 | 2633 | 4370 |
| Significance | 0.001 | 0.001 | |

$^z$2005 data for 'Star' only.

$^y$Low = 175 g/plant (granular) or 87.5 g/plant (liquid) for 2003, and 400 g/plant (granular) or 200 g/plant (liquid) for 2004 and 2005. Medium = 258 g/plant (granular) or 129 g/plant (liquid) for 2003 and 525 g/plant (granular) or 263 g/plant (liquid) for 2004 and 2005. High = 417g/plant (granular) or 208.5 g/plant (liquid) for 2003 and 675 g/plant (granular) or 338 g/plant (liquid) for 2004 and 2005. (Previously reported in HortTechnology 19:152–157).

Fig. 1. Excavation of a 'Star' blueberry plant grown in pine bark culture. Very few roots were located below the pine bark layer.

of pine bark, and the shallow rooting depth of blueberry plants grown in pine bark bed culture probably contributed to the high fertilizer requirement. Daily irrigations were necessary during the absence of rain to prevent drought stress during the late spring and summer when plant water demands were high. It is likely that the plants responded to high rates of fertilizer because frequent irrigations and summer rains leached a portion of the fertilizer below the shallow root profile. The pine bark system described in this study produced excellent plant growth and yield but appeared to be difficult to manage for high water and fertilizer use efficiency. One possible alternative is to incorporate pine bark into the soil before planting, which might promote greater rooting

Fig. 2. Excavated 'Star' blueberry plant showing the shallow, spreading, root system in pine bark bed production.

depth and thus more efficient use of irrigation water and fertilizer. Additional studies are needed to evaluate different soil management systems for southern highbush blueberry with the goal of increasing water and fertilizer use efficiency while maintaining vigor, plant health, and productivity.

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