The water content increase in the clay soil was similar in many ways to that of the loamy soil. Water content increase was moderate compared to the two previous soil types. In addition, all points started to increase in water content at the same time with the exception of the 0-cm point. The slope of increase in the water content was much smaller than that of the sandy or even the loamy soils. This is clear evidence of the multidirectional spreading of the water front with clay soil. All monitoring points showed simultaneous increases in their water contents.

The spread of the water front illustrates the performance of drip irrigation for these distinct soils. With sandy soil conditions, water front movement is dominated by its vertical component. In other words, water has a tendency to move vertically rather than horizontally. Water moves in soils as a result of the matric potential (directly related to water content) and gravitational potential (tendency of the water to move downward as a result of gravity). In dry soils, matric potential is dominant compared with gravitational potential. As soils get wetter, gravitational potential dominates the matric potential. Sandy soils are dominated by large pores compared with fine texture soils such as clay and loamy soils. In order for water to move from a wet portion to a dry portion of a sandy soil, water uses large pores. Once the large pores of a sandy soil are filled, the driving force of water movement is dominated by the gravitational potential. Hence, the water content directly under the dripper (N1) increased from its initial level before irrigation to its maximum level in a short time. However, it took 4 to 5 times longer to reach the same point (N1) for the other two soil types (loam and clay). Consequently, to be able to wet horizontally a sandy soil compared to a clay soil, a drip system must run twice as long. By that time, water underneath the dripper would have moved beyond the root zone. This could increase production costs by causing excess water percolation and leaching of fertilizers and pesticides beyond their target zone of action.

The maximum radial extent of the water front during these 24-h simulations was 24, 38, and 47 cm for the sand, loam, and clay soils, respectively. Drip systems are expected to work better in clay soils than in loamy soils. Similarly, they will perform relatively better in loamy soils than in sandy soils. To have the same horizontal coverage in sandy soils as in clay soils, growers should use twice as many drippers per unit area. However, they only need 1.5 times as many emitters in loamy soils.

Drip irrigation can increase water use efficiency. This work shows that it is essential before choosing such an irrigation system to evaluate its suitability based on evaluation of the physical and water holding properties of the soil. More field work will be conducted to validate the findings of the simulations reported here.

**MARKET WINDOWS FOR FLORIDA BLUEBERRIES**

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**Abstract.** Using various combinations of locations, cultivars, and cultural methods, Florida growers could harvest blueberries for the fresh market without interruption from 15 Mar through 15 Aug., a period of about 22 weeks. However, production systems that yield ripe blueberries during some of these weeks are very expensive, and market prices for fresh blueberry varieties are low during other weeks of this period due to competition from other production areas. In addition, the summer rainy season normally begins in the northern half of the Florida peninsula in early June, and rains can cause problems with harvest scheduling and with berry quality after the second week in June. It appears that southern highbush blueberry varieties planted from south-central Florida to northeast Florida for the 10 Apr. to 10 May market currently offer the best prospect for Florida blueberry growers. As production increases during this market window, two other production opportunities may become more attractive: (1) Protected culture of low-chill highbush varieties, which would allow harvest to begin about 20 Mar., and (2) cultivation of new, early-ripening varieties of rabbiteye blueberries in northeast Florida east of the St. Johns River, which could be mechanically harvested for the fresh market between 25 Apr. and 25 May.

Before 1980, fresh blueberries were only available in North American markets from 20 May, when harvest began in


**Literature Cited**


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southeastern North Carolina, to late Sept., when harvest ended in Michigan and in the Pacific northwest. Chile began producing blueberries for export to North American markets in the early 1980s, and imports of Chilean blueberries into the U.S. and Canada increased rapidly throughout the 1990s. Most of the Chilean blueberries arrive between 20 Nov. and 20 Mar. (Lyrene and Munoz, 1997). Also during the 1980s and 1990s, Florida growers began planting the new southern highbush blueberry varieties that were being developed by the University of Florida and by the U.S. Department of Agriculture. When planted from Ocala to Jacksonville, these varieties could be harvested from 25 Apr. to 25 May (Sharpe and Sherman, 1976a, b; Sherman and Sharpe, 1977).

In recent years, growers, wholesalers, and retailers of fresh blueberries have recognized the market advantages of having a continuous supply of fresh blueberries available to consumers throughout the year. This has lead to intense competition to fill the spring and fall market gaps, particularly from 15 Mar. to 15 May and from 15 Sept. to 15 Nov.—periods during which large supplies of high-quality fresh blueberries are not available from either hemisphere. The purpose of this paper is to discuss the blueberry harvest season in Florida and to examine possible ways Florida growers could increase blueberry production during the most favorable market windows.

Types of Blueberries Grown in Florida

Two types of blueberries are grown commercially in Florida—southern highbush and rabbiteye (Lyrene and Sherman, 1984). Southern highbush are complex hybrids based largely on crosses between northern highbush blueberry (Vaccinium corymbosum L.) cultivars from New Jersey and Michigan and V. darrowi Camp, a heat-tolerant, evergreen, low-growing blueberry native in Florida pinelands (Lyrene, 1986). The southern highbush varieties that have been developed at the University of Florida are the result of interspecific hybridization followed by many generations of recurrent selection for a combination of traits including early ripening season, well-adapted, vigorous, upright-growing plants, and high berry quality. The southern highbush cultivars now recommended for cultivation in the northern and central part of the Florida peninsula ripen 90% of their crop in the Gainesville area between 20 Apr. and 20 May in an average year.

The second type of blueberry cultivated in Florida is the rabbiteye blueberry (Darrow and Scott, 1966). The older rabbiteye cultivars were bred entirely from V. ashei Reade, a vigorous, late-ripening species native to the western Florida panhandle, adjacent south Alabama, and southeast Georgia and northeast Florida. The cultivars that have been most widely planted ripen 90% of their crop between 20 May and 15 July in Gainesville, and thus begin ripening fully a month later than the southern highbush cultivars.

Market Windows for Southern Highbush Blueberries

The main blueberry harvest season in Chile is from 20 Nov. through 1 Mar. The latest-ripening varieties grown in Chile, for example the highbush variety ‘Elliott’ grown around Orsino, and the late rabbiteye varieties ‘Powderblue’ and ‘Centurian’, grown around Los Angeles, have long harvest seasons. Particularly with the rabbiteyes, the flowering season on a single plant can extend for more than 2 months, and berries from the last flowers ripen when nights are becoming longer and cooler. Thus, a small percentage of the crop can still be harvested in mid-Mar., even though most of the berries from these plants are harvested in Jan. and Feb. Most of the Chilean blueberries shipped to North America after 15 Mar. have been held in controlled atmosphere (CA) or modified atmosphere storage at temperatures near 0°C for 2-10 weeks. The quality of these berries when they reach the consumer varies widely, depending on the cultivar, the storage conditions and duration, and the post-storage handling conditions. By 1 Apr., if not earlier, fresh blueberries harvested in Florida should be superior in quality to imported berries.

Two factors have historically ended the most favorable market window for Florida blueberries—the harvest of large quantities of highbush blueberries in southeastern North Carolina between 20 May and 10 June and the advent of the summer rainy season in Florida about 10 June (Lyrene, 1989). From 1950 to 1970, almost 4,000 acres of highly-productive northern highbush blueberries were planted in North Carolina. Varieties were selected that would ripen as early as the climate allowed, because growers wanted to avoid having to harvest in the heat, humidity, and rains of late June, and because they wanted to avoid the market competition presented by 10,000 acres of highbush blueberries in southern New Jersey.

The southern highbush varieties grown in Florida ripen during an ideal market window—after the last fresh blueberries are harvested in Chile and before the start of harvest in North Carolina. However, the rabbiteye varieties that were planted in northern Florida during the 1970s and 1980s ripened from 20 May to 20 June for the earliest varieties (‘Climax’, ‘Aliceblue’, ‘Beckylblue’, and ‘Bonita’) and from 1 June to 15 July for the mid- to late-season varieties (‘Bluegem’, ‘Brightwell’, ‘Tifblue’, and ‘Powderblue’). The 20 May to 20 June harvest season for the early rabbiteyes coincided with the harvest of highbush blueberries in North Carolina, resulting in low market prices. ‘Croatan’, the principal highbush variety grown in North Carolina for the past 20 years, has a rather short postharvest life. The rabbiteye berries harvested in Florida in late May and early June were much firmer and had a far longer postharvest life than ‘Croatan’ and could have been marketed in distant locations where ‘Croatan’ berries were not firm enough to go, but marketers during the 1980s and 1990s were not prepared to pay Florida growers higher prices for berries that could have been used to open new, higher-priced export markets. In addition, yields on the early-ripening rabbiteyes were often disappointingly low due to fruit set problems, now believed to have been due largely to two insect pests, blueberry gall midge (Dasineura oxyococana Johnson) and flower thrips (Frankliniella spp.). The later-ripening rabbiteyes had better yields, but their harvest season competed with both North Carolina and New Jersey, and the hot, rainy weather with high dew points that was common in north Florida after 10 June interfered with harvest and lowered berry quality. Consequently, few new rabbiteye plantings were made in Florida during the 1990s, and some growers removed rabbiteyes to plant southern highbush (Williamson et al., 2000).

Possible Further Opportunities for Blueberries in Florida

1. Increased production of high-quality highbush blueberries in the early season (15 Apr. to 20 May). Production during this window is increasing due to increased acreage and increased yields per acre in Florida and southeastern Geor-

Observations of test selections in the breeding program at Gainesville suggest that varieties could be developed that would ripen as much as 15-20 d earlier than standard early varieties such as 'Star', 'Millennia', 'Emerald', and 'Jewel'. This would allow harvest (10% of the crop mature) to begin about 5 Apr. in Gainesville in an average year using current cultural methods. Some of these varieties might ripen an additional 7-10 d earlier if grown in the central part of the Florida peninsula.

Another way of producing blueberries for the late-Mar. and early Apr. market would be to plant blueberries south of Lake Okeechobee and keep them from entering winter dormancy (Obreza et al., 2000). Many details of this system would require investigation before economic feasibility could be determined, but the genetic potential to accomplish Mar. harvest is known to exist in southern highbush germplasm. Vigorous, young plants of many southern highbush varieties flower prolifically from mid-Dec. to mid-Mar. if grown through the winter in a minimally-heated (solar heat during the day, temperature maintained above 3°C with heaters at night) greenhouse in Gainesville. If the early flowers are cross-pollinated, a significant fraction of the crop can be harvested between 10 Mar. and 1 Apr. A similar flowering period could probably be obtained on some varieties in the Immokalee area using overhead irrigation to protect winter flowers and berries from freezes. A good fungicide program to keep the leaves healthy and high N fertilization in the fall and winter would be needed to keep the plants from entering dormancy.

3. Producing rabbiteye blueberries for the 20 May to 20 June market. Although rabbiteye blueberries have some disadvantages compared to southern highbush—notably late ripening and more problems with fruit set—they do have some advantages. The plants are more vigorous and can support a higher yield. Rabbits are less soil organic matter than highbush. This allows them to be grown on many Florida soils where highbush would only thrive if the soil was heavily amended with pine bark or sawdust. On deep, well-drained, acid soils, rabbiteyes develop a much deeper root system than highbush, and require less-frequent irrigation. Because soils can be kept drier with rabbiteyes, phytophthora root rot can be less troublesome with rabbiteyes than with highbush. It is also easier to develop rabbiteye varieties with good fruit scar, firmness, and color. Berries that can be machine-harvested for the fresh market also seem easier to obtain with rabbiteye varieties than with highbush.

During the 1970s, 1980s, and early 1990s, much effort was expended at the University of Florida in a recurrent selection program to develop earlier-ripening rabbiteye varieties. Part of this program involved incorporating genes from an early-ripening relative of the rabbiteye blueberry, V. constablaei, which grows only on the highest mountain balds of the southern Appalachians. Although no crosses have been made in this program for the past 5 years, a group of 10 to 20 advanced selections from this program are being tested in northern Florida and southeast Georgia. The earliest of these that appear to have commercial possibilities ripen from about 20 Apr. to 20 May in Gainesville if grown with overhead irrigation for freeze protection. Within 5-7 years, several of these selections are expected to be released for grower trial. It is expected that their greatest utility would be in conjunction with mechanical harvest.

Summary and Conclusion

The easiest and highest yielding blueberries to produce in Florida are the late rabbiteyes that ripen from 10 June through 1 Aug. However, due to erratic prices for processed blueberries and due to the abundance of blueberries on the market from New Jersey and Michigan after 20 June, late rabbiteyes have not been very profitable for Florida growers. The fastest-growing segment of the Florida blueberry industry is production of southern highbush blueberries for the fresh market. The harvest on these is mostly between 20 Apr. and 20 May in the Gainesville area and a week to 10 d earlier in central part of the Florida peninsula. Highbush blueberries could also be harvested in Florida from 15 Mar. through 15 Apr. by avoiding dormancy with the lowest-chill cultivars in the warmest parts of the state, but the economic feasibility of doing this has not been determined, and much research would be needed to find the right varieties and work out the right systems of production. Another possibility for the future is the production of early-ripening, machine-harvested rabbiteye blueberries for the fresh market in the area between Orlando and Jacksonville. Again, much research remains to be done to determine the economic feasibility of such an enterprise.

Literature Cited


