Table 3. Soil analysis means for 16 plots for each mulch type.

	Polyfabric	Bark
pH	4.8	4.6 ns[z]
% organic matter	2.13	2.08 ns
Ca ppm	391	166 **
K ppm	18.1	17.2 ns
P ppm	119	118 ns
Al ppm	558	569 ns

[z]ns Not significantly different at 5% level.
*,** Significantly different at 5% and 1% levels, respectively.

affected by mulch type. Evaporation of the high-calcium (ca 60 ppm) irrigation water is the probable source of increases *in soil calcium* during the 2½ year experiment (3). Since irrigation rates with the overhead system were virtually identical for both treatments, it is possible that higher evaporation rates were responsible for more rapid calcium buildup beneath the polyfabric mulch. Soil temperature readings averaged for twenty days in August, 1989 (Table 4), were substantially higher under the polyfabric mulch treatments than under the bark mulch. The relatively uninhibited circulation of air beneath and throughout the woven polyfabric fibers may also have facilitated rapid evaporation of irrigation water.

Although high calcium levels are generally undesirable for blueberries, soil pH was relatively unaffected by the calcium concentration differences between the pine bark and polyfabric mulched plots. Thus, lower calcium levels are probably only partially, if at all, responsible for the superior growth achieved in the pine bark mulched plots.

Perhaps the most important field observation in contrasting these mulch types was the proliferation of shallow, matted feeder roots throughout the zone of interface between the pine bark mulch and the soil. The particles of decomposing pine bark in this zone were almost completely screened out of the soil samples in preparation for analysis, but they are apparently fine enough to provide a moist, well aerated medium for blueberry root development.

Table 4. Average afternoon soil temperatures under pine bark and polyfabric mulches.[z]

Depth	Polyfabric	Bark
5 cm	35.8°C	32.5°C
15 cm	31.1°C	28.7°C

[z]Temperatures recorded daily at 3:00 PM and averaged over a 20-day period in August, 1989.

Both mulches provided satisfactory, durable, in-row weed control and prevented soil compaction around the root zone. Maintenance of a weed-free strip along the borders of the mulched rows was easily accomplished with contact herbicides which prevented encroachment of rhizomatous weeds. Planting was somewhat slower in the polyfabric mulch since the cutting of holes and removal of soil from the fabric surface required extra time. This effort is probably balanced, however, by the labor required if pine bark mulch is spread by hand.

Literature Cited

1. Bell, R. W. 1985. Weed matting mulch for blueberries. Acta Horticulturae. 165:167-170.
2. Creech, D. 1989. Status of the polyfabric, bark mulch, zero above ground and peat moss, bark, zero below ground amendment study. Proc. Texas Blueberry Growers Assn.; 1989:68-74.
3. Lyrene, P. M. and T. E. Crocker. 1987. Florida Blueberry Handbook. Florida Coop. Ext. Service Cir. 564.

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THE FLORIDA CLIMATE AS IT RELATES TO BLUEBERRY PRODUCTION

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Abstract. **Mild temperatures from January through April in south-central Florida offer the possibility of producing blueberries (*Vaccinium* species) well before the start of the blueberry season in established blueberry-growing areas farther north. However, late-winter cold waves that produce temperatures below 28°F between 15 January and 1 April are potentially devastating to blueberry flowers and fruit, and frost-protection systems are needed on most sites. Low rainfall and high percentage of possible sunshine from January through May favor production of early-ripening blueberries in the Florida peninsula, but heavy rains in June and July cause problems during harvest of late-ripening rabbiteye cultivars. Mild winters in most of the Florida peninsula make it necessary to plant low-chill cultivars bred especially for the state. Because blueberries grow best on peat or sandy-peat soils where heavy rains can cause flooding, good drainage and raised planting beds are needed for growing blueberries in most areas in Florida. Neither strong winds nor hail are likely to be regular problems with Florida blueberry production.**

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The cultivated blueberry industry (Table 1) has arisen almost entirely during the past 60 years (4). Acreage, production, and consumption have all increased rapidly throughout this period. During recent years, blueberry cultivation has been spreading to new areas of the country, including Florida.

Florida's first blueberry plantings were made between 1887 and 1930 when enough wild rabbiteye (*V. ashei*) plants were transplanted from the woods to plant 2225 acres in cultivated fields (8). This enterprise was unsuccessful due to poor markets. Improved rabbiteye blueberry cultivars were planted in Florida after 1960, at first for pick-your-own marketing and later for the fresh-fruit shipping market. The first low-chill highbush cultivars (largely *V. corymbosum* × *V. darrowi* segregants) were released by the University of Florida in 1976 and 1977 (13) and after

Table 1. Primary sources of fresh-market blueberry production in the United States.

Production (Area & type)	1989 acreage	Acreage trend	Primary harvest season	Percent for fresh market
Florida Highbush	600	increase	April 1 - May 20	100
Georgia Highbush	50	increase	May 10 - June 10	100
Florida Rabbiteye	1,500	increase	May 20 - July 20	60
North Carolina Highbush	4,000	steady	May 20 - June 20	60
Arkansas Highbush	1,200	increase	May 25 - July 15	80
Georgia Rabbiteye	5,000	increase	June 1 - Aug. 1	40
New Jersey Highbush	12,000	steady	June 15 - Aug. 15	60
Michigan Highbush	15,000	increase	July 1 - Sept. 15	40

a period of grower testing, began to be planted for the fresh-fruit shipping market after 1983.

Blueberry Markets

Blueberries are marketed both fresh and processed (mostly frozen). For North America as a whole, approximately 60% of the blueberry tonnage goes to the processed-fruit market. Profitable blueberry growing for the processing market requires high yields, mechanical harvesting, and relatively low-cost production. The season of harvest is not of great importance, because frozen blueberries can be stored through the year at modest cost.

By contrast, harvest date is very important in determining the profitability of blueberry production for the fresh market. More than half of the world blueberry crop is harvested during July, with June and August accounting for most of the rest. Production in the southern hemisphere, where December, January, and February are the primary months of harvest, is increasing but is still minor compared to North American production. Low availability of fresh blueberries in North American markets from October through May has resulted in high prices for fresh blueberries harvested during these months, and these high prices have caused interest in blueberry cultivation in Florida.

Blueberry Production in Florida

Blueberries grow best in acid, well-drained soils. Highbush blueberries have the additional requirement of organic matter in the soil, preferably 2% or more. The possibility of harvesting blueberries in April and May has been a major stimulus to the planting of highbush blueberries in the central Florida peninsula. In some years, highbush blueberries can be harvested as early as the last week in March in south-central Florida. Even with the new low-chill highbush cultivars that have been developed recently for the lower Gulf coast from southern Georgia to southeast Texas, it seems unlikely that blueberries will be marketed in significant quantities from states north of Florida before May 5. Thus, April provides a substantial market window for growers in south-central Florida.

Many areas of the Florida panhandle west of the Apalachicola River, and some areas in northeast Florida appear to provide suitable sites for the high-yield, low-cost production necessary to compete in the processed blueberry market. Good sites, mechanical harvesting, and late-flowering cultivars are necessary for this purpose.

In Ocala, and in areas with January mean temperatures higher than in Ocala, production of blueberries for the processed market appears infeasible with currently available cultivars because higher yields are obtained when the same cultivars are grown in colder locations. Neither the low-chill highbush cultivars nor the early-flowering rabbiteye cultivars have the yield potential in Florida that late-flowering rabbiteyes have in south Georgia and in the Florida panhandle. Thus, most of the interest in blueberries in the Gainesville and Ocala areas and south down the peninsula has been in production of early-ripening berries for the fresh market.

Effects of Temperature on Blueberry Production in Florida

Chilling requirement. At least three effects of temperature are important in blueberry production in Florida: chilling needed to satisfy dormancy requirements; heat units needed to promote early flowering, leafing, and fruit development after the chilling requirement has been satisfied; and the threat of damaging freezes during or after flowering.

Blueberry cultivars differ greatly in chilling requirement. The northern highbush cultivars grown in North Carolina, Michigan, and New Jersey are short lived and unproductive throughout Florida, because their chilling requirements are not met during the mild Florida winters. On the other hand, two evergreen blueberry species are native in Florida, *V. myrsinites* as far south as Miami, and *V. darrowi*, as far south as Lake Placid. These appear to have no chilling requirement. *V. darrowi* has been used extensively in breeding the low-chill southern highbush cultivars such as 'Sharpblue', 'Flordablue', 'Avonblue', 'Gulf Coast', 'Cooper', 'Georgiagem', 'O'Neal' and FL 2-1. These cultivars range in chilling requirement from very low-chilling for 'Sharpblue' to medium for 'Cooper'. If a blueberry plant enters dormancy in fall or winter, due to some combination of short photoperiod, low temperature, drought or nutrient stress, it is slow to resume growth as a result of subsequent warm temperatures unless its chilling requirement is first satisfied. Thus, a high chilling requirement tends to delay the time of flowering in late winter or spring, reducing the risk of freeze damage to the fruit but also delaying the time of fruit ripening. Because chill requirements in the germplasm available to breed Florida blueberry cultivars range from zero to very high, cultivars with any desired chill requirement can be bred (6, 7,10,11,12). Nonetheless, the high variability in Florida winters from year to year makes it hard to eliminate problems with excessive or inadequate chilling in different winters.

In parts of eastern Australia where no killing freezes occur in an average winter, the low-chill Florida cultivar 'Sharpblue' never enters dormancy if planted on good soil with ample water and fertilizer. Vegetative growth, flowering, and fruiting occur throughout the year, although at lower rates during winter. In south-central Florida (e.g. Highlands County) 'Sharpblue' and other low-chill highbush may tend to behave in a similar way during mild winters.

Rabbiteye blueberry cultivars were bred from a single, deciduous species, *V. ashei*, which is not native south of the Santa Fe River in northern Alachua County. Although rabbiteye cultivars are low in chill requirement compared to the highbush cultivars grown from North Carolina north, *the rabbiteye cultivars* tested so far yield far less in Clermont and Sebring than the same cultivars planted in colder areas such as Gainesville, Florida, Tifton, Georgia, or Mobile, Alabama. Vegetative growth can be excellent on rabbiteye plants in south-central Florida, even in cases where fruit production is much depressed. It is hoped that the problem of low yields on rabbiteye blueberries in the southern half of the Florida Peninsula can be overcome by new cultivars, combined with a better understanding of the mechanisms involved in yield reduction.

Heat unit accumulation. Heat unit accumulation in February, March, and April is much higher in the Sebring-Plant City production areas than it is in north Florida, southeast Georgia, and in the blueberry growing areas from Alabama to southeast Texas (Fig. 1-4). Once the chill requirement of a blueberry cultivar has been satisfied, leaf and flower buds will resume growth at temperatures as low as 45°F, but development is much faster at higher temperatures up to a limit of about 90°F. Examination of mean temperatures and flowering dates for various blueberry production areas in the eastern United States suggests that

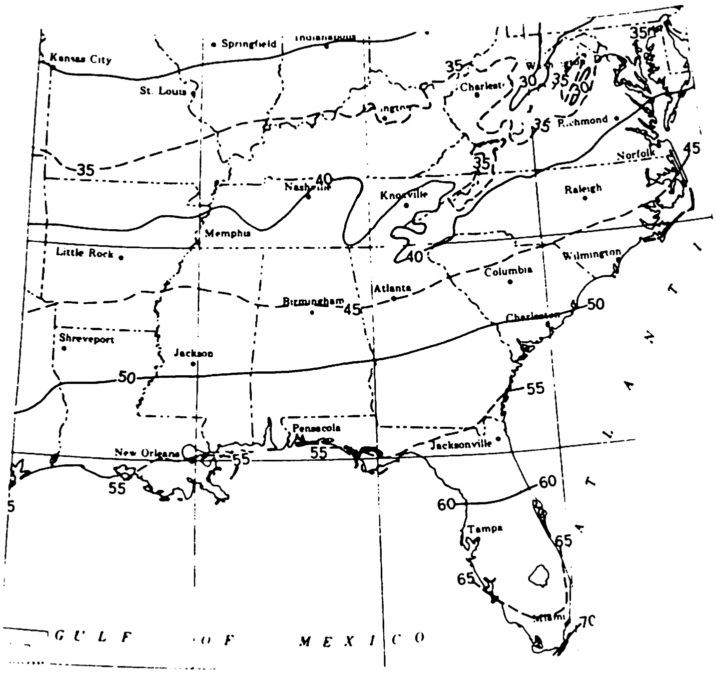

Fig. 1. January mean temperatures F°.

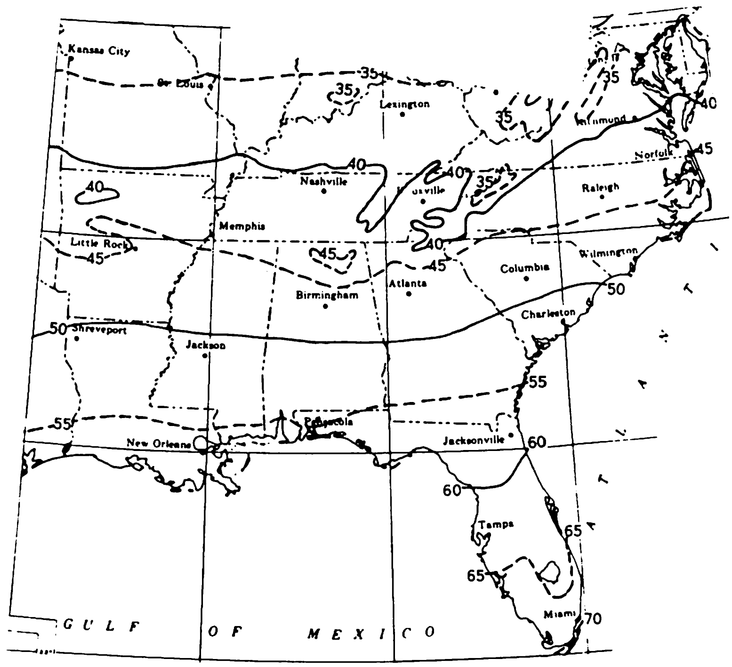

Fig. 2. February mean temperatures.

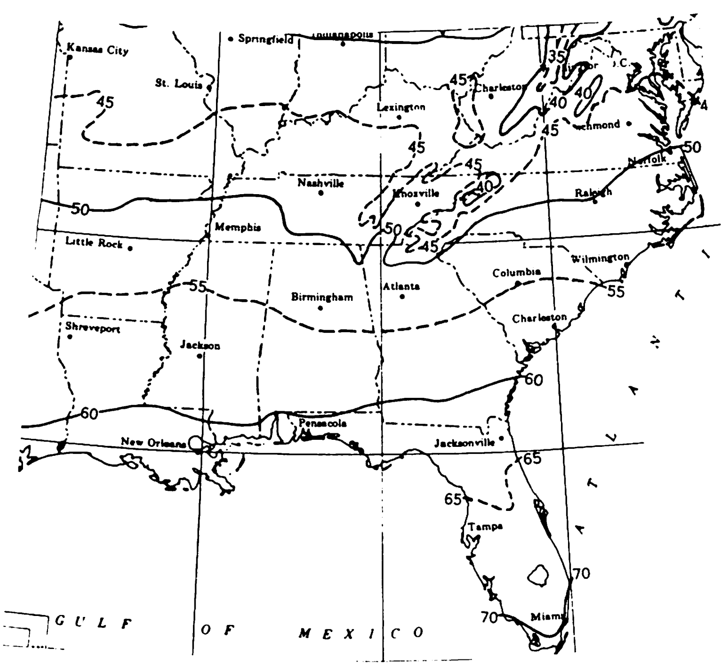

Fig. 3. March mean temperatures.

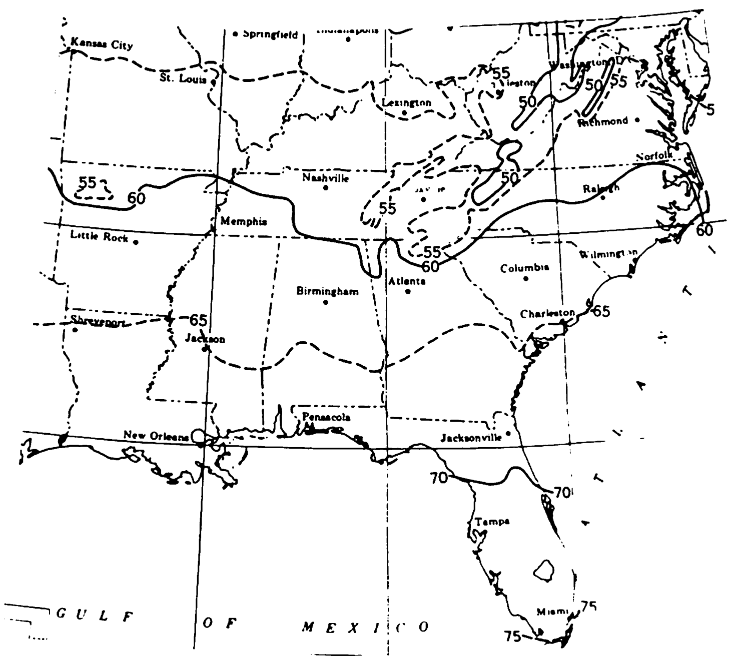

Fig. 4. April mean temperatures (all charts from ref. 1).

growers in each production area have selected cultivars that reach full flowering at a date in the spring such that the subsequent 30 day period will have a mean temperature of about 62°F. If this generalization holds in Florida, it appears that sufficient heat units are available in most winters in Highlands County to support vegetative growth, flowering, and fruit development throughout January and February. Thus, if very low-chill cultivars are grown and the problem of January through March freezes can be solved it should be possible to have the plants flower in early January at Lake Placid and ripen beginning in mid-March. Whether or not this can be routinely achieved with 'Sharpblue' in Highlands County remains to be seen. In extreme north Florida, heat units sufficient to promote rapid development of blueberry flowers and leaves normally do not begin to accumulate until about March 1 (Fig. 1-4). With good cross-pollination, first commercial harvest in this area should be about the first week in May with early-ripening highbush cultivars.

Damaging freezes. Late-winter and early-spring freezes can devastate a blueberry crop, and Florida growers have suffered substantial crop losses over the past decade. Temperatures above 28°F in the field normally do not damage fruit or flowers. The effects of lower temperatures depend on the stage of development of the flower buds, flowers, or fruit at the time of the freeze. Fruit and opened flowers are normally destroyed at about 28°F. Flowers that are not yet opened are somewhat hardier, and dormant flower buds are hardy below 0°F. The later a cultivar flowers, the less often it will suffer crop reductions due to freezes. In Florida, the risk of freeze damage is high for low-chill cultivars unless protective measures are taken. The most common protective measure is overhead irrigation. A well-designed system, although expensive, can protect the crop down to about 20°F on nights with no wind (5). Although crop losses can still occur with windy (advective) freezes, these are much less common than radiation freezes.

Maps showing the mean dates of the last 28° temperature are useful but often misleading. These maps are usually based on data from urban stations, which are significantly warmer (2° to 5°F) than nearby farmland on radiation-freeze nights. Seemingly minor elevation differences can also result in large differences in minimum temperatures within a few square miles on frost nights. Soils with organic matter sufficient for growing blueberries usually occur in pockets that are cold and freeze-prone compared to nearby sandy ridgeland. Temperatures low enough to damage a blueberry crop can occur as late as April 1, even as far south as the colder areas of Highlands County. Nonetheless, freeze damage should average much lower in the south-central production areas than in northern Florida if the same cultivars are planted in both areas.

Rainfall and Blueberry Production in Florida

The Florida peninsula north of Lake Okeechobee averages 50 to 55 inches of rain per year, most of which falls in the 4 months from June through September. The panhandle west of the Apalachicola River averages 60 to 65 inches per year. This heavy rainfall greatly reduces the need for irrigation, but can also have adverse effects such as leaching soil nutrients, promoting foliage, flower and root diseases, interfering with harvest, and reducing fruit quality by causing fruit cracking and a loss of fruit surface waxes.

The rainfall distribution pattern in most of Florida provides another reason (other than higher market prices for early fruit) for planting early rather than late-ripening blueberry cultivars in Florida (1). Compared *to most other* blueberry production areas, rainfall patterns in the Florida peninsula are highly favorable for blueberry harvest in April and May, but unfavorable after mid-June. April and May, the harvest months for highbush blueberries, each average less than 3.5 inches of rain per month in the peninsula north of Lake Okeechobee. By contrast, June rainfall averages about 7.4 inches in south central Florida, 7.2 inches in north-central Florida, and 5.9 inches in northeast Florida. July rainfall averages near 8 inches over most of the peninsula. In the panhandle west of the Apalachicola River, May (highbush harvest season) rainfall averages about 4.1 inches and June and July rainfall (rabbiteye season) averages 5.2 and 8.1 inches, respectively. July rainfall will frequently cause harvest problems throughout Florida for any berries ripening that late. Excellent drainage should be provided for late-ripening rabbiteye cultivars planted for machine harvest.

Heavy rainfall and/or long rainy periods are also highly undesirable during the season of blueberry flowering, because they promote blossom blight (*Botrytis cinerea*) and reduce the effectiveness of pollinating bees. January, February, March, and April all provide good flowering weather in most years in the Florida peninsula, with monthly rainfall averaging 2 to 3.5 inches. In the western panhandle, conditions are less favorable, with an average rainfall of 5.5 inches during the primary flowering month (March) and 4.8 inches in April.

Excessive rains (for example, 4 inches in 48 hours, 8 inches in 2 weeks, or 12 inches in 4 weeks) occur with some regularity over localized areas throughout Florida during the summer and early fall. Such rains can be extremely damaging if they overwhelm the drainage system provided for the blueberry field. Water standing around the roots of the plants for 24 hours or more and soils that remain saturated for a week or more in the top 18 inches around the blueberry plants can cause severe root damage or death if *Phytophthora cinnamomi* is present in the soil. The extent of the damage may not be apparent for several months, and the connection between the earlier flooding episode and the later decline of the plants is not always recognized. Damage to blueberry plants in different flooding episodes varies widely depending on the duration of the excessively wet period, the season of the year, the condition of the plants at the time of the flood, and, perhaps most important, the level of *Phytophthora cinnamomi* infection *in the* field (2,3,9). Excessively wet soils and *Phytophthora* root rot are a lethal combination in a blueberry field and can do enormous damage. Growers should provide blueberry fields with drainage systems sufficient to handle occasional deluges, and in extreme floods, when the soil has remained saturated around the plants for several days during the warm season, all legal methods available should be used to prevent a subsequent outbreak of Phytophthora root rot. Planting blueberries on raised beds is very important in combating Phyotophthora root rot on most Florida blueberry soils.

Hurricanes and Other Strong Winds

No part of Florida is entirely free from the threat of hurricanes, although the greatest threat of damaging winds is along the lower east coast and near the coastline of the panhandle. Even in these areas, the probability of wind damage from hurricanes on a particular farm in a particular year is low. By far, most hurricanes that seriously affect Florida occur during August, September, and October, which is after the fruit has been harvested. Blueberry plants on well-drained soil are not readily damaged by high winds, but where a high water table has prevented development of a deep root system, plants may be uprooted by winds well below hurricane force (75 mph). Such strong winds in Florida occur more commonly from thunderstorm downbursts than from hurricanes. Excessive rains from hurricanes and tropical storms can occur anywhere in Florida, and represent a greater threat to the blueberry grower than do high winds.

Occasionally during April, strong westerly winds that follow the passage of cold fronts can blow part of the fruit off highbush blueberry plants in Florida. Some rabbiteye blueberries may also be blown off the bushes by severe thunderstorms that occur during rabbiteye ripening season. Hail can be very damaging to blueberries during the fruiting season, but hailstorms are rare in Florida.

In summary, the Florida climate presents both problems and opportunities for the potential blueberry grower. High mean temperatures during January, February, and March suggest that some low-chill cultivars grown in Highlands County could ripen fruit at least a month before the start of blueberry harvest in the areas from southeast Georgia through southeast Texas and at least 7 weeks before North Carolina. On the other hand, freezes during February and March will frequently put the crop in jeopardy. Florida's normally low rainfall and bright sunshine from January through May enhance berry quality and facilitate harvest, but heavy summer rains can cause problems with flooding and with *Phytophthora* root rot.

Literature Cited

1. Baldwin, John L. 1968. Climatic Atlas of the United States. National Climatic Data Center, Federal Building, Asheville, NC 28801.
2. Crane, J. H. and F. S. Davies. 1988. Flooding duration and seasonal effects on growth and development of young rabbiteye blueberry plants. J. Amer. Soc. Hort. Sci. 113:180-184.
3. Crane, J. H. and F. S. Davies. 1989. Flooding responses of *Vaccinium* species. HortScience 24:203-210.
4. Eck, P. and N. F. Childers. 1966. Blueberry Culture. Rutgers Univ. Press, New Brunswick, NJ.
5. Harrison, Dalton, J. S. Gerber, and R. E. Choate. 1974. Sprinkler irrigation for frost protection. Fla. Coop. Ext. Serv. Cir. 348.
6. Lyrene, P. M. 1987. Early-flowering, early-ripening blueberry germplasm for central Florida. Proc. Fla. State Hort. Soc. 100:296-300.
7. Lyrene, P. M. and W. B. Sherman. 1988. Cultivation of highbush blueberries in Florida. Proc. Fla. State Hort. Soc. 101:269-272.
8. Lyrene, P. M. and W. B. Sherman. The rabbiteye blueberry industry in Florida—1887 to 1930—with notes on the current status of abandoned plantations. Economic Botany 33:237-243.
9. Ploetz, R. C. and B. Schaffer. 1987. Effects of flooding and Phytophthora root rot on photosynthetic characteristics of avocado. Proc. Fla. State Hort. Soc. 100:290-294.
10. Sharpe, R. H. 1954. Horticultural development of Florida blueberries. Proc. Fla. State Hort. Soc. 66:188-190.
11. Sharpe, R. H. and G. M. Darrow. 1959. Breeding blueberries for the Florida climate. Proc. Fla. State Hort. Soc. 72:308-311.
12. Sharpe, R. H. and W. B. Sherman. 1971. Breeding blueberries for low-chilling requirement. HortScience 6:145-147.
13. Sharpe, R. H. and W. B. Sherman. 1976. 'Sharpblue' blueberry. HortScience 11:65.

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GUAVA AND PASSIONFRUIT AS COMMERCIAL CROPS IN FLORIDA

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Abstract. **Guava and passionfruit are commercial crops in Dade County. About 80 acres of guava and 30 acres of passionfruit have been planted in South Florida (J. Crane, personal communication, 1989). Their popularity with growers and shippers varies considerably between seasons and year-to-year. Disease, storage problems, and varying market, however, are serious problems of the two new crops. Many grower questions are still unanswered. What can I do to fight disease? Which variety should I plant? What are the best handling methods? Can the fruit be stored successfully? Volume shipped of either fruit can exceed 100,000 pounds annually. An uncommonly large percentage of fruit shipped is rejected. The customer's minimal knowledge of the fruit and improper handling can cause rejections; so can overproduction at certain peak times. These fruits are inherently difficult to store and ship because of their rapid ripening. Both fruits are extremely well suited for processing but little or none of this is done in Dade County. Growers, packers, and buyers must work together and educate themselves about growing requirements, proper handling practices, and marketing strategies for the expansion of these fine fruits in the U.S. marketplace.**

Passionfruit and guava have been grown in South Florida for many years, primarily as dooryard fruits. Attempts to cultivate guava on a commercial scale have met with limited success over the years. Recently, however, these two fruits have seen a dramatic increase in consumer popularity. Along with this popularity has come an increase in acres cultivated and pounds shipped from Dade County. The cultivation, harvest and shipping of these crops presents the grower with a unique set of problems and challenges.

Passionfruit

Passionfruit is a woody, perennial vine (1). There are currently about 30 acres of passionfruit in Dade County. A commercial passionfruit planting consists of a wire and post trellis. Most are made to a height of 6 feet to allow management of the system entirely by hand. The arrangement of the trellis may vary from a simple upright post to a "T" configuration. Posts and wire should be strong