ing. However, the reduction in net CO_2 assimilation on a whole plant basis is still great after unflooding due to the reduction of leaf area.

Flowering and fruiting. Under normal conditions, carambola fruit retention is markedly lower than fruit set (7). In this study, flooded trees retained the greatest number of fruit. Therefore, flooding stress possibly increases fruit retention of carambola. However, more research is needed in this area.

In summary, 'Golden Star' carambola appeared to be somewhat flood tolerant and has the ability to recover from flooding stress with respect to net gas exchange. However, both continuous and intermittent flooding result in decreased biomass accumulation. In addition, flooding of carambola appears to slightly increase flowering and fruit set.

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ACREAGE AND PLANT DENSITIES OF COMMERCIAL CARAMBOLA, MAMEY SAPOTE, LYCHEE, LONGAN, SUGAR APPLE, ATEMOYA, AND PASSION FRUIT PLANTINGS IN SOUTH FLORIDA

JONATHAN H. CRANE
University of Florida, IFAS
Tropical Research and Education Center
18905 S.W 280 St.
Homestead, FL 33031-3314

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Abstract. **A survey of seven commercial tropical fruit crops grown in south Florida was conducted to determine current acreage, total number of trees, primary cultivars, grove ages, and predominant plant spacings. Current acreage is as follows: carambola (*Averrhoa carambola* L.), 435; mamey sapote (*Calocarpum sapote* (Jacq.) Merr.), 267; lychee (*Litchi chinensis* Sonn.), 190; longan (*Euphoria longana* (Lour.)**

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Steud.), 72; sugar apple (*Annona squamosa* L.), 49; atemoya (*Annona cherimola* Mill. x *A. squamosa* L.), 47; and passion fruit (*Passiflora edulis* Sims), 20 acres. Most of the carambola, lychee, longan, atemoya, and passion fruit acreage is 4 years old or younger. In contrast, more than half the mamey sapote and sugar apple acreage is 5 years old or older. Most carambola, lychee, and sugar apple acreage is planted at moderate plant densities while most mamey sapote, atemoya, and longan acreage is planted at low plant densities. Intermediate within-row plant spacings (e.g., 15 ft, 20 ft) are favored by many growers, while some utilize close within-row plant spacings (e.g., 10 ft.) with the idea of removing trees upon crowding. Acreage and production of these tropical fruit crops are expected to increase in the near future. The survey information should be useful in determining possible research and marketing needs for these crops.

South Florida's commercial tropical fruit acreage has historically been dominated by avocados, 'Tahiti' limes, and mangos (13, 18). Recent figures estimate south Florida has 11,239 acres of avocados, 6,792 acres of limes, and 2,895 acres of mangos (1). Many other tropical fruits such as papaya, acerola, sapodilla, guava, banana, mamey sapote, and lychee have been grown commercially on a minor scale (i.e., <400 acres each) for the past 20-30 years (2, 3).

During the past 5-10 years, commercial acreage of carambola, atemoya, sugar apple, longan, and passion fruit has been established and acreage of mamey sapote and lychee has increased (4, 5, 11, 12). Papaya, acerola, sapodilla, and guava acreages have remained near previous levels.

Recommended cultural practices and cultivars have been described for carambola (6, 9), mamey sapote (7, 17), lychee (8, 14), longan (3, 14, 15), sugar apple (4, 11, 16), atemoya (4, 10, 11), and passion fruit (4, 12). However, little information is available on the current acreage and plant spacings employed by commercial growers of these crops. With this in mind, an extensive survey was conducted of south Florida groves with the objective of determining the current acreage, number of trees, primary cultivars, grove ages, and plant densities and spacings. This information may be of value to the tropical fruit crops industry (e.g., growers, packers, marketers) in determining future trends in production and marketing and in helping identify possible research needs.

Materials and Methods

The bulk of the data reported in this study was compiled by the Research Committee of the Tropical Fruit Growers of South Florida, Inc. and the author during the summer of 1988. Initial and subsequent computations and updates (Nov., Dec., 1988; Jan., 1989) were carried out by the author. The last update occurred during May 1989 and is reported here.

To obtain the desired data, the Research Committee composed a list of commercial growers. A survey form was designed by the author and used when interviewing commercial growers by telephone or in person. Commercial carambola growers were defined as growers with 50 or more trees, while plantings of 25 or more plants of mamey sapote, lychee, longan, sugar apple, atemoya, and passion fruit were considered commercial.

The survey form was used to record the number of acres and trees, cultivars grown, area planted and number of trees of a particular cultivar (if available), number of acres and trees at a particular plant spacing, and tree ages. Groves of <100 trees per acre were considered planted at low density; 100 to 200 trees per acre, moderate density and >200 trees per acre, high density. Effort was made to contact all commercial growers with established and new plantings.

Results and Discussion

South Florida currently has approximately the following numbers of commercial growers: carambola, 68; mamey sapote, 30; lychee, 40; longan, 20; sugar apple, 16; atemoya, 9; and passion fruit, 13. However, the number of commercial growers and plantings will most likely increase in the near future due to increased consumer demand and the high prices obtained for these crops (5).

Dade and Lee Counties have commercial plantings of all 7 crops. Small acreages of lychee and carambola can be found in Broward and Palm Beach Counties, respectively and some interest has been shown in establishing plantings for all these crops in Collier County.

Carambola. About 435 commercial acres of carambola are currently in south Flcrida. Eighty-nine percent of the acreage is 4-years-old or younger. Ninety-four percent (410 acres) is planted to sweet cultivars and 6% (25 acres) to tart cultivars. There are about 50,858 carambola trees in commercial plantings; 97% (49,050 trees) of the trees are sweet cultivars and 3% (1,808 trees) are tart cultivars. The predominant sweet cultivar is 'Arkin' and predominant tart cultivar 'Golden Star'. The sweet cultivar 'Fwang Tung', is grown commercially to a very limited extent.

Seventy-seven percent of carambola acreage is planted at moderate plant densities (e.g., 145 trees/acre) (data not shown). Of that 77%, 58% is set at 6 moderate plant spacings (Table 1). Low density plantings (e.g., 69-87 trees/acre) account for about 18% of the acreage (Table 1). About 5% of the acreage is planted at high density (e.g., 290 trees/acre or more) with the majority of that acreage utilizing a 10 ft x 15 ft spacing (data not shown).

Interplanting of low and moderately spaced carambola trees is a common practice in south Florida. Generally, the interplanted species is a fast growing fruit crop such as papaya or banana which affords the young carambola trees

Table 1. Carambola plant density and percentage of acreage at various spacings.

Plant density	Plant spacing (ft)	Number of trees per acre	Percent of total acreage
Moderate	15 x 22	132	16
Moderate	15 x 20	145	15
Moderate	15 x 25	116	11
Low	25 x 25	69	11
Low	20 x 25	87	7
Moderate	20 x 20	108	6
Moderate	12.5 x 25	139	5
Moderate	16 x 23	118	5
Misc.[z]	—	—	24

[z]Various plant densities and spacings, each accounting for less than 5% of carambola acreage.

some wind protection and the grower early income. When crowding occurs, the interplanted papaya or banana plants are easily removed. Generally, high density plantings are not interplanted and are designed to be hedged and topped to form hedge-rows as they mature.

Mamey sapote. South Florida currently has about 267 acres and 23,267 mamey sapote trees in commercial production. About 60% of the acreage is 5 or more years old and the predominant cultivars are 'Pantin' ('Key West') and 'Magana'. Selections like 'Prolific', 'Cuban No.2', and 'Pace' are also planted to a limited extent.

Fifty-nine percent of the mamey sapote acreage is planted at low plant densities (e.g., 48-96 trees/acre) (data not shown). Most (54%) low density plantings utilize 18-25 ft within row and 25-30 ft between row spacings (Table 2). Moderate plant densities account for 40% of the acreage, with the 15-20 ft within row and 16-20 ft between row plant spacings accounting for 32% of the acreage. Only 1% of the acreage is planted at high density and all of this uses a 10 ft x 20 ft spacing.

Lychee. South Florida has about 190 acres of lychee. Thirty-four percent of the acreage (64 acres) is planted to 'Brewster', 65% (124 acres) to 'Mauritius', and 1% (about 2 acres) to miscellaneous cultivars. Similarly, of the 16,690 total trees in commercial production, 34% (5,686 trees) are 'Brewster', 65% (10,820 trees) are 'Mauritius', and 1% (184 trees) are of other cultivars (mostly 'Bengal'). Nearly 71% of the commercial lychee acreage is 4-years-old or less.

Low density (e.g., 40-96 trees/acre) lychee plantings account for about 45% of the total lychee acreage while 52% and 3% of the acreage is planted at moderate (e.g., 103-174 trees/acre) and high (e.g., 217 trees/acre) densities, respectively (data not shown). Most low (34%) and moderate (43%) density groves utilize just 4 different plant spacings (Table 3) while a 10 ft x 20 ft spacing is used in all high density groves (data not shown).

Low density groves are typically interplanted with a precocious fruit crop (e.g., sugar apple, banana) and many of the moderately dense groves are double-set (e.g., 10 ft x 25 ft, 12.5 ft x 25 ft) within rows (Table 3). In both cases, tree removal is planned for interplanted trees because of the large size (40 ft tall and wide) of mature lychee trees (8).

Longan. South Florida has about 72 acres and 7,297 longan trees in commercial production. The predominant cultivar grown is 'Kohala' and about 69% of the acreage is 4-years-old or less.

Table 2. Mamey sapote plant density and spacing and percentage of acreage at various spacings.

Plant density	Plant spacing (ft)	Number of trees per acre	Percent of total acreage
Moderate	20 x 20	108	26
Low	30 x 30	48	20
Low	18 x 30	86	10
Low	20 x 30	72	10
Low	20 x 25	87	9
Low	25 x 25	69	5
Misc.[z]	—	—	20

[z]Various plant densities and spacings, each accounting for less than 5% of mamey sapote acreage.

Table 3. Lychee plant density and spacing and the percentage of acreage at various spacings.

Plant density	Plant spacing (ft)	Number of trees per acre	Percent of total acreage
Low	25 x 30	58	14
Moderate	10 x 25	174	14
Moderate	20 x 20	108	12
Moderate	12.5 x 25	139	12
Low	20 x 25	87	8
Low	25 x 25	69	6
Low	25 x 26	67	6
Moderate	15 x 25	116	5
Misc.[z]	—	—	23

[z]Various plant densities and spacings, each accounting for less than 5% of lychee acreage.

Most (58%) of the longan acreage is planted at low densities (e.g., 41-91 trees/acre). Of that 58%, 56% have trees set at 20-30 ft within rows and 25-30 ft between rows (Table 4). Thirty-five percent of the acreage is planted at moderate densities (e.g., 108-145 trees/acre). Seven percent of the plantings are set at 10 ft x 20 ft spacing (Table 4).

As with lychee and mamey sapote, interplanted or double-set longan groves are common. Tree removal is recommended when crowding begins since longan trees have the potential to get quite large (35 ft high and 45 ft wide) (15).

Sugar apple. South Florida has about 49 acres and 5,261 sugar apple trees in commercial production. About 40% of the acreage is 4-years-old or younger. Sugar apple growers generally plant seedlings of known or unknown parentage because there appears to be little variability among seedling trees and seedlings are precocious bearers (16).

About 49% of the sugar apple acreage is at moderate (e.g., 108-174 trees/acre) plant densities while 22% and 28% are at low (e.g., 48-96 trees/acre) and high (e.g., 223-290 trees/acre) plant densities, respectively (data not shown). Forty-eight percent of the sugar apple acreage is set at 5 different moderate plant spacings, 11% at a wide spacing (30 ft x 30 ft), and 8% at a close spacing (10 ft x 20 ft) (Table 5).

Generally, moderate and high density sugar apple plantings are not interplanted while many low density sugar apple plantings are the result of sugar apple trees being used as the interplant among another fruit crop

Table 4. Longan plant density and spacing and percentage of acreage at various spacings.

Plant density	Plant spacing (ft)	Number of trees per acre	Percent of total acreage
Low	20 x 25	87	19
Low	25 x 30	91	12
Moderate	12.5 x 25	139	11
Moderate	12.5 x 24	145	11
Low	20 x 30	72	11
Low	25 x 25	69	9
High	10 x 20	217	7
Low	30 x 30	48	5
Moderate	20 x 20	108	5
Misc.[z]	—	—	10

[z]Various plant densities and spacings, each accounting for less than 5% of longan acreage.

Table 5. Sugar apple plant density and spacing and percentage of acreage at various spacings.

Plant density	Plant spacing (ft)	Number of trees per acre	Percent of total acreage
Moderate	15 x 20	145	17
Low	30 x 30	48	11
Moderate	12.5 x 20	174	10
Moderate	15 x 25	116	9
High	10 x 20	217	8
Moderate	13.5 x 24	134	7
Moderate	20 x 20	108	5
Misc.[z]	—	—	33

[z]Various plant densities and spacings, each accounting for less than 5% of sugar apple acreage.

(e.g., mamey sapote, lychee, and longan). The sugar apple tree's small size (15-20 ft in height and 20 ft in width) (4, 16) accounts for its use as an interplant tree among other fruit crops.

Atemoya. There are about 47 acres and 5,702 atemoya trees in commercial production in south Florida. About 55% of the acreage is 4-years-old or younger and the predominant cultivar grown is 'Gefner'.

Most (42%) of the atemoya acreage is planted at low plant densities (e.g., 57-87 trees/acre) (Table 6). Thirty-four percent of the acreage is planted at moderate plant densities (e.g., 108-174 trees/acre) (data not shown). High plant densities (e.g., 217-290 trees/acre) account for 24% of the acreage and 22% of the high density plantings use a 10 ft x 20 ft spacing (Table 6). Because mature atemoya trees can reach a height and spread of over 30 ft (10), tree removal and/or pruning is planned for most high density atemoya groves. Interplanting with sugar apple or some other fruit crop is common in low density atemoya groves.

Passion fruit. South Florida currently has about 20 acres and 6,280 vines of commercial passion fruit. However, acreage estimates are difficult because many growers plant passion fruit along fence rows. In formal plantings where trellises are used, vines are planted every 5-12 ft and trellises are spaced every 10-15 ft apart. Nearly 52% of the present passion fruit plantings are 1-year-old.

Conclusions. South Florida has seen a substantial increase in carambola, lychee, longan, atemoya, and passion fruit acreage in the last 4 years as evidenced by the proponderance of young groves of these fruit crops. This is due to an increased consumer demand and the high prices growers receive for these crops. Because of the current good market for these fruits, new and established growers are planning to increase lychee, longan, atemoya, and passion fruit acreage. However, as these young plantings mature and fruit production increases, increased marketing will become essential.

Most mamey sapote and sugar apple acreage is 5 years old or older suggesting that new planting of these 2 crops has slowed. This does not mean new acreage will not be planted in the future. Rather it reflects the fact that the mamey sapote market has remained limited and the shelf life of sugar apples has restricted the distance and time it can be marketed. Acreage will most likely increase if new uses (e.g., ice cream) and markets are developed for these 2 crops.

Table 6. Atemoya plant density and spacing and percentage of acreage at various spacings.

Plant density	Plant spacing (ft)	Number of trees per acre	Percent of total acreage
Low	20 x 25	87	38
High	10 x 20	217	22
Moderate	12.5 x 20	174	11
Moderate	15 x 20	145	7
Moderate	20 x 20	108	4
Moderate	12.5 x 22	158	4
Low	27 x 28	57	4
Moderate	15 x 23	126	4
Misc.[z]	—	—	6

[z]Various plant densities and spacings, each accounting for less than 4% of atemoya acreage.

Most carambola, lychee, and sugar apple acreage is planted at moderate densities while most mamey sapote, atemoya, and longan acreage is planted at low densities. However, interplanting is common and in some instances within row distances among the same crop may be wide (every other tree) but distances between different tree crops close.

Research is needed to determine optimum spacings as evidenced by the wide variability in spacings for all 7 of these crops. Tree size control and training are 2 related areas of research that would also benefit the tropical fruit crops industry.

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