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Hurricane Andrew Damages Tropical Fruit Crops in South Florida

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Abstract

On 24 August, 1992, Hurricane Andrew struck South Florida's tropical fruit production area with sustained winds of 230 kph and gusts exceeding 280 kph. Damage to fruit crops included defruiting, defoliation, limb and trunk breakage, windthrowing (uprooting), sunburning and the stripping of bark from the trunks and limbs by flying debris. In general, older and taller trees were more severely damaged than younger and shorter trees. Selective limb removal, topping and other pruning practices that reduced overall tree height and opened up the canopy greatly reduced the occurrence of windthrow and severe breakage. Severe damage occurred on lime, mango, passion fruit, lychee, longan and sapodilla; damage was moderate on atemoya, avocado, banana, coconut, mamey sapote, papaya and sugar apple; and light damage occurred on carambola and guava. The full extent of injury cannot yet be determined as additional losses will occur due to the direct trauma of the hurricane, insects and diseases, cold temperatures and drought.

South Florida has a unique tree fruit industry due to the various tropical and subtropical fruits grown commercially there and nowhere else in the continental United States (2, 4, 6). Tropical fruit orchards are concentrated in southern Dade County, with additional orchards extending northward in a narrow band along both coasts of the state to about 28° latitude. In 1992, there were about 8,900 ha of tropical fruit orchards in Dade County that produced crops with an estimated gross value of $74 million (9). On 24 August, 1992, Hurricane Andrew passed through this production area with maximum sustained winds of 230 kph and gusts in excess of 280 kph. The impact on the local populace was enormous, but the damage inflicted on fruit trees was equally devastating and provided an exceptional opportunity to observe the influence of hurricane-force winds on different fruit crops.

Materials and Methods

Observations were made on experimental tropical fruit orchards at the Fairchild Tropical Garden's Research Center, the University of Florida, and on many commercial orchards in South Florida. The conclusions presented are the compilation of observations by all of the authors. Specific information about percentages of lost acreage are the result of personal observations and recording by the authors and surveys of damage conducted at grower's meetings after the Hurricane. Observations are general, as the extent of damage varied due to cultural practices, orchard site, tree age, wind speed, and damage due to debris.

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General Observations

Walker (10) reported that taller trees and trees with a greater trunk cross sectional area in a forest community in Puerto Rico were more subject to windthrow (uprooting) and breakage than smaller trees during Hurricane Hugo. Similar observations were made following Hurricane Andrew in tropical fruit orchards in South Florida. Thus, younger, smaller trees—regardless of the fruit crop—generally sustained less damage than older, larger trees if other conditions were equal.

Pruning was an important factor in the severity of tree damage caused by the hurricane (Figs. 1 and 2). Pruning by selective removal of limbs or by topping and hedging, significantly reduced tree wind resistance, improving the chances for the tree to remain upright (Fig. 1). Often, recently pruned trees (within 3 years) had the branches produced since the last pruning broken by the wind while the larger scaffold limbs remained. Therefore, there was significant breakage, but the basic architecture of the tree remained. In general, these trees have had more vigorous regrowth than righted windthrown trees, probably because their roots had less damage.

Planting method also influenced hurricane damage regardless of the crop. In the shallow limestone soils of South Florida, trenches are often used for planting fruit trees to provide a greater volume of soil for root development and improved anchorage. Trenches are usually dug into the oolitic limestone rock (0.5 m deep) in two directions and backfilled with the soil and crushed rock; trees are planted where the trenches cross. Trees planted in this manner were windthrown less compared to trees planted without trenches; however, breakage was often severe. In the areas of the strongest winds, the trees often broke off low on the trunk near the soil line. Trees planted without trenches, with their shallower root systems were prone to windthrow (Fig. 2), but limb and trunk breakage was less severe. Past experience has shown that with proper care the windthrown trees can be righted (set up) with good reestablishment (Figs. 3 and 4).

Just before the hurricane, much of the farm land in South Florida was being prepared for planting vegetables. Soil and rocks from these open fields were propelled by the hurricane winds, resulting in severe damage to the bark of trees. In many cases this blowing debris removed all of the bark on the upwind side of the tree. Whether trees with this damage can properly heal these injuries and remain commercially viable is unknown at this time.

With the removal of the foliage and the horizontal orientation of the windthrown trees, sunburning of the exposed trunk has been severe on nearly all fruit crops. White-washing can protect against this damage, but with the number of trees windthrown and the inability to move equipment through the orchards, it has not been feasible to treat the trees in many orchards. Sunburned trees have developed large necrotic areas on their trunks and limbs, and on many trees there has been severe die-back as a result of this damage.

Specific Fruit Crops

In addition to the general observations presented above, there were differences among the specific tree fruits damaged by the hurricane (Table 1).

Atemoya and sugar apple. The 40 ha of atemoya (*Annona cherimola* L. X *A. squamosa* L.) and sugar apple (*Annona squamosa*) were lightly to moderately damaged by the hurricane compared with other crops. These two related fruits both form small (4.5 m), open canopies. Trees were defruited and defoliated, with some limb breakage and substantial windthrowing. However, because the trees were small, they were easily righted. Their

Figure 1. Recently pruned forty-year-old avocado orchard with defoliation and light limb breakage immediately following Hurricane Andrew.

recovery has been slow to moderate in most orchards.

Avocado. Avocado (*Persea americana* Mill.) orchards were moderately damaged by the hurricane, with severe limb and trunk breakage and many trees were windthrown (Fig 2). It is estimated that 35% of the 3,500 ha of avocados were destroyed as a result of the hurricane. The damage to avocado orchards was variable, due to extreme differences in size and age of trees and pruning practices (Figs. 1 and 2). Many orchards which had been regularly pruned had 60% or more of the trees still standing, and trees that were promptly righted and well cared for have shown substantial recovery (Fig. 3). Other orchards with large unpruned trees lost the majority of the trees to windthrow and severe breakage of limbs and trunks. There has been a significant bloom on the trees that remained standing following the hurricane, and even on some of the righted trees. Brooks (1) reported that West Indian race avocados were slower to recover from hurricane damage than trees of the Guatemalan or hybrid races; West Indian and hybrid races are both grown commercially in South Florida. To date, differences in the recovery rate of West Indian avocados has not been observed following Hurricane Andrew.

Banana. About 200 ha of bananas (*Musa* hybrids) were grown in South Florida prior to Hurricane Andrew. These were mostly nontraditional (not 'Cavendish') cultivars sold through specialty markets. Mature banana plants have multiple succulent pseudostems which were heavily damaged by the hurricane winds. However, due to the suckering habit of the plants and the fast growth rate, recovery has been swift and they will produce fruit within the coming year.

Carambola. Carambolas (*Averrhoa carambola* L.) are grown commercially on 200 ha in South Florida. Damage as a direct result of the wind was light when compared with other crops. Trees were defruited and defoliated,

Figure 2. Unpruned twenty-five-year-old avocado orchard with severe windthrowing, defoliation and breakage immediately following Hurricane Andrew.

but there was little limb breakage and windthrowing. Hurricane winds were presumably less damaging to carambola than to other crops because of the flexibility of the carambola branches. Also, the majority of the carambola trees were still young and less than 6 m tall. Areas where damage to carambola trees was more severe had stripping of bark by flying debris and other materials such as shade cloth used for windbreaks in commercial carambola plantings. Recovery of severely damaged carambola trees is a concern as the trees are quite susceptible to desiccating winds during the winter. Such stress can cause severe dieback and even death during the winter in South Florida (5, 8). Many carambola trees refoliated and bloomed within one month after the hurricane, but set no fruit; a second bloom occurred on some cultivars (e.g. 'Kary,' 'Arkin') two months after the storm and an appreciable crop was set.

Coconut. Twenty ha of coconut (*Cocos nucifera* L.) are grown in South Florida for fresh consumption. Trees were moderately damaged, with the majority of the fronds broken or twisted. All of the fruit were lost. Windthrowing was common, although the trees could usually be easily righted. Recovery of righted and damaged trees has been moderate to fast and the righted trees have begun to flower.

Guava. Guava (*Psidium guajava* L.) trees had only minor damage as a result of the hurricane. This was due to the small, open growth habit of the tree and the rigorous pruning practices used with this crop. There was some limb breakage and windthrowing, but the trees have recovered quickly and most of the 32 ha will be salvageable. A light crop was set within two months after the hurricane.

Lime. The 2,500 ha of 'Tahiti' lime (*Citrus latifolia* Tan.) sustained the greatest damage from Hurricane An-

Table 1. Damage to fruit crops in South Florida by Hurricane Andrew (24 August 1992).

Fruit crop	Hectares	Severity of damage	Type of damage[z]	Recovery rate
Atemoya/sugar apple	40	Light-moderate	DFR, DFO, W, S	Slow-moderate
Avocado	3500	Moderate	DFR, DFO, B, W, S	Moderate-fast
Banana	200	Moderate	B, W, S	Fast
Carambola	200	Light	DFR, DFO, S	Moderate-fast
Coconut	20	Moderate	DFR, DFO, W	Moderate-fast
Guava	32	Light	DFR, DFO, S	Fast
Lime	2500	Severe	DFR, DFO, B, W, S	Slow
Longan	40	Moderate-severe	DFO, B, W, S	Slow-moderate
Lychee	80	Moderate-severe	DFO, B, W, S	Slow-moderate
Mamey sapote	120	Moderate	DFR, DFO, B, S	Modrate-fast
Mango	1170	Severe	DFO, B, W, S	Moderate
Papaya	120	Moderate	DFO, B, S	Slow-moderate
Passion fruit	20	Severe	DFR, DFO, B, S	Slow-moderate
Sapodilla	6	Moderate-severe	DFR, DFO, B, W, S	Fast

[z]Predominant type of damage including defruiting (DFR), defoliation (DFO), breakage (B), sunburning (S) and windthrowing (W).

drew. Preliminary estimates are that nearly 60% of the total area devoted to 'Tahiti' limes was lost as a result of the storm. The damage was enhanced because the majority of the new orchards were planted with marcot (air-layered) trees. Marcots are used because of their precocity when compared to grafted trees (3). However, marcot trees have a shallower root system compared to grafted trees and are more prone to windthrow (1, 3). Windthrown marcot trees were not only uprooted, but the trees were often blown long distances from their original positions, making resetting of the trees impractical. Older orchards of budded trees fared better, with significantly less windthrow and many damaged, yet salvageable trees.

Longan. There were 40 ha of longan (*Euphoria longana* Lam.) grown in South Florida and damage from the hurricane was moderate to severe in most cases. Damage was variable, however, with defruiting, defoliation, breakage and windthrowing common. Many righted longan trees made healthy new growth, only to die suddenly. This may have been the result of carbohydrate depletion due to the unusually heavy fruit load that many longan trees had just before the hurricane.

Lychee. Lychee (*Litchi chinensis* Sonn.) is produced on about 80 ha in South Florida. There were differences between the two major lychee cultivars, 'Mauritius' and 'Brewster' in the severity of damage from the hurricane, as was previously noted during other hurricanes in South Florida (R. O. Nelson, personal communication).

Table 2. Tree losses in an individual mango orchard (20 years old) at the Research Center of Fairchild Tropical Garden.

Total tree number	Total Windthrows	Total dead[z]	Total with weak growth[z]
418	167	32	15

[z]Evaluated 8 months after Hurricane Andrew.

Figure 3. Twenty-five-year-old avocado orchard (same orchard as in Fig. 2) 6 months after Hurricane Andrew. The trees were righted 2 months after the hurricane.

'Mauritius' had severe breakage and many trees were windthrown. Breakage on 'Mauritius' involved not only scaffold branches, but many trunks actually broke off just above the soil line; most of these trees later died. 'Brewster' trees sustained severe limb breakage, but the trees had less of a tendency for windthrowing. Recovery in severely damaged lychee orchards has been slow.

Mamey sapote. 120 ha of mamey sapote (*Pouteria sapota* Merr.) were grown in South Florida before Hurricane Andrew. Generally damage to mamey sapote was moderate. Mamey sapote trees were defruited, defoliated and badly broken in the storm, but there was little windthrowing. As a result, the trees have recovered faster than many other fruit crops because root damage was less severe. On trees that refoliated soon after the hurricane, blooming commenced within two months and on many trees the fruit are developing normally.

Mango. Mango (*Mangifera indica* L.) is the third largest fruit crop grown in South Florida with 1,170 ha prior to Hurricane Andrew. Damage to mango trees was variable. In areas with the highest winds, many orchards had the majority of the trees windthrown, with few trees salvageable due to excessive breakage and root damage. Other orchards in areas which had less severe winds or more severe pruning practices had significant damage, but the trees were salvageable and with prompt righting, few trees were lost (Fig. 4; Table 2). Sunburning has been severe on windthrown mango trees. Historically, mangos are known to recover quickly from hurricane damage (7). However, recovery following Andrew has been slow in many areas (particularly inland locations), with significant die-back of new sprouts and even death of entire trees. The loss of these trees may be the result of previous damage from freezes, or general poor health before Hurricane Andrew.

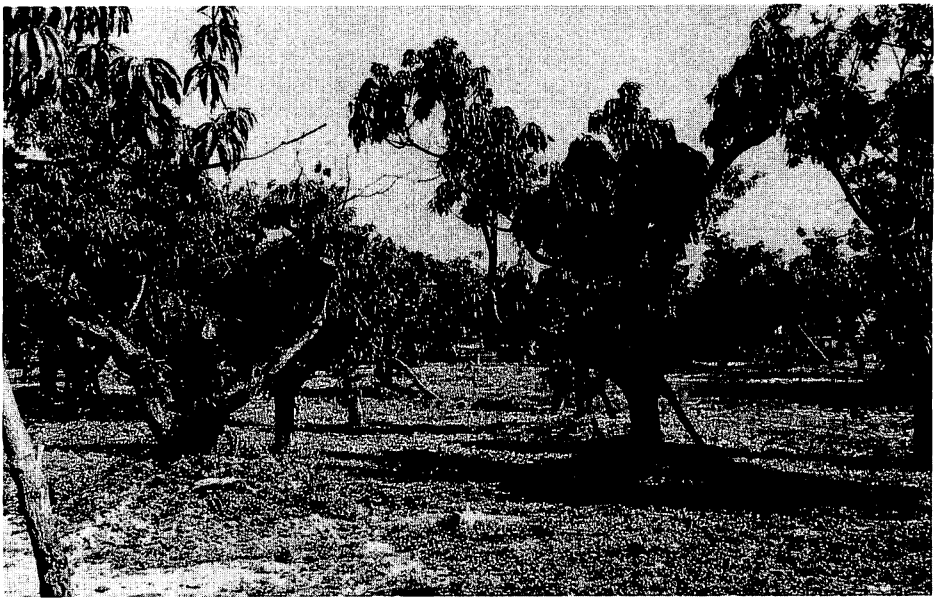

Figure 4. Twenty-year-old mango orchard 6 months after Hurricane Andrew. The trees were righted 1 month after the hurricane.

Papaya. Papaya (*Carica papaya* L.) plants were defoliated and often broken by the hurricane. Damaged plants have refoliated, but their recovery has been slow. Historically, papaya plants that have been damaged have a reduced growth rate allowing for viral diseases to have a greater effect on the trees. Thus, plants do not recover well, if at all. Given the fast growth of papaya plants, many of the 120 ha are being replanted

Passion fruit. Passion fruit (*Passiflora edulis* Sims) vines are commercially grown on 20 ha of trellises in South Florida. Nearly all of the above-ground portions of the vines were severely twisted and broken and not salvageable. Some vines have sprouted from below the ground, but many have died, probably due to fungal diseases. Trellis systems were severely damaged in most areas and may need replacement.

Sapodilla. There are 6 ha of sapodilla (*Manilkara zapota* Van Royen) grown in South Florida, predominantly as windbreaks. Damage was moderate to heavy with severe limb breakage and some windthrowing. Sapodilla trees were usually not pruned when used as windbreaks; therefore, damage to these trees was quite severe. Recovery has been rapid and the trees began to bloom within 3 months of the hurricane.

Additional Observations and Discussion

Tree loss as a result of damage from Hurricane Andrew will not be fully evident for months or even years to come. Whigham et al. (11) reported that for 2 years following Hurricane Gilbert, tree loss in forest communities was four to five times greater than normal. Management techniques (fertilizers, fungicides, pesticides, pruning)

will reduce further tree losses, however, due to biotic and abiotic factors, accelerated tree loss will continue for some time after the hurricane.

Insect pressure, specifically woodboring beetles (*Buprestidae, Cerambycidae*) and root feeding weevils (*Curculionidae*) has been greater following the hurricane. Also, leaf-feeding lepidopterous larva have been more of a problem presumably due to the lack of usual food sources. Diseases are also a concern due to the excessive breakage and damage to limbs and roots and the general weakened condition of the trees. Much of the regrowth following the hurricane has been distorted and chlorotic. Applications of both granular and foliar fertilizers, including micronutrients have alleviated this condition in some orchards, but not in all cases. Many trees have suddenly died following an initial flush of growth.

Warm temperatures and ample rainfall following the hurricane were conducive to vegetative growth of the hurricane-damaged trees. These weather conditions have helped in the recovery of the trees, but due to the continued vegetative growth, the trees will be less cold-hardy and thus more susceptible to cold injury during the coming winter. Cold injury is a serious concern with many of these fruit crops. With the reduced root systems due to hurricane damage, trees will probably also be more prone to drought stress during the typically dry winter and early spring season in South Florida.

Hurricane Andrew has provided an opportunity to study the influence of hurricane force winds on a wide range of tropical fruit crops. As discussed, there were some outstanding differences in the response of the different crops and orchard cultural practices to this stress. In the months and years ahead we will learn more about the differing recovery potentials of these fruit. The information presented and future observations can help us plan for future hurricanes and their aftermath.

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