HURRICANE DAMAGE TO TROPICAL PLANTS

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On Sept. 15, 1945 a rather small but severe hurricane entered Florida in the southern part of Dade County and crossed it in a northwesterly direction. The "eye" or calm center of the storm probably was not over ten miles in diameter and passed between Homestead and Perrine, but hurricane winds were felt for a number of miles south of Homestead and to the northern part of Miami. Thus practically the entire area of truck gardening and of commercial mango, avocado and citrus growing in the county was exposed to the storm and suffered extensive damage, as did nearly all other plantings, and there was considerable structural loss as well.

Since the climate of south Florida permits, an immense number of tropical and subtropical plants already have been introduced here until no other part of the United States can boast so large or diversified a flora of exotic plants, but still the tropics of both hemispheres offer many times as many plants as have been established here. Unquestionably the beauty, appealing peculiarities and commercial prospects of these plants, in combination with the climate, have attracted an ever-increasing number of permanent residents and temporary visitors from the north. The behavior of these plants under all conditions of soil, weather and treatment, are, therefore, matters of great importance to practically every resident in the region. Repeated tests have shown that certain desirable tropical plants cannot be grown here for one reason or another. Moderate winter cold prevents growing the breadfruit, mangosteen, giant Victoria pond lily, and the beautiful seacoast tree *Barringtonia speciosa.* Summer heat prevents growing of the Hawaiian hibiscus relative, *Kokia rockii,* which is native where temperatures are moderate and fluctuate little. Acid-soil plants are ruled out of most of our locations except where special treatments are given to acidify the soil. Many plants, native of dense jungles or places where severe winds do not occur, are affected by constant trade winds and badly broken by severe storm winds. Following the passage of the September hurricane the effects of various storm factors on plants could be seen throughout the region.

At the U. S. Plant Introduction Garden, 6½ miles south of Coconut Grove, several thousand species of introduced plants are growing in the scant soil on the oolitic limestone rock that is typical of the southern part of the county, and in the coastal lowland marl as well. The center of the hurricane passed only a few miles to the south, consequently the Garden was for a time in the northern, right-hand quadrant of the hurricane where the advancing speed of the storm was added to the speed of the wind and maximum wind velocities were attained. It has been estimated that at the height of the storm, velocities of at least 135 miles per hour were experienced. The wind blew from the east, swinging to the southeast and south, as the center of the storm passed. The tide rose and sea water covered the lower part of the Garden to a depth of 6 or 7 feet. Rainfall, during the 24-hour period in which the storm occurred, amounted to 6.75 inches.

At this Garden, as elsewhere, the greatest and most direct effect of the wind naturally was the breakage of limbs, uprooting of trees, and defoliation of a host of dicotyledonous plants. From previous storm experience it was known that *Pithecellobium dulce* and the Australian *Acacia auriculaeformis,* both shallow-rooted trees used extensively in the past for street planting, were easily uprooted. This fact was again demonstrated, for many of these trees were overturned and those that stood

were severely broken. The handsome dark green, dense foliaged *Casuarina lepidophloia*, used in many Garden locations as a windbreak, and one of the trees that held its leaves, was an early victim of the storm, for practically every tree was blown down by the wind that came from the east as the storm approached. Trees of *Casuarina equisetifolia*, taller but of more open character and planted in windbreaks on the low land where the water table was about 3 feet below the surface, also were uprooted or broken off, almost without exception, and other species of the same genus, planted in smaller numbers, suffered the same fate. These two windbreak species, in falling, did extreme damage to plantings they were supposed to protect, and a tremendous amount of labor was expended in their removal and in restoration of plants they had crushed. *Melaleuca leucadendron*, extensively planted on the same low ground, withstood the storm fairly well with some breakage of limbs but almost no uprooting in spite of its failure to lose its leaves. Ficus species, which tended to hold their leaves, were overturned in many locations, especially where planted in shallow holes or on the low land where the water table prevented deep rooting. Trees of *Ficus nitida* and *F. benjamina* in such locations were outstanding victims in spite of numerous supporting trunks developed from aerial roots. The African mahogany tree, *Khaya nyasica*, that in other respects appeared well adapted to the region and offered commercial possibilities for cabinetwood, was planted in a number of locations at this Garden and a large planting had been under observation in recent years at the Sub-Tropical Experiment Station at Homestead. Scarcely one of these trees remained standing after the storm. The related Cuban cedar, *Cedrela odorata*, planted in smaller numbers at the Garden, suffered a similar fate. Members of the genus *Swietenia*, including the native *S. mahagoni*, fared better, with no uprooting, although breakage of limbs caused some damage. Breakage of limbs of avocado and mango trees was severe and where these trees were planted in shallow holes on the rock, overturning was common; even in deep soil areas the heavy rain so softened the earth that the constant buffeting of the wind caused a few trees to go down. This effect of the rain undoubtedly hastened the uprooting of many trees that probably would have fallen even had there been little or no rain, but trees that otherwise might have survived, like *Terminalia arjuna* and *Bucida buceras*, had their long roots pulled through the sodden earth and thus fell.

A great many trees and shrubs that were not blown down nevertheless were bent over badly and suffered considerable damage to their root systems and still more when they were returned to an upright position after the storm. As a consequence of plants being blown down, inclined or having branches badly broken or defoliated, shaded parts of the trees were exposed to full sunlight and there was considerable scalding of bark on trunks and limbs of many trees before they could be set up or before new leaves gave them protection.

A factor that contributes tremendously to plant damage in hurricanes is the veering of the wind as the storm progresses. This shifting of the wind is increasingly pronounced as the center of a storm is neared and is most extreme where the center passes over any given point, for here the wind blows from one direction as the center approaches and suddenly changes to the opposite direction as the center passes. Thus plants are buffeted in different directions and the resulting loosening and breaking of roots and branches is increased.

Prompt defoliation in a storm contributes immeasureably to a tree or shrub's chances of survival, for bare branches offer little resistance to the wind. Loss of leaves is a temporary matter and, with satisfactory conditions following a storm, new leaves seldom are long in appearing, and complete recovery from storm effects may be rapid. An unexpected example of early defoliation and the protection it offers was the very tropical appearing member of the *Araliaceae*, locally known as the

Australian Umbrella-tree, *Schefflera actinophylla*. This tall, many-stemmed, soft-wooded plant lost practically every leaf and thus was reefed down to bare poles that bore the full brunt of the storm with little other damage, and after the storm new leaves were quickly produced and today the plants show little evidence of the ordeal they weathered.

Another outstanding plant that gains protection through loss of leaves is the Royal Palm. In a severe storm, such as that in September, the Royal Palms lose their leaves as the fury of the gale increases until only the tightly wrapped heart leaves remain, and in this condition the palms usually survive the storm. Since the species of Royal Palms are native in Florida and the Greater and Lesser Antilles, where hurricanes are of almost annual occurrence, their survival may, in part at least, be attributed to this characteristic which few other palms have in the same degree.

With trees that fail to lose their leaves, much damage is done to the smaller branches and to the foliage by the whipping, tearing and bruising by the wind, and often salt spray is charged with contributing to the injury and may account for some of it, especially where the sea is nearby, and salt concentration in the spray and wind-driven rain is high. Generally speaking, foliage damage from any cause in one of these storms, while making plants unsightly for a while, seldom seems to have a lasting effect on most plants, as new leaves usually are produced in a few weeks.

On some trees, however, notably those from jungle environments, not only is there severe leaf injury, but the beating of the wind on slender stems and branches may completely wear away the bark and cause the death of these parts. The African rubber-producing tree *Funtumia elastica* was a striking example of this, and after the storm the white inner wood of the small branches was exposed in remarkable contrast to the larger branches, where the dark brown bark still remained. The Para rubber-tree, *Hevea brasiliensis*, also suffered in this way and, having brittle wood, was rather badly broken, but there was no overturning of trees since the species is anchored by an exceedingly sturdy tap-root.

In the lower part of the Garden that was flooded by the sea, damage directly due to salt poisoning was evident in surprisingly few cases. Here were a large majority of trees, shrubs, vines, palms, and bamboo species represented elsewhere in the Garden. These species were completely covered or had salt water at their bases probably for several hours. The soil in this area consists of marl that was pumped from the mangrove swamp in the first World War to form a flying field. This marl takes up water slowly and probably had become nearly saturated with rain before the sea rose and hence absorbed little salt water about the roots of plants. Plant losses directly attributed to salt water flooding were lychees, a few small bamboo plants that were completely covered, and mature specimens of the following palm species: *Butia capitata* and *B. bonneti*, *Martinezia corallina* (referred by Burrett to *Aiphanes minima*), *Dictyosperma alba* and *Attalea spectabilis*. Several species of *Caryota* were injured but there were many species of palms, some so small or young that they were entirely flooded, that showed no effects of the salt water.

As a class the palms, aside from those affected by salt water flooding, and the bamboos at the Garden and elsewhere in the storm area withstood the storm better than dicotyledonous plants. Practically no palms were overturned, as it would seem that their dense mass of fibrous roots so firmly anchored them that the force of the storm, even aided by the moistening of the soil by rain or flooding, was not sufficient to uproot them. A considerable number of coconuts and old Royal Palms were broken off at ground level where the trunks were constricted at the root-crown but this did not happen to other palms, and very tall specimens of *Washingtonia* and *Livistona* were standing almost unscathed after the storm. Several immense *Borassus* palms were uninjured although one was slightly forced over.

In the collection of bamboos practically

every specimen planted in a suitable location survived with little breakage of canes or loss of leaves. A number of dense clusters of the spiny bamboo, *Bambusa arundinacea,* from seventy to a hundred feet high and planted in less than a foot of soil on the top of a crushed rock ramp of the old airfield, were overturned but, when they were severely pruned back, the mats of roots and stumps fell back into position and new shoots soon were pushing up.

While almost no plants in the Plant Introduction Garden escaped some injury, the fact that specimens of most species had been planted in several locations, on the high pine land as well as on the lower filled area, usually resulted in the survival of at least one representative of a species and relatively few introduced species were completely lost as a result of the storm.

Following the observations made on this storm, it seems that some precautions that will minimize losses can be taken in the future. It appears that there are no trees that can be recommended for windbreaks that will give the desired protection under normal weather conditions and will also withstand hurricane winds. Planting of large, shallow-rooted trees, that are known to be susceptible to uprooting, should be avoided except where their fall will not damage buildings or other plants. Trees that attain large size should not be planted on land where the water table is so close to the surface that deep rooting is restricted, as such trees are too easily overturned. Planting in shallow soil or in blasted holes that are too small for the plants when mature is also a dangerous practice and does not give optimum conditions, even under normal circumstances. Actually, however, the best advice that can be given regarding precautions against a hurricane is to avoid it completely.

HURRICANE DAMAGE TO COMMERCIAL FRUIT TREES IN DADE COUNTY

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The hurricane of September 15, 1945, as you know, had a top wind velocity of 150 to 160 MPH. The path of greatest destruction was only 40 miles wide running from the town of South Miami to slightly south of Florida City. The lowest barometer reading was 28.09 at the Army Air Base. This area embraces 75 to 90% of the production of avocados, limes and mangos in the state. Winds of hurricane force lasted approximately four hours, the lull lasting between 45 and 50 minutes.

This paper deals mainly with damage to avocados, limes and mangos.

Damage to Avocados: The damage to avocados varied greatly depending upon size and height of trees, and to a lesser degree on variety and condition of the tree at the time of hurricane. There seems to be some little difference in ultimate damage between a grove which was encircled with an Australian-pine windbreak or other type of windbreak, and those not having any windbreak. The windbreaks did some good while the wind was 90 to 100 miles but when the wind reached a higher velocity than this the windbreak was blown over on to the fruit trees, causing more damage than the wind itself. Trees that were high and very large blew down quickly and suffered more damage than those that were not as tall. There was some difference between varieties but this was due mainly to the type of growth that these varieties have; that is, if they are short, low-headed trees rather than tall, slender ones. It seems to me there was one variety which suffered considerably less damage than other varieties and that is the Collinson. They seemed to stand up better than