Citrus Tristeza disease a new threat for the Caribbean Basin. Report of a survey to Colombia, Dominican Republic, Guadeloupe, Martinique and Trinidad.

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CITRUS TRISTEZA DISEASE A NEW THREAT FOR THE CARIBBEAN BASIN.
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ABSTRACT - The brown citrus aphid *Toxoptera citricidus* Kirkaldy was recently found in various territories of the Eastern Caribbean area. This most efficient vector of *Tristeza* is present in Trinidad with some occasional CTV infected citrus plants. *T. citricidus* was reported for the first time in 1991 from French West Indies (Martinique and Guadeloupe). But so far CTV detection by ELISA tests failed to give positive results in these Islands. *T. citricidus* was also found recently in the Dominican Republic and Puerto Rico thus threatening to invade Cuba and Florida in the future.

LA *TRISTEZA* UNE NOUVELLE MENACE POUR L'AGRUMICULTURE CARIBEENNE.
COMPTE RENDU D'INVENTAIRE EN COLOMBIE, REPUBLIQUE DOMINICAINE, GUADELOUPE, MARTINIQUE ET TRINIDAD.

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RESUME - Le puceron brun des agrumes *Toxoptera citricidus* Kirkaldy est subitement apparu dans les îles de l'arc caraïbe. Il s'agit du vecteur le plus efficace du virus de la *Tristeza*. A Trinidad sa présence est associée à celle de ce virus. Dans les Antilles françaises (Martinique et Guadeloupe) *T. citricidus* a été observé fin 1991 mais tous les tests de dépistage de la *Tristeza* se sont avérés jusqu'ici négatifs. *T. citricidus*, qui a été également signalé à St Domingue et Puerto Rico, risque de gagner assez rapidement Cuba et la Floride.

AN INTRODUCTION TO *CITRUS TRISTEZA* AND ITS APHID VECTORS

Historical and epidemiological background.

No *Citrus* species are indigenous to America. The first introduction of this botanical genus took place under the form of seeds of oranges, lemons and citrons during the second expedition of Columbus to *Hispaniola* (Dominican Republic) in 1493 (1). Citrus was subsequently disseminated to continental America essentially by seeds, a propagating method that avoids the transmission of most virus and virus-like diseases of citrus, especially Tristeza.

Citrus Tristeza Virus (CTV) and its efficient aphid vector *Toxoptera citricidus* (Kirkaldy) were introduced into Argentina in the 1930's apparently through contaminated planting material originated from South Africa. The immediate consequence was the development of CTV epidemics in Argentina and Brazil, destroying large plantations of oranges previously established on sour orange rootstock (2).

Since the introduction of both organisms into this part of the New World, their spread expanded slowly but inexorably northward through South America for reaching Colombia and Venezuela over the last three or four decades

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(3). In one of its latest spread *C.T.V.* was reported from Venezuela by the early 1960's from various foci near the Colombian and Brazilian borders. It subsequently widespread in this country because of the ingress of *T. citricidus* in 1975 (2). In fact a rapid movement of this aphis was observed in Venezuela between 1975 and 1978 (4).

More recently the threat of *C.T.V.* and its efficient vector has been found in countries North of the Isthmus of Panama and the Caribbean Islands. A high incidence of *C.T.V.* and *T. citricidus* is presently occuring in Panama and Costa Rica, while low indicence is still reported from Belize, El Salvador, Guatemala, Honduras and Nicaragua, the latter countries having escaped so far *T. citricidus* invasions if we except small scattered areas in El Salvador, Nicaragua and Honduras (5).

The aim of the present report is to assess the recent status of CTV and *T. citricidus* in the Caribbean Islands with special attention to : i) Trinidad, the southerner Island separated from Venezuela by a channel of only 28 km and ii) various islands located in the Eastern side of the Caribbean area. Our data were collected from three successive visits to the region :

- november 1991 : Martinique and Trinidad.
- december 1991 : Colombia.
- february 1992 : a second visit to Martinique where a a regional workshop was held under the sponsorship of IICA-FIC (Interamerican Institute for Cooperation in Agriculture + Inter Caribbean French Funding) and convening the Plant Protection Officers or citrus specialists of seven countries/territories i.e. Dominica, Dominican Republic, Guadeloupe, Guayana, St Lucia, Trinidad and Tobago. This workshop has facilitated the access to sampling materials that were subsequently dispatched by the participants to relevant specialists.

Furthermore, the second author was able to launch a thorough survey of the aphid population in Guadeloupe and pay a visit to the Dominican Republic.

The results of our findings will be presented and discussed in the light of the recent investigations conducted by various plant pathologists and entomologists in the region, especially the recent surveys carried out in Puerto Rico by the Horticultural Research Laboratory of USDA Orlando and the Animal and Plant Health Inspection Service (6).

Specific aspects of citriculture in the Caribbean Basin.

As mentioned above, the origin of citriculture in the region can be traced back five centuries, and has gradually expanded into true industry. There are three major groups of countries bordering the Caribbean Sea (cf. Fig. 1).

- Nine continental countries in the South and West : Venezuela, Colombia, Panama, Costa Rica, Nicaragua, Honduras, Guatemala, Belize and Mexico with the Yucatan Peninsula. Although facing exclusively the Pacific Coast, El Salvador is included in the region.

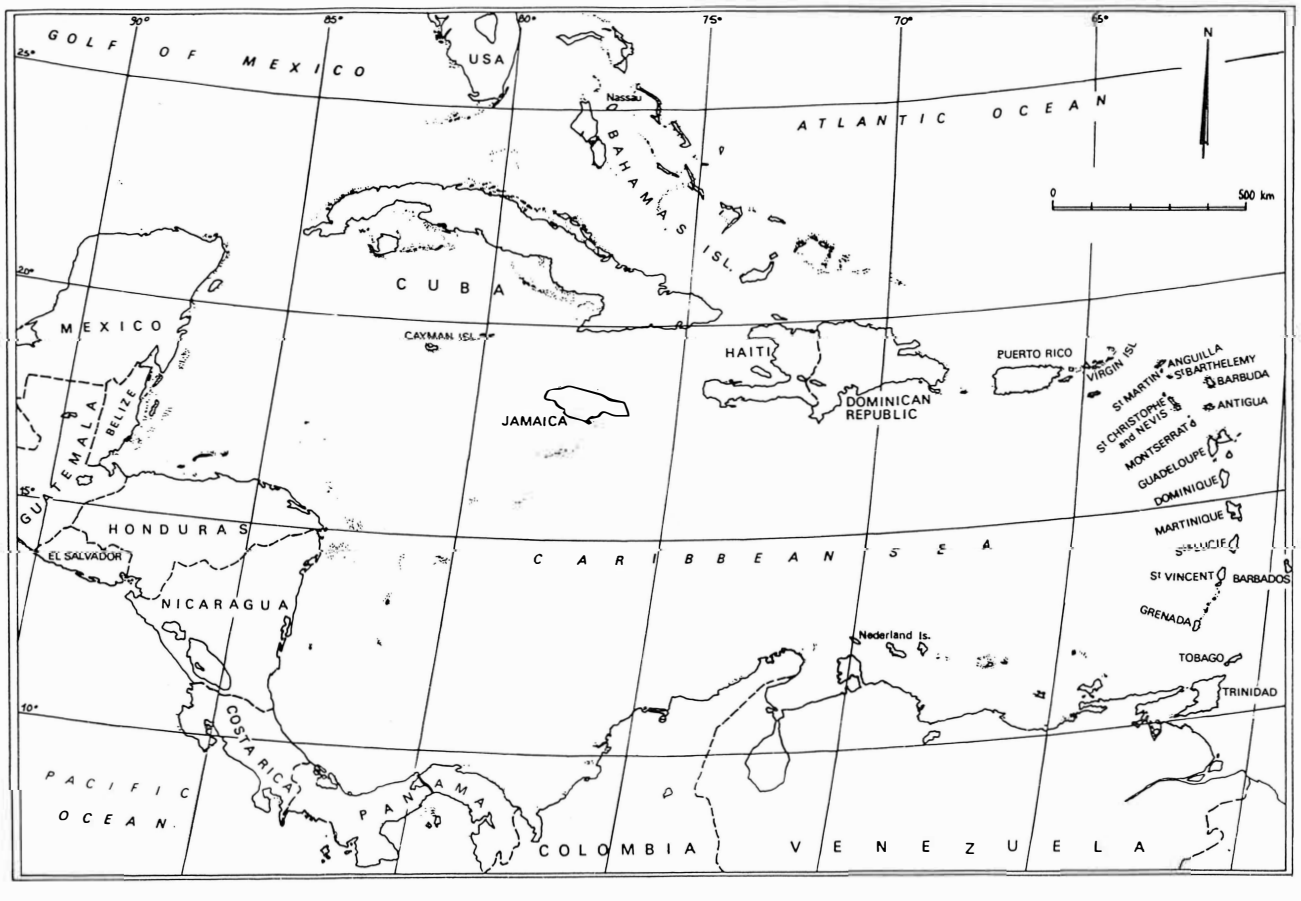


FIGURE 1 - THE DIFFERENT COUNTRIES AND TERRITORIES OF THE CARIBBEAN BASIN.

• Four large islands in the North : Cuba, Haiti + the Dominican Republic, Puerto Rico and Jamaica.

• A total of 48 inhabited small islands in the East separated by corresponding channels generally not exceeding 150 km.

The Bahamas and Floridian Peninsula are bordering the northern fringe of this vast geographical entity which comprises globally 1 million square miles of continental land (26 millions km^2), one hundred thousand square miles of big Islands (260.000 km^2) and only ten thousand square miles of small inhabited Islands (26.000 km^2).

Citrus output in the region amounts to 5.8 millions tons for a population of 208 millions inhabitants (cf. Table 1). A regional production of 6,2 millions tons is expected by the turn of this century for a population of 250 millions (these figures do not include Florida).

There are common characteristics with regard to the citriculture in the region. The area is located below the 20th degree parallel North, i.e. under tropical mild winter or winterless climates where citrus trees often display more than one blooming season per year. In coastal areas the rainfall generally amounts 1500 to 2500 mm and irrigation is not essential. The monsoon season is often disturbed by hurracanes and night temperatures are generally too high to induce a marked coloration of conventional mandarines and oranges.

Research Institutions addressing citrus production problems that envolve long range orchards experiments are few. In particular, not enough attention has been paid

TABLE 1 - Populations and corresponding Citrus production in the various countries of the Caribbean Basin.

	Population in 000		Citrus production in 000 MT				
	Populations 1991	Projected Pop. 2000	Oranges	Limes	Grapefruits	Mandarines	Total
Continental countries							
Mexico	90,208	109,724	2,200	612	100	169	3,081
Colombia	33,236	39,720	350	60	-	-	410
Venezuela	20,238	25,275	427	15	9	34	485
Guatemala	9,560	11,835	100	10	-	15	135
Honduras	5,425	7,141	49	9	36	3	97
El Salvador	5,311	6,236	90	9	-	-	99
Nicaragua	3,709	4,797	66	-	-	-	66
Costa Rica	3,116	3,960	86	-	-	-	86
Panama	2,474	2,983	34	-	-	-	34
Guyana	763	757	15	-	-	-	15
Belize	184	226	55	-	32	-	87
Total	**174,224**	**212,654**	**3,472**	**715**	**177**	**221**	**4,585**
Major Northern Islands							
Cuba	10,639	11,532	520	68	280	30	898
Dominican Republic	7,408	8,931	66	9	9	-	84
Haiti	6,500	7,367	30	25	10	9	74
Puerto Rico	3,314	3,374	29	1	3	-	33
Jamaica	2,540	2,803	20	24	40	20	104
Total	**30,401**	**34,007**	**665**	**127**	**342**	**59**	**1,193**
Windward Islands							
Trinidad and Tobago	1,294	1,547	7	1	4	4	16
Guadeloupe + dép.	346	372	1	2	1	-	4
Martinique	335	347	1	1	-	-	2
Barbados	300	325	-	-	-	-	
Curacao and Bonaire	184	187	-	-	-	-	
St Lucia	158	197	-	-	-	-	
UK Virgin Islands	16	17	-	-	-	-	
US Virgin Islands	111	127	-	-	-	-	
St Vincent	106	112	-	1	-	-	1
Dominica	86	99	5	6	9	-	20
Grenada	90	91	1	1	-	-	2
Antigua and Barbuda	64	65	-	-	-	-	
Arruba	63	65	-	-	-	-	
St Kitts and Nevis	40	41	-	-	-	-	
Anguilla	6	7	-	-	-	-	
St John	-	-	-	-	-	-	
Monserrat	10	10	-	-	-	-	
Bahamas	254	297					
Total	**3,463**	**3,906**	**15**	**12**	**14**	**4**	**45**
	208,088	**250,567**	**4,152**	**854**	**533**	**284**	**5,823**

to rootstocks trials and the present nursery practices rely excessively upon the sour orange rootstock. In many situations, sour orange is, indeed, the only rootstock that is currently used.

In the past, Belize, Jamaica, Trinidad and the Dominican Republic have been the major citrus producers with a trend towards development of the oranges or hybrids of oranges. Recently Cuba, Venezuela, Colombia and Costa Rica have emerged as new challengers with more emphasis on new grapefruits, limes and tangelos/tangors.

As for the small Islands of eastern Caribbean, commercial orchards are expanding in Trinidad (oranges and grapefruits), Dominica (limes and grapefruits), while new rootstocks and scion cultivars are being successfully experimented in Martinique and Guadeloupe by CIRAD-IRFA with considerable interest for promoting a modern type of orchards in the monsoon climates that avoid Tristeza risks and promote the development of high yielding compact trees using dwarfing rootstocks.

The symptomatology and host range of the *Citrus Tristeza* disease.

Tristeza is a graft and aphid transmissible disease caused by a threadlike virus particle of the Closterovirus type. The particle contains a large viral genome of approximately 20 kilobases.

The disease is expressed by three major types of syndroms on specific citrus species or scion-rootstock combinations. Although being induced by the same causal agent, these syndroms can be regarded as different maladies.

i) The first type of disorder caused by Tristeza is a **stionic decline** affecting specific scion rootstock combinations such as oranges, mandarins, tangelos, tangors grafted on Sour Orange. Damage observed on the combination grapefruits/sour orange is eventually less drastic for the life of the tree although yet sizable from the standpoint of cropping behaviour. The above scions on certain other roostocks may also undergo similar stionic decline when grafted on Palestine sweet lime or eventually *Citrus macrophylla.*

   The name *Tristeza* (or *Tristeza sensu stricto*) is often referring only to this stionic decline.

   This type of affliction has killed over 25 millions trees in Argentina, Brazil and Peru, 3 millions trees in California. Moreover, several millions trees of sweet orange grafted on sour orange have been killed or rendered unproductive in Florida, Venezuela and Spain. The problem is presently of serious concern for the Caribbean Basin.

   The affected citrus combinations exhibit a general decline with defoliation or bronzed appearance of the foliage (Photo 1). Such trees should be tested by ELISA for a confirmation of the diagnostic. But a good indication of Tristeza stionic decline is the presence of **inverse stem pitting** (woody pits on the cambial layer) below the budunion, with corresponding **«pinholing»** or **«honey combing»** on the bark (Photo 2 A and B). The disease hinders the movement of starch down to the roots and the iodine test shows no coloration below the budunion. The ensuing root starvation is conducive for intense rotting of the feeder and secundary roots with the subsequent declining and death of affected trees. When invading a new territory, the disease incubates several years (3 to 6 years or more) before showing up in severe outbreaks.

ii) The second type of disorder caused by Tristeza is the **stem pitting** symptom on species and varieties whether used as seedlings, scions or rootstocks. The stem-pitting symptom can be seen on twigs, young branches, scaffold branches trunk and roots. It consists of a protrusion of the bark into the wood (Photo 3 A). For a given species cultivar or clone, the severity of stem-pitting is related to the aggressiveness of the local Tristeza strains, with a general trend as follows :

   a) In California, Florida, Spain, Israel ... where *T. citricidus* is not present the stem pitting symptoms affect mostly the following citrus : Mexican lime, Yuzu, Palestine sweet lime, *C. excelsa*, Etrog Citron, *C. hystrix* and *C. macrophylla*.

   Affected Mexican limes and *C. hystrix* exhibit typical **vein-clearing** of the leaves (Photo 2 B).

   b) In South Africa, South America, South East Asia and Australia where *T. citricidus* is present the severity of stem pitting is such that the following citrus are also affected : grapefruits, other acid limes, various citranges, limequat, Pera Sweet Orange, etc. Not only **vein-clearing** will be detected as in a) but **vein-corking** will appear on the adaxial surface of mexican lime or *C. hystrix*.

   When such strains of CTV are encountered, grapefruit and limes do not thrive well and their production may undergo a sizable decrease.

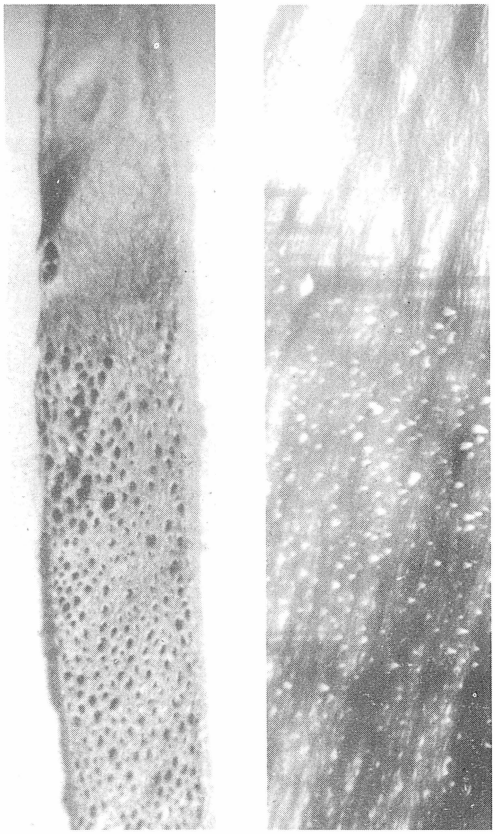
   c) In various citrus producing areas, ultra virulent strains of Tristeza may be found. Such areas include : Japan, Capao Bonito in Brazil, Malang in Indonesia, Nyombe in Cameroon, Coastal Peru, Taiwan, Thailand's Central Province, etc.

   A common characteristic of these strains is to induce severe dysfunctions of the cambial layer of most citrus wood (limes, lemons, grapefruits, pomelos, oranges and even mandarins) with abnormal bark thickness, short internodes, upright small leaves and eventual vein clearing, tiny fruits, and brittle stems and twigs.

   Most of the severe strains of Tristeza have the **Seedling Yellow** component, a CTV viral combination that induces the leaf yellowing of sour orange and lemon seedlings (non grafted sour orange wood is normally tolerant to Tristeza).

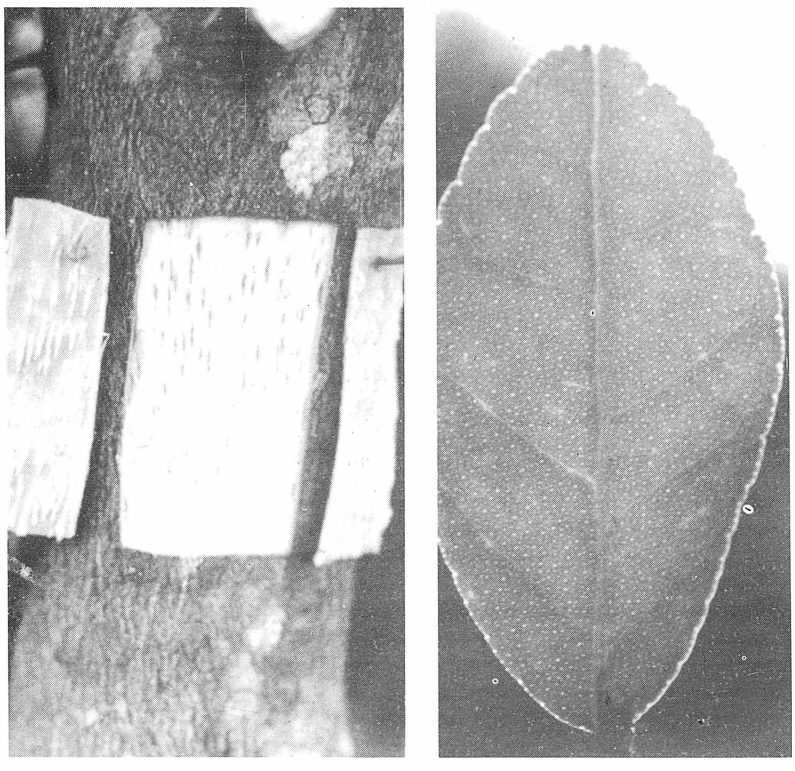
iii) **Seedling yellow** reaction of non grafted sour orange and lemon is therefore the third major symptom caused by Tristeza and is most often indicative of severe strains of CTV.

Photo 1 - *Tristeza* induced **stionic decline** of sweet orange on sour orange rootstock (left). The disease often appears suddenly and is therefore called **quick decline**. It is in fact the result of root starvation.



A B

Photo 2 - When the bark is peeled back at the budunion line *Tristeza* affected trees exhibit pinholing or honey combing on the bark (A), with corresponding woody pit on the sour orange wood (B).



A B

Photo 3 - Symptoms of **stem-pitting** (A) and **vein-clearing** (B) on Mexican lime.
Mexican lime in one of the most susceptible citrus to the stem-pitting form of *Tristeza*, Severe strains of *Tristeza* induce stem-pitting on grapefruits while ultra severe strains are responsible for similar cambial dysfunction on oranges and mandarins.

The aphid vectors.

Citrus aphids are a major component of the Tristeza status in a given territory. Among the seven species known to transmit CTV, *T. citricidus* is the most efficient vector. While a single *T. citricidus* is able to transmit the disease in less than one hour, dozens of *T. aurantii*, *Aphis gossypii* or *A. craccivora* are necessary for successful transmission. *Myzus persicae*, *A. spiraecola* and *Microsiphum euphorbiae* are considered minor vectors. However *A. gossypii* the cotton aphid is considered to have recently developed some adaptation in vectoring specific CTV strains in Spain and Israel. But *T. citricidus* is by far the most dangerous vector, likely to increase notably Tristeza epidemics when it invades nex territories.

A list of the seven aphids found on citrus and able to transmit Tristeza is presented in Table 2. They appear by order in CTV transmission efficiency. As *T. citricidus* is often mistaken with *T. aurantii*, a field key identification is given on Fig. 2.

There are some other characteristics regarding citrus aphids : i) Tristeza is a **semi-persistant virus**, the aphids becoming infective within a short acquisition period of 30 min, but lose their infectivity within 24 hours if they have no further access to contaminated citrus ii) Aphid population dynamics are sometimes markedly affected by natural enemies as in several provinces of Mainland China where *T. citricidus* outbreaks are moderately low iii) While most aphids species are building up on non rutaceous reservoir plants, *T. citricidus* is feeding mostly on citrus or citrus relatives such as *Severinia*, *Murraya*... but the latter species do not support detectable multiplication of C.T.V. virus. Occasional *T. citricidus* colonies may be found on the West Indian Cherry (Acerola) : *Malpighia punicifolia*, and Azalea. iv) Virus spread has been correlated with aphid population densities (7).

The virus-vector-host plant relationships.

The Tristeza status in a given territory and its ultimate commercial damages are answerable to three main biological factors i) the scion rootstock combination that are chosen by the farmers, ii) the severity of local CTV strains,

TABLE 2 - The seven aphids transmitting Tristeza and some typical behaviour.

	Host range feeding	Behaviour on Citrus
Toxoptera citricidus (Kirkaldy)	Citrus, citrus relatives, Malpighia	Feeding mostly on young citrus flush
Aphis spiraecola Patch	Spiraea species + Citrus, Polyphagous	Severe crinkling of young shoots
Aphis gossypii Glover	Cotton, Melon, Citrus	On young shoots, under the leaves
Toxoptera aurantii (Boyer de F.)	Tea, Coffee, Cocoa, Citrus	Concerted circular oscillations of the colonies
Aphis craccivora Koch	Mostly on leguminous plants, Polyphagous	Found on Citrus in mixed colonies
Myzus persicae (Sulzen)	Highly polyphagous	Low colonies on Citrus
Macrosiphum euphorbiae (Thomas)	Extremely polyphagous	Found under old leaves

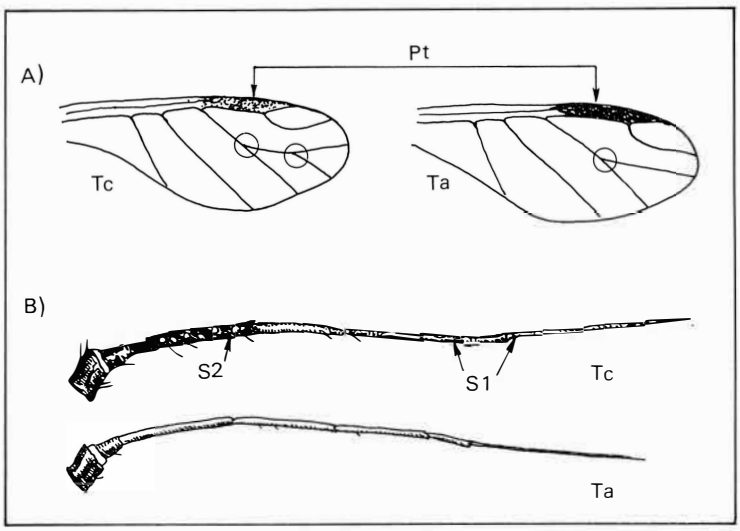


FIGURE 2 - FIELD KEYS FOR THE DIAGNOSTIC OF WINGED ADULTS OF *TOXOPTERA CITRICIDUS* (Tc) AND *TOXOPTERA AURANTII* (Ta).

A - Front wing with dark pterostigma (Pt) and no secundary division of the median vein for Tc.

B - Dark aspect of the S_2 antennal segment for Tc (after STROYAN, 1961).

which is often related to the accidental introduction of contaminated budwood and iii) the aphid vector situation.

Each country or territory displays a specific pattern of CTV in relation to its citrus historical background, the exchange of budwood and the movement of aphids. Four main stages of disease intensity can be identified as shown on table 3. Initially a lag period is experienced between the early introduction of the virus and the natural spread by aphids. Furthermore, a given situation should not be considered as immutable, especially under high conditions of CTV transmissibility. The ingress of *T. citricidus* is likely to be associated with an increased CTV virus propagation conducive to more severe epidemics. The strategy of using tolerant rootstocks can no longer be effective when scion varieties themselves deteriorate. At the latest stage there is a loss of ability to grow a wide range of citrus varieties.

PRESENT SITUATION OF TRISTEZA IN THE CARIBBEAN BASIN

In this section the status of Tristeza in several countries of the Caribbean Basin will be examined. The survey does not include Central America for which an updated information was recently presented (5).

As mentioned earlier, our data will cover Colombia and various islands of the Eastern Caribbean Basin.

Material and methods.

Field observations included the diagnosis of Tristeza symptoms on selected individual trees in order to assess the severity of the disease by relevant field symptoms : stionic decline, stem-pitting, vein clearing ...

Young flushes were inspected with a hand lens for identifying aphid colonies. Winged adults were collected in alcohol to amend the permanent collection of reference of INRA-ENSAM Montpellier and receiving taxonomic confirmation.

ELISA tests were run on samples collected from young flush tissues and processed at the CIRAD-IRFA laboratory of Fort de France (Martinique). The samples were tested only against the standard CTV polyclonal antibody obtained from the PLANTEST-SANOFI Kit.

Results and discussions.

• Colombia.

The survey conducted in Colombia with local citrus specialists and pathologists included a visit to the Central Station of **ICA Palmira** where various foundation blocks and rootstock trials were inspected. A visit was paid also to the coffee area of **Venezia** where new citrus orchards are being

TABLE 3 - Various scenari in Tristeza severity with corresponding damages and possible control strategies.

Severity of strains:	Ultramild	Conventional	Severe	Ultra Severe
Types of disorders :				
Symptoms :				
VC+ SP on Mexican lime	-	+	+	+
SD on Sour orange rootstock	-	+	+	+
Seedling yellow	-	occasional	(+) a	(+) a
other symptoms (b)	not known		SP on grapefruits	In addition to grapefruits SP on oranges and mandarins
Serological detection :				
Polyclonal antibodies	+	+	+	+
Specific monoclonal antibodies	-	-+	+	+
Vectors associated :	not known	all species besides *T. citricidus*	mostly *T. citricidus*	mostly *T. citricidus*
Commercial losses expected :	not known	destruction of the orchard grafted on S.O.	crop losses on grapefruits and limes (b)	crop losses on oranges and mandarins(b)
Strategies of control :		new rootstock policy	cross protection by mild strains	eradication if feasible
Countries or group of countries concerned :	Florida and Corsica (only on kumquat)	Mediterranean Basin Caribbean Basin Florida-California	South Africa South America South East Asia Australia	specific regions of Brazil Peru, Indonesia Thailand Taiwan, Japan ...

VC : vein clearing SP : stem pitting SD : stionic decline
a : frequent b : irrespective of the rootstocks tolerant to SD

established, followed by an observation of the foundation block of **Caicedonia**. A large private plantation in the Valle del Cauca was also visited at **Agrovelez Tamondi.**

At ICA Palmira a 12 years old Bears lime grove was found abnormally weak, with trees showing short internodes, excessive bark thickness of twigs and occasional inverse stem-pitting on the wood. Vein-clearing was faint.

In all the sites visited we noticed stem-pitting symptoms on adult Minneola Tangelo affecting the trunk and scaffold branches. At Caicedonia several 10-year-old Dancy tangerines showed consistent stem-pitting on the trunk and branches. We presume that Minneola and Dancy stem-pitting is due to Tristeza rather than Cristacortis. An experiment is being conducted on certified disease free budwood imported from Corsica for confirming the diagnosis. Grapefruits were heavily pitted, with small caliber fruits and juiceless vesicles.

Tristeza stionic decline affecting sweet orange grafted on sour orange was noticed in Colombia as early as the mid 1940'. *Toxoptera citricidus* is now widespred in the country, and Cleopatra mandarin or citranges are presently the most common rootstocks used by nurserymen.

The history of citrus budwood movement at the central station of ICA Palmira is presented in Table 4. Between 1933 and 1991 there have been seven introductions covering a total of 191 cultivars.

In conclusion, local aphid inoculation of certified disease-free Corsican material especially Dancy tangerine and Minneola tangelo will be tested for confirming a specific severity of Colombian CTV strains versus these cultivars. So far the stem-pitting symptoms on Dancy and Minneola seem to affect only the trunk and the main branches without any apparent detrimental effect on the yield. But in the future Mild strains could be sought to test the benefit of cross protection.

• Trinidad.

The area presently dedicated to citrus in Trinidad amounts to 5,000 ha, all established on sour orange. This area is divided into three types of orchards :

- A Cooperative Citrus Growers Association CCGA accounting for 2,000 ha with 425 small holders.

- Caroni LTD, a sugar company involved in citriculture with 1,200 ha of newly planted oranges and grapefruits (7).

- Various independent growers and Private Companies such as Palo Seco LTD who are attempting to diversify in citriculture.

Five state nurseries are delivering citrus planting material in Trinidad. One of the most important is located at St Augustine and is run by the Ministry of Agriculture. An adjacent foundation block is established at the perimeter of the St Augustine station.

CARONI LTD has also developed its own nursery with budwood taken from healthy looking trees grafted on Sour Orange that were planted in the late 1970's in an isolated farm belonging to this company.

Our tristeza survey during november 1991 took place at the following locations : **Caroni La Gloria Estates, Caroni Todds Road Estates,** and **St Augustine station.**

i) At La Gloria (700 ha) and Todds Road (500 ha), two estates located in the South and Center of Trinidad Island respectively, no Tristeza symptoms were noticed. In both estates the percentage of various citrus species is 70% oranges, 26% grapefruits and 4% mandarines and hybrids, all grafted on sour orange.

No declining trees, bronzed foliage, or defoliated trees were detected during the field survey that was conducted with five CARONI Senior and field officers. Four samples of young flushes were taken on abnormally weak trees (two from each estate) and gave negative ELISA tests for Tristeza. Multiple checks made on the canopies failed to detect the presence of *T. citricidus.*

At the time of our visit, it is clear that no CTV threat was impending on either CARONI Estates. This should, however, ne confirmed by a larger random sampling for ELISA detection. The main characteristics of these estates were the very low population level of aphids and the absence of *T. citricidus.*

ii) St Augustine nursery.

This nursery produces some 20,000 trees per year, all grafted on sour orange. In one of the nursery plot, young Mexican lime showed typical vein-clearing

TABLE 4 - Importations of Citrus budwoods at the Central ICA Station of Palmira.

Origin	Number of cultivars	Year of introduction
Riverside, California	126	1933
IPEACS, Brazil	21	1963
Winter Haven, Florida	5	1964
India, California	15	1964
Orlando, Florida	3	1964
IVIA, Spain	11	1987
SRA, Corsica, France	10	1991
Total	**191**	

symptoms (Photo 3 B). But these plants did not show any specific stionic decline. When subjected to ELISA they tested positive for tristeza (see Fig. 3). Observation of the mother trees in the adjacent foundation block revealed stem pitting on lime trees one of which was more severe (Photo 3 A) and gave a clear positive ELISA test.

Another typical feature of the St Augustine nursery was the presence of numerous *Toxoptera citricidus* colonies on the new flushes of the young grafted plants in nursery blocks.

In conclusion the Trinidad survey has shown that :

i) CTV is affecting several lime mother trees of the foundation block of St Augustine station. These trees are grafted on an unknown rootstock and seem to have been infected several years ago. These individuals are extremely dangerous CTV carriers that should be destroyed immediately.

The disease is presently propagated by graft from this contaminated budwood source. Although limes represent a minor percentage of the St Augustine nursery (about 15%) this is enough to spread CTV in Trinidad.

ii) What makes the situation more dangerous is the fact that *T. citricidus* has invaded the St Augustine nursery. Therefore, not only CTV but also its most efficient vector is presently spreading on the Island.

iii) The St Augustine aphid outbreak seems recent (one or two years at the most) and had not yet affected CARONI plantations at the time of our visit. This is substantiated by the fact that no specific decline was detected on sweet oranges or grapefruits grafted on sour orange in La Gloria and Todds Road Estates.

iv) If no action is taken the disease will most likely continue to incubate on St Augustine and the symptoms of **Stionic decline** will appear more and more frequently on young sweet oranges grafted on sour orange. With time the disease could expand from the St Augustine focus and be spread throughout the territory.

Considering the high efficiency of *T. citricidus*, the following recommendations are made :

i) Immediately destroy the CTV contaminated lime trees of St Augustine (both affected mother trees and young grafted plants. Avoid further distribution of lime plants and trace back the consignments of plants already delivered and destroy these found. Regrowths should be burnt out by Kerosene or killed by herbicides.

ii) Stop the sales of orange and grapefruit plants from St Augustine nursery in order to assess the CTV situation of these species. It will be necessary also to burn all contaminated individuals.

iii) Prior to any destruction of nursery plants, spray insecticides to avoid the further spread of *T. citricidus*.

iv) Establish a repository of certified disease free budwood under screenhouse at St Augustine and restart nursery production from this nucleus. The nursery plants can be grown outdoor with a chemical protection of aldicarb.

v) Stop the over reliance on sour orange rootstock and use new tolerant rootstocks : citranges, citrumelos, *Poncirus trifoliata*. Make sure the new budwood is not contaminated by *Exocortis* as these stocks are sensitive to this viroid.

vi) Because it is likely that CTV will gradually expand in Trinidad, the economic losses in commercial orchards could be minimized by launching a **preventive program of inarching** on existing plantations, when feasible.

vii) Monitor the CTV and *T. citricidus* spread in Trinidad and Tobago for adjusting relevant strategies of control (full eradication and/or preventive actions).

• Martinique.

In Martinique various field surveys were conducted in private Estates such as Moulin à Eau, Bellevue Marigot and at the CIRAD-IRFA Station of Rivière Lézarde.

None of the samples collected to investigate the presence of CTV by ELISA has shown positive results. In the private estates the major citrus production is Tahiti lime along with various cultivars of grapefruits oranges, and hybrids of mandarins all obtained from the nursery of Rivière Lézarde.

The CIRAD-IRFA Station is supplying disease-free registered materiel imported from the Station of San Giuliano in Corsica. Besides running the state nursery delivering a yearly average of 15.000 plants, this station has embarked on a large varietal and rootstock programme covering 160 scion cultivars and more than 10 rootstocks.

All the budwood is obtained from the Station of Corsica, while 60% of rootstock seeds are currently imported from Willits and Newcombs in California.

Over the last 12 to 18 months an upsurge of Citrus aphids was noticed in this Island. A close inspection of these aphids has shown that *T. citricidus* was a recent invader in Martinique. The taxonomic identification of this aphid was confirmed by Leclant *et al.*, 1992 (9).

At Bellevue Marigot some 15-year-old Tahiti lime trees presently show some stem-pitting symptoms on the trunk and scaffold branches. However none of these individuals has tested positive for Tristeza when subjected to the ELISA tests. This stem-pitting symptom of unknown origin so far has not been related to any infectious causal agent.

To sum up, the present situation seems to indicate that *T. citricidus* was blown by trade winds. It is speculated that a very low percentage of these new aphids reaching Martinique were viruliferous. The permanent ELISA surveys being carried out in Martinique will provide additional information in the near future. It is worth mentioning that strict quarantine regulations are applied to the move-

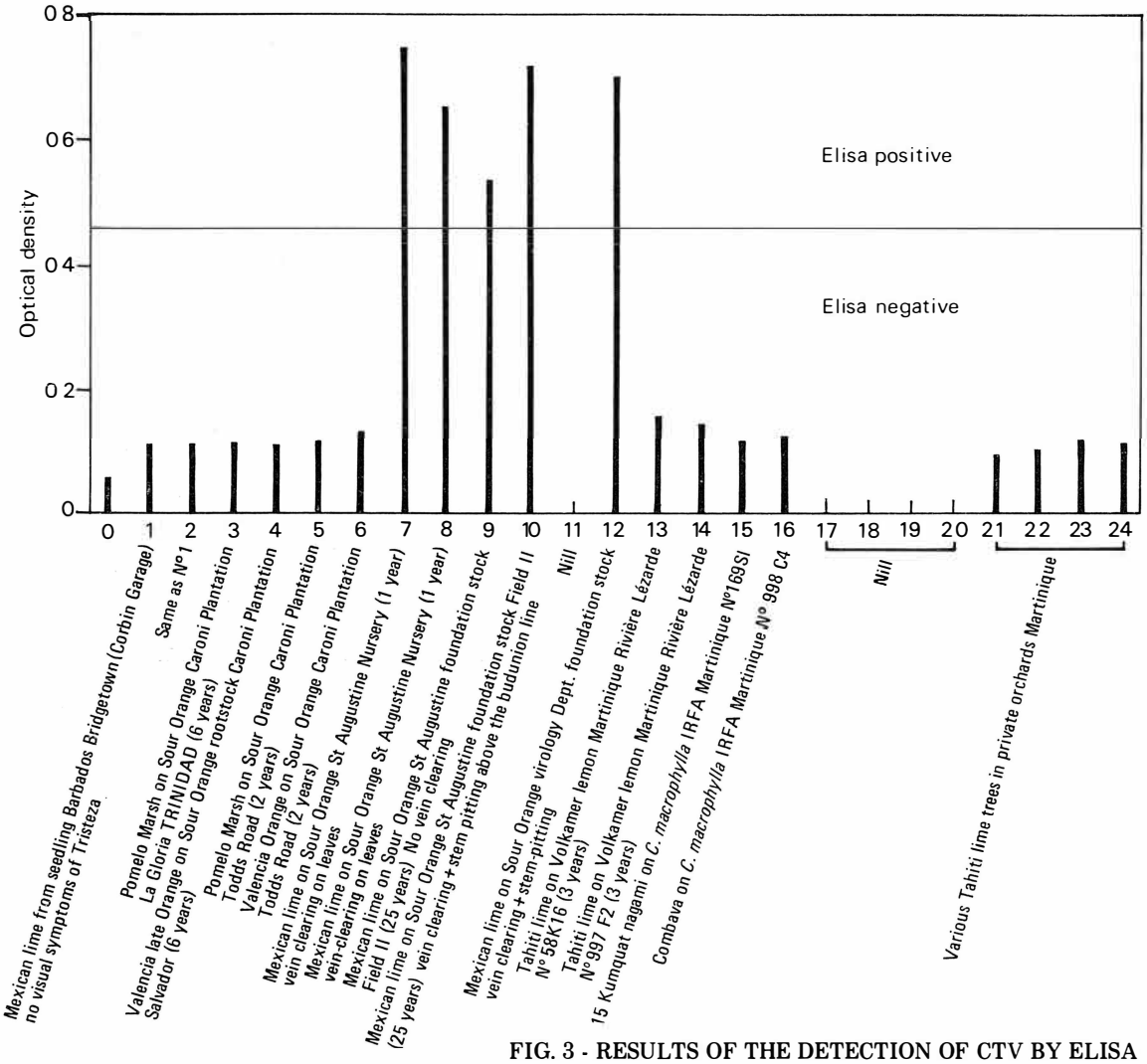


FIG. 3 - RESULTS OF THE DETECTION OF CTV BY ELISA

ment of citrus budwood into Martinique. Only Corsican SRA certified disease-free budwood is authorized by local Plant Protection Officers. This island is so far free from Tristeza, Blight, Citrus Canker and any disease of economic importance.

- St Lucia.

After the workshop held in Martinique, Dr. Lennox Andrews was able to send aphid samples fixed in alcohol to Montpellier. The insects were collected in various places of St Lucia and their taxonomic study revealed the presence of *Toxoptera citricidus*.

- Guadeloupe.

The situation of Guadeloupe is quite similar to that experienced in Martinique. A local branch of CIRAD-IRFA is managing a disease-free foundation block along with certified nursery. The citrus material is exclusively originated from the SRA Corsican accessions.

In december 1991 the second author (J.E.) found the brown citrus aphid *Toxoptera citricidus* suddently disseminated in the Island. Out of 20 collecting zones, 18 were infested with *T. citricidus* an aphid that had never been recorded previously from this territory (9).

- Dominican Republic.

While no information is presently available concerning the Tristeza status in the Dominican Republic, the brown citrus aphid was detected in march 1992 from the citrus groves of HATO MAYOR. Winged adults sent to Montpellier that had been erroneously attributed to *T. aurantii* were in fact identified as *T. citricidus*. The second author (J.E.) who visited the country between april 16th and 23rd was able to find *T. citricidus* in many places. He believes that the insect might have invaded Haiti as well.

DISCUSSION AND CONCLUSION

Citrus Tristeza is one of the major disease affecting citrus production worldwide. The economic losses caused by this malady varies considerably according to the particular horticultural situations in each epidemic areas. Since the Argentinian outbreak of the early 1930's, Tristeza damage can be evaluated to hundreds of millions of US dollars.

In almost all cases, infections of nurseries and move-

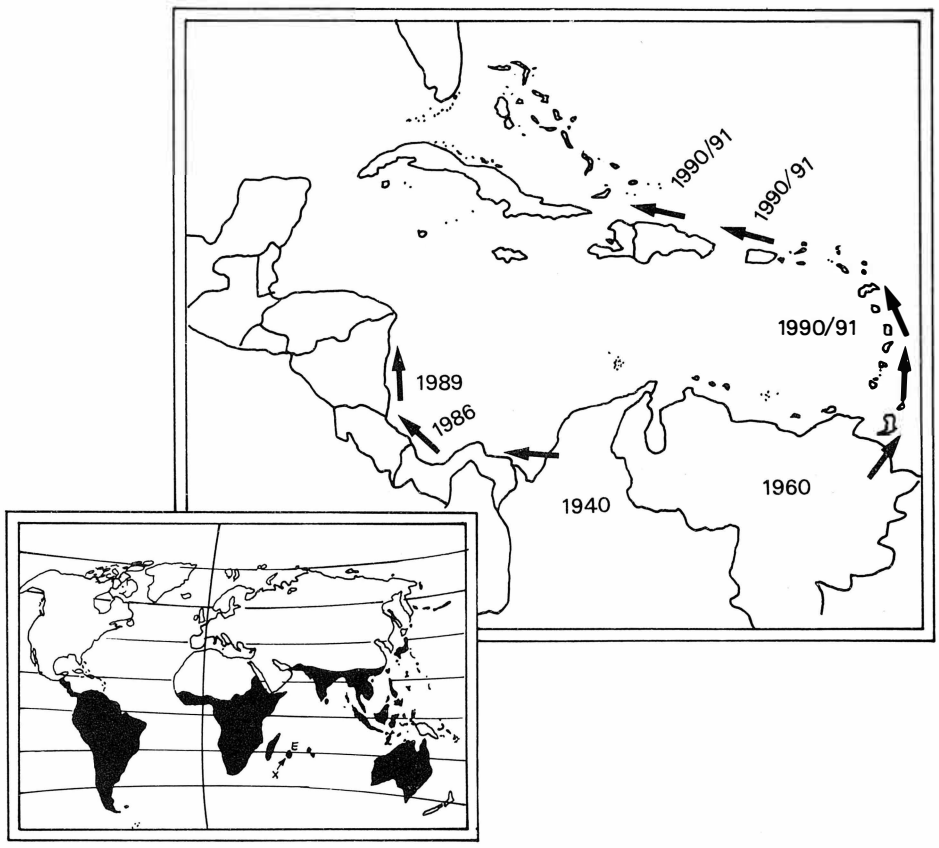


FIGURE 4 - WORLD DISTRIBUTION OF *TOXOPTERA CITRICIDUS* AND ITS RECENT MOVEMENT INTO THE CARIBBEAN BASIN.

ment of infected propagative material were the main sources for distant infections and eventually contributed to the fast spread of the disease (7).

The new threat presently impending on the Caribbean Basin originates from the sudden invasion of *T. citricidus* northward, as this aphid is undoubtedly more effective than other vectors in spreading Citrus Tristeza Virus. During a recent survey made in Puerto Rico (May 1992), S. GARNSEY and R. YOKOMI have found *T. citricidus* in the Central Region (San Juan - Corozal - Aibonito) and the Western Region (Mayaguez - Aguadilla - Lares) (6). This aphid was apparently not recorded during an earlier survey in May 1990. Tristeza detection by ELISA indicates that CTV is definitely present in Puerto Rico (10).

It is clear that the sudden spread of *T. citricidus* in the Caribbean Basin through continental America and the Windward Islands is an extremely serious threat for the citriculture of Cuba, Florida, Central America and Mexico where farmers are relying heavily upon the sour orange rootstock.

Among the possible control strategies it is advisable to avoid an excessive dependance upon a particular rootstock, but rather to rely on a range of rootstocks that would ensure reasonable yields of good quality for a long economic life. Tristeza tolerance can be combined with foot rot tolerance, good yield and high brix inducing rootstock. Carrizo citrange, Swingle citrumelo and *Poncirus trifoliata* are potential solutions.

Biological control directed against *T. citricidus* is another possible avenue of control, especially through the introduction and acclimatization of exotic natural enemies.

First preference should be given to specific parasitoids that establish not only on crop plant but also on alternative host plants that afford shelter to the vectors i.e. *Lysiphlebus japonicus, L. fabarum, L. testaceipes, L. delhiensis*... Second preference should be given to general predators that are effective at low prey densities and are active at the early flushing season (11).

Finally a coordinated research program is necessary to further assess the severe strains of CTV that are being found in the Caribbean Basin and monitor the various epidemiological scenarios in different ecological situations to implementing relevant preventive measures.

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EL VIRUS DE LA *TRISTEZA* UNA NUEVA AMENAZA PARA LA CITRICULTURA DE LA ZONA CARIBE.
INFORME DE INVENTARIO EN COLOMBIA, REPUBLICA DOMINICANA, GUADALUPE, MARTINICA y TRINIDAD.

B. AUBERT, J. ETIENNE, R. COTTIN, F. LECLANT, Ph. CAO VAN, C. VUILLAUME, C. JARAMILLO y G. BARBEAU.

Fruits, May-Jun. 1992, vol. 47, nº 3, p. 393-404.

RESUMEN - El pulgón moreno de los cítricos *Toxoptera citricidus* Kirkaldy apareció súbitamente en las islas de la zona Caribe. Se trata del vector más eficaz del virus de la *Tristeza*. En Trinidad su presencia es asociada a la de este virus. En las Antillas francesas (Martinica y Guadalupe) *T. citricidus* fué observado a final de 1991 pero todas las pruebas para detectar la *Tristeza* se han revelado hasta la presente negativas. *T. citricidus* igualmente señalado en Santo Domingo y Puerto Rico amenaza bastante rápidamente Cuba y Florida.