Incidence and Distribution of Papaya Viruses in Southern Florida

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ABSTRACT

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Surveys of papaya (*Carica papaya*) showed that papaya ringspot virus (PRV) was widely distributed in three counties of southern Florida. Incidence of PRV ranged from 0 to 100% in 30 plantings in Dade, Monroe, and Sarasota counties. In Dade County, the only county where papaya is grown commercially, 14 of 20 fields showed 100% PRV infection. In Monroe County, PRV infection of domestic plants averaged 64%, and in Sarasota County, only 14% of the domestic plants examined were infected. Papaya droopy necrosis virus (DNV) was also observed in Dade, Monroe, and Sarasota counties; incidence of DNV ranged from 0 to 22.2%. Neither PRV nor DNV was observed in Broward, Manatee, Charlotte, or Lee counties. Papaya mosaic virus and papaya bunchy top were not observed during the surveys.

Virus diseases are limiting factors in papaya (*Carica papaya* L.) production in southern Florida (3,4,9,14). In 1962, Conover (3–5) described three sap-transmissible viruses affecting papayas: mild mosaic, distortion ringspot, and faint mottle ringspot viruses. Faint mottle ringspot virus is considered to be a strain of distortion ringspot virus (5). In 1965, DeBokx (10) designated mild mosaic virus as papaya mosaic virus (PMV) and distortion ringspot virus as papaya ringspot virus (PRV). PRV is a potyvirus and PMV is a potexvirus (22,26,28). In 1981, Wan and Conover (33) described papaya droopy necrosis, a disease associated with a rhabdovirus, in southern Florida. Some properties of these viruses, such as host range, transmission, physical and chemical properties, vectors, and particle morphology, were studied previously (3–5,9,10,12,26,28,32–34). Information about the incidence and distribution of these viruses in Florida, however, and the presence of other viruses and viruslike diseases (8,18,31) affecting papayas is lacking. This paper reports the results of papaya virus disease surveys made during autumn of 1981 in seven counties in southern Florida where papayas are grown.

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MATERIALS AND METHODS

Survey. Commercial, domestic, and wild papaya plants grown in counties in southern Florida were surveyed, based primarily on characteristic host symptomatology. For domestic and small commercial papaya plantings, individual plants were examined, whereas for large commercial plantings, four to eight rows of plants including the peripheral rows of the fields were chosen and examined for virus-induced symptoms. PRV was diagnosed on the basis of leaf distortion and greasy-appearing streaks on stems and rings on fruits (4), whereas droopy necrosis virus (DNV) was diagnosed by the presence of recurvature, yellowing, and stiffening of young leaves in apical buds and shortening and stiffening of petioles (33). PMV, previously described from Florida (3,5) and Venezuela (15), would have been diagnosed by the presence of green mottle on leaves without distortion and the absence of symptoms on fruits and stems (5). Papaya bunchy top caused by a mycoplasmalike organism, the most serious disease in the Caribbean area (16,21,31), would have been diagnosed on the basis of the absence of latex from wounds made on field papaya plants (8,31).

Assays. Four or five samples from different papaya plants, including symptomatic and asymptomatic leaves, were collected from each field visited. Inocula were prepared by triturating field leaf samples in water with a mortar and pestle. Carborundum (600-mesh) was used as an abrasive. Papaya and pumpkin (*Cucurbita pepo* L. 'Small Sugar') were used as test plants. PRV induces systemic mottle and veinclearing on Small Sugar pumpkin, whereas PMV does not infect this host (4,5,10). Eight papaya and four Small Sugar pumpkin plants were inoculated for each field sample.

Field samples and leaves from inoculated test plants were assayed serologically for PMV and PRV by double-diffusion tests, using a medium containing 0.5% sodium dodecyl sulfate, 1.0% sodium azide, and 0.8% agar (13,27). Antigens were prepared by triturating leaf tissue in a mortar and pestle without diluent, expressing the sap through cheesecloth, and storing the undiluted juice frozen until used. Antisera to watermelon mosaic virus-1 (WMV-1), PRV, and PMV were used to detect PRV and PMV infections. The PMV and WMV-1 antisera were obtained from D. E. Purcifull (University of Florida) and the PRV antiserum was from D. Gonsalves (New York State Agricultural Experiment Station, Geneva). The homologous antigens of WMV-1, PRV, and PMV (in leaf extracts) used as controls were also obtained from D. E. Purcifull. Because PRV was not purified in this work and sufficient amounts of PRV antisera were not available, antiserum to WMV-1, which is serologically related to PRV (12,26,29), was used in routine detection of PRV infection.

RESULTS

The incidence and distribution of PRV and DNV in southern Florida are presented in Table 1. PMV and bunchy top were not observed in any of the counties surveyed.

Dade County is the only county in Florida where papayas are grown commercially, and PRV was detected in all but one of the 20 plantings surveyed. In plantings that were 7–36 mo old, PRV incidence ranged from 20.6 to 100%. In fields D, G, and H (Table 1) where plantings were established only 3–5 mo previously, PRV incidence was low or absent (0, 3, and 12.2%, respectively). In Monroe County, PRV incidence averaged 64% and in Sarasota County, only 14% of the domestic plants examined were infected. Incidence of DNV was much lower than PRV (Table 1). Where DNV incidence was highest, plantings were 1.5–3 yr old.

In Broward, Manatee, Charlotte, and Lee counties, all the papaya plants surveyed were free of virus symptoms

although the age of the plants varied from several months to several years.

During the surveys, aphid colonies and cucurbitaceous weeds like *Melothria pendula* L. (creeping cucumber), which may be potential reservoirs of PRV (R. A. Conover, *unpublished*), were not found in or around the papaya fields. Colonies of whiteflies and mites (*Teranychyus* spp.) were commonly found on papaya plants, especially in counties on the western coast.

All papaya seedlings inoculated with extracts from field samples and diagnosed as PRV-infected developed characteristic symptoms (Fig. 1). Inoculated Small Sugar pumpkin developed chlorotic spots, veinclearing, veinbanding, and systemic mottling typical of PRV infection (9,10) (Fig. 2).

A preliminary reciprocal test using antigens and antisera of PRV and WMV-1 confirmed the previous reports that PRV reacts identically with WMV-1 (12,29). From 86 PRV-infected samples tested against WMV-1 antiserum, however, only about 10% showed immunoprecipitin bands. No precipitin bands occurred between PMV antiserum and field samples and inoculated test plants. Neither antiserum reacted with antigens from healthy pumpkin or papaya nor were there reactions between normal sera and any of the antigens.

Table 1. Incidence of papaya ringspot (PRV) and droopy necrosis (DNV) viruses in papaya in south Florida counties

County	Grower	No. plants surveyed	Nature of planting[a]	Incidence (%)[b]	
				PRV	DNV
Dade	A	263	Com	82.1	0.0
	B	211	Com	100.0	0.0
	C	174	Com	20.6	0.0
	D	412	Com	0.0	0.4
	E	348	Com	100.0	1.4
	F	723	Com	100.0	0.6
	G	693	Com	3.0	1.1
	H	1194	Com	12.2	0.2
	I	50	Com	40.0	0.0
	J	454	Com	100.0	19.3
	K	475	Com	100.0	5.9
	L	607	Com	100.0	0.8
	M	304	Com	100.0	0.6
	N	870	Com	100.0	2.3
	O	145	Com	100.0	1.3
	P	479	Com	100.0	3.7
	Q	190	Com	100.0	15.2
	R	229	Com	100.0	1.3
	S	159	Com	100.0	5.6
	T	301	Com	100.0	22.2
Monroe	A	15	Dom	93.3	0.0
	B	15	Dom	86.6	0.0
	C	4	Dom	50.0	0.0
	D	9	Dom	100.0	11.1
	E	7	Dom	14.2	0.0
	F	14	Dom	42.8	0.0
	G	24	Wil	62.5	0.0
	H	19	Wil	84.2	0.0
Broward	A	3	Dom	0.0	0.0
	B	6	Dom	0.0	0.0
	C	4	Dom	0.0	0.0
	D	4	Dom	0.0	0.0
	E	32	Dom	0.0	0.0
	F	5	Dom	0.0	0.0
	G	15	Dom	0.0	0.0
	H	1	Dom	0.0	0.0
	I	23	Dom	0.0	0.0
Manatee	A	2	Dom	0.0	0.0
	B	3	Dom	0.0	0.0
Sarasota	A	34	Dom	5.8	0.0
	B	45	Dom	20.0	6.6
Charlotte	A	6	Dom	0.0	0.0
Lee	A	7	Dom	0.0	0.0

[a] Com = commercial, Dom = domestic, and Wil = wild.
[b] Based on host symptomatology.

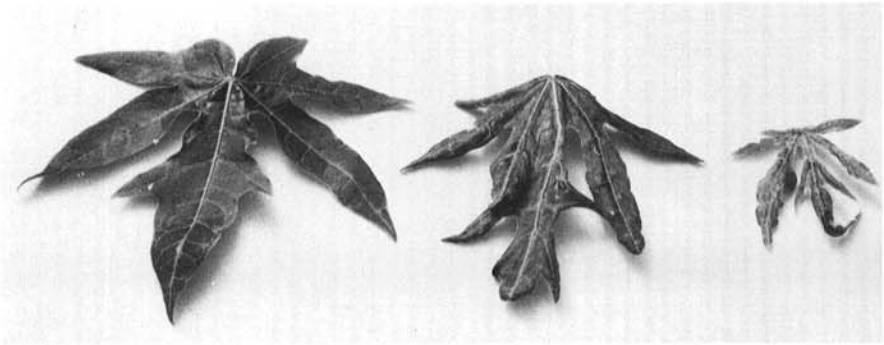

Fig. 1. Leaves of inoculated papaya test plants showing systemic mottle and leaf distortion symptoms after inoculation with a papaya field sample that showed symptoms characteristic of papaya ringspot virus.

DISCUSSION

The high incidence and wide distribution of PRV in Dade, Monroe, and Sarasota counties probably reflect a very high inoculum potential and the prevalence and efficiency of aphid vectors in transmitting PRV.

The comparatively lower incidence of DNV could be attributed to several factors, including vector efficiency and/or vector prevalence. Some type of phloem-feeding insect is probably responsible for the spread of DNV because the vectors of other rhabdoviruses are aphids, leafhoppers, and plant hoppers (11,17). The papaya leafhopper (*Empoasca papayae*), reported to transmit papaya bunchy top (1,30), and papaya apical necrosis, a disease caused by a rhabdovirus in Venezuela (18), is not known to occur in Florida (21,25). The vector of the DNV in Florida therefore remains unknown. During the surveys, the only phloem-feeding pests of papaya encountered were whiteflies (Aleyrodidae).

PMV, which had been found in Bradenton (Manatee County) in 1962 (R. A. Conover, *unpublished*), was not observed during the surveys, probably because it has no known natural vectors (28). Papaya bunchy top disease also was not found, presumably because the pathogen and its vector, *E. papayae*, do not occur in Florida (21,25).

In double immunodiffusion tests, only about 10% of the samples showing PRV symptoms reacted with WMV-1 antiserum. This was probably due in part to low antigen titer in papaya. Although more time is needed for symptom development, mechanical inoculations and field symptomatology are more reliable for PRV detection than immunodiffusion tests using WMV-1 antiserum as employed in this work. It is likely that PRV antiserum would be more useful for serological detection of PRV. Serum specific electron microscopy and enzyme-linked immunosorbent assay techniques, which can be more sensitive than immunodiffusion tests (2,24), may be useful in future surveys.

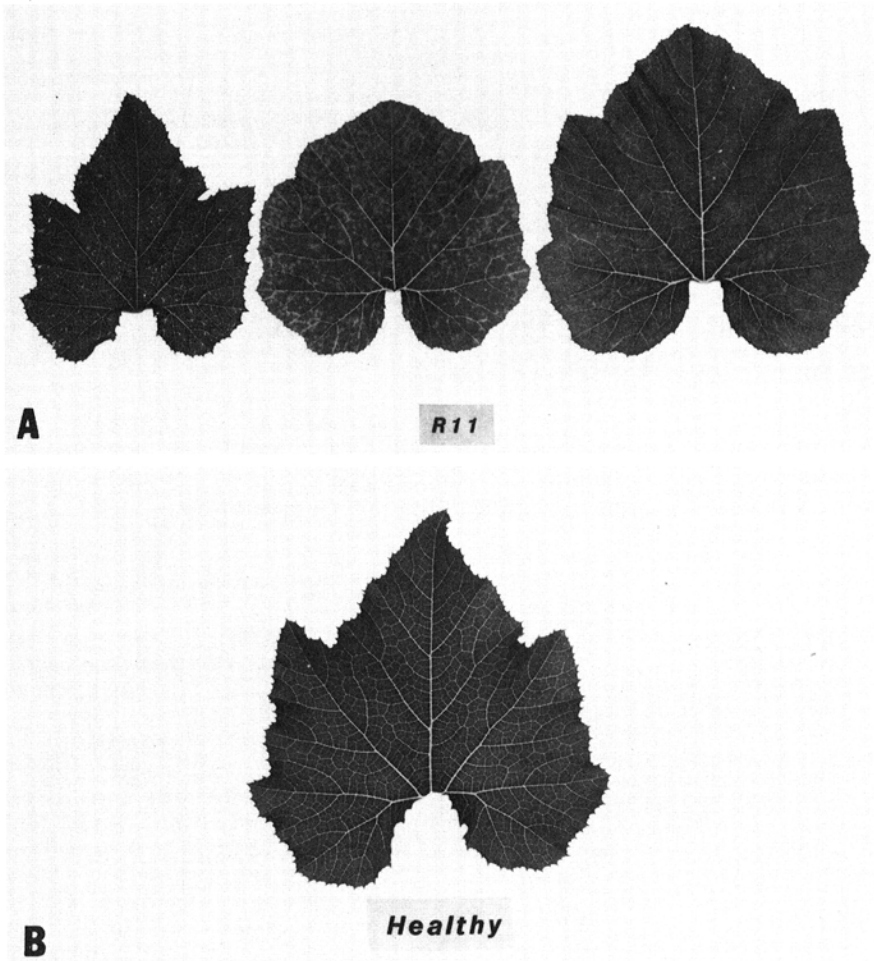

Fig. 2. (A) *Cucurbita pepo* 'Small Sugar' leaves showing (from left to right) veinclearing and chlorotic spots, vein banding, and systemic mottle after inoculation with a field papaya sample that showed characteristic symptoms of papaya ringspot virus. **(B)** Healthy *C. pepo* 'Small Sugar' leaf.

Unquestionably, papaya ringspot is currently the most serious disease of papaya in Florida. Control measures have not been developed for PRV in Florida (6,7,9,12,19,20). Eradication, which appears to be effective in Hawaii (12), is not likely to be practical in Florida because PRV appears to have natural reservoirs other than papaya, although these have not yet been identified. This assumption is based upon the rapid reappearance of PRV even after breaks between successive crops. If the suspected alternative host of PRV could be identified, eradication might be effective in Florida. Breeding for PRV-resistant or -tolerant papayas is currently considered a more practical alternative (6,7). No PRV-resistant papayas have yet been found (6,7,9,23), although PRV-tolerant cultivars have been developed through recurrent selection with polycrossing among some PRV-tolerant papayas (R. A. Conover, *unpublished*).

Papaya droopy necrosis has been observed in Florida since 1947 (R. A. Conover, *unpublished*) and between 1977 and 1979, it eliminated all of the papaya plantings in the experimental fields of the University of Florida Agricultural Experiment Station at Homestead. DNV appears to be increasing in importance and could threaten Florida papaya production in the future. Because neither an alternative host nor a vector of DNV has been identified, the suggested control measure at present would be a vigorous program of eradication whenever diseased trees are found. At the Agricultural Research and Education Center in Homestead, DNV incidence increased to a higher level when there was an overlap of old and new plantings. Avoiding an overlapping between successive crops, coupled with rouging all suspicious plants, has reduced DNV incidence at Homestead since 1979 (R. A. Conover, *unpublished*).

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