Spring Aphid Flights and Incidence of Watermelon Mosaic Viruses 1 and 2 in Florida

W. C. Adlerz

University of Florida IFAS, Agricultural Research Center, Leesburg 32748.
Florida Agricultural Experiment Stations, Journal Series Paper No. 4943.
The author gratefully acknowledges that aphid identifications were made in collaboration with A. N. Tissot.
Accepted for publication 14 September 1973.

ABSTRACT

The peak of spring aphid flights in both central and south Florida usually occurred between the last week in March and the last week in April in the years 1966-71. Initial symptoms of watermelon mosaic virus 1 (WMV-1) were observed on watermelon in south Florida prior to the peak in spring aphid flights, whereas initial symptoms of watermelon mosaic virus 2 (WMV-2) in central Florida were observed after peak flights. This may explain why outbreaks of mosaic in south Florida are consistently more severe than those in central Florida.

The difference in time of initial infection with the two viruses relative to peak aphid flights did not correlate with initial flights or abundance of specific vectors but may be explained by the distribution and abundance of weed hosts of the virus. In south Florida, the cucurbit weed *Melothria pendula* hosts a large reservoir of WMV-1 close to watermelon plantings. In central Florida, the principal source of WMV-2 remains to be identified, but the virus may occur in a variety of noncucurbit hosts. Reservoirs are probably small, necessitating relatively large numbers of aphids to effect initial transmission of the virus to watermelon.

Myzus persicae was invariably present as a major component of the vector populations during initial and secondary spread of both viruses, and it is considered one of the important vector species.

Phytopathology 64:350-353

Additional key words: Aphis spiraecola, Aphis craccivora, Hyadaphis pseudobrassicae, epidemiology.

Mosaic diseases caused by watermelon mosaic viruses 1 and 2 (WMV-1 and -2) are a continual deterrent to cucurbit production in Florida. Total crop failure resulting from 100% infection is not uncommon. Although both viruses can be found in weed hosts or crop plants in much of the state, WMV-1 has been the only important cause of mosaic disease of cucurbits in the Collier and Hendry County area of south Florida since 1964 (1) and was recently found to be the predominant virus in squash in Palm Beach County (2). In central and northern Florida, however, WMV-2 has been the predominant virus (1).

Recent studies of the weed hosts of these viruses in Florida emphasized the epidemiological importance to WMV-1 of *Melothria pendula* L. in Collier and Hendry Counties and of *Momordica charantia* L. in Palm Beach County (2, 3). Although several weed hosts of WMV-2 in central Florida were identified (1), none was found to be a major source of WMV-2 for spring infection of cucurbits.

Since 1966, various studies of aphid flights and the distribution of weed hosts of WMV-1 have been conducted in Collier and Hendry Counties in southwest Florida. Aphid flights and the incidence of WMV-2 have been studied in Lake County in central Florida. This paper correlates the spread of WMV-1 and WMV-2 with spring aphid flights, and relates certain characteristics of spread to weed sources of inoculum.

MATERIALS AND METHODS.—In 1966-68 at Immokalee (Collier County) and Felda (Hendry County), water-pan traps were 23-cm diam cake pans painted yellow (John Deere Yellow, Martin-Senour No. 7823) on the inside and flat black on the outside. Traps were placed on green plywood platforms 25 cm above the soil in watermelon rows. Aphid data in 1966, 1967, and 1968 were from nine, nine, and 12 traps, respectively, at various locations within single fields. In 1970 and 1971 at Immokalee, aphids were taken on sticky board traps located near watermelon fields of about 81 hectares (200 acres) each. Each trapping site had two sticky boards, one oriented north-south and another east-west. Trap boards were 13 × 25 cm, painted John Deere Yellow and coated with Stickem Special® (Michel and Pelton, Emeryville, California). Sticky boards were oriented vertically 1.8 m above the soil and 3 m apart.

Lake County observations were made on experimental plantings of about 6.1 hectares (15 acres) at the University of Florida Agricultural Research Center at Leesburg. Aphid-trapping data were from 10 water-pan traps distributed within the 6.1 hectares (15 acres) in 1967 and 1968, four water-pan traps in 1969, and two sticky boards in 1970 and 1971.

Aphids for laboratory transmission tests were from uncrowded, healthy colonies. *Myzus persicae* (Sulzer) was reared on sweet pepper (*Capsicum frutescens* L. 'California Wonder'), *Aphis gossypii* Glover on watermelon [*Citrullus lanatus* (Thunb.) Mansf. 'Charleston Gray'], *Aphis craccivora* Koch on cowpea (*Vigna sinensis* Savi 'Blackeye'), and *Aphis spiraecola* Patch on *Chenopodium ambrosioides* L.

Pumpkin (*Cucurbita pepo* L. 'Small Sugar') was used as the virus source and test plant. Virus source plants were inoculated 14 days before inoculum was needed. Test plants were inoculated in the cotyledon stage.

Aphids were starved in Erlenmeyer flasks for at least 30 min before they were allowed inidividual 10- to 60-s naturally-terminated acquisition probes on virus source plants. Probing aphids were observed through a hand lens. Inoculation access periods on test plants were 1.0 h. Plants were held in a greenhouse after aphids were killed by fumigation with nicotine.

RESULTS.—*Peak aphid flights and first mosaic symptoms.*—The peak of spring aphid flights which effected initial transmission of viruses to watermelon occurred between the last wk in March and the last wk in

April in both Collier and Hendry Counties in south Florida and in Lake County in central Florida (Fig. 1).

In all 5 yr at Immokalee or Felda (Collier and Hendry Counties, respectively), WMV-1 was transmitted very early to watermelon when numbers of aphids trapped were very small (Fig. 1). First symptoms of infection were observed between the second wk of March and the first wk of April, which was before the peak aphid flights.

In each of the 5 yr at Leesburg, WMV-2 was transmitted to watermelon about 1 mo later than WMV-1 was transmitted to watermelon in Immokalee-Felda. First symptoms of infection were observed between the second wk of April and May while aphid numbers were declining from the March-April peak. During the second wk in May 1971, unusually high aphid populations, mostly *A. spiraecola,* were recorded after symptom appearance (Fig. 1); these, however, were too late to affect the crop.

Aphid species and virus spread.—At the time of first infection at Immokalee-Felda, the winged aphids trapped in largest numbers and with greatest annual frequency were *M. persicae, Hyadaphis pseudobrassicae* (Davis), *A. craccivora,* and *Rhopalosiphum rufiabdominalis* (Sasaki) (Table 1). These aphids comprised a large proportion of the total aphids trapped during the initial spread period in at least 4 of the 5 yr. *A. spiraecola* occurred in relatively large numbers in this period but in only 3 of the 5 yr. *M. persicae* was most prevalent overall, ranking first or second in abundance each year.

Aphids flying in greatest abundance and with greatest annual frequency during the period of secondary spread in Immokalee-Felda were the same as during initial spread. *M. persicae* and *A. craccivora* were abundant every year, and *H. pseudobrassicae, R. rufiabdominalis,* and *A. spiraecola* in 4 of the 5 yr.

At Leesburg, *A. spiraecola* and *M. persicae* were the only species that occurred as major components of the winged aphid population every year at the time of first infection in watermelon (Table 2). *M. persicae* ranked first or second in abundance each year except 1971 and *A. spiraecola* each year except 1968. *H. pseudobrassicae* also was relatively common but in only 3 of the 5 yr.

Aphids flying in greatest abundance during the period of secondary spread in Leesburg were the same as during initial spread in both order of abundance and frequency of occurrence; i.e., *A. spiraecola* and *M. persicae.*

Virus-transmission efficiency of aphids.—In preliminary tests with Florida isolates, *M. persicae* and *A. gossypii* were comparably efficient vectors; both transmitted WMV-1 and WMV-2 equally well. In tests with a WMV-1 isolate from Immokalee and a WMV-2 isolate from Leesburg, transmission efficiencies of four aphid species that occurred commonly in spring flights were relatively high (Table 3). Some *A. spiraecola* individuals would not feed on Small Sugar pumpkin virus source plants, thus, reducing the number of tests completed with this vector.

In limited tests, *H. pseudobrassicae* was an inefficient vector of both isolates compared with *M. persicae.* Therefore, one of the relatively common species flying in both areas, and especially in Immokalee, may be less important than its numbers might otherwise indicate.

Studies designed to correlate the incidence of mosaic caused by a stylet-borne virus with numbers of any one species of aphid have been known to fail because these viruses are often transmitted by many species (4). *M.*

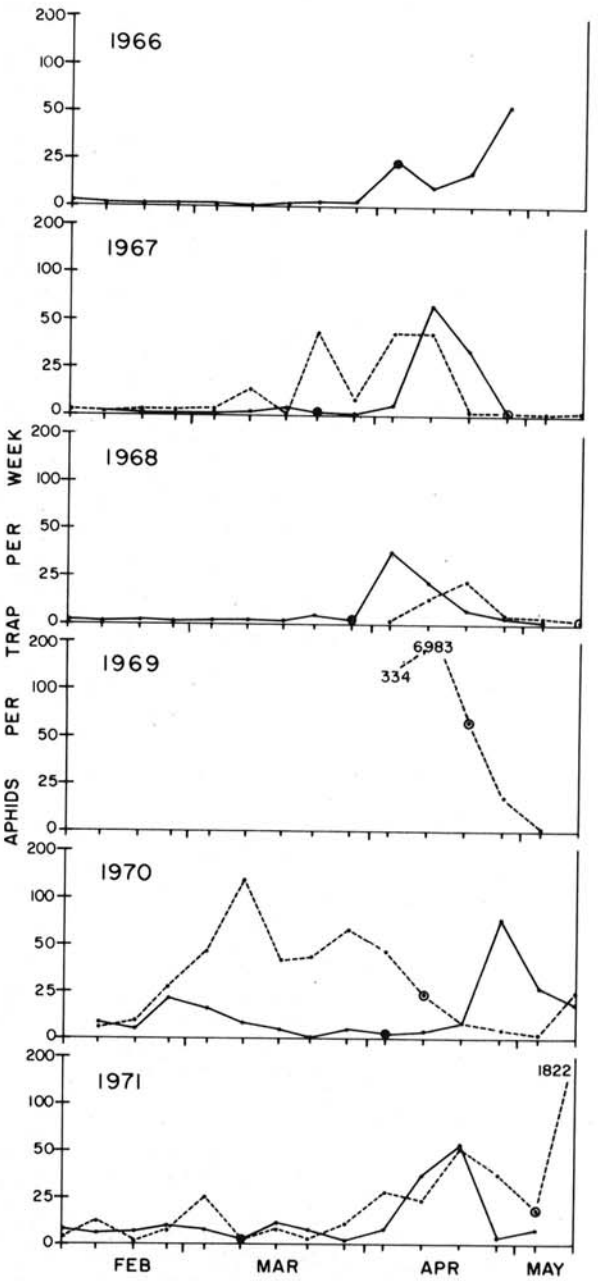

Fig. 1. Alate aphids trapped near watermelon fields in Collier and Hendry Counties of south Florida (————) and first incidence of watermelon mosaic virus-1 (WMV-1) (————•————). Alate aphids trapped near a watermelon field in Lake County of central Florida (--------) and first incidence of WMV-2 (----Θ----). South Florida: average from nine water-pan traps in 1966-67, 12 water-pan traps in 1968, and number from two sticky boards in 1971. Central Florida: average from 10 water-pan traps in 1967-68, four water-pan traps in 1969, and number from two sticky boards in 1970-71.

TABLE 1. Numbers of aphids of several species trapped at Immokalee or Felda, in southern Florida in 1966-68 and 1970-71 during each of two time periods: (i) at about the time of first infection of watermelon with WMV-1; (ii) during the period of secondary spread

Aphid species	Numbers of aphids trapped									
	Period of first infection					Period of secondary spread				
	66[a]	67[a]	68[b]	70[c]	71[c]	66[a]	67[a]	68[b]	70[c]	71[c]
Myzus persicae	29	12	54	1	4	79	782	374	2	19
Hyadaphis pseudobrassicae	32		1	1	2	43		34	1	28
Aphis craccivora	13	2		1	1	1,043	22	90	55	32
Rhopalosiphum rufiabdominalis	6		1	1	3	18		2	19	5
Aphis spiraecola	16	35	2			6	5	213	19	
Tetraneura hirsuta				1	1				1	5
Rhopalosiphum maidis	13									
Aphis coreopsidis		4								
Schizaphis graminum	3					110			1	
Aphis nerii				1						
Misc. species	44	4	6			146	14	64	22	47

[a] Average from nine water-pan traps.
[b] Average from 12 water-pan traps.
[c] Number from two sticky boards.

TABLE 2. Numbers of aphids of several species trapped at Leesburg, central Florida, in 1967-71 during each of two time periods: (i) at about the time of first infection of watermelon with WMV-2; (ii) during the period of secondary spread

Aphid species	Number of aphids trapped									
	Period of first infection					Period of secondary spread				
	67[a]	68[a]	69[b]	70[c]	71[c]	67[a]	68[a]	69[b]	70[c]	71[c]
Aphis spiraecola	1,571	35	293	23	21	75	18	6,862	14	2,469
Myzus persicae	49	97	28	27	7	13	5	159	13	5
Hyadaphis pseudobrassicae		7		16	17	5	10		8	2
Anuraphis middletonii		90			8		97			2
Aphis gossypii	14	7				8	21			
Aphis craccivora				6	6				2	
Capitophorus eleagni					10					
Rhopalosiphum padi				5						
Rhopalosiphum rufiabdominalis				5					7	
Tetraneura hirsuta				3					6	
Misc. species	44	35	13	26	32	35	24	48	14	16

[a] Average from 10 water-pan traps.
[b] Average from four water-pan traps.
[c] Number from two sticky boards.

persicae may be one of the more important vectors of watermelon mosaic viruses in Florida because: (i) it was an efficient vector of WMV-1 and -2 in laboratory tests; and (ii) it was consistently one of the major components of aphid populations in central and south Florida during both initial and secondary spread periods. Other vectors have been shown to be efficient virus transmitters and may be more important than *M. persicae* at times. This is especially true of *A. spiraecola,* which occasionally develops very large populations.

Survey for WMV-2 weed hosts.—Attempts were made to extract WMV-2 from weeds near infected cucurbits in central Florida. Special attention was paid to plants in the families Leguminosae, Chenopodiaceae, Malvaceae, and Umbelliferae because WMV-2 was originally distinguished from WMV-1 by its ability to infect hosts in these families (14). Some plant species were found by the author (1) to be naturally infected with WMV-2, but the only infected perennial was not considered important in the epidemiology of the disease in watermelon.

Recent efforts have been concentrated on aphid extraction from *C. ambrosioides,* a common perennial weed near watermelon plantings in central Florida, that has been recently identified as a WMV-2 host (10). Since it has been shown that infection gradients indicate the direction of virus spread into crops (8, 12, 13), many of the samples evaluated were taken from watermelon plantings at the point of strong border effects soon after mosaic symptoms developed, but all efforts to find infected weeds failed.

One of the most important weed hosts of WMV-2 in Arizona, *Malva parviflora* L. (12), is not endemic in Florida and is rarely found there.

DISCUSSION.—Data in this paper are characteristic of conditions in which virus source plants are outside the fields and vectors flying into the fields are responsible for

TABLE 3. Transmission of an Immokalee (southern Florida) isolate of watermelon mosaic virus-1 (WMV-1) and a Leesburg, (central Florida) isolate of WMV-2 by four species of aphids

Aphid vector	WMV-1 (isolate 78)	WMV-2 (isolate 18)
Aphis gossypii	36/39[a] 92%	33/39 85%
Myzus persicae	27/39 69%	30/39 77%
Aphis craccivora	23/39 59%	15/39 38%
Aphis spiraecola	17/21 80%	8/21 38%

[a](Plants infected)/(plants inoculated), followed by the calculated percentage.

both primary introductions and secondary spread. *A. gossypii,* the only aphid to colonize watermelon in Florida, is kept under excellent control and colonization within the field is not an important factor in virus spread.

Watermelons grown in south Florida usually are marketed about 1 mo before those grown in central Florida. South Florida growers plant in volume in mid-December whereas central Florida growers cannot profitably plant watermelon until late January or early February.

As a result of the different planting times, watermelon plants commonly reach late running size (just before setting fruit) in late March in south Florida and late April in central Florida. Since these are also the respective times when the spread of WMV-1 and WMV-2 begins, watermelon becomes infected at about the same stage of growth regardless of location; therefore, size of plant at first infection is usually not a factor in relative severity of outbreak in the two areas. Infection relatively late in plant development appears to be common in other cucurbit production areas as well (5, 6, 7, 11).

The difference in time of virus spread to watermelon relative to peaks in spring aphid flights may be one of the most important reasons why south Florida mosaic outbreaks are characteristically more severe than those in central Florida. Mosaic symptoms first develop in south Florida watermelon during periods of increasing populations of alate aphids, thus permitting rapid secondary spread of mosaic, whereas symptoms in central Florida watermelon first appear during periods of declining aphid populations.

The warmer winters of south Florida not only permit earlier production of cold-sensitive crops, but are also an important factor in the abundant and voluminous growth of *M. pendula,* a common weed host of WMV-1. The common availability of inoculum near the crop plants (3) in a plant mass large enough to be encountered frequently by vectors is the probable reason why virus spread begins when the spring aphid flight begins and takes place even with very low aphid populations. In these circumstances, marked border infection gradients typical of transmission from a nearby source (12, 13) often result (3).

WMV-2 hosts of epidemiological consequence in the spring have not been identified in Leesburg; nevertheless, just as with WMV-1 in Immokalee, strong border effects are common in infected watermelon fields, possibly indicating proximity to a source of virus. The later spread of WMV-2 relative to peak aphid populations may be due to the relative paucity of inoculum, or in the case of a frost-sensitive perennial, the necessity for host weeds to attain sufficient size for vectors to encounter them.

There was no correlation of initial spread of WMV-1 or WMV-2 with first flights of any one aphid species. Although the early spread of WMV-1 might have been accomplished by a number of vector species, the common occurrence through initial and secondary spread periods of the efficient vector *M. persicae* enhanced the probability of transmission. *M. persicae* was also one of the major components of flights during WMV-2 spread. Initial spread, however, was not correlated with first flights of *M. persicae;* flights of this species began early and continued through the periods of both initial and secondary spread.

The proclivity of *M. persicae* to transmit stylet-borne viruses is well known (9). *M. persicae* does not colonize watermelon and probably can be expected to engage in short flights, thereby increasing its vector effectiveness as described by Dickson et al. (6).

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