Assessment of Virus Disease Incidence and Whitefly Populations in an Isolated Agroecosystem in Central Arizona

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SUMMARY

A survey study was undertaken to identify the plant viruses, to document the occurrence of virus diseases, and to document the seasonal population dynamics of insect vectors in a semi-isolated agricultural site in Central Arizona. A typical year-round cropping history at the site consists of cotton and seasonal sequences of vegetables. The most abundant insects caught using 24-hr exposures of yellow sticky traps were whiteflies (Trialeurodes abutilonea Haldeman and Bemisia tabaci Genn.) and the cotton (or melon) aphid (Aphis gossypii Glover). Of the three, only B. tabaci and A. gossypii are recognized as virus vectors in Arizona. The most prevalent plant virus identified in vegetable crops and/or weeds was lettuce infectious yellows virus (LIYV), a whitefly-transmitted virus. The virus was detected in lettuce, (greenleaf, romaine, iceberg, red leaf) watermelon, cantaloupe, spinach, and cilantro. In addition, the watermelon curly mottle/squash leaf curl virus complex (WCMoV-SLCV), watermelon mosaic virus 2 (WMV-2) zucchini yellow mosaic virus (ZYMV), cucumber mosaic virus (CMV), and squash mosaic virus (SqMV) were identified in cucurbits at various times and locations throughout the season.

INTRODUCTION

The sweet potato whitefly, Bemisia tabaci (Genn.), and the plant viruses it transmits became of paramount importance to agriculture in Arizona, other southwestern states, and Mexico in the last decade (1, 3, 5, 7). Devastating losses due to virus diseases and/or direct feeding damage caused by the whitefly in vegetable and fiber crops have been realized in both major irrigated agricultural regions of Arizona, as well as in more isolated production areas in the state (1, 2, 3, 4, 6, 13). The two major regions which are serviced by either the Colorado River (Yuma and vicinity) or the Salt River (Phoenix and vicinity) have become year-round reservoirs of a number of newly recognized plant viruses (2, 4, 6, 8) and their whitefly vector due to the availability of suitable host plants and mild climatic conditions. An increase in population levels of the bandedwing whitefly, Trialeurodes abutilonea (Haldeman), has occurred simultaneously with those of B. tabaci. Though damage due to feeding and deposition of honeydew can cause losses in some cases, to date, the T. abutilonea has not been implicated as a vector of plant viruses in Arizona (6).

In addition, numerous viruses which are transmitted either by aphids, beetles, fungi, or thrips have been reported previously in Arizona vegetable crops (6, 10, 11, 12, 13). Though losses due to these virus diseases are not considered as serious as those resulting from the whitefly-transmitted viruses on a routine basis, yields are reduced dramatically in some instances.

Because of the diversity of crops grown, and the sequential and overlapping cropping systems currently established in Arizona, it has been difficult to assess the seasonal dynamics of vector activities and, thus, the epidemiologies of the diseases incited by whitefly-transmitted viruses. (The situation is further complicated by the potential impact from similarly cropped agricultural regions in adjacent states and Mexico.)

An agricultural site was identified in central Arizona and selected as a model system in which to monitor insect populations, disease incidence, and the impact of virus diseases in vegetable and fiber crops. The site, located near Coolidge, bounded on the north by the Gila and on the south by the Santa Cruz Rivers, is spatially isolated from production areas in Yuma and Phoenix. The types of crops and cropping sequences are typical of those generally implemented in most other areas in the state where cotton and vegetables are grown. Though the degree to which the nearest major agricultural regions will affect the insect and disease dynamics at this somewhat isolated site is not known, it is postulated that each area has resident over-seasoning insect populations and sources of virus inoculum. It may be possible to ascertain the potential level of influx of viruses and vectors from nearby areas after monitoring the site for an extended time period.

The overall objectives of this long-term study are: (1) to monitor the virus disease incidence and associated vector populations, and the impact of the respective virus diseases at the site over time; (2) to determine whether varying the spatial and temporal patterns and cropping sequences will impact on the activities of the vector and/or the epidemiology; and (3) to utilize this information to develop, implement, and evaluate a variety of management strategies, which will ultimately reduce yield losses.

The first-year objectives of the study are: (1) survey and identify the plant viruses present in cultivated and weed species, (2) monitor the insect populations which can serve as virus vectors in both cultivated and weed species, and (3) locate the potential over-seasoning reservoirs of viruses and vectors which could serve as the primary loci for subsequent virus infections and insect infestations on a seasonal basis. Here, we report the results of the first six months of the survey conducted at the study site described above.

MATERIALS AND METHODS

Site History

An inspection tour was made to the experimental site in mid-July, 1988. The site consists of two independently farmed units (farm #1 and farm #2), located within a few miles of the other but separated by an uncultivated vegetated area. Routine sampling sites were located on both farms, and in uncropped but vegetated areas, within a 12 by 4 square mile area. At this time, cotton, spring and summer planted mixed melons, watermelon, and squash were in various stages of growth and maturation. Whiteflies were observed in cotton fields, as well as in spring planted melons. Squash and watermelon that had been planted on July 7 were in the seedling stage. The first lettuce (greenleaf, iceberg, and romaine) fields were planted about August 30. Staggered plantings of lettuce, spinach and other winter vegetables were scheduled for the fall 1988 and winter 1988-89. Cotton harvests were scheduled for November and December, 1988.

Insect Monitoring

The number and species of potential insect vectors were monitored at 1 1/2 - 2 wk intervals from September 1988 through February 1989, using yellow sticky trap cards (15 cm X 30 cm) placed at the edge of the field or ditch bank for a 24-hour exposure. Trapped insects were identified and counted. The major emphasis was on whiteflies and aphids, which were believed to be the two most important types of insect vectors in this area. When catches were low during the winter, whitefly eggs were counted on leaves collected from the predominant cultivated and weed species.

Virus Survey

Plant samples were collected routinely (on trapping days) and diagnosed for virus infection by bioassay using insect transmission to indicator plants (3, 4, 5), by serological testing in the laboratory (9), and/or by electron microscopy. Symptomatologies and sampling sites were noted and the results of the assays recorded.

RESULTS AND DISCUSSION

Insect Monitoring

Adult whiteflies were the predominant insect caught with the 24-hour exposure, yellow sticky trap, monitoring method. The population counts of B. tabaci and T. abutilonea at various locations at the study site are summarized in Table 1. General trends observed at farm #1 were: High population levels in cotton and vegetable crops planted in the spring or summer with lower populations present in fall- and winter-planted vegetable crops. Levels of T. abutilonea almost always exceeded those of the virus vector, B. tabaci, regardless of the crop or time of planting. However, as the temperatures began to fall in November and population levels decreased for both insects, an increase in the ratio of B. tabaci to T. abutilonea was observed. At farm #2, T. abutilonea was the predominant whitefly present in both cotton and ditch-bank weeds sampled. Thus, only low levels of B. tabaci were documented in the area which was planted primarily to cotton (Table 1).

Ditch-bank weeds, as well as cultivated species, were good sources of both species of whitefly (Table 1). In the ditch-banks, sunflower and camphorweed were early fall sources; cheeseweed became more important in the late fall and winter. In late February, sowthistle and London rocket were the next weeds in the continuum. Cotton was an excellent source of whiteflies in the summer and fall; during defoliation/harvest periods, populations in cotton dropped off rapidly. Subsequent catches in fall- and winter-planted vegetables increased, suggesting the likelihood that whiteflies were dispersed from cotton to vegetables.
Extremely cold temperatures, documented in late November and again in the late December, appeared to be responsible for the sudden decrease in whiteflies caught on traps, despite the availability of cultivated and weed hosts. Between December 21-26, approximately 60 hrs of temperatures below 0° C were accumulated at the site, based upon data obtained from the Arizona Meteorological Network (data collection site is at farm #1). Total whitefly egg counts made on cheeseweed at six locations at the site ranged between 546-1589 on November 23, 116-696 on Dec. 7, 0-17 on Dec. 15, 61-274 on Dec. 21, and 66-376 on Dec. 29, 1988, thus, indicating the potential for over-seasoning of whiteflies at the site.

Although relatively insignificant compared to whiteflies, alate aphids (A. gossypii Glover) were the second most abundant insects trapped. Two migrations were documented. The first occurred at farm #2 (before traps were in place), following rains which occurred July 29-August 1, 1988. The second migration was documented on October 21, during which 62 aphids were trapped in a 24-hour exposure.

Virus Survey

The whitefly-transmitted lettuce infectious yellows virus (LIYV) was detected for the first time at the site in symptomatic watermelon and cantaloupe, in mid-September. Another whitefly-transmitted virus, watermelon curly mottle virus/squash leaf curl virus complex (WCMoV-SLCV complex) was identified in symptomatic zucchini squash from samples collected on September 13. In addition, the aphid-transmitted viruses watermelon mosaic virus-2 (WMV-2) and zucchini yellow mosaic virus (ZYMV), were identified in symptomatic squash, cantaloupe, and watermelon collected on the same date. Squash, planted in July at farm #1 and melons at farm #2, were not harvestable as a result of the damage caused by the virus diseases, and fields were plowed under. The beetle-transmitted squash mosaic virus (SqMV) was detected in cantaloupe and squash plants in mid-September, but did not appear to be a limiting factor. During the remainder of September, October, and November, typical yellowing and/or and stunting symptoms were observed in lettuce (green leaf, romaine, and iceberg) and watermelon; LIYV was detected in symtomatic plants in lab assays. Planted later in the fall, red leaf lettuce was stunted, but yellowing symptoms typically associated with LIYV infection were not observed. The LIYV was detected in red leaf plants, however, in lab assays.

By early December, typical LIYV symptoms occurred to some degree (4%-97%) in all lettuce plantings at farm #1. In some cases, lettuce was not of harvestable quality. In green leaf and romaine plantings scheduled for harvest in mid-November to early December, 60% and 97% of the crops were lost due to virus infection (samples from these fields were positive for LIYV). Following extremely cold temperatures at the end of December, an iceberg lettuce planting, with lab assays of samples that were positive for LIYV, was plowed under. A combination of stresses resulting from LIYV infection and cold temperatures were likely responsible for crop failure.

Planted at the end of September, red leaf and Boston lettuce and spinach did not show severe symptoms due to virus infection until mid-December; LIYV was detected in symptomatic plants in lab assays. Later plantings remained free of symptoms and harvests were as scheduled for the end of December and January.

Plantings of cilantro exhibited severe stunting and yellowing in mid-January; bioassays were positive for LIYV.

In addition, various weed species were assayed for virus presence. The LIYV was the only virus detected in symptomatic sunflower and cheeseweed collected from ditch bank weed patches. Similar levels of virus were also detected in cheeseweed plants which showed no symptoms.

DISCUSSION

LIYV was the most important virus with respect to disease incidence and yield losses in summer, fall and winter vegetables; ZYMV was important in a few isolated cases. The diagnoses of LIYV infection in spinach and cilantro are the first documentations of these crops as hosts of LIYV in Arizona. Although cilantro is a member of the Umbelliferae which is known to contain hosts of the LIYV, to our knowledge, it has not been reported previously as a host of LIYV.

The predominant insect pests trapped using the yellow sticky trap (24-hr exposure) method were the whiteflies, T. abutilonea and B. tabaci. The cotton (or melon) aphid was also trapped during seasonal migrations, but they were of minor importance, with the exception of losses due to WMV-2 and ZYMV infections in squash and melons planted shortly before the summer aphid migration. The sweet potato whitefly, B. tabaci was identified as the most important insect vector associated with vegetable plantings at farm #1 where vegetables and cotton were interspersed. Populations of B. tabaci remained low throughout the season at farm #2, where cotton was the predominant crop, with a few scattered melon plantings.

Additional information will be collected following monitoring of the study site for the remainder of the 1989 growing season. It is hoped that information of this nature can be used to establish baseline levels for the temporal and spatial dynamics of whitefly and aphid populations, for the types of viruses which are prevalent, and of the incidence of virus diseases. This information will ultimately prove vital in defining, implementing, and evaluating management strategies for the control of insect vectors and the viruses they transmit.

Table 1. **Sticky trap catches (24-hr exposure) of adult whiteflies at various locations at the study site. In each column, Bt = Bemisia tabaci and Ta = Trialeurodes abutiloea.**

Location	09/28/88		10/12/88		10/24/88		11/02/88		11/15/88		11/28/88		12/06/88		12/14/88		01/31/89		02/16/89		02/24/89	
	Bt	Ta	Bt	Ta	Bt	Ta	Bt	Ta	Bt	Ta	Bt	Ta	Bt	Ta	Bt	Ta	Bt	Ta	Bt	Ta	Bt	Ta
Farm #1																						
Watermelon B-16	371	2309	477	887	165	660	291	310	538	248	7	38	12	41	5	22	*	*[1]	*	*	1	213
Lettuce: Greenleaf NE B-7 371	3095	266	1589	761	2022	204	578	28	13	120	1	148	11	25	4	0	0	0	0	1	205	
Iceberg NW B-7	*	*	*	*	*	*	*	*	33	15	141	10	73	5	14	0	NT[2]	NT	0	3	0	18
Lettuce: Romaine SW B-8	207	4129	248	1034	310	887	186	702	36	21	82	7	52	10	21	11	0	5	0	3	1	215
Cotton B-6 NE A-18	619	1009	206	536	310	290	248	724	2519	415	229	309	NT	NT	1	20	*	*	*	*	0	60
Cotton B-6 NW B-6	452	1878	1011	1527	1217	2228	1094	1940	1671	1405	371	2210	NT	NT	42	94	*	*	*	*	1	215
NE B-9	NT	NT	NT	NT	NT	NT	NT	NT	619	142	NT	NT	NT	NT	NT	NT	*	*	0	3	5	1389
Cotton S-6 SE B-20	167	681	619	2309	784	1135	268	350	1981	922	805	910	NT	NT	12	14	0	3	0	2	0	81
Ditchbank-1 (sunflower/camphor/ cheeseweed)	1485	1185	248	2208	227	598	291	371	NT	NT	47	58	78	105	162	148	0	9	0	34	2	108
Ditchbank-2 (cheeseweed)	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	NT	11	8	56	44	0	20	0	15	0	106
Winter Vegetables * Location-7	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	16	0	24	2	61	
Spinach NE B-17	*	*	*	*	*	*	*	*	*	*	*	*	*	*	7	9	0	2	NT	NT	0	145
Spinach SW B-17	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	4	15	0	0	9	0	183
Spinach SE C-6	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	*	0	6	0	116
Farm #2																						
Cantaloupe	279	4228	206	3198	179	1157	248	390	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Watermelon	NT	NT	268	2744	206	536	105	310	*	*	*	*	*	*	*	*	*	*	*	*	*	*
Ditchbank-3 (cheeseweed/ sowthistle)	*	*	*	*	*	*	*	*	*	*	73	44	0	1	134	29	0	16	0	35	0	99
Ditchbank-4 (cheeseweed/ sowthistle/ london rocket)	62	2332	21	1671	19	619	12	328	NT	NT	14	23	6	8	91	32	0	2	NT	NT	0	156

*[1] Plant source was not available at sampling time.

NT[2] Trap was not placed at sampling time.

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