Occurrence, Distribution, and Relative Incidence of Seven Viruses Infecting Greenhouse-Grown Cucurbits in Iran

Hossain Massumi, Asghar Samei, Akbar Hosseini Pour, and Mehdi Shaabanian, Department of Plant Pathology, College of Agriculture, Shahid Bahonar University, Kerman, Iran; and Heshmetollah Rahimian, Department of Plant Pathology, College of Agriculture, Mazandaran University, Sari, Iran

ABSTRACT

Massumi, H., Samei, A., Hosseini Pour, A., Shaabanian, M., and Rahimian, H. 2007. Occurrence, distribution, and relative incidence of seven viruses infecting greenhouse-grown cucurbits in Iran. *Plant Dis.* 91:159-163.

Greenhouse-grown cucurbit crops in several Iranian regions were surveyed for the incidence of *Cucumber mosaic virus* (CMV), *Squash mosaic virus* (SqMV), *Papaya ring spot virus-type W* (PRSV-W), *Watermelon mosaic virus-2* (WMV-2), *Zucchini yellow mosaic virus* (ZYMV), *Cucumber necrosis virus* (CuNV) and *Tomato spotted wilt virus* (TSWV) from September 2002 to June 2004. In all, 1,304 random and 1,085 symptomatic leaf or fruit samples were collected. Samples were analyzed for virus infection by enzyme-linked immunosorbent assay. CMV and ZYMV were the viruses most frequently detected, accounting for 21.2 and 18% of the infected plants, respectively. WMV-2 was detected with 4.3% incidence in 15 regions and TSWV with 1.25% incidence only in 2 regions. CuNV, SqMV, and PRSV-W were not detected in any samples. Double and triple infections involving different combinations of CMV, ZYMV, WMV-2, and TSWV were noted in 117 and 4 samples, respectively. Natural infection of cucumber with TSWV and ZYMV is reported for the first time from Iran. Of 16 plant species from 14 genera, growing in or around greenhouse facilities, 6 were found infected with ZYMV, TSWV, WMV-2, and CMV and may act as reservoirs of the viruses. Four species are reported as new hosts of these viruses.

Additional keyword: *Cucurbitaceae*

Iran cultivates the second-largest total cucurbit acreage (77,000 ha) in the world, exceeded only by China, and is the third-largest producer of cucurbits after China and Turkey (7). Cucurbits in greenhouses or under plastic covers are grown in most areas of Iran, with cucumber accounting for approximately 98% and watermelon and melon for 1.5 and 0.5% of the total acreage, respectively. Virus infections represent a major limiting factor in cucurbit production in Iran (10). Of over 30 viruses reported on cucurbitaceous plants worldwide (22), *Zucchini yellow mosaic virus* (ZYMV), *Ourmia melon virus* (OMV), *Watermelon mosaic virus-2* (WMV-2), *Squash mosaic virus* (SqMV), *Watermelon chlorotic stunt virus* (WmCSV), *Cucumber green mottle virus* (CGMV), *Cucumber mosaic virus* (CMV), *Cucurbit yellow stunting disorder virus* (CYSDV), and *Papaya ringspot virus* (PRSV) are known to occur in field grown cucurbits in Iran (3,5,8,10,12,13,17).

Surveys of cucurbit fields in southern California showed that WMV-2 and ZYMV were the most predominant viruses (16). Studies of field-grown cucurbits in Brazil conducted during 1997 to 1999 indicated that PRSV-W and ZYMV were the most prevalent viruses (21).

In 1991, ZYMV, PRSV-W, and CMV were the three viruses detected in cucurbits from some Hawaiian Islands (20). Surveys of melon fields during 1995 and 1996 have shown that CMV and WMV-2 were the most frequently found viruses in Spain, whereas PRSV-W and ZYMV were detected at fewer sites and at lower incidences (14). In the field-grown cucurbits, ZYMV also has been the most prevalent virus on cucumber in Jordan and Malaysia (1,19).

A survey of viruses infecting cucurbit crops in Shiraz and vicinity (Fars province) showed that WMV-2, CMV, and CGMV were the most prevalent viruses, with incidences of 77.6, 16.2, and 3.5%, respectively (18). However, there are no records of the incidence and distribution of viral diseases in cucurbits and their impact on production in other provinces of Iran. Moreover, no information is available on the identity of viruses infecting cucurbits grown under greenhouse conditions. In 2001, viral epidemics in cucurbits and, in particular, cucumber (*Cucumis sativus* L.) grown in greenhouses were observed.

Symptoms in leaves included mosaic, mild to severe yellow mottling, vein clearing, green vein banding, blistering, and leaf distortions. A high proportion of cucumber fruit on infected vines were malformed and reduced in size. A 2-year survey encompassing all Iranian regions where greenhouse cucurbits are grown was conducted to estimate the incidence and prevalence of CMV, TSWV, PRSV-W, WMV-2, SqMV, ZYMV, and CuNV. The study also was focused on identification of possible weed hosts growing inside and around greenhouses in the Jiroft region that may serve as a reservoir for these viruses.

MATERIALS AND METHODS

Sample collection. Samples were collected from September 2002 to June 2004 from a total of 241 greenhouses located in 31 regions of 15 provinces where cucumber, watermelon (*Citrullus lanatus* (Thunb.) Mtsum & Nakai), and melon (*Cucumis melo* L.), are grown (Tables 1 and 2). In each region, surveys were conducted during the mid-developmental stage of the vines when the first fruit were set. Two groups of leaf samples were collected from plants in each greenhouse: (i) four to five symptomatic plants exhibiting mosaic, green vein banding, mild to severe mottling, or leaf and fruit malformation; and (ii) five to six plants chosen randomly irrespective of their symptoms. Young leaves were placed in plastic bags and carried to the laboratory in an ice-filled chest box. Samples were kept at -20°C until used in assays.

Samples of symptomatic and asymptomatic weeds growing inside or in the vicinity of 50 cucumber greenhouses in the Jiroft region, the major cucurbit-growing area in southeast Iran, also were collected. Samples consisted of the youngest or young fully expanded leaves collected during the spring seasons of 2002 and 2003.

Virus identification. Cucurbit and weed leaf samples were tested by the double-antibody sandwich enzyme-linked immunosorbent assay (DAS-ELISA; 4) for the presence of ZYMV, WMV-2, PRSV-W, SqMV, and CuNV. Plate-trapped antigen (PTA)-ELISA (15) was used to detect CMV. Samples representing 16 cucumber cultivars, 3 cultivars of melon, and 1 watermelon cultivar were collected. Antisera to ZYMV, WMV-2, PRSV-W, CuNV, and

Corresponding author: H. Massumi
E-mail: masoomi@mail.uk.ac.ir

Accepted for publication 25 August 2006.

the positive virus controls were purchased from DMSZ (Braunschweig, Germany). SqMV and TSWV antisera were obtained from Bioreba (CH-4153 Reinach BL1, Switzerland). CMV antiserum was provided by P. Jones (IACR-Rothemsted, Harpenden, Herts, UK). For DAS-ELISA, plates were coated with 100 µl of each immunoglobulin G diluted 1:1000 in carbonate coating buffer (0.06 M Na₂CO₃ and 0.14 M NaHCO₃, pH 9.6) and the assays were carried out according to the manufacturer's instructions.

The incidence of CMV was determined by PTA-ELISA with minor modification. Briefly, samples were ground in a 1:10 dilution of carbonate coating buffer, added to ELISA plate wells, and incubated for 2 h at 37°C in flat-bottom Nunc maxisorb microtiter plates (Nalge Nunc International). Extracts from *Curcubita pepo* L. cv. Khoi infected with CMV and extracts from healthy *C. pepo* L. cv. Khoi were used as positive and negative controls, respectively.

Reactions for both DAS-ELISA and PTA-ELISA were measured spectrophotometrically at 405 nm using an EL3900 ELISA reader (Bio-Tek Instrument). Virus positive and negative controls were included in all tests. A sample was consid-

ered virus-positive if the optical density (OD) exceeded the mean plus three standard deviations of the OD of the healthy controls.

Inoculation of assay hosts. Samples of weed plants with positive reactions in ELISA to CMV, ZYMV, WMV-2, and TSWV were selected and macerated in 0.06 M potassium phosphate buffer, pH 7.5, containing 0.0013 M ethylenediamine-tetraacetic acid (EDTA), 0.01% Na₂SO₃, and 2% polyvinylpyrrolidone (PVP). The extracts then were mechanically inoculated to *Datura stramonium* L., *Chenopodium quinoa* Willd., *C. amaranticolor* Coste & Reyn, and *Cucurbita pepo* L. for further confirmation of their infection and infectivity of the viruses carried. The inoculated test plants were kept in an insect-proof greenhouse at 15 to 25°C.

RESULTS

Surveys for virus identification. Of the 2,389 samples collected from cucumber, watermelon, and melon, 506 were infected singly with CMV, 430 with ZYMV, 104 with WMV-2, and 30 with TSWV, but none with PRSV-W, SqMV, or CuNV (Tables 1 and 2). Single infections accounted for 40% (956/2,389) of the samples collected from plants. Plants infected with

two viruses were detected in 4.9% (117/2,389) of the samples. Among the doubly infected plants, 3.5% (84/2,389) were infected with ZYMV and CMV, the most frequently occurring viruses throughout the country except in the Taft, Kermanshah, Sahneh, and Javanrud regions. Plants infected with WMV-2+ZYMV and TSWV+ZYMV accounted for 0.9 (21/2,389) and 0.5% (12/2,389) of the collected samples, respectively. Only four plants were infected simultaneously with three viruses encountered in the surveys.

Symptoms varied from mild mosaic or vein banding to severe mosaic and malformation. Mild symptoms most often were associated with single infection of WMV-2, whereas other symptoms were found associated with mixed infections of ZYMV and CMV or ZYMV and WMV-2.

Disease incidence was 83.3% in symptomatic plants in greenhouse-grown cucumber in the southwest (Shiraz) and central (Esfahan, Yazd, Jiroft, and Kahnuj) regions and 72% in the southeast (Zabol, Khash and Iran-shahr) regions of Iran (Table 1). No symptoms were observed and no virus was detected by ELISA in eight greenhouses in the northwest (Kermanshah, Javanrud, and Sahneh) regions. CMV and ZYMV were found in 86 and 70%,

Table 1. Occurrence of viruses on symptomatic cucurbit species collected from 31 greenhouses in different regions of Iran from September 2002 to June 2004

Province	Region	No. surveyed ^c	DAS-ELISA ^a			PTA-ELISA ^b		Infection	
			ZYMV	WMV-2	TSWV	CMV	Double	Triple	
Yazd	Yazd	15	50/86	4/86	0/86	31/86	17/86	0/86	
	Taft	2	0/4	0/4	0/4	0/4	0/4	0/4	
Esfahan	Esfahan	10	8/50	5/50	0/50	42/50	8/50	0/50	
Tehran	Ghaleh sorkh	9	5/30	0/30	0/30	23/30	1/30	0/30	
	Karaj	6	5/35	0/35	0/35	9/35	0/35	0/35	
	Varamin	5	2/10	1/10	0/10	0/10	0/10	0/10	
Kerman	Jiroft	30	81/108	7/108	22/108	8/108	16/108	1/108	
	Kahnuj	10	13/45	2/45	5/45	5/45	1/45	0/45	
	Shahre babak	5	14/20	0/20	0/20	5/20	1/20	0/20	
	Zarand	2	4/10	0/10	0/10	4/10	0/10	0/10	
	Mahan	2	1/4	0/4	0/4	0/4	0/4	0/4	
Hormozgan	Haji abad	6	3/28	3/28	0/28	0/28	0/28	0/28	
Mazandaran	Ghaem shahr	12	24/70	6/70	0/70	20/70	6/70	0/70	
	Sari	5	5/22	0/22	0/22	7/22	0/22	0/22	
	Juibar	8	8/37	2/37	0/37	13/37	1/37	0/37	
Gilan	Astaneh ashrafieh	10	5/45	0/45	0/45	7/45	0/45	0/45	
	Lahijan	6	3/20	0/20	0/20	4/20	0/20	0/20	
Golestan	Gorgan	10	20/52	9/52	0/52	23/52	7/52	0/52	
	Minudasht	13	30/68	11/68	0/68	42/68	24/68	0/68	
Kermanshah	Kermanshah	3	0/13	0/13	0/13	0/13	0/13	0/13	
	Sahneh	2	0/7	0/7	0/7	0/7	0/7	0/7	
	Javanrud	2	0/6	0/6	0/6	0/6	0/6	0/6	
Ghom	Ghom	6	0/23	0/23	0/23	2/23	0/23	0/23	
Fars	Shiraz	18	56/92	7/92	0/92	41/92	16/92	0/92	
	Marvdasht	10	22/60	21/60	0/60	32/60	19/60	0/60	
Sistan and Baloochestan	Zabol	6	9/27	4/27	0/27	8/27	0/27	3/27	
	Khash	4	0/17	3/17	0/17	12/17	0/17	0/17	
	Iran-shahr	5	0/19	2/19	0/19	11/19	0/19	0/19	
Semnan	Damghan	2	0/6	0/6	0/6	4/6	0/6	0/6	
Khorasan	Mashhad	8	0/27	0/27	0/27	9/27	0/27	0/27	
	Chenaran	9	0/44	0/44	0/44	10/44	0/44	0/44	
Total	...	241	368/1,085	87/1,085	27/1,085	372/1,085	117/1,085	4/1,085	

^a Double-antibody sandwich enzyme-linked immunosorbent assay (DAS-ELISA) for *Zucchini yellow mosaic virus* (ZYMV), *Watermelon mosaic virus-2* (WMV-2), and *Tomato spotted wilt virus* (TSWV); number of infected plants/number of plants sampled.

^b Plate-trapped antigen (PTA)-ELISA for *Cucumber mosaic virus* (CMV); number of infected plants/number of plants sampled.

^c Number of greenhouses surveyed.

respectively, of the other regions (south-west, central, and southeast). WMV-2 and TSWV were detected in 53 and 6% of the areas surveyed, respectively. SqMV, PRSV-W, and CuNV were not detected in any plant samples tested.

Weed plants as hosts of cucurbit viruses. Results showed that many weeds growing inside the greenhouses or in the neighboring fields harbored ZYMV, WMV-2, CMV, and TSWV. Plants of six species in five genera belonging to five families were positive by ELISA for the above-mentioned viruses (Table 3). Infection with these viruses was confirmed in *Citrullus colocynthis* (L.) Schrad., a *Sonchus* sp., a *Malva* sp., and *Convolvulus arvensis* L. following mechanical inoculation to *Datura stramonium* L., *Chenopodium quinoa* Willd., *C. amaranticolor* Coste & Reyn., and *Cucurbita pepo* L.. The most frequently encountered weed hosts were species in the Amaranthaceae family, followed by members of the Cucurbitaceae, Malvaceae, Convolvulaceae, and Compositae families (Table 3). Species of *Amaranthus*, *Chenopodium*, *Cynodon*, *Heliotropium*, *Trigonella*, *Medicago*, *Sonchus*, *Cyprus*, and *Portulaca* were found inside cucurbit greenhouses, whereas *Citrullus*, *Bromus*, *Malva*, *Tribulus*, and *Convolvulus* spp. were found outside in the

vicinity of the greenhouses. TSWV, WMV-2, ZYMV, and CMV could not be detected by ELISA or through mechanical inoculation in plants of 10 species from seven families growing in the greenhouses or in the nearby areas (Table 3). Most weed species found to be infected with TSWV, WMV-2, ZYMV, or CMV, as determined by ELISA, were symptomless. However, symptoms of ZYMV and WMV-2 infection, including vein clearing, and blistering and mosaic, were found on some infected plants of *Citrullus colocynthis*. PRSV-W, SQMV, and CuNV were not detected in any weeds species tested.

DISCUSSION

The results of the surveys conducted in 2002 to 2004 showed that CMV, WMV-2, TSWV, and ZYMV infect cucumber grown under greenhouse conditions in Iran. Other viruses that previously had been recovered from cucurbits in Iran, including SqMV (10), were not encountered in the present study. CMV was the most widely distributed and prevalent virus infecting greenhouse-grown cucurbits in Iran, followed closely by ZYMV. Widespread occurrence of ZYMV in most cucurbit-growing areas of Iran would implicate its major impact on cucurbit production throughout the country. Double infections involving CMV

and ZYMV, WMV-2 and ZYMV, and TSWV and ZYMV occurred at rates of 3.5, 0.9, and 0.5%, respectively, and were encountered in some areas surveyed, the highest rates being recorded in three provinces in northern (Golestan), central (Yazd), and southern (Kerman) Iran (Table 1). It appears that the patterns for such mixed infections are random and are not related to any specific area.

Historically, CMV has been one of the first cucurbit viruses found occurring on cucumber, cantaloupe, long melon, and some non-cucurbitaceous field and horticultural crops, including ornamental species in Iran (2,11). WMV-2 was the second cucurbit virus identified in both the central and southern provinces of Iran (5,18).

In a 2-year (1974 to 1975) survey made on the distribution and prevalence of mosaic-inducing cucurbit viruses in Fars province, CMV, WMV-2, and CGMV were found to be the only viruses infecting cucurbits in the area. CGMV was encountered in only a few cases on long melon plants and only in 1974. The incidence of CMV and WMV-2 varied somewhat in the 2 years of survey; however, WMV-2 was the prevalent virus in both years, accounting for about 75% infections of the mottled vines sampled. Mixed infections (CMV+WMV-2) also were recorded, although in

Table 2. Occurrence of viruses on asymptomatic cucurbit species collected from 31 greenhouses in different regions of Iran in September 2002 to June 2004

Province	Region	No. surveyed ^c	DAS-ELISA ^a			PTA-ELISA ^b
			ZYMV	WMV-2	TSWV	CMV
Yazd	Yazd	15	4/49	0/49	0/49	16/49
	Taft	2	0/6	0/6	0/6	0/6
Esfahan	Esfahan	10	2/57	1/57	0/57	36/57
Tehran	Ghaleh sorkh	9	0/60	0/60	0/60	12/60
	Karaj	6	0/25	0/25	0/25	1/25
	Varamin	5	0/40	0/40	0/40	0/40
Kerman	Jiroft	30	19/222	3/222	3/222	4/222
	Kahnuj	10	0/55	0/55	0/55	1/55
	Shahre babak	5	2/10	0/10	0/10	0/10
	Zarand	2	0/10	0/10	0/10	0/10
	Mahan	2	0/6	0/6	0/6	0/6
Hormozgan	Haji abad	6	0/35	0/35	0/35	0/35
Mazandaran	Ghaem shahr	12	2/50	0/50	0/50	0/50
	Sari	5	0/28	0/28	0/28	1/28
	Juibar	8	2/43	0/43	0/43	5/43
Gilan	Astaneh ashrafieh	10	0/55	0/55	0/55	0/55
	Lahijan	6	0/30	0/30	0/30	0/30
Golestan	Gorgan	10	8/58	3/58	0/58	17/58
	Minudasht	13	7/62	4/62	0/62	13/62
Kermanshah	Kermanshah	3	0/17	0/17	0/17	0/17
	Sahneh	2	0/8	0/8	0/8	0/8
	Javanrud	2	0/9	0/9	0/9	0/9
Ghom	Ghom	6	0/37	0/37	0/37	0/37
Fars	Shiraz	18	7/88	1/88	0/88	18/88
	Marvdasht	10	9/70	5/70	0/70	8/70
Sistan and Baloochestan	Zabol	6	0/33	0/33	0/33	0/33
	Khash	4	0/24	0/24	0/24	0/24
	Iran-shahr	5	0/14	0/14	0/14	0/14
Semnan	Damghan	2	0/14	0/14	0/14	0/14
Khorasan	Mashhad	8	0/43	0/43	0/43	0/43
	Chenaran	9	0/46	0/46	0/46	2/46
Total	...	241	62/1,304	17/1,304	3/1,304	134/1,304

^a Double-antibody sandwich enzyme-linked immunosorbent assay (DAS-ELISA) for *Zucchini yellow mosaic virus* (ZYMV), *Watermelon mosaic virus-2* (WMV-2), and *Tomato spotted wilt virus* (TSWV); number of infected plants/number of plants sampled.

^b Plate-trapped antigen (PTA)-ELISA for *Cucumber mosaic virus* (CMV); number of infected plants/number of plants sampled.

^c Number of greenhouses surveyed.

less than 5% of the mottled plants analyzed. Because of its extremely broad host range and the ability to be transmitted in a nonpersistent manner by more than 80 aphid species (6), CMV is one of the most difficult plant viruses to control. Relatively mild winters in most provinces of Iran in the past two decades might have allowed overwintering of both the aphid vectors and weed hosts of the virus and most probably have been a major contributing factor in the increasing incidence of CMV. Despite regular application of insecticides on cucumber and other crops grown in greenhouses, the year-round presence of both the vectors and virus inoculum sources provides continuous exposure to infection by this virus.

High populations of *Thrips tabaci* Lindeman were observed on the greenhouse-grown cucumber plants infected with TSWV. The presence of susceptible neighboring crops, including tomato and weed species, with high populations of thrips was the suspected contributing factor in the incidence of TSWV in greenhouses in Jiroft and Kahnuj.

In our study, *Amaranthus retroflexus* and *A. viridis*, which represent 11.5 and 14%, respectively, of the whole weed population tested, were infected with WMV-2, ZYMV, and TSWV in greenhouses (Table 3). Therefore, these two weed species may serve as potential inoculum sources for infection of greenhouse-grown cucumber plants. *Malva* sp., a predominant weed

species encountered in many fields and greenhouse surroundings in several regions, was naturally infected with CMV. It also is one of the preferred hosts of the melon aphid (*Aphis gossypii* Glov.), an efficient vector of this virus (22). This weed species survives the mild winter conditions prevailing in the southern regions of Iran and would contribute to CMV perpetuation and dissemination.

Infected plants of *C. colocynthis* were frequently found in the vicinity of greenhouses in the Jifrot region. Thus, *C. colocynthis* plants potentially could act as reservoirs of WMV-2 and ZYMV for greenhouse-grown cucumber. Nevertheless, more extensive studies are required to elucidate the relationships between weeds, thrips, or aphids as virus sources and their impact on the perpetuation and spread of cucurbit viruses.

Cucumber cultivars resistant to CMV have been developed and are available commercially (22). These and other cultivars tolerant to CMV and WMV-2 are favored and grown by some greenhouse owners. However, the presence of different strains of these viruses in Iran (17) makes such cultivars still vulnerable to infection. Transgenic cucumber lines or cultivars containing the coat protein gene of CMV also have been developed and provide acceptable levels of resistance to some strains of these viruses (9).

Sanitary and proper crop management practices, including implementation of

improved weed control programs inside and around greenhouse sites and regular inspection and rouging of mottled or otherwise suspicious vines, should be practiced as additional measures to reduce yield losses in greenhouse-grown cucumber.

ACKNOWLEDGMENTS

This research was supported by grant number 503614 from the Shahid Bahonar University of Kerman and by the Department of Environmental Science, International Center for Sciences High Technology and Environmental Science, Kerman, Iran. We thank officers of the regional agricultural services for their help in conducting the surveys, and P. Jones for kindly providing CMV antiserum.

LITERATURE CITED

1. Al-Musa, A. M. 1989. Severe mosaic caused by *Zucchini yellow mosaic virus* in cucurbits from Jordan. *Plant Pathol.* 38:541-546.
2. Bahar, M., Danesh, D., and Filsouf, F. 1983. Prevalence and identity of cucurbit infecting viruses in Isfahan. Page 72 in: *Proc. 7th Plant Prot. Congr. Karaj, Iran.*
3. Bananej, K., A., and Ahoonmanesh, A. K. 2002. Host range of an Iranian isolate of *Watermelon chlorotic stunt virus* as determined by whitefly-mediated inoculation and agroinfection, and its geographical distribution. *J. Phytopathol.* 150:423-430.
4. Clark, M. F., and Adams, A. N. 1977. Characteristics of microplate method of enzyme-linked immunosorbent assay for the detection of plant viruses. *J. Gen. Virol.* 34:475-483.
5. Ebrahim-Nesbat, F. 1974. Distribution of *Watermelon mosaic virus* 1 and 2 in Iran. *Phytopathol. Z.* 79:352-358.
6. Edwardson, J. R., and Christie, R. G. 1991. *CRC Handbook of Viruses Infecting Legumes*. CRC Press, Boca Raton, FL. pp. 157-158.
7. FAO. 2002. *FAO Production Yearbook*, Vol.56.

Table 3. Infection of selected weed species by viruses that infect members of Cucurbitaceae

Family, species	Common name	No. of samples	Virus ^a			
			ZYMV	WMV2	CMV	TSWV
Amaranthaceae						
<i>Amaranthus retroflexus</i> L.	Red root pigweed	19	3/19*	1/19*	0/19	7/19**
<i>A. viridis</i> L.	Green amaranth	23	4/19*	1/19*	0/19	3/19*
Chenopodiaceae						
<i>Chenopodium murale</i> L.	Nettle-leaved goosefoot	12	0/12	0/12	0/12	0/12
<i>C. rubrum</i> L.	Red goosefoot	12	0/12	0/12	0/12	0/12
Gramineae						
<i>Bromus</i> sp.		7	0/7	0/7	0/7	0/7
<i>Cynodon dactylon</i> (L.) pres.	Bermudagrass	5	0/5	0/5	0/5	0/5
Cucurbitaceae						
<i>Citrullus colocynthis</i> (L.) Schrad.	Colocynth	26	15/26*	5/26*	0/26	0/26
Boraginaceae						
<i>Heliotropium</i> sp.	Goerden heliotrope	18	0/18	0/18	0/18	0/18
Fabaceae						
<i>Trigonella</i> sp.	Fenugreek	4	0/4	0/4	0/4	0/4
<i>Medicago lupulina</i> L.	Black medick	5	0/5	0/5	0/5	0/5
Compositae						
<i>Sonchus</i> sp.	Sowthistle	7	0/7	0/7	0/7	3/7 [†]
Cyperaceae						
<i>Cyperus rotundus</i> L.	Musta	6	0/6	0/6	0/6	0/6
Malvaceae						
<i>Malva</i> sp.	Mallow	5	0/5	0/5	2/5**	0/5
Convolvulaceae						
<i>Convolvulus arvensis</i> L.	Field bind weed	4	0/4	0/4	0/4	1/4*
Zygophyllaceae						
<i>Tribulus terrestris</i> L.	Puncturevine	2	0/2	0/2	0/2	0/2
Portulacaceae						
<i>Portulaca oleracea</i> L.	Little hogweed	9	0/9	0/9	0/9	0/9
Total	...	164	22/164	7/164	2/164	14/164

^a Enzyme-linked immunosorbent assay was used for detection of viruses in weeds. Shown are number of infected plants/total number of weed plants; * = new host of virus and ** = new host of virus in Iran.

- FAO Statistics Series No. 176. Food and Agriculture Organization of the United Nations, Rome.
8. Ghorbani, S. 1988. Isolation of *Zucchini yellow mosaic virus* in the Tehran province. Iran. J. Plant Pathol. 24:25-34.
 9. Gonsalves, D., Chee, P., Provvidenti, R., Seem, R., and Slightom, J. L. 1992. Comparison of coat protein-mediated and genetically-derived resistance in cucumbers to infection by cucumber mosaic virus under field conditions with natural challenged inoculations by vectors. Bio/Technology 10:1562-1570.
 10. Izadpanah, K. 1983. *Squash mosaic virus* as the cause of melon vein banding mosaic in Iran. J. Phytopathol. 120:278-283.
 11. Izadpanah, K. 1986. Unreported diseases of cucurbits in the Bushehr province. Page 122 in: Proc. 8th Plant Prot. Congr. Isfahan, Iran.
 12. Keshavarz, T., and Izadpanah, K. 2004. Report of *Cucurbit yellow stunting disorder virus* (Genus *Crinivirus*) in Iran. Page 264 in: Proc. 16th Plant Prot. Congr. Tabriz, Iran.
 13. Lisa, V., Parvizy, R. G., and Milne, R. 1990. Outbreaks and new records. Iran. *Ourumia melon virus* and other cucurbits viruses in west Azerbaijan, Iran. FAO Plant Prot. Bull 38:218-219.
 14. Luis-Artega, M. J. M., Alvarez, J. I., Alonso-Prados, A., and Moriones, Battle, E. 1998. Occurrence, distribution, and relative incidence of mosaic viruses infecting field-grown melon in Spain. Plant Dis. 82:979-982.
 15. Mowat, W. P., and Dawson, S. 1987. Detection of plant viruses by ELISA using crude sap extracts and unfractionated antisera. J. Virol. Methods 15:233-247.
 16. Perring, T. M., Farrar, C. A., Mayberry, K., and Blua, M. J. 1992. Research reveals pattern of cucurbit virus spread. Calif. Agric. 46:35-40.
 17. Rahimian, H., and Izadpanah K. 1977. A new strain of *Cucumber green mottle mosaic virus* from Iran. Iran. J. Agric. Res. 5:25-34.
 18. Rahimian, H., and Izadpanah K. 1978. Identity and prevalence of mosaic inducing cucurbit viruses in Shiraz, Iran. Phytopathol. Z. 92:305-312.
 19. Sidek, Z., and Sako N. 1996. Isolation of five viruses naturally infecting cucurbit plants in Malaysia. J. Biosci. 7:114-121.
 20. Ullman, D. E., Cho, J. J., and German, T. L. 1991. Occurrence and distribution of cucurbit viruses in the Hawaiian Islands. Plant Dis. 75:367-370.
 21. Yuki, V. A., Rezende, J. A. M., Kitajima, E. W., Barroso, P. A. V., Kuniyuki, H., Groppo, G. A., and Pavan, M. A. 2000. Occurrence, distribution, and relative incidence of five viruses infecting cucurbits in the state of Sao Paulo, Brazil. Plant Dis. 84:516-520.
 22. Zitter, T. A., Hopkins, D. L., and Thomas, C. E. 1996. Compendium of Cucurbit Diseases. American Phytopathological Society, St. Paul, MN.