Incidence, Economic Importance, and Control of Tomato Yellow Leaf Curl in Jordan

ABDULLAH AL-MUSA, Assistant Professor, Department of Plant Protection, University of Jordan, Amman

ABSTRACT

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In the Jordan Valley, the incidence of tomato yellow leaf curl at the end of the season ranged from 0 to 13.2% in spring-grown tomatoes and from 93 to 100% in fall-grown tomatoes. Under greenhouse conditions, yield losses were significant (63%) when tomato plants were inoculated 10 wk after sowing; inoculations at 15 wk did not produce significant yield reductions. In field tests, cucumbers, eggplants, or corn were planted in rows alternating with tomatoes 30 days before the tomato seedlings were transplanted, and tomato yellow leaf curl was effectively delayed in plots interplanted with cucumber but not in plots interplanted with corn and eggplants. Cucumbers were better hosts than tomatoes, eggplants, and corn were for whiteflies, which may explain why cucumbers were effective in delaying infection of tomatoes.

Tomatoes are the major vegetable crop grown in Jordan. About 39% of the cultivated area under irrigation was planted to tomato in 1978 (1). Tomato yields in Jordan are among the lowest in the world (8). The low productivity is due to several factors, among which infection with tomato yellow leaf curl virus (TYLCV) is the most significant. The disease caused by this virus was identified in Jordan by Mink (7) and Makkouk (5), but incidence, economic importance, and control of the disease were not studied. Chemical control of the vector, *Bemisia tabaci* Genn., is only partially effective in reducing incidence of the disease (10). Although straw mulch reportedly delays infection with TYLCV (3), its application is not practical. Accordingly, a more practical approach to delay or prevent infection was attempted by interplanting tomato plots with cucumbers, eggplants, or corn. Cucumbers and eggplants were reported to be hosts for the whitefly in Jordan (9). In addition, cucumbers (4), eggplants, and corn (*unpublished data*) were immune to TYLCV.

This paper reports the incidence and economic importance of TYLC and the effects of interplanting tomatoes with cucumbers, eggplants, or corn on spread of the disease and on the behavior of the whitefly vector under field conditions.

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MATERIALS AND METHODS

Incidence. Incidence of TYLC in spring-grown tomatoes was studied in six fields located in Al-Muthaleth Al-Masri, Swalha, Dair alla, Wade Al-Yabis, Kraimeh, and Tel-Al-Arabeen along the Jordan Valley. The survey was initiated on 15 March and terminated 31 May 1979. In each field, disease incidence was determined from 100 plants taken at random at weekly intervals.

Incidence in fall-grown tomatoes was determined from 15 October to 15 December 1980 in four fields at Al-Rameh, Al-Karameh, Dair alla, and Tel-Al-Arabeen along the Jordan Valley.

Economic importance. Seeds of the cultivar Claudia RAF were sown in 36 clay pots (40 × 20 cm). One set of 12 plants was graft-inoculated with TYLCV 10 wk after sowing; another set of 12 plants was graft-inoculated 5 wk later. Another 12 plants were maintained as controls. The experiment was laid out in a completely randomized design with three treatments replicated four times.

Prevention. Cucumber, eggplant, or corn plants, referred to hereafter as bait plants, were sown (cucumber and corn) or transplanted (eggplant) 30 days before transplanting virus-free tomato seedlings produced as described previously (2). Each bait plant was planted in rows alternating with rows of tomatoes in plots measuring 8 × 10 m. Tomato plots with no bait plants were controls. The experimental design was a randomized complete block with four treatments replicated four times. The interplanted tomato plots will be referred to as

cucumber, eggplant, or corn treatments.

Incidence of TYLCV-infected plants in each plot was determined weekly. Whitefly populations on bait plants and tomatoes were monitored by using Cohen and Melamed-Madjar's procedure (3) modified as follows: Four fully expanded leaves from tomatoes and from bait plants were taken at random from each replicate. Eggs, larvae, and pupae of whiteflies were counted on three sections (1 × 1 cm each) cut out at comparable positions from each leaf. Counts were made weekly and extended until cold weather.

RESULTS

Incidence. The incidence of TYLC in several tomato fields during the spring of 1979 ranged from 0 to 9% at the beginning of the survey and from 0 to 13.2% at the end of growing season (Fig. 1). The incidence of the disease was higher and increased more rapidly in the fall of 1980 than in the spring. The incidence ranged from 0 to 28% at the beginning and from 93 to 100% at the end of the survey (Fig. 2).

Economic importance. Yields were significantly reduced (63%) when the plants were inoculated at 10 wk after sowing (Table 1). Yields from plants inoculated 15 wk after sowing were not significantly different from the controls.

Prevention. TYLC incidence was consistently reduced in the cucumber treatment during the first 2 mo after the tomato seedlings were transplanted (Table 2). Between 18 and 60 days after tomatoes were transplanted, the incidence of TYLC in tomato plots interplanted with cucumbers was 30 and 80%, respectively, of that in the control plots. There were no significant differences in disease incidence in control tomato plots and those interplanted with corn at all dates. Eggplants seemed to transiently reduce disease incidence 32 and 39 days after tomato transplanting. This reduction was not as pronounced as with cucumbers and was masked in later counts.

Among bait plants, cucumbers were the preferred host of whiteflies (Table 3). There were no significant differences in whitefly populations on eggplants and corn. Whitefly populations were significantly higher on tomatoes in the control plots than on tomatoes in the cucumber, eggplant, or corn treatments 18 days after tomato transplanting (Table 4). Subsequently, whitefly populations on tomatoes were significantly lower in one count in the eggplant treatment and in two counts in the corn treatment than on the tomatoes in the control plots. Whitefly populations were, however, consistently lower on the tomato plants in the cucumber treatment as long as 46 days after tomato transplanting.

The degree of host preference by whiteflies was determined by calculating the ratios between whitefly populations on tomato plants and on interplanted bait plants (Table 5). Whiteflies seemed to prefer cucumbers as indicated by the 4:1 ratio observed when the two crops were planted in one plot. Preference for cucumbers was maintained as long as 32 days after tomato transplanting. The whiteflies then shifted to the tomatoes, and large populations developed quickly. This shift occurred when the cucumbers were senescing and partially killed by cold weather. The whiteflies seemed to prefer tomatoes to corn and eggplants at all times.

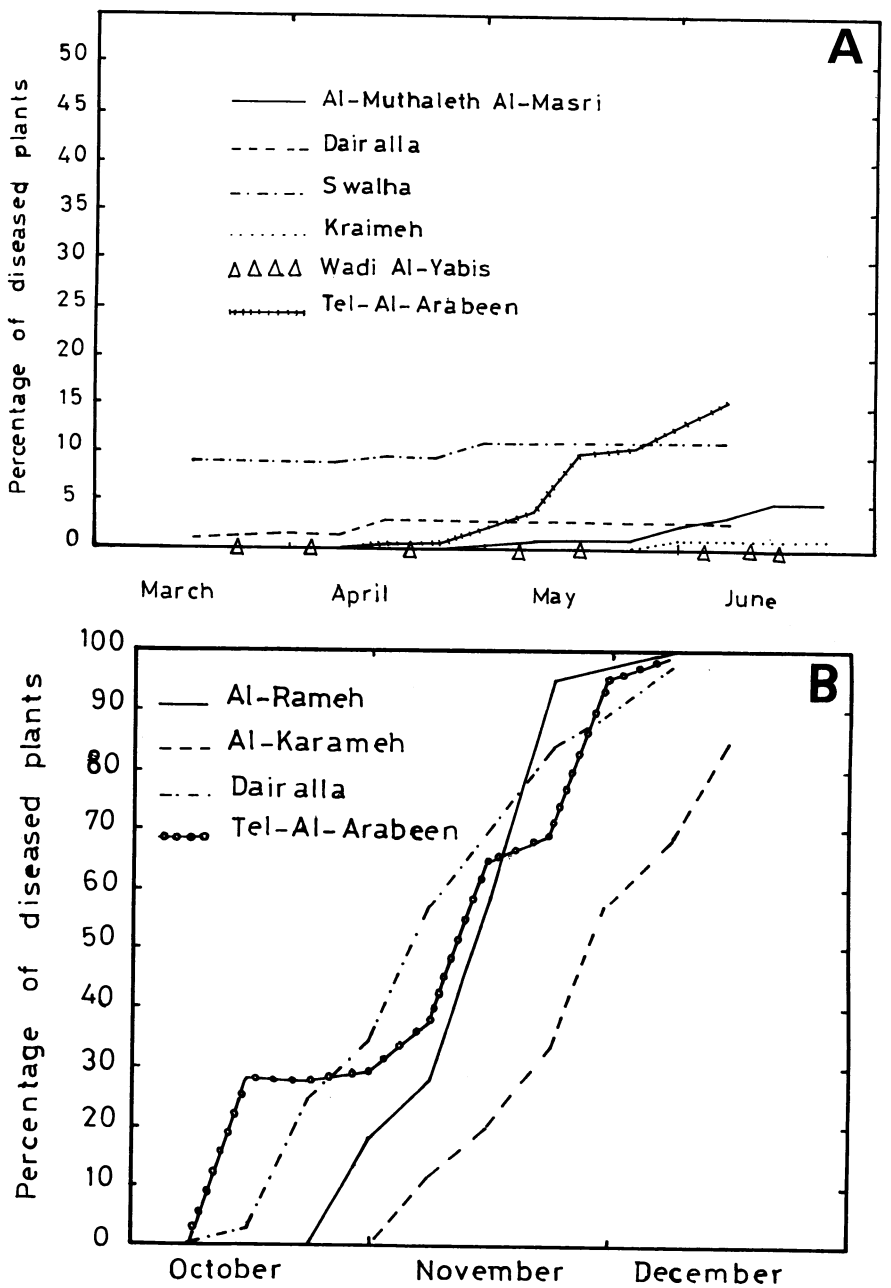

Fig. 1. Incidence of tomato yellow leaf curl in the Jordan Valley in 1980: **(A)** In spring-grown tomatoes at six locations. **(B)** In fall-grown tomatoes at four locations.

DISCUSSION

The incidence of TYLC increased more rapidly and to a higher level in the fall than in the spring in the Jordan Valley. This could be attributed to higher whitefly (vector of TYLCV) populations in the fall. Maximum whitefly populations in the Jordan Valley are reached during the fall but they reduce drastically in the winter months (11).

Yield reductions by TYLC were expected because the virus causes flower

Table 1. Yield of Claudia RAF tomatoes graft-inoculated with tomato yellow leaf curl virus 10 and 15 wk after sowing

Time of inoculation	Yield per plant (g)	No. of fruit per plant
10 wk	252.9 a[a]	3.3 a
15 wk	593.6 b	14.6 b
Healthy control	686.0 b	14.3 b

[a] Means in the same column followed by the same letter do not differ significantly ($P = 0.05$) according to Duncan's multiple range test.

Table 2. Incidence of tomato yellow leaf curl at 7-day intervals starting 18 days after transplanting tomatoes in plots interplanted with cucumbers, eggplants, or corn

	Incidence (%)[a] at day								
Interplant	**18**	**25**	**32**	**39**	**46**	**53**	**60**	**67**	**74**
None	15.5 a	32.7 a	71.2 a	78.6 a	78.6 a	80.7 a	82.5 a	97.6 a	98.4 a
Cucumbers	4.7 b	16.3 b	42.5 c	45.6 c	63.1 b	65.8 b	67.3 b	72.2 b	81.2 a
Corn	13.1 a	35.4 a	64.1 ab	65.4 ab	79.8 a	83.8 a	84.2 a	85.3 ab	89.4 a
Eggplants	10.8 a	31.9 a	50.8 bc	62.7 b	78.7 a	83.1 a	83.3 a	82.4 ab	84.9 a

[a] Means in the same column followed by the same letter do not differ significantly ($P = 0.05$) according to Duncan's multiple range test.

Table 3. Whitefly populations (eggs, larvae, and pupae) on cucumbers, eggplants, and corn interplanted in tomato plots at 7-day intervals starting 18 days after tomato transplanting

	Number[a] at day				
Interplant	**18**	**25**	**32**	**39**	**46**
Cucumber	88.4 a	95.3 a	38.3 a	11.0 a	14.6 a
Eggplant	1.5 b	2.5 b	0.8 b	1.0 b	2.6 b
Corn	0.0 b	2.3 b	0.0 b	0.6 b	1.3 b

[a] Means in the same column followed by the same letter do not differ significantly ($P = 0.05$) according to Duncan's multiple range test.

Table 4. Whitefly populations (eggs, larvae, and pupae) on tomatoes at 7-day intervals starting 18 days after tomato transplanting

	Number[a] at day				
Interplant	**18**	**25**	**32**	**39**	**46**
None	42.9 a	44.0 a	38.0 a	65.5 a	13.8 a
Cucumbers	22.6 b	10.0 b	8.0 b	3.0 b	16.3 a
Eggplants	25.6 b	23.8 ab	28.0 a	16.8 b	12.3 a
Corn	22.4 b	34.8 ab	14.0 b	14.3 b	10.3 a

[a] Means in each column followed by the same letter do not differ significantly ($P = 0.05$) according to Duncan's multiple range test.

Table 5. Ratios between whitefly populations on bait plants and on tomato plants at 7-day intervals starting 18 days after tomato transplanting

	Bait plant		
Day	**Cucumber**	**Eggplant**	**Corn**
18	3.9:1	0.06:1	...[a]
25	4.2:1	0.11:1	0.06:1
32	4.8:1	0.02:1	...[a]
39	0.3:1	0.06:1	0.042:1
46	0.9:1	0.21:1	0.102:1

[a] Too low to detect.

abortion (7). Results of my study indicate that early infection resulted in higher losses, but late infection only slightly affected yields. This confirms results of an earlier investigation (6).

Attempts to delay early TYLCV infection were successful when cucumbers were planted in tomato plots. Interplanting with eggplants or corn was not effective. The preference of whiteflies for cucumbers seemingly explains the high whitefly populations on cucumbers and the simultaneous low populations on tomatoes planted in the same plot. Because cucumbers are immune to TYLCV (4), whiteflies reared on them probably were nonviruliferous. In addition, because whiteflies remain viruliferous for only about 20 days after they acquire the virus (4), viruliferous whiteflies that are attracted to cucumbers for more than 20 days will probably lose the virus. This may explain why the disease increased only slowly in plots interplanted with cucumber until the onset of cold weather.

When the cucumber interplants began to die (32–39 days after tomato transplanting), the whiteflies probably migrated to tomatoes in the plot. This would explain the sharp increase in whitefly populations observed on the tomatoes without a corresponding sharp increase in disease incidence for 28 days after this shift occurred. Thirty-five days after the population had shifted to the tomatoes, however, the incidence of TYLC in the cucumber treatment was not significantly different from that in other treatments. Because TYLC symptoms appear 18–40 days after inoculation, depending on environmental conditions (3,7), the immigrant whiteflies probably acquired the virus from infected tomato plants and inoculated the uninfected plants during the first week after the population shift. This late infection eventually masked the early effect of the cucumber interplants. According to greenhouse results, however, these late infections probably had little effect on tomato yield.

Although eggplants and corn were hosts for whiteflies and immune to TYLCV, they were not effective in delaying the infection of tomato by TYLCV. This was probably because these plants were less preferred by whiteflies than were the tomatoes.

ACKNOWLEDGMENTS

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