CHAPTER 2.6

Tomato Yellow Leaf Curl Virus and Tomato Leaf Curl-like Viruses in Eastern and Southern Africa

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Introduction

Tomato (*Lycopersicon esculentum* Mill.) is one of the most popular vegetables in eastern and southern Africa. It is a high-value crop, providing a good source of income to small-scale farmers. Tomato is consumed both in fresh and processed forms. The processing industry often provides good rural employment opportunities and products for export.

The productivity of tomato in Africa, particularly in eastern and southern Africa, is unfortunately among the world's lowest. For example, the mean yield per hectare of tomato in southern African countries ranges from 1.5 to 14 tons per hectare as compared to the world average of 25 tons per hectare based on the 1989 Food and Agriculture Organization (FAO) production estimates. Several fungal, bacterial and viral diseases have drastically hampered the cultivation of tomato in eastern and southern Africa (AVRDC 1996; 1997; 1998). Among viral pathogens, *Tomato yellow leaf curl virus* (TYLCV) and tomato leaf curl-like viruses account for most losses in farmers' fields (unpublished results). However, adequate information on the epidemiology of TYLCV and associated viruses in eastern and southern Africa remain scanty.

This chapter refers to the emergence of TYLCV and associated viruses in tomato in eastern and southern Africa and describes the development of our understanding of their identification and management.

Impact and Assessment Losses

Over the past decade, TYLCV and leaf curl-like viruses have caused significant losses for tomato farmers in eastern and southern Africa. Yield losses depend on the growing season, tomato cultivars and growth stage at which plants become infected. Recent on-farm surveys indicated that the average perceived yield losses in tomato were up to 40% in Malawi, 50% in Kenya, 75% in Tanzania and 100% in Sudan (CIAT, 1998). In Sudan, yield losses due to TYLCV have been reported to vary in different regions (Yassin and Nour, 1965; Makkouk et al., 1979). Moreover, Ioannau and Iordanou (1985) indicated that losses due to TYLCV vary between 50% and 82% depending on the time of infection.

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In East Africa, TYLCV was first reported in the Sudan (Yassin and Nour, 1965). The disease has since spread to Tanzania (Czosnek et al., 1990; Nono-Womdim et al., 1996), Malawi and Zambia (AVRDC, 1996). Recent survey studies have indicated that this virus occurs in Namibia and Swaziland (AVRDC, 1998), and in Kenya and Uganda (Table 1). A similar disease caused by a distinct virus, tentatively named "*Tomato leaf curl virus-Tanzania*" (TLCV-Tan; now accepted as ToLCV-Tz) (Chiang et al., 1997) has been reported in the central region of Tanzania (Nono-Womdim et al., 1996).

Table 1. Occurrence of *Tomato yellow leaf curl virus* (TYLCV) in eastern and southern Africa.

Country	Year of survey[a]		
	1996	1997	1998
Kenya	16/43	23/81	-
Tanzania	-	73/271	162/344
Uganda	-	5/35	10/58

a. Number of infected samples/number of tested samples on which squash blot hybridization tests were performed using a specific DNA probe for TYLCV from Israel (TYLCV-Is).

Tomato plants infected with TYLCV exhibit severe and varied symptoms. Common symptoms consist of leaf curling, yellowing, chlorosis of leaf margins, leaf distortion, reduction in leaf size, shortening of the internodes or stunting. In some cases, infected plants show excessive branching and flower abscission. Symptoms of TYLCV vary with strain, tomato cultivars, plant age at the time of infection and environmental conditions. In eastern and southern Africa, epidemics of TYLCV occur during the summer months.

Diagnosis

In east and southern African countries, TYLCV is primarily identified by the presence of symptoms that consist of yellowing, leaf curling and stunting. However, visual diagnosis is not useful for the implementation of effective control strategies since the symptoms are very clear on old plants that are already fruiting.

Selected monoclonal antibodies developed against *African cassava mosaic virus* (ACMV) or *Indian cassava mosaic virus* (ICMV) have been used to detect different isolates of TYLCV (Macintosh et al., 1992; Givord et al., 1994). These antibodies also were used to identify TYLCV isolates from Tanzania (unpublished results). It has been shown that many whitefly-transmitted begomoviruses are serologically related (Roberts et al., 1984). Therefore, serological tests for identification of TYLCV are unspecific and do not differentiate strains or different leaf curl viruses.

Nucleic acid hybridization assay is commonly used for the detection of TYLCV. Many cDNA probes prepared against different strains of TYLCV are now available (Czosnek et al., 1990; Kheyr-Pour et al., 1991). Some of these probes currently are being used to identify leaf curl isolates from eastern and southern Africa.

Etiology

TYLCV belongs to the Geminiviridae family and has small geminate particles measuring about 20 × 30 nm (Harrison et al., 1977; Czosnek et al., 1988). The genome of TYLCV consists of a circular single-stranded DNA encapsulated by a single capsid protein (Navot et al., 1991). Many isolates from eastern and southern Africa are closely related to TYLCV from Israel (TYLCV-Is).

TYLCV has been reported to have a wide host range, including plant species belonging to Acanthaceae, Asteraceae, Canicaceae, Euphorbiacea, Leguminosae, Malvaceae, Oxalidaceae, Pedaliaceae, Plantaginaceae and Solanaceae (Singh and Reddy, 1993). In Tanzania, TYLCV was detected in three newly identified hosts, *Achyranthes aspera*, *Euphorbia heterophylla* and *Nicandra physalloides* (Nono-Womdim et al., 1996). These weeds are widespread and serve as a major reservoir of TYLCV.

TYLCV is transmitted by the whitefly *Bemisia tabaci* (Gennadius), not by seeds. In four African countries, Kenya, Malawi, Tanzania and Sudan, several populations of *B. tabaci* have been collected from TYLCV-infected tomato samples and characterized (CIAT, 1998).

TYLCV diseases exhibit various symptoms indicating the existence of different strains. Preliminary identification studies conducted in 1994 showed that several tomato samples from Tanzania, with typical leaf curl and yellowing symptoms, did not hybridize with the Egyptian and/or Israel DNA probes (Nono-Womdim et al., 1996). Two of these Tanzanian leaf curl samples were positive for begomovirus by polymerase chain reaction (PCR) using a primer which specifically amplifies part of the replicase (*AC1*) open reading frame (ORF), the intergenic region and the coat protein (*AV1*) ORF of whitefly-transmitted begomoviruses. Furthermore, the nucleotide sequence of the PCR fragment was compared with the sequences of several distinct begomoviruses, including TYLCV-Is, TYLCV-Th, TYLCV-Sar, TYLCV-Ind, etc. that infect tomato, as well as with the sequence of ACMV, ICMV and *Mung bean yellow mosaic virus* (MYMV). It was found that the Tanzanian isolate shows less than 80% nucleotide identities with these other begomoviruses (Chiang et al., 1997). Since it has been proposed that two isolates of the same begomovirus species have nucleotide sequence greater than 90%, the Tanzanian begomovirus, TYLCV-Tz, is different from all previously characterized begomoviruses from the Old World. Recent survey studies have shown that TYLCV-Tz is now widespread in Tanzania (Table 2). A few leaf curl samples from Malawi have shown a weak positive reaction in squash blot hybridization with the DNA probe of TYLCV-Tz. These results indicate that this virus, or another closely related begomovirus, might be present in this country.

Recently, another study conducted on the identification of leaf curl viruses of tomato indicated the presence of a newly identified virus in Uganda that has 73% homology with TYLCV-Is and 78% homology with ToLCV-Tz. The leaf curl virus from Uganda is tentatively named ToLCV-Ug (Charles Sskyewa, personal communication, 1999).

These findings indicate the presence of at least three different leaf curl viruses of tomato in eastern and

Table 2. Preliminary results on the distribution of tomato leaf curl disease in Tanzania using two specific DNA probes against tomato yellow leaf curl virus-Egypt (TYLCV-Eg) and *Tomato leaf curl virus*-Tanzania (ToLCV-Tz).

Region	Disease incidence[a]	
	TYLCV-Is	ToLCV-Tz
Arusha	13/40	39/40
Dodoma	79/113	96/113
Kilimanjaro	12/30	29/30
Morogoro	34/70	60/70
Zanzibar	5/29	6/29

a. Number of positive samples in DNA hybridization tests/number of samples with leaf curl symptoms.

southern Africa. The causes of this new emergence of leaf curl viruses in Africa have not been investigated yet.

Management

Several management strategies to control TYLCV and associate viruses have been reported (Singh and Reddy, 1993; Polston and Anderson, 1997). These strategies include cultural practices, control of the insect vector and the use of resistant varieties. In eastern and southern African countries, the implementation of cultural practices such as use of virus-free seedlings, reduction of virus inoculum (roguing), elimination of sources of infection and intercropping to control TYLCV has not been performed at farmers' field level. Many African farmers still cannot recognize TYLCV in order to apply these cultural practices for management. However, the use of insecticides, primarily to control whiteflies and not TYLCV, is very common in eastern and southern Africa (CIAT, 1998).

Experiments have been conducted since 1995 at AVRDC Africa Regional Program to identify tomato varieties with resistance to TYLCV (Table 3). The varieties Fiona and Tyking are resistant to TYLCV in Tanzania. Plants of these species are symptomless and TYLCV is not detected by DNA hybridization. Generally, resistance to TYLCV is quite specific. For instance, tomato cultivars with resistance or tolerance to TYLCV from the Old World are susceptible to tomato leaf curl viruses from the Western Hemisphere (Polston and Anderson, 1997). The situation seems to be different in Africa. In recent field screening tests, Fiona, Tyking and TY52, which are resistant to TYLCV, were found to resist ToLCV-Tz as well. Such lines will provide an efficient control strategy for the management of TYLCV and ToLCV-Tz since both viruses occur in mixed infections in Tanzania.

Table 3. Field screening of *Lycopersicon* accessions for resistance to *Tomato yellow leaf curl virus*.

Lycopersicon accessions	Final disease incidence (%)
Chepertylc C-1	96
4-2	95
FI-3	100
J-7	100
L-7	100
Sin-3	100
Siv-5	100
Siv-6	100
Columbian 36	100
EC-104395	100
Jackal	55
LA 3214	100
LA 3216	95
Lignon C8-6	100
PSR-403511	5
PSR-407111	9
Roza	100
Ty-20	54
8476	75
Fiona	0
Tyking	0
MoneyMaker	100
Roma	100

Conclusion

This chapter summarizes recent outbreaks of TYLCV and leaf curl-like viruses in eastern and southern Africa. The virus was first reported in Sudan in the 1960s, where it has been a threat for several decades. Then, in 1990, it was found in Tanzania. To date, TYLCV is widespread in many countries of the subregion. It is not well known whether TYLCV has occurred in these countries from some time ago, as in Sudan, or whether it has spread southwards from Mediterranean countries.

Until 1997, TYLCV was the only begomovirus reported to cause disease on tomato in eastern and southern Africa. Two additional viruses, namely

ToLCV-Tz and ToLCV-Ug, which are different from TYLCV, have been reported recently (Chiang et al., 1997; Charles Sskyewa, personal communication, 1999). Recent surveys indicate that many tomato leaf curl samples do not hybridize with the available cDNA probes in nucleic acid hybridization tests. This may indicate the existence of additional African indigenous leaf curl viruses.

In Tanzania, tomato varieties with resistant to TYLCV under field conditions have been identified. These resistant tomatoes are hybrid varieties that many farmers in eastern and southern Africa cannot afford.

At AVRDC, a breeding programme has been initiated aimed at incorporating the TYLCV resistance derived from *Lycopersicon chilense* (Zakay et al., 1991) into cultivated tomato. However, until open-pollinate varieties with resistance to TYLCV become available, there is a need to develop alternative control strategies for African farmers that will include control of the insect vector and cultural practices.

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