



Infection of tomato in Iraq with tomato leaf curl Palampur virus and multiple variants of tomato yellow leaf curl virus

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Abstract

Tomato yellow leaf curl disease (TYLCD) and tomato leaf curl disease (TLCD) cause serious losses in tomato production, especially in tropical and sub-tropical regions. In 2014–2015, tomato samples with TYLCD/TLCD-like symptoms were collected from different provinces of Iraq and infection with tomato yellow leaf curl virus (TYLCV) identified. To study the diversity of TYLCV, DNA of eight positive samples from this survey was used for rolling-circle amplification, cloning and sequencing. Pairwise nucleotide sequence comparisons with complete genomes showed that the Iraqi TYLCV isolates belonged to the strains TYLCV-IL and TYLCV-Mld. In a phylogenetic analysis, the Iraqi TYLCV-IL isolates grouped into three distinct clades, consisting of TYLCV-IL (A) and the two new variants TYLCV-IL (D) and TYLCV-IL (E). The Iraqi isolate of TYLCV-Mld grouped into the newly proposed TYLCV-Mld (D) variant. For one sample, sequencing also revealed co-infection with tomato leaf curl Palampur virus (ToLCPalV). The phylogenetic tree of ToLCPalV DNA-A showed a close relationship between the isolates of different hosts from Iraq and Iran. No evidence of recombination was detected in ToLCPalV DNA-A, but recombination was observed for the TYLCV isolates. The results indicate that there is a high diversity of TYLCV in Iraq, including new variants, that is partly shared with Kuwait and countries in the Eastern Mediterranean Region. Occurrence of multiple TYLCV variants and ToLCPalV can act as a potential threat to tomato production in Iraq.

Keywords Tomato yellow leaf curl disease · Tomato leaf curl disease · *Begomovirus* · TYLCV-IL · TYLCV-Mld · Recombination

Introduction

Tomato yellow leaf curl disease (TYLCD) is one of the most serious and economically important diseases of tomato (*Solanum lycopersicum*). TYLCD was first reported in the Jordan Valley, Israel and has subsequently spread into the Mediterranean Basin and most tropical and subtropical regions of the world (Lefeuve et al. 2010). The disease is caused by a complex of viruses belonging to at least 13 species of the genus *Begomovirus*, family *Geminiviridae* (Yan et al. 2021). The genus *Begomovirus* is the largest genus of plant-infecting viruses and viruses of this genus have a circular single-stranded monopartite or bipartite DNA genome of 2.8 kb or 5.6 kb, respectively. Among TYLCD-causing viruses, tomato yellow leaf curl virus (TYLCV) has become established worldwide, resulting in economic losses (Rojas et al. 2018). Although TYLCD can be found worldwide, only viruses of two strains, the Israel (TYLCV-IL) and Mild (TYLCV-Mld) strains of TYLCV, are truly global

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