VIRTIGATION – Emerging viral diseases in tomatoes and cucurbits: Implementation of mitigation strategies for durable disease management

Deliverable 3.2
Defined tomato plant resistant to TYLCV and beta satellite

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1 PUBLISHABLE SUMMARY

The tomato is one of the most important agricultural vegetables. Tomatoes are grown in large areas, both in open field and under protected structures. One of the most hazardous threats to tomato production is the begomovirus Tomato yellow leaf curl virus (TYLCV). Members of the Begomovirus genus are transmitted by the whitefly *Bemisia tabaci* (Gennadius) and infect dicots. Begomoviruses are transmitted in a persistent, circulative manner, e.g. once the whitefly acquires the virus from an infected plant, transmission can occur within hours and continue for the life span of the whitefly. Due to the large numbers of whiteflies, and their worldwide spread, TYLCV has long become a major threat to tomato production. TYLCV genome consists of a single circular single-strand DNA, of nearly 2800 nucleotides.

TYLCV control measures usually rely on heavy application of insecticides, or growing the plants under protected covers, to inhibit the spread of the whitefly vector. The heavy insecticides application is not efficient enough and has hazardous effect on the environment. Growing plants under protected covers is expensive and creates problems of overheating and shading. Natural virus resistance is of major agricultural importance and an attractive solution for viral diseases in general, and particularly to whitefly-transmitted viruses. Indeed, many breeding programs aimed at developing TYLCV-resistance, were initiated. Today, five resistance loci have been mapped and characterized, termed Ty-1 to ty-5. Ty-1 to Ty-4 exhibit dominance inheritance, while ty-5 is recessive. Ty-1 and Ty-3 were found to be alleles of the same resistant gene. When tested for their effect on TYLCV infection, it was found that Ty-1/Ty-3 and ty-5 have a major inhibitory effect on TYLCV, while Ty-2 and Ty-4 are more minor.

TYLCV-resistant tomato plants containing the resistant loci Ty-1/Ty-3 were grown in the field in Jordan. Surprisingly, the resistant plants expressed severe disease symptoms. It was found that the plants were infected with TYLCV and with a satellite DNA known as betasatellite. Apparently, the presence of the betasatellite broke down this specific TYLCV resistance.

Betasatellites are small DNA molecules associated with various monopartite begomoviruses. The genome of betasatellites is composed of a circular ssDNA molecule, encoding a single gene, BetaC1. The BetaC1 gene codes for a protein which is a suppressor of gene silencing. It was shown that in many instances, the plants infected with both a begomovirus and a betasatellite developed much more severe symptoms when comparing to the same plant infected with the virus alone. Today it is thought that the BetaC1 suppresses the gene silencing of the infected plant, and thus the virus can induce extremely severe symptoms, or in the case of TYLCV plus betasatellite induce breakdown of genetic resistance.

Our working hypothesis was that while the combination of TYLCV plus betasatelite can indeed breakdown TYLCV resistance, a combination of two or more resistance genes may hold under the joint attack of the virus and betasatellite. Hence, we have developed near-isogenic tomato lines (NIL) carrying all possible combinations of the four known TYLCV-resistant loci, Ty-2 through ty-5, in the same genetic background. We have developed 16 tomato NIL's, from

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susceptible line to lines containing combinations of two, three and four resistant loci. The NIL's were inoculated with either TYLCV alone, or with TYLCV and betasatellite, and tested for their resistance level. Indeed, it was found that tomato lines expressing a combination of TYLCV-resistance genes exhibited a very high level of resistance to both TYLCV and betasatellite.

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