Study on the Plant Resistance Mechanisms against Viruses

Kazuhiro Ishibashi (Institute of Agrobiological Sciences, NARO)
bashi@affrc.go.jp

Plants evolved defense mechanisms to fight viruses. Many genes that confer resistance to specific viruses, namely, resistance genes, encode nucleotide-binding site and leucine-rich repeat (NB-LRR)-containing proteins. These proteins elicit a defense reaction upon recognition of viral infection. *Tm-1* is a semi-dominant resistance gene of tomato against tomato mosaic virus (ToMV). Before I started this study, *Tm-1* was suggested to inhibit ToMV multiplication in a unique mechanism, however, positional cloning has been hampered by the extremely low frequency of recombination around the *Tm-1* locus.

I identified the *Tm-1* gene product through biochemical purification of an inhibitor of *in vitro* ToMV RNA replication from a tomato cell extract [1]. The amino acid sequence of the polypeptide had no similarity to any characterized proteins. I characterized the mechanisms of action of Tm-1 and found that the Tm-1 protein binds ToMV replication proteins and inhibits formation of ToMV replication complex. Replication proteins of resistance-breaking ToMV mutants did not bind Tm-1, suggesting that ToMV mutants break the resistance by escaping the inhibitory interaction.

Tm-1 was derived from a wild relative of tomato, *Solanum habrochaites*. To explore the evolutionary history of *Tm-1*, I sequenced the *Tm-1* gene of *S. habrochaites* accessions and found that a small part of the *Tm-1* gene is under positive selection, suggesting that this region underwent rapid amino acid changes against selective pressure by ToMV infection. Crystal structures of a fragment of the Tm-1 protein and a complex between the Tm-1 fragment and a ToMV helicase domain fragment of replication proteins revealed that Tm-1 and ToMV have coevolved by changing both sides of the interaction interface [2].

Viruses infect a specific range of hosts, and thus most plant species are nonhosts of a virus. However, why viruses cannot infect nonhost plants had remained unknown because of the inapplicability of classical genetics approaches. Tomato is a nonhost of tobacco green mild mosaic virus (TMGMV) and pepper mild mottle virus (PMMoV), relatives of ToMV. ToMV-susceptible tomato cultivars have a *Tm-1* allele, *tm-1*, whose product neither binds to ToMV replication proteins nor inhibits RNA replication. I found that tm-1 is a functional inhibitor of TMGMV and PMMoV replication proteins [3]. Replication proteins of these viruses (tobamoviruses) are multifunctional that also act as an RNA silencing suppressor. A TMGMV mutant that can escape the inhibition by tm-1 lost the ability to suppress RNA silencing. Therefore, the multifunctionality of replication proteins is an evolutionary constraint of tobamoviruses that restricts their host ranges.

References

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