The Battle Against Plant Viruses

Wilhelm Gruissem
Plant Biotechnology, Department of Biology, ETH Zurich, Switzerland

Like all other viruses, plant viruses are composed of a small DNA or RNA genome and a protein coat, and they depend on their host plants for replication and multiplication. But unlike many animal and human viruses that spread through aerosols, plant viruses depend on vector organisms such as insects or nematodes for transmission. In infected plants viruses spread by moving through plasmodesmata, the cytoplasmic connections between plant cells which are otherwise separated by a solid wall. Once viruses have infected plants, they are difficult to fight because chemical strategies are not effective. As the result, viruses cause many important plant diseases and are responsible for huge agricultural losses and often entirely destroyed crops. Plant breeders are continuously searching for resistance genes against viruses to protect our crop plants. But because viruses can also change their genome rapidly through recombination and mutations, they often evade resistance strategies and become virulent again.

So, why are plants not always infected by viruses? Unlike animals and human, plants do not produce antibodies that neutralize virus particles. It has been known for many decades, however, that prophylactic inoculation of plants with less virulent strains can be used to control viral diseases. This 'cross-protection' has uncovered an effective mechanism that plants have developed to shut off or 'silence' virus genes, and thereby prevent multiplication and spreading of the virus throughout the plant. Today we know that most eukaryotic organisms suppress foreign genetic elements, such as viruses or transposons, through a specific RNA turnover mechanism that is referred to as 'RNA silencing'. In higher plants, where more than 90% of viruses have a highly replicating RNA genome, the activity of the viral genome triggers the production of 21-25 nucleotide long small interfering RNAs (siRNAs), which bind to the virus RNAs and cause their efficient degradation. This makes it a potent defence mechanism against virus infection. In the battle between viruses and plants, however, viruses have also learned how to inactivate RNA silencing by expressing proteins that can bind siRNAs and therefore neutralize their protective function. But understanding the molecular mechanism of RNA silencing is now providing scientists and breeders new tools and strategies to combat plant viruses.

Early attempts to genetically engineer virus resistance in crop plants relied on expressing viral coat proteins at high levels, which blocks the progression of virus infection. The protection of papaya against the papaya ringspot virus is the best-known example for the success of this strategy. More recently, genetic engineering of virus protection in crop plants is taking advantage of RNA-based strategies using siRNAs and another class of small RNAs, so called microRNAs (miRNAs), to interfere with virus replication and spread throughout the host plant. Together, these novel technologies are promising advances in our battle against plant viruses and efforts to protect our crop plants around the world.