Aphid triggered immunity in melon: key determinants for durable resistance to virus and aphids

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Title

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Abstract

The *Vat* gene in melon is unique in conferring resistance to both *A. gossypii* and the viruses it transmits. This double phenotype is controlled by a cluster of genes including a CC-NLR which has been characterized in detail. Copy-number polymorphisms (for the whole gene and for a domain that stands out in the LLR region) and single-nucleotide polymorphisms have been identified in the *Vat* cluster. The *Vat* gene structure suggests a functioning so called effector-triggered immunity (ETI), with separate recognition and response phases. During the recognition phase, the VAT protein is thought to interact (likely indirectly) with an aphid effector introduced by aphid salivation within the plant cells. A few hours later, several miRNAs are upregulated in *Vat* plants. Peroxidase activity increases, and callose and lignin are deposited in the walls of the cells adjacent to the stylet path, disturbing aphid behavior. In aphids feeding on *Vat* plants, the levels of miRNAs are modified. At the plant level, resistance to aphids is quantitative (aphids escape the plant and display low rates of reproduction). 'Aphid-ETI' has qualitative and local effect against non circulative viruses (CMV, ZYMV, WMV) and but quantitative effect against circulative virus such as CABYVs.

Durability of ETI is highly variable. At population level, 'Aphid-ETI' reduces aphid density and genetic diversity, and durability of the 'Aphid-ETI' strongly depends on the agro-ecosystem. Some clones are adapted to *Vat* resistance, putatively either by introducing a polymorphic effector not triggering ETI, or by adapting to the defenses they triggered.

Several ways to enhance 'Aphid-ETI' durability will be proposed. 'Aphid-ETI' against viruses decreases the intensity of *Cucumber Mosaic Virus* (CMV) and *Cucurbit aphid-borne yellows virus* (CABYV) epidemics. Laboratory experiments strongly suggested that non circulative viruses cannot adapt to 'Aphid-ETI' and therefore durability of 'Aphid-ETI' against CMV is predicted long. Field experiments combined to modelling suggested that highly durable resistance against CABYV could be obtained by combining within a same melon genotype the *Vat* gene with recessive genes conferring resistance to CABYV. Extension of those results to any other circulative viruses will be discussed.