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Breeding Poplars with Durable Resistance to *Melampsora larici-populina* Leaf Rust: A Multidisciplinary Approach to Understand and Delay Pathogen Adaptation

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During the last decades, European poplar breeders learned the hard way that *Melampsora larici-populina* has an impressive adaptive potential. This pathogen defeats qualitative (*i.e.* complete) resistances in less time than needed to grow a poplar tree. After several resistances inherited from *Populus deltoides* had been overcome, breeding for quantitative resistance (QR) was considered a more durable strategy.

At least three recent results raise doubts on this optimistic point of view. First, elucidating the genetic determinism of quantitative resistance in *P. detloides x P. trichocarpa* hybrid progenies did not reveal as complex a genetic determinism as expected. Loci with major effects on one or several QR components were identified, such as R_{US} inherited from *P. trichocarpa.* Second, quantitative and qualitative resistances did not appear to be completely independent. Most identified defeated qualitative resistances inherited from *P. deltoides* (e.g. R_1), had statistical effects on QR. Third, strains of the pathogen able to defeat the R_{US}-mediated QR have been identified, possibly due to pre-adaptation in the pathogen's populations.

Being both "easy" to map and defeated, R_{US} is used as a model locus to understand host-pathogen quantitative interactions. Fine mapping of R_{US} is being conducted using a 1,410 genotype F_1 progeny, and a BAC library was constructed to generate a physical map of 2,000 kb around R_{US}. The first results support the idea that qualitative and quantitative resistances share not only functional but also structural similarities.

Urged by poplar growers to deliver new cultivars, breeders explore multiple (possibly combinable) very pragmatic strategies to delay pathogen adaptation. Sources of resistance are being diversified. In particular, the genetic variability available in the co-evolved European species *P. nigra* is being explored more attentively. A collection of 1,100 *P. nigra* genotypes collected in different European populations has recently been screened for rust resistance. The available variability for additional traits like avoidance and tolerance is also being tested in fungicide-treated *vs.* untreated experiments while new deployment strategies, such as using clonal mixtures, are also evaluated.