Second-generation biotech approaches for durable disease resistance in cereals

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Broad-spectrum, quantitative pathogen resistance is of high importance to plant breeders due to its expected enhanced durability. However, it is usually controlled by multiple quantitative trait loci and therefore, challenging to handle in breeding practice. Knowing about the underlying genes would facilitate its more targeted utilization by allele introgressions. Identified candidate genes can also be used for increasing resistance by genetic engineering. Three approaches to confer durable pathogen resistance to barley and wheat by transgene technology will be presented here.

The first approach focuses on the silencing of potential susceptibility-related genes of barley during the interaction with the powdery mildew fungus *Blumeria graminis* f. sp. *hordei* (Bgh). These genes are either silenced alone or in combinations of three, under the control of a constitutive or a pathogen-inducible promoter. In order to identify genes that affect race-nonspecific resistance of barley to the powdery mildew fungus *Blumeria graminis* f.sp. *hordei* we combined a functional-genomics approach based on genomewide transcript profiling and transient-induced gene silencing (TIGS, over 1,000 genes) with association-genetic (re-sequencing) and meta-QTL mapping approaches. This guided us to a shortlist of approximately 40 candidates with converging evidence for an important role in race-nonspecific resistance of barley. Several of those candidates enhanced resistance upon TIGS and thus might function as susceptibility factors. The second approach focuses on host-induced gene silencing (HIGS) in fungal pathogens attacking transgenic plants that carry RNAi constructs directed against transcripts of the pathogen. Proof of concept was obtained in the barley/Bgh system and in wheat attacked by the *Fusarium* head blight fungus *F. culmorum*. The third approach is based on pathogen-inducible over-expression of combinations of three defense-related genes involved in cell-wall modification or in signaling. Transgenic lines were evaluated for enhanced resistance to Bgh, rice blast, scald and spot blotch.

The prospects and limitations of these approaches will be discussed and put into the context of sustainable, knowledge-based improvement of biotic stress resistance in crop plants.