

## Benefits of rational management of disease-resistant crop varieties

Theoretical studies (INRA, AU, WUR) have shown that smart deployment of disease resistance in crop cultivars can significantly contribute to enhanced resistance durability and makes entire growing systems more stable.

### Economical

- Improved durability of crop production systems.
- Improved return on investment in resistance breeding.
- Decreased losses caused by the disease.
- Facilitating disease control by other means.
- Improved market value of resistant varieties.

### Environmental

- Protection of genetic resources.
- Reduced pesticide use in crop production.
- Compatible with organic farming practices.

### Image

- Promotion of sustainable agricultural practices of High Environmental Value.

Use of disease resistant cultivars is a key to environmentally friendly and economically sustainable disease control in modern crop production. It is put at risk by the evolutionary potential of pathogens to overcome disease resistance of crop cultivars. Three different modeling tools have been developed that consider key evolutionary mechanisms and driving forces behind pathogen evolution. The models can be used to examine how pathogen evolution, disease development and spread are likely to be affected by a broad range of strategies for deploying crop cultivars with various types and sources of disease resistance.

Using these models can assist in designing sustainable resistance deployment strategies, on a temporal as well as spatial scale, that control disease problems and minimise food security risks such as those caused by evolution of new virulent pathogen strains or pathogen "super races".

### Participants

Aarhus University (AU), Denmark;  
Institut de la Recherche Agronomique (INRA), France;  
Wageningen Plant Research International (WUR), The Netherlands.

[www.endure-network.eu](http://www.endure-network.eu)



ENDURE coordinator (Pierre Ricci) ~ [endure.coord@sophia.inra.fr](mailto:endure.coord@sophia.inra.fr)



A NETWORK OF EXCELLENCE

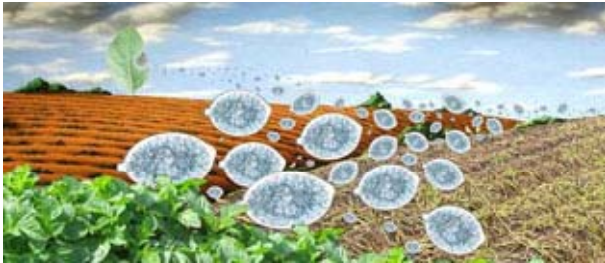


## Recommendations for the deployment of disease resistance in crop cultivars



SIXTH FRAMEWORK PROGRAMME

## Large-scale epidemic dispersal model (WUR)



The general idea is to confront the pathogen with a genetically diverse host population in time and space. This will delay or even prevent epidemic development with benefits for both growers (reduced production costs and reduced chemical input), breeders (increased durability of resistance) and society (healthier production systems, reduced side effects on the environment).

Results show that mixing of resistances at the smallest possible spatial scale (the field) is most effective in delaying or preventing epidemic development. Additional benefits occur when resistances are also mixed at larger (regional) spatial scales.

For atmospherically dispersed pathogens, simulation studies have shown that the conclusions above hold for a very wide range of dispersal capabilities making these measures applicable for a wide range of pathogens.

Contact: Geert.Kessel@WUR.NL

## Parsimonious model of pathogen population evolution (AU)

Numerical experiments indicate that the extended use of R genes for complete specific resistance triggers the build-up of corresponding virulent pathogen genotypes. The extended use of multiple R genes, whether rotated over time in different cultivars or combined (“pyramided”) into a single cultivar, increases the risk for selection and development of pathotypes (“super races”) with matching multiple virulences overcoming multiple specific R genes.

Modelling results suggest that maintaining an as high as possible proportion of host genotype area planted to partially resistant cultivars is beneficial because it greatly reduces the virulence selection pressure on the pathogen population, thus particularly lowering the risk for formation of super races.

The fitness costs associated with specific virulences in pathotypes and the aggressiveness of individual pathogen genotypes greatly affect the evolution of pathogen populations and thus the durability of specific resistances: increasing fitness costs for virulence reduces the likeliness for development of pathotypes and particularly super races expressing the respective virulences, thus prolonging the durability of the corresponding specific resistances. High aggressiveness of pathogen genotypes may compensate for high fitness costs, thus increasing their overall fitness.

The model thus underlines that identifying the “best” R gene deployment strategy requires quantitative information on fitness costs associated with individual virulences and on aggressiveness of individual pathogen genotypes.

Contact: Hans.Pinnschmidt@agrsci.dk

## Reaction-diffusion model of host-pathogen dynamics (INRA)

Instead of the qualitative resistance, characterised by the complete inability of a pathogen to infect plants, plants can carry quantitative resistance varying their susceptibility. The model allows us to derive conditions under which the qualitative and quantitative plant resistance can be used in plant diversification strategies to control epidemic spread.

### For breeders

The effect of multigenic qualitative resistance on the pathogen population can be produced by a random patterning of monogenic qualitative resistances.

### For land managers

Random mixtures including resistant varieties reduce both density and genetic diversity of the pathogen population and delay invasion promoted by sexual recombination. In contrast, patchy distributions diversify pathogen population and hence reduce the efficacy of resistance genes.

### Specific (wheat rust)

The model shows that the effective two-component random mixtures reducing wheat rust severity to 20% can be composed of: (1) resistant and highly or moderately resistant (less than 70% of the mixture) varieties; (2) highly and moderately resistant (less than 55%) varieties; (3) resistant and susceptible (less than 40%) varieties.

Contact: Natalia.Sapoukhina@angers.inra.fr