

POTATOES

MANAGING LATE BLIGHT sustainably



In Europe, late blight remains the main threat to potato crops, nearly two centuries after the introduction of this plant.

Third food resource after rice and wheat, potato plays a key role in feeding the world. Overall, potato crops show a rather high Treatment Frequency Index (TFI), estimated at 16.7 in France, 12.8 of which is attributable to fungicides. The latter are essentially used to control late blight, caused by *Phytophthora infestans*; in years of severe infection like in 2007, up to 25 treatments were carried out in one season in some countries.

Without fungicide protection, entire crops can be lost. However, such a level of protection is difficult to sustain in the long term. Its financial cost is around 450€/ha/year in Europe, which represents 10 to 20% of production costs. And there is also an environmental and a safety quality cost. This protection is doubly unsustainable as it contributes to the emergence of populations that are resistant to some of the active substances used. In such a context, creating potato varieties that are resistant to *P. infestans* seems to be a key action lever to reduce treatments and production costs, as well as to develop the alternative protection methods expected by consumers.

Controlling late blight in potatoes while reducing the use of fungicides constitutes a challenge. Several complementary projects are focussing on pathogen resistance to fungicides and varietal resistance breakdown.

Genetic diversity and resistance breakdown

However, the way in which *P. infestans* populations evolve undermines the long-term resistance of potato varieties to late blight.

Very significant sampling work carried out as part of the Euroblight network has helped to compare the genetic composition of *P. infestans* populations in Europe (figure 1). This data highlighted two types of oomycete reproduction; populations in western and southern Europe mainly reproduce through cloning, whereas populations in northern and north-eastern Europe (Scandinavia, Baltic states, Poland), which are genetically very diverse, probably reproduce sexually. Despite the absence of the genetic mixing provided by sexual reproduction, cloned *P. infestans* populations often evolve dramatically due to the rapid replacement of cloned lines. As a result, different genetic pools often coexist within a same population, at least temporarily. This genetic diversity, added to great variability, makes the pathogen particularly apt to breaking down the varietal resistance of potatoes.

« 35 genes can provide potatoes with specific resistance to late blight. »

There are two types of resistance in this case. One (most of the time) or more “R” gene(s) provide(s) specific resistance by inducing hypersensitivity which blocks the colonisation of tissues and parasite reproduction at an early stage. There is also a quantitative (or partial) resistance, presumed to be non specific, with more complex genetic characteristics.

Up until now, 35 “R” genes have been identified among various wild species related to the cultivated potato. Most of them have been integrated into commercial varieties. On the whole, those genes’ efficacy is short lived. Even if a variety combines several of them, once it is put into production, resistance can be broken down within a few years.

The complex genetic characteristics of quantitative resistance makes it more difficult to break down; it is therefore more sustainable and stable in a large variety of environments. The combination of several “R” genes providing quantitative resistance could then, theoretically, prolong the sustainability of resistance to late blight; this type of strategy has proved successful for other phytosystems such as potato cyst nematode.

« The combination of specific resistance genes and quantitative resistance factors should prolong the sustainability of resistance to late blight. »

Varietal control pushed to the fore

It is from this varietal angle that between 2017 and 2019 the PoTStaR(1) project will tackle the challenge of sustainably protecting potatoes from late blight. With this aim in mind, it will combine two different but complementary approaches. The first will focus on the potato, and phenotyping(2) will be carried out in relation to late blight on INRA’s collection of 282 seed stock varieties (potato varieties enhanced for quality or resistance to various bioaggressors); this will be done in field conditions, and with or without fungicides. The observation sites, situated in major production areas, present contrasting climates, with therefore different levels of pressure from late blight. Data from previous trials will also be utilised.

Markers that are associated with stable resistance to late blight and can be used for marker-assisted selection (MAS) will then be identified. Conventional selection is penalised when several genes are involved to provide resistance to late blight; this is because, without markers, it is difficult to build genotypes that carry complex

resistance.

The second approach focuses on the pathogen, and late blight strains sampled during the trials will be genotyped and phenotyped. The data will be compared to previous results obtained from natural late blight populations in the same geographical areas, in order to detect the potential adaptation of the pathogen to resistant potato genotypes. Finally, the risk of *P. infestans* populations evolving in response to the future cropping of the selected resistant varieties will be assessed.

A complementary epidemiologic approach

The alternative strategies that have been developed will only be sustainable if they are able to cope with the variability and rapid evolution of *P. infestans* populations. This supposes that the pathogen populations’ genotypes and phenotypes are monitored, both in terms of virulence and aggressiveness and sensitivity to fungicides.

To that effect, the IPM Blight 2.0(3) project, which started in 2016, will determine the relevant characteristics of European *P. infestans* populations by analysing genotypic and phenotypic variations in the samples of sexed and cloned pathogens from the control collections in the various partner countries. It will establish whether genotypes accurately predict phenotypic characteristics (virulence, aggressiveness), and how those characteristics evolve.

Numerous models will be developed and integrated into decision support tools (DSTs) for fungicide treatments. Existing DSTs will be improved in order to offer a risk assessment based both on the likelihood of epidemiologic infection guided by weather conditions and on the pathogens’ phenotypes. The DSTs’ new modules will give improved recommendations on tactical choices (“Should I spray now?”) and strategic decisions (“Should I trust this cultivar?”) and improve late blight control.

(1) Partners of the PoTStaR project (CASDAR 2016 project): INRA, the Fédération Nationale des Producteurs de Plantes de Pomme de terre, the Association des Créateurs de Variétés Nouvelles de Pomme de terre and ARVALIS-Institut du végétal.

(2) Phenotyping a plant consists in listing the characteristics that can be observed and result from interactions between its genes and its environment. Genotyping consists in listing its genes.

(3) Partners of the IPM Blight 2.0 project: INRA, the Aarhus University (Denmark), NIBIO (Norway), the Estonian University of Life Science, ARVALIS-Institut du végétal, the Association des Créateurs de Variétés Nouvelles de Pomme de terre, the Norwegian Department for Agricultural Development and the James Hutton Institute (Scotland).

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The dominant *P. infestans* genotype in France is resistant to metalaxyl and breaks down numerous resistance genes in potatoes.

INFESTANS POPULATIONS: their great diversity has an impact on control methods

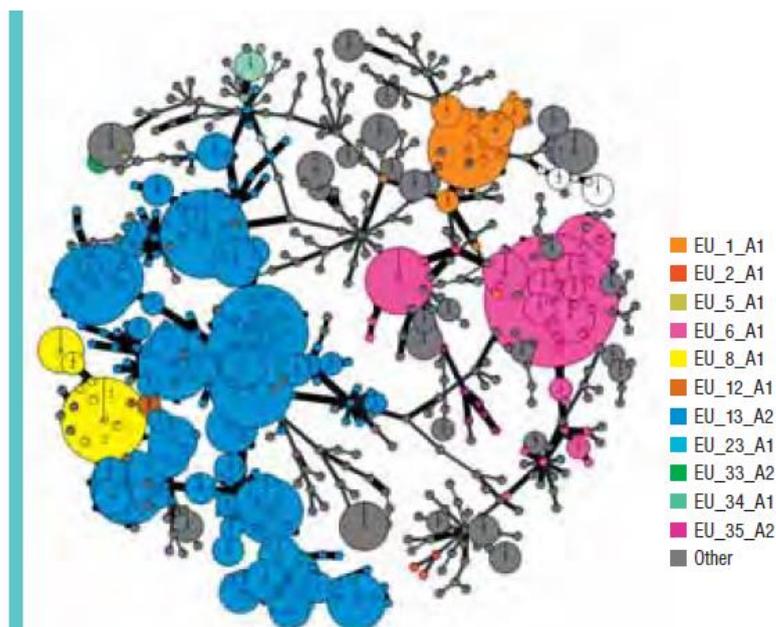


Figure 1: Genetic tree of *P. infestans* populations responsible for late blight. The lines that were chosen are in colour and individual genotypes, all different, are in grey. The 13_A2 clonal line now represents 35% of the samples collected in Europe, and more than 60% of those gathered in France in 2016; it presents a greater internal diversity than 6_A1.

The biocontrol challenge

Potato producers don't currently have any biocontrol solutions against late blight. The MilPomBio (*) project, which started in 2015, aims to offer them biocontrol products provided with directions for use to help them limit symptoms to an acceptable level.

As a result, two biocontrol products are currently being selected among the most promising ones on the market. Both products will be tested on a panel of 15 resistant potato varieties in order to look for potential synergies between the plant's genetics and biocontrol products; the forms of resistance being studied include both physiological resistance and resistance provided by the plants' and covers' architecture. This research work will be carried out under greenhouse as well as field conditions.

The second phase of the project will see the development of two strategies to use the selected products as part of an integrated protection system combining biocontrol products and/or conventional products and/or resistant potato varieties.

(*) *The MilPomBio project is a partnership between VegeNov, INRA-UMR IGEPP, ARVALIS-Institut du Végétal and Bretagne Plants.*



Strengthening the integrated protection of potatoes against late blight also involves developing effective biocontrol