Trends in Late Blight Resistance Breeding in Western Europe

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Western Europe has a long history of resistance breeding against *Phytophthora infestans,* starting with the arrival of the pathogen in the region around 1845. At that time *Solanum tuberosum* had some genetic diversity, developed after it was brought to Europe at the end of the 16th century. Subsequent introductions from South America of varieties such as Daber (1830) and Rough Purple Chili (1851) added to this variation. When the pathogen arrived, natural selection took place among existing varieties and continues until today. As a result, current varieties are far less susceptible than the varieties that dominated in the early days of the potato. This level of resistance is what we term susceptible today.

In 1845, the laws of genetics and the fungal nature of plant diseases were unknown. Yet, as early as 1851, attempts were made to introduce resistant *S. demissum* from Mexico, and improve its vitality by starting from fresh botanical seed, derived from crosses with potato. The German Klotsch made these early attempts. Unfortunately, the resulting hybrids proved susceptible and were probably abandoned.

Later attempts since 1908 by Broili in Germany and Salaman in the UK resulted in resistant varieties but the resistance was lost in 1932, even before the first of the new varieties was brought into trade. The breeding populations resulting from their work were extensively used throughout Germany, the UK and the Netherlands. Some varieties with useful resistance were introduced, but the resistance did not prove durable in any of them.

Resistance of a more durable nature was present in the European gene pool of the cultivated potato that had undergone natural selection since 1845. Paterson's Victoria (1856), Nicholl's Champion (1863), Richter's Imperator (1875) and Robijn (Dutch Robin, 1926) are examples of varieties with durable resistance of a moderate level.

However, selection for other traits dominated potato breeding programs of the twentieth century from the onset. One such trait was earliness, which is negatively correlated with resistance. Also, breeding stocks were continually renewed to allow for introgression of new traits, often from late blight susceptible sources. The lack of adequate selection pressure, together with the polygenic nature of durable resistance, resulted in considerable susceptibility in many of the popular varieties of today. Attempts to introgress polygenic resistance, for example from *S. verrucosum* by Tazelaar (1981), failed because the genes were not kept together in the backcrossing process.

Breeders prefer monogenic resistance. The reason for this is clear. Potato breeding aims at combining different genes for many traits of interest in one genotype. Only very few genotypes will have at least the minimum set of genes to make them acceptable from an agronomic point of view. It is highly unlikely that any of these rare prize types would also possess a sufficient number of late blight resistance genes. Recent history shows that resistances successfully introgressed into commercial varieties are all monogenic. Examples are the resistances to potato cyst nematode (*Globodera rostochiensis*), wart (*Synchytrium endobioticum*) and potato virus X.

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Unfortunately, major genes and durability do not go together very well in the case of *Phytophthora infestans*, because the pathogen has many generations per season and spreads rapidly over long distances.

The strategy of breeders in this situation is to look for major genes from other sources, hoping that this will lead to durable resistance. Some of the sources used are *S. bulbocastanum*, *S. microdontum* and *S. berthaultii*. Pyramiding of such genes would make them more durable and can be done with the help of molecular markers. The pyramided genes should be combined with a genetic background of minor genes, to further reduce the risk of resistance breakdown. For the near future, this appears to be the only possible strategy.

However, in order to attain long lasting durable resistance, we need to learn more about the mechanisms of durable resistance. Key genes in the host that enhance durable resistance and cannot be overcome by the pathogen may then be found and employed. The finding by Vleeshouwers that the hypersensitive response is a common feature both to durable resistance and to non-durable major gene resistance to late blight opens possibilities. Modifying genes could also yield gene constructs rendering durable resistance.