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Can novel breeding techniques deliver a solution to late blight?

TEAGASC researchers are evaluating the potential of novel techniques such as cisgenics to deliver durable blight resistance.

Potato late blight disease remains the primary stressor of commercial potato production across the EU, responsible for ~€1bn in annual damage to the EU potato sector alone. In the absence of resistant varieties that meet consumer demands on taste and appearance, growers are wholly dependent on fungicide applications to preserve yields. In Ireland alone, this equates to >10 sprays per crop, to offset losses.

The recently published Farm to Fork (F2F) strategy of the European Commission outlines the need to reduce chemical inputs by up to 50 % by 2030. To achieve this ambitious goal, multiple strategies need to be considered to assist farmers in reducing current reliance on inputs while maintaining the economic sustainability of Irish potato production.

Sources of genetic resistance to late blight disease do exist in wild potato species but the transfer of this resistance into commercial varieties through conventional breeding practices is time consuming due to the complexity of the potato genome. It typically takes ~12 years to breed a new potato variety, but introducing traits from wild germplasm can extend this even further, as seen with varieties Sarpo Mira, Bionica and Toluca.

A previous article in this series on breeding potatoes highlights the gains that exist with the use of molecular techniques to increase the efficiency of breeding in the delivery of more stress-resilient varieties. More recently, novel breeding techniques have illustrated the potential to enhance existing varieties further through the addition of a single trait via a process termed 'cisgenics'.

Cisgenics

Cisgenic refers to the transfer of genes within a genus (e.g., from a wild potato to a commercial potato), but because of the method used to transfer the genes they are still covered by genetic modification (GM) legislation. This contrasts with the traditional understanding of GM, which is transgenic. In this case, genes are taken from one genus and transferred into any other (e.g., transferring a gene from a fish into a plant).

Significantly, a 2010 Eurobarometer survey on the theoretical marketing of a cisgenic variety to Irish consumers reported that while only 36 % of Irish people surveyed would accept a transgenic variety, 61 % would accept a cisgenic variety.

Through cisgenics, novel potato lines can be engineered in a matter of weeks, highlighting the potential of the technique to accelerate the potato breeding process and address a trait deficit (e.g., late blight susceptibility), without compromising the processing/quality traits the variety already possesses.

The EU-funded 'AMIGA' project was established to assess and monitor the impact of specific GM crops on agro-ecosystems. As partners in this project, we undertook field evaluations, at a licensed site in Oak Park Carlow, of a potato line, which possessed a late blight resistance gene (Rpi-vnt1.1) taken from

the wild potato species *Solanum venturii* (**Figure 1**). Through three consecutive field seasons the impact of the cisgenic potato line (A15-031) on specific parameters of soil biodiversity was investigated. In addition, the potential of integrated pest management (IPM) strategies to support the durability of this source of late blight resistance against Irish late blight strains was also determined.

Significantly, the IPM control strategy adopted in the study, and based on the use of the cisgenic potato line, reduced the average fungicide input by 80-90 %, without compromising late blight control or yield.

Results

Significantly, the IPM control strategy adopted in the study, and based on the use of the cisgenic potato line, reduced the average fungicide input by 80-90 % across the three years, without compromising late blight control or yield. This was made as a direct comparison with the experimental control variety, cv. Desiree. Of interest, the work was also completed at a site in The Netherlands, and delivered equivalent fungicide reductions, in spite of the higher level of late blight pressure experienced there compared to what was recorded at Oak Park. Separately, the environmental side-effects of late blight control were reduced significantly. For this, in-depth studies looked at the impact of growing the cisgenic potato line on soil bio-indicators, including nematodes, which play a key role in soil processes, with alterations in the nematode community structure having the potential to considerably influence ecosystem functioning. As a result, fluctuations in nematode diversity and/or community structure can be gauged as a 'barometer' of a soil's functional biodiversity. Based on the metrics studied, the cultivation of the cisgenic potato line exerted no significant effect on nematode community diversity. In fact, greater disturbance of nematode diversity was recorded from the yearly weather patterns, as opposed to from the material grown. Similarly, investigations also concluded that there were no tangible effects associated with the cultivation of the field-grown cisgenic potatoes on soil microbial communities either.

Impact

The results from the AMIGA project have been fully published with a significant proportion of the work focussed on monitoring the impact of the cisgenic potato line on biodiversity. Based on the three-year study, the environmental and agronomic impact of the cisgenic line was positive and indicates the potential of certain breeding techniques to rapidly deliver novel potato lines with enhanced field performance while reducing fungicide reliance.

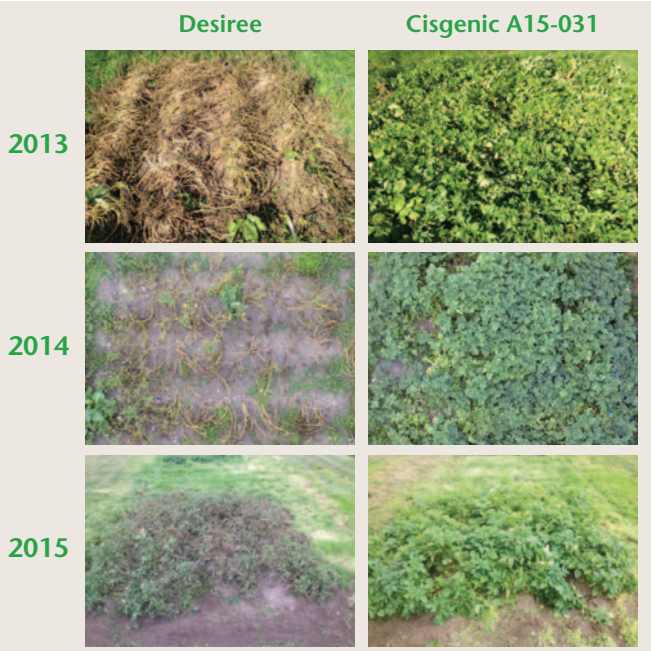

FIGURE 1. Resistance of cisgneic potato line A15-031 (right) relative to its equivalent comparator non-GM variety Desiree (left) against natural late blight at a licensed field location in Carlow, Ireland. Field assessments were conducted in 2013, 2014, and 2015. A15-031 was cisgenically engineered at Wageningen University through the DuRPh programme.

As with all disease control strategies, the durability of the therapeutic is dependent on the presence/absence of supporting measures. Late blight has a fantastic ability to rapidly evolve new strains and this constant 'arms race' between plant and disease is continuous. However, while the cisgenic line used in the AMIGA study contained a single R gene, it is technically straightforward to include a series of R genes in the modification step. If deployed as part of an IPM-based strategy, this material has the potential to negate the high level of current fungicide inputs while attaining the processing quality required.

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