

Test for mapping potato disease

How a nematode makes potatoes sick

PCN disease is one of the biggest threats to potato crops. The disease is caused by the potato cyst nematode (PCN). Plant breeders developed new potato varieties that are resistant to the disease, but more and more nematodes have found a way round the resistance, letting them continue with their pathogenic behaviour. PhD candidate Arno Schaveling discovered how the nematode *Globodera pallida* does this. Text Roelof Kleis

When Schaveling started his PhD research four years ago, the nematode was only a problem in the north of the Netherlands and the adjoining part of Germany. It never seemed likely that the situation would stay that way and it didn't. 'That's so sad,' says Schaveling. 'The problem has only got worse since then. The nematode is increasingly breaching the resistance in commercial potatoes. After we found the genetic basis for this in Dutch populations, I was able to demonstrate it in German, French and British populations as well. That means the whole of Western

Europe is facing the same problem.'

The battle between potatoes and nematodes has been going on since time immemorial. Like so many organisms in nature, the two are engaged in a constant arms race. The potato has had the edge since the 1990s, when plant breeding companies were able to incorporate resistance from wild potatoes into commercial potatoes. Schaveling says they probably all used the same resistance. 'I tested 26 potato varieties and kept coming across the same resistance taken from the potato *Solanum vernei*. That must have been widely available.'

One trick

That 'easy' victory is behind the success of the nematode this time round. The worm only has to develop a way round a single

form of resistance to defeat all potato varieties. 'The nematodes are only ever being exposed to one kind of selection pressure,' is how Schaveling puts it in scientific terms. That made his own task simpler: he just had to find out what that one trick is that the nematodes are using and design a test for it. In fact, he suspects this would have been impossible to do if multiple forms of resistance were involved. The trick used by *Globodera pallida* is a protein created by a gene called Gp-pat-1. 'We think it is what is known as an effector,' says Schaveling, 'a protein that manipulates the host in a way that helps the intruder. Our hypothesis is that



Sex and sugar

The nematodes that cause PCN disease only reproduce sexually but the individual's sex is still undetermined when they emerge from the egg and penetrate the root of a plant. Schaveling has shown that the surroundings have a big influence on the sex. If a lot of nutrients (i.e. sugars) are available, the nematode becomes female, and if the conditions are less favourable the nematode becomes male. 'It had long been thought the surroundings had an effect,' says Schaveling. 'We were able to prove that the sex is not predetermined and we have strong indications that the default is to become male. They only switch to being female if the conditions are very favourable. That is logical, as being female costs about 60 times more energy. The females have fat bodies full of eggs; the males are much thinner.'



PhD candidate Arno Schaveling developed a test that gives farmers a simple way of measuring where in a potato field they can expect problems.

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under normal circumstances the potato's resistance gene will produce a protein that detects that effector, triggering an immune response. But repeated use of the same form of resistance has led to preferential selection of effector variants that are no longer detected. This lets the nematode do what it wants unhindered.' Schaveling cannot yet *prove* that this is what happens. 'To do that, you need the potato's resistance gene and we don't yet have that. We know where in the genome the resistance is, but we don't know precisely which gene is involved.

Nematode test

The more nematodes have the deviant effector, the more harm the population causes. Schaveling therefore developed a Covid-style PCR test that farmers can use to test the disease potential of their fields. Schaveling: 'Except that a Covid test gives a yes or no as an answer, whereas my PCR test measures what proportion of the nematode population

is pathogenic.' The test is being developed further by an external project partner, with the aim of launching it on the market.

Schaveling's test is a diagnostic tool and not a cure for PCN disease. 'The test can be a cheap, fast tool that farmers can use to help them take decisions,' says Schaveling. At present, farmers often implement crop rotation every two years as a precaution. The test gives a simple measurement of where they can expect problems. 'There is often a lot of variation within one field. One spot

The worm only has to get round a single form of resistance to affect all potato varieties

might have lots of virulence and another very little. My PCR test quickly gives you a picture of the whole field.'

A new form of resistance is needed to protect potato plants from this potato disease. Schaveling found a suitable form of resistance in the potato *Solanum sparsipilum*. His experiments showed this new form of resistance is effective against the nematodes. 'But it needs to be cross-bred into the commercial varieties. The breeding companies are working on that but they aren't there yet.' ■