Work Package 3: Resistance Marker Development

PCN ACTION SCOTLAND

This work package is led by Ingo Hein and his colleagues Thomas Adams, Xinwei Chen, Glenn Bryan and Micha Bayer at the James Hutton Institute.

- Potato cyst nematodes or PCN are an important pest of potatoes and across Europe, PCN reduces potato yields and quality.
- In Scotland, the PCN infested land area is doubling every 7 years[1].
- Resistant potato varieties can be used to control PCN.
- Many popular varieties are resistant to *Globodera rostochiensis* but nearly all are highly susceptible to *Globodera pallida*.
- In 2019, 55% of potatoes produced in Scotland were varieties with high resistance to *G. rostochiensis* (scores from 7 to 9) while only 2.6% of varieties had strong resistance to *G. pallida*[2].
- *G. pallida* is becoming more prevalent, so developing new resistant varieties to control this species of PCN is a priority.

Figure 1: Potato breeding programme in a glasshouse at JHI.

Table 1: Top ten varieties (by area) grown for seed in Scotland (2021)[3]

	Resistance rating to PCN (scored from 1 = Highly susceptible to 9 resistant)	
	G. rostochiensis	*G. pallida*
Maris Piper	9	2
Hermes	2	2
Cara	9	2
Desiree	2	2
Innovator	2	8
Royal	9	3
Atlantic	9	2
Markies	9	2
Maris Peer	2	2
L. Rosetta	9	2

Aims

- To find and develop markers within specific resistance genes that are effective in controlling both species of PCN.
- To introduce new resistances from wild potato species into pre-breeding programmes to ensure long-term PCN resistance.

What is resistance to PCN and how does it control the pest?

Resistance is the ability of a variety to **limit PCN multiplication**. A resistant variety stimulates nematode eggs to hatch (just as a susceptible variety does), but the juvenile nematodes cannot form a feeding site on the roots (a syncytium). With no syncytium to feed on, the nematodes never reach the adult stage, so their lifecycle is cut short, and the population decreases.

Background

- Within the genome of the sequenced potato, there are about 750 putative resistance genes of which the majority provide little plant protection. For a tetraploid potato cultivar (which has 4 copies of genetic material), this translates to some 3000 individual genes, but only a handful might be effective in controlling diseases. This makes breeding for a specific resistance such as PCN, a slow and expensive process.
- Breeding PCN resistant varieties would be quicker and easier with resistance markers as breeders could look for the marker rather than testing every potential potato for resistance (often more than 100,000 individual seedlings) from a breeding programme.
- Marker-assisted selection (MAS) can also guide breeders on creating broad resistance via informed combination of resistance genes from multiple resources.

[1]https://www.planthealthcentre.scot/sites/www.planthealthcentre.scot/files/2021-04/pcn_working_group_-_final_report.pdf [2]https://www.cabi.org/cabebooks/FullTextPDF/2021/20210466450.pdf [3]https://www.sasa.gov.uk/sites/default/files/2021%20Final%20Statistics.pdf

The Marker Development Process

Cultivars that are resistant or susceptible to PCN are identified by breeders.

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The genotype of these plants are assessed with a focus on sequencing PCN resistance genes.

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The phenotypic and genotypic information are combined in a computational analysis referred to as association genetics.

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All resistance genes that are only found in PCN resistant varieties but absent in susceptible are treated as candidates.

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An approximate marker is determined for genes that display correlation with resistance only.

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Testing to determine marker strength.

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Marker incorporated into commercial breeding programmes to improve selection for PCN resistance.

Definitions

Genome – A complete set of DNA, including all genes present in an organism.
Phenotype – Characteristics which can be observed e.g., infection symptoms, plant defence responses.
Genotype – The genetic composition of an organism.
Marker - A marker is a DNA fragment (e.g., a gene) with a known physical location on a chromosome which is genetically linked to the phenotype. The marker gene must be easily detectable, recognisable and be located close to the target gene (resistance gene in this case) to be informative.

Figure 2: PCN cysts on potato roots (image courtesy of Scottish Agronomy Ltd)

1. Economics	2. Decision Support	3. Resistance Markers	4. Accelerated Breeding	5. Tolerance to PCN	6. Groundkeeper Control	7. Integrated Pest Management	8. Knowledge Exchange

More information and factsheets about each work package can be found on **pcnhub.ac.uk**

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