

Biofumigation for control of potato cyst nematodes

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Aim: To identify brassicas with high potential to control potato cyst nematodes, *Globodera pallida* and *G. rostochiensis* in UK potato production.

1. Potato cyst nematodes (PCN) in UK agriculture



Figure 1: Potatoes growing in untreated (left) and nematicide-treated (right) soil.

- PCN impose an annual cost of >£50 million in the UK.
- The EU has recently banned the most widely used nematicide, Aldicarb, because of environmental concerns, leaving UK potato farmers in crisis.

2. Biofumigation appears suitable for PCN control



Figure 2: White mustard, *Sinapis alba*, being ploughed into soil after wheat harvest in potato rotation. Image from McGuire, Crop Management (Aug 2003).

- A biofumigant crop can easily fit into the potato rotation, being sown in autumn and ploughed in either before (Figure 2) or after the winter.
- PCN are specialists of Solanaceae and cannot multiply on brassicas.

3. Toxicity assay

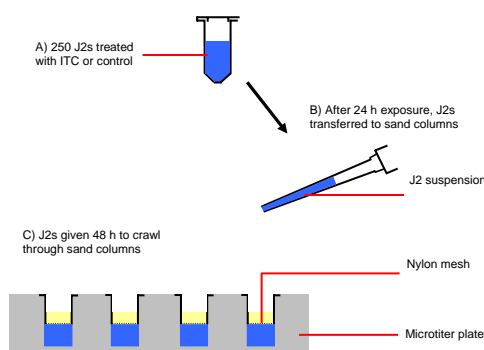


Figure 3: Toxicity assay protocol.

- A toxicity assay was developed in which second stage juveniles (J2s) were exposed to isothiocyanates (ITCs), plant extracts or control treatments.
- Five ITCs were tested at a range of concentrations and leaf extracts from 23 different plants were tested at a single concentration.

4. Toxicity of pure isothiocyanates

- Infective second stage juveniles of *G. pallida* (J2s) were exposed to five isothiocyanates at a range of concentrations and live, motile animals were recovered through sand columns.
- The rank order of toxicity was benzyl > phenethyl > 2-propenyl > 3-(methylthio)propyl > 2-methylbutyl, with a six-fold difference between the ED₅₀ of the most and least toxic compound (Fig. 4).

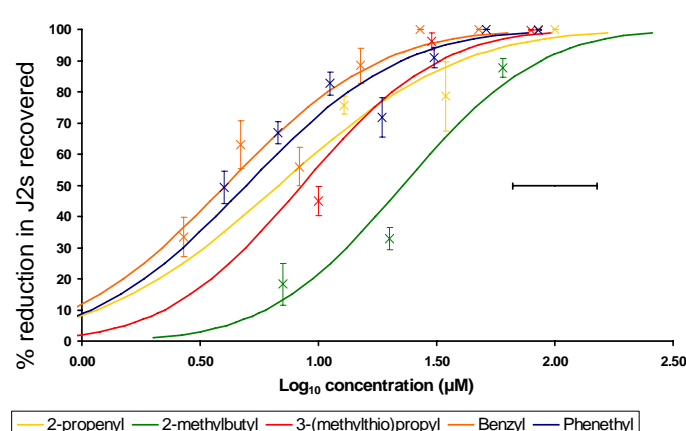


Figure 4: Probit dose-response curves for five isothiocyanates against *G. pallida* juveniles. Values are means \pm SEM. The horizontal error bar estimates the 95% confidence interval of the ED₅₀ values.

5. Toxicity of candidate biofumigant crops

- 23 potential biofumigant crops were selected on the basis of their glucosinolate profiles and screened for toxicity to *G. pallida*. The most effective were *Raphanus sativus* cv. Weedcheck, *Nasturtium officinale* and *Brassica juncea* cv. Nemfix (Figures 5 and 6).

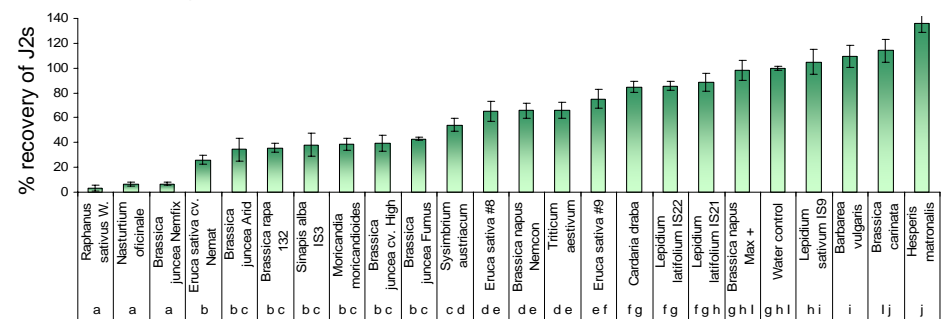


Figure 5: Mean recovery of live juveniles of *G. pallida* from sand columns after treatment for 24 h with leaf extracts from a range of plants (1.8 mg leaf tissue per ml water) relative to a water only control. One-way ANOVA with SNK post-hoc test revealed significant differences between treatments ($P < 0.001$). Letters represent SNK subsets. Error bars show SEM values.

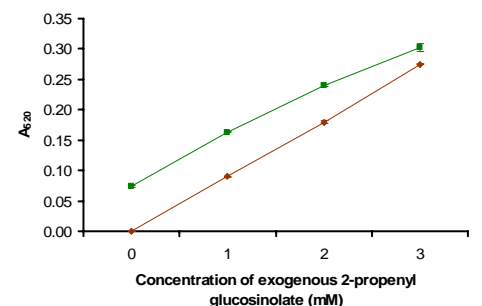


Figure 6: The three plants found to possess greatest efficacy against *G. pallida*: A) *Raphanus sativus*; B) *Nasturtium officinale*; C) *Brassica juncea*.

6. Glucosinolate content of candidate biofumigant crops

- The efficacy of plants of interest relates to qualitative and quantitative aspects of their glucosinolate profiles.
- Therefore an assay was validated to quantify glucosinolate from plant tissues by measuring total glucosinolate in leaf extracts (Figure 7).

Figure 7: Mean optical density at 520nm in replicate colorimetric assays for total glucosinolate content of leaf extract with added concentrations of exogenous glucosinolate. The difference in elevation between the two regression lines represents the difference in glucosinolate levels of two *B. juncea* cultivars.



7. Further work

- The proportion of the plants' efficacy against *G. pallida* that relates to total glucosinolate content will be determined for the 23 brassica species/cultivars.
- The toxicity of 4-methylthio-3-butenyl isothiocyanate from *R. sativus* will be determined now that it has been established as the most effective species tested (Figure 5).
- Both spring and autumn sowings will be used to determine efficacy achievable under field conditions within the rotation course.
- Efficacy against an important fungal pathogen of potato, *Rhizoctonia solani* will also be defined. Control of both nematode and fungal soil pathogens enhances commercial potential of biofumigation in UK potato production.