Developing the biofumigant potential of Brassicas for controlling Rhizoctonia in potatoes

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ABSTRACT

Glucosinolates have biocidal activity and can control a range of fungal and insect pests. Biofumigation occurs when plant material from Brassicas is incorporated in the soil, where the active breakdown products are released from the plants and 'fumigate' the soil. *Rhizoctonia solani* is a major fungal pathogen of potatoes, attacking stems before emergence and also causing unsightly hard black superficial blemishes on tubers called black scurf, which are becoming increasingly unacceptable with the potato trade and consumers. No fungicide treatments are proven to be effective in controlling soil borne Rhizoctonia and there is a need to develop a novel, environmentally friendly means of soil borne Rhizoctonia suppression. An aim of this work is to evaluate the effectiveness of biofumigation and ultimately to provide information for its use in a control system for potatoes. A range of brassicas were grown under controlled conditions to supply plant materials with a range of glucosinolate profiles. These were then tested in the lab for activity against Rhizoctonia colonies grown on agar plates and exposed to biofumigation from the different Brassica material. Significant differences in activity of different sources of glucosinolates have been apparent and work has also shown a dose response. Work is ongoing to test the effectiveness of Brassicas to control soil borne Rhizoctonia in the field. The Brassicas swede oilseed rape, turnip oilseed rape, brown mustard and white mustard have been selected on the basis of their glucosinolate profile and also likely winter hardiness. A system of utilising these crops to provide biofumigation before the potato crop is planted in the spring will be discussed.

Key words: glucosinolates – biofumigation – *Rhizoctonia solani* – potatoes – field trials

INTRODUCTION

The breakdown products of glucosinolates contained by Brassicas have been shown to have biocidal effects on a range of organisms including the plant diseases clubroot and Pythium and pests such as slugs and aphids (Booth *et al*, 2000). The concept of biofumigation allows glucosinolates to be released when Brassica material is incorporated in the soil and offers the potential of a convenient means of delivery to the target.

Rhizoctonia solani causes damage of significant financial value to the UK potato crop. It restricts growth of stems and stolons underground leading to slow or patchy emergence and is associated with the black scurf symptoms on mature tubers, greatly reducing the market value of the crops. Soil borne Rhizoctonia is becoming increasingly important and fungicidal treatments for control are very limited. There is a need to develop a novel, environmentally friendly means of Rhizoctonia control for conventional production and also with potential for use in organic systems. The overall aim of the work is to contribute to the development of a system of utilising the biofumigation potential of glucosinolates within Brassica species to control Rhizoctonia symptoms in potatoes.

MATERIALS AND METHODS

A range of Brassica species with a range of glucosinolate profiles were grown under controlled conditions. The above and below ground plant parts were harvested just prior to flowering and then freeze dried and milled. This material was then tested in terms of ability to control Rhizoctonia using the technique described by Kirkegaard *et al*. (1996). Rhizoctonia cultures were isolated from potato tubers, maintained on potato dextrose agar (39 g/l) at 16 – 18 ˚C and grown in petri dishes in the laboratory. Plant material was used at rates of 0, 100 and 500

mg/plate in a randomised block design with 5 replicates. Plates were incubated at 18 ˚C for 3 days and the diameter of colonies measured.

Field experiments were carried out over 2 seasons; 2000/01 and 2001/02, at a site known to be contaminated with soil borne Rhizoctonia in Aberdeenshire. The 4 brassicas *Brassica napus* (swede oilseed rape), *B campestris* (turnip oilseed rape), *B juncea* and *Sinapis alba* were selected for their contrasting glucosinolate profiles. The brassicas were sown at the beginning of September at the conventional sowing time for winter oilseed rape in plots 8m x 6m in a randomised block design with 5 replicates. Agronomic treatments followed normal practice for winter oilseed rape. Plots of Brassica crops were compared to plots planted with winter barley (a crop which contains no glucosinolates) and fallow plots. The crops were maintained until spring growth was well underway, then chopped and ploughed down. In the 00/01 season, brassicas were chopped on 2 May and ploughing was delayed until 14 May, whereas in the 01/02 season, ploughing down on 17 April immediately followed chopping on 16 April. After ploughing, the land was left undisturbed for biofumigation to take place and potato planting occurred on 31 May in the 00/01 season and 21 May in the 01/02 season. The potatoes were planted in plots superimposed on the sites of the Brassica and control plots.

The potatoes were grown according to standard practice. Detailed assessments of symptoms associated with Rhizoctonia were undertaken at full emergence of the crop on 4 plants selected from each plot. Total number of stems and stolons and number of pruned stems and stolons were assessed. Individual stems and stolons were evaluated assessed for stem canker lesions and given a 0 – 3 score (0 = no necrosis, 1 = 0 – 33%, 2 = 33 – 66% and 3 = 66 – 100% circumference of stem/stolon affected). This data was converted to give a class score, as follows; (1 x number of stems/stolons scoring 1) + (2 x number of stems/stolons scoring 2) + (3 x number of stems/stolons scoring 3)/total number of plants. After harvest, the percentage area of 50 tubers per plot covered with symptoms associated with Rhizoctonia including black scurf and russeting, was assessed according to a MAFF scale.

RESULTS

The lab results showed that there were significant differences in activity of different sources of glucosinolates. Results from the 500 mg rate are shown in Table 1. Below ground root material from *B campestris* was particularly effective. Root material from *B oleracea*, *B juncea*, *S alba* and *B napus* (Synergy) also caused a large reduction in colony size, as did above ground material from *B napus* (forage rape), *B Campestris*, *S alba* and *B juncea*.

Table 1. Effect of Brassica leaf and root material on growth of *R solani* cultures

Brassica species	Above/below ground part	Colony size as % untreated
B juncea (brown mustard)	above	58.5
	below	47.3
S alba (white mustard)	above	55.3
	below	46.7
B napus (oilseed rape var. Synergy)	above	77.8
	below	47.1
B napus (oilseed rape var. Bristol)	above	100.7
	below	61.9
B napus (forage rape)	above	50.5
	below	61.9
B campestris (turnip oilseed rape)	above	55.9
	below	31.9
Raphanus sativus (forage radish)	above	91.8
	below	79.0
B oleracea (thousand head kale)	above	97.4
	below	41.7
Untreated		100.0
LSD ($p \leq 0.05$)		30.62

The 2000/01 field trials developed only low levels of Rhizoctonia symptoms and differences between treatments were not apparent on the growing crop or on the tubers. For the 2001/02 trials, higher levels of Rhizoctonia were observed. With regard to Rhizoctonia symptoms on the stems there was a tendency for the *B juncea* and Synergy biofumigant treatments to be associated with less severe symptoms, whereas the fallow was associated with more severe symptoms, but this was not significant (Table 2). Black scurf incidence on tubers tended to be greatest for fallow and winter barley and least for the Synergy treatment with russeting symptoms being greatest for the fallow treatment, however again differences were not significant.

Table 2. Effect of biofumigation on Rhizoctonia symptoms on potato crop, 2001/02 experiment

Treatment	Rhizoctonia score on stems	Rhizoctonia score on stolons	Black scurf on tubers, % severity	Russeting on tubers, % severity
B campestris	6.60	0.69	15	1.19
B juncea	2.08	1.20	11	0.98
S alba	5.00	3.77	13	0.91
B napus (Synergy)	3.47	1.75	5	1.02
Winter barley	5.56	3.71	17	0.67
Fallow	13.19	2.73	24	1.77
significance	ns	ns	ns	ns

DISCUSSION

The laboratory work with brassica tissue has demonstrated effectiveness in controlling Rhizoctonia *in vitro*. Experiments using the same range of brassica material with powdery scab, another significant disease of potatoes, have also shown effectiveness in control under controlled environment conditions (Wale and Lees, 2003).

The present field work indicates a potential biofumigation effect from brassicas. The timing of field operations may be an important factor in determining the effectiveness of biofumigation. Ploughing was delayed in 2001, but it may be necessary to plough immediately after chopping the plant material to ensure that glucosinolate volatilisation and loss to the atmosphere is minimised.

Growing a brassica crop over winter prior to using it to biofumigate the soil before planting the potato crop was considered to give a viable method for practical usage of brassica biofumigation. However, more work is required to optimise the methods of biofumigation to maximise effectiveness.

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