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CONTRACT REPORT

HEATHERS: Comparison of fungicides for control of botrytis, cylindrocarpon and pestalotiopsis during propagation
HO/17b/87

COMMERCIAL - IN CONFIDENCE

PRINCIPAL WORKERS

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AUTHENTICATION

I declare that this work was done under my supervision according to the procedures described herein and that this report represents a true and accurate record of the results obtained.

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Introduction

Disease problems are frequently encountered by heather growers and many routinely use a comprehensive fungicide programme to control fungal disease and produce a high quality product.

Botrytis cinerea is one of the most damaging diseases and under conditions of high humidity especially if plants are under stress can spread rapidly and cause extensive browning of the foliage. In some situations the characteristic grey fluffy fungal growth covers the shoots, but this can disappear quickly when the relative humidity drops.

Pestalotiopsis guepinii and Cylindrocarpon destructans do not cause such striking damage but nonetheless can seriously affect the quality of the crop. Pestalotiopsis is similar to botrytis in that it attacks the foliage but usually invades stem tissue causing shoot dieback and browning of the foliage and flowers. Cylindrocarpon destructans is a root pathogen and is frequently isolated from the roots of poorly growing heather plants. It is often found in association with Pythium species. Cylindrocarpon destructans is often considered to be a weak pathogen; only causing damage to already weakened or stressed plants. Even so infection by Cylindrocarpon further damages the plant and restricts new root development.

The main objectives of the experiment were;-

i) to assess the biological efficacy of new and existing fungicides ~~on~~ for the control of

a) Botrytis cinerea

b) Pestalotiopsis guepinii

and c) Cylindrocarpon destructans infection on heather cuttings

Materials and Methods

Site

The trials were all carried out within the glasshouse complex at the ADAS Regional Office, Coley Park, Reading.

Design

The experiments were of a randomised block design with four replicate blocks. Each plot consisted of a seed tray (22 cm x 17 cm) containing 100 cuttings.

Separate experiments were carried out for each of the three pathogens included in the investigation.

Husbandry

Cutting material of the heather variety, Robert Chapman and compost for propagation were supplied by Mr John Hall, Winchfield Nursery according to commercial practice. After sticking, the trays were placed on a heated bench in the glasshouse and covered with a sheet of thin polythene. The temperature of the compost was maintained at 15-18°C. Shading was provided to protect the cuttings from direct sunlight.

Disease Inoculation

To ensure disease development within each experiment area, the cuttings were inoculated at the time of sticking with a specific pathogen as follows;

a) Botrytis cinerea. Cultures of botrytis were grown on potato dextrose agar at 25°C for ten days and a spore suspension prepared by washing spores off the surface of the agar in distilled water. The resulting suspension was agitated well and applied to the cuttings as a fine spray until run-off.

b) Pestalotiopsis guepinii. Cultures of pestalotiopsis were grown on potato dextrose agar at 25°C and incubated under black light to stimulate pycnidial development. Mature spore producing pycnidia developed within four weeks and a spore suspension was prepared as for botrytis in distilled water. Cuttings were inoculated prior to sticking by immersing them in the spore suspension for 10 minutes.

c) Cylindrocarpon destructans. Cultures were grown as for botrytis and a spore suspension prepared. The remaining agar cultures were removed from the petri dishes and pulverised before being incorporated into the compost to be used for sticking. Approximately 20 agar plates were mixed with the compost to fill the 40 seed trays in the experiment. After sticking the cutting into the inoculated compost they were also sprayed with the cylindrocarpon spore suspension.

Fungicides

Table 1. Fungicides, active ingredients (a.i.) and dose rates

Fungicide	a.i.	Amount a.i. in product	Dose rate product/litre
Octave	manganese + prochloraz	50%	1 g
Elvaron	dichlofluanid	50%	2 g
Rovral Flo	iprodione	250 g/l	1 g
Repulse	chlorothalonil	500 g/l	2.2 ml
Compass	iprodione + thiophanate-methyl	167 g/l 167 g/l	2.5 ml
FD 4215	ICI material		7.5 g
Benlate	benomyl	50%	1 g
Delsene M	carbendazim + maneb	50 g/l 320 g/l	2 ml

Treatments

1 Untreated - Water
2 Octave
3 Elvaron
4 Rovral
5 Repulse
6 Compass
7 FD 4215
8 Benlate
9 Delsene M

Treatments were applied 24 hours after sticking the cuttings and were repeated every two weeks. A total of five sprays were applied on 25 August, 7 September, 22 September, 5 October and 19 October 1988.

Fungicide Application

Fungicides were applied as a high volume spray to the experiments inoculated with botrytis and pestalotiopsis, using a hand-held Polypack pressurized

sprayer. Fungicides were applied as a drench to the cylindrocarpon experiment.

Assessments

Counts were made of numbers of cuttings with foliage affected by Pestalotiopsis, botrytis or general browning and numbers of dead cuttings per plot on 1/9, 22/9, 5/10 and 19/10/88. The final assessment was made on 23/11 and roots and foliage were assessed for vigour on 1-5 scale.

Foliage	Roots
1. Dead	1. No roots
2. Single shoot	2. Few roots
3. Several small shoots	3. Moderate roots
4. Some strong shoots	4. Good root development
5. Vigorous healthy plant	5. Extensive root development

Statistical Analysis

All data were subjected to analysis of variance. Where required, data was transformed before analysis. Treatment means were separated using Duncan's Multiple Range Text.

Results

i) Comparison of fungicides for control of botrytis

Table 2. Disease Development: 7 days post-sticking

Treatment		% cuttings affected by:		
		sporulating botrytis	browning	botrytis + browning
1	Untreated	10.0 abc	7.2	17.2 ab
2	Octave	4.0 ab	16.5	20.5 ab
3	Elvaron	3.7 ab	13.5	17.2 ab
4	Rovral	9.7 ab	7.5	17.2 ab
5	Repulse	5.7 ab	17.5	23.2 ab
6	Compass	16.0 ab	8.2	24.2 ab
7	FD 4215	0.0 a	14.7	14.7 a
8	Benlate	8.5 ab	12.0	20.5 a
9	Delsene M	23.0 c	12.5	35.5 b
	CV %	98.9	NS	38.0
	SED	6.27		123

Botrytis is readily identified in the early stages of infection when it is visibly sporulating but infected healthier tissue rapidly dries out and botrytis is seen as a general browning. Sporulating botrytis was present on 10 per cent of untreated cuttings. No sporulating botrytis was seen on the FD4215 treatments and infection levels were lower on the Octave, Elvaron and Repulse treatments.

Table 3. Disease Development: 34 days post-sticking

Treatment		% cuttings affected by botrytis	% cuttings affected by browning	% cuttings healthy
1	Untreated	1.0	13.0 ab	43.2 ab
2	Octave	0.0	12.7 ab	15.5 ab
3	Elvaron	0.0	20.0 ab	53.5 ab
4	Rovral	0.0	25.5 ab	57.5 ab
5	Repulse	0.0	15.5 ab	53.5 ab
6	Compass	0.0	19.0 ab	34.5 ab
7	FD4215	0.0	3.0 ab	40.7 ab
8	Benlate	0.0	10.7 ab	62.2 b
9	Delsene M	0.0	24.2 b	13.2 a
	CV %	NS	56.9	47.9
	SED		0.149	0.237

Levels of sporulating botrytis were very low 34 days after sticking and symptoms were only seen on the untreated cuttings. All treatments were affected by browning of the cuttings. Those treated with FD4215 had the lowest levels of browning and those treated with Delsene M had the highest levels. The Delsene M treated trays also had the lowest number of healthy cuttings.

Table 4. Effect of fungicide treatment on vigour of foliage and root system

	TOPS	ROOTS
Treatment	Treatment Mean	Treatment Mean
Untreated	2.68	2.14
Octave	3.07	2.56
Elvaron	2.94	2.42
Rovral	3.06	2.36
Repulse	2.85	2.37
Compass	3.25	2.68
FD4215	2.72	2.37
Benlate	2.65	2.14
Delsene M	3.14	2.51
CV %	NS	NS
SED		

All fungicide treatments with the exception of Benlate increased the vigour of the foliage and root system when expressed as a vigour index but this was not significant at the 95% probability level. No treatments had lower vigour indices than the untreated.

ii) Comparison of fungicides for control of Pestalotiopsis

Table 5. Disease Development: 7 days after sticking

Treatment		% cuttings affected by pestalotiopsis	% cuttings affected by browning	% cuttings healthy
1	Untreated	2.75 b	20.2	76.5
2	Octave	0.00 a	6.5	93.5
3	Elvaron	0.25 a	12.7	87.0
4	Rovral	0.75 a	17.7	81.5
5	Repulse	0.25 a	10.5	89.2
6	Compass	0.00 a	17.7	82.2
7	FD4215	0.00 a	9.0	91.0
8	Benlate	0.25 a	28.2	71.5
9	Delsene M	0.00 a	10.2	89.7
	CV %	171.1	NS	NS
	SED	0.571	0.149	0.237

Table 6. Disease Development: 34 days after sticking

Treatment		% cuttings affected by pestalotiopsis	% cuttings affected by tipping	% cuttings healthy
1	Untreated	15.0 b	26.0 b	58.5 ab
2	Octave	1.5 a	22.7 ab	74.0 ab
3	Elvaron	9.2 ab	19.7 ab	67.4 ab
4	Rovral	7.7 ab	25.2 b	64.2 ab
5	Repulse	2.2 a	20.2 ab	77.5 ab
6	Compass	8.7 ab	22.5 ab	68.0 ab
7	FD4215	2.5 ab	12.5 a	85.0 b
8	Benlate	20.0 b	28.5 b	57.2 a
9	Delsene M	1.2 a	14.2 ab	84.5 b
	CV %	65.5	24.7	20.9
	SED	0.109	0.081	0.149

Levels of Pestalotiopsis increased during the trial period; 34 days after sticking 15.5% of untreated cuttings were infected with pestalotiopsis. All fungicides apart from Benlate reduced levels of infection and there were significant reductions after treatment with Octave, Repulse and Delsene M. There were also noticeable symptoms of shoot tipping which was significantly reduced by sprays of FD4215.

Table 7. Effect of fungicide treatment on vigour of foliage

Treatment	
Untreated	3.23 ab
Octave	3.35 b
Elvaron	3.09 ab
Rovral	3.66 b
Repulse	3.22 ab
Compass	2.49 a
FD 4215	3.56 b
Benlate	3.02 ab
Delsene M	3.07 ab
CV %	15.9
SED	0.508

Cuttings treated with Octave, Rovral and FD4215 had the highest vigour scores and the cuttings in the trays treated with these products were noticeably larger and well branched.

iii) Comparison of fungicides for control of Cylindrocarpon

Table 8. Disease development 7 days post-sticking

Treatment		% cuttings affected by browning	% cuttings healthy
1	Untreated	12.2	87.7 ab
2	Octave	14.7	88.2 ab
3	Elvaron	17.0	83.0 a
4	Rovral	9.5	90.5 ab
5	Repulse	4.0	97.0 b
6	Compass	12.5	87.5 ab
7	FD 4215	7.2	92.7 ab
8	Benlate	18.7	81.2 a
9	Delsene M	13.7	86.2 ab
	CV %	52.0	12.2
	SED	0.109	0.109

Table 9. Disease Development: 34 days post sticking

Treatment		% cuttings affected by browning	% cuttings healthy
1	Untreated	7.2	76.7
2	Octave	3.5	65.7
3	Elvaron	11.2	47.2
4	Rovral	4.0	81.0
5	Repulse	2.0	84.7
6	Compass	8.5	73.0
7	FD 4215	1.7	82.5
8	Benlate	*	65.5
9	Delsene M	9.5	63.7
	CV %	NS	17.2
	SED		0.129

All trays of cuttings showed signs of foliar browning within the first week after sticking but there was no marked increase in the subsequent numbers of cuttings showing browning. Treatments drenched with FD4215 and Repulse had the lowest degree of browning both one week after sticking and 34 days post sticking.

Table 10. Effect of fungicide treatment on vigour of foliage and root development

Treatment		TOPS Foliar Vigour/Index	ROOTS Root Vigour/Index
1	Untreated	3.50 ab	2.25 b
2	Octave	3.55 abc	2.12 ab
3	Elvaron	2.76 a	1.74 a
4	Rovral	3.80 bc	2.27 b
5	Repulse	3.82 bc	1.70 a
6	Compass	3.91 bc	2.44 b
7	FD4215	4.38 bc	2.51 b
8	Benlate	4.42 c	2.43 b
9	Delsene M	3.54 abc	2.31 b
	CV %	14.7	14.9
	SED	0.549	0.328

Root growth was impaired following drench treatment with Elvaron and Repulse as reflected in the root vigour index. There was an overall reduction in the branching and development of the root system plus browning of the root tips. In the Elvaron treatments there was an associated reduction in the vigour of the foliage but this was not as obvious in the cuttings treated with Repulse, where the vigour index was not significantly different from that of the best treatment. Benlate, FD4215 and Compass treatments produced cuttings with the highest vigour indices.

Discussion

The levels of infection present in these experiments were low despite growing the cuttings under optimum conditions for infection to occur, however several useful results were obtained.

Inoculation with botrytis had the most significant effect on the health and subsequent success rate of rooting of the cuttings. After inoculation only 43 per cent of the untreated cuttings were healthy in trays receiving no fungicide treatment compared to 58 and 76 per cent respectively in trays inoculated with pestalotiopsis and cylindrocarpon. The three experiments were carried out simultaneously under identical conditions. The overall vigour of the foliage was also affected by botrytis inoculation, the vigour index being 2.92 compared with 3.19 for cuttings inoculated with pestalotiopsis and 3.74 for cuttings inoculated with cylindrocarpon.

None of the fungicide treatments significantly reduced levels of botrytis compared with the untreated. The experimental fungicide FD4215 reduced levels of browning of the cuttings although this was not reflected in the number of healthy cuttings. In a preliminary experiment (see Appendix I) treatment with Rovral + FD4215 did increase the number of healthy cuttings and vigour index of the above ground position of the cuttings.

Delsene M was the least effective fungicide for botrytis control.

Under conditions favourable for botrytis infection sprays applied at 14 day intervals do not appear to be effective disease control and reduction of the spray interval to seven days should be considered.

Following inoculation with pestalotiopsis symptoms were seen as areas of browining with development of pycnidia and an associated brown tipping of the shoots. All fungicides with the exception of Benlate reduced direct symptoms from pestalotiopsis.

Delsene M and FD4215 were most effective at reducing both browning symptoms and tipping and trays treated with either of these two products had the highest numbers of healthy cuttings.

The effects of cylindrocarpon inoculation of the base of the cuttings were more difficult to assess than foliar disease. The appearance of the cuttings was deceptive since the vigour index of the foliar was greater than that for the cuttings inoculated with botrytis but the index for the roots was lower. The practical implications of this observation are significant since under nursery conditions, cuttings with a well developed shoot system are likely to be considered of high quality for potting on providing they have a reasonable root system. The root system will not be closely examined because at potting-on care is taken to minimise root damage. Plant development may continue satisfactorily until conditions arise which subject the plant to stress eg moisture stress induced by hot, dry-weather or the initiation of flowering, when the infected root poor developed system is unable to meet the demands for moisture from the foliage and the plant rapidly collapses.

The performance of fungicides for control of cylindrocarpon was variable. Drench treatments with Elvaron and Repulse were phytotoxic. Root development in cuttings treated with either of these products was significantly poorer than that of inoculated untreated cuttings. Elvaron

treated cuttings also had a poorer foliar development and reduced number of healthy cuttings, unlike the Repulse treated cuttings, most of which were healthy and had made good top growth despite having extremely poor root development.

Benlate drenches resulted in cuttings with foliar development significantly better than untreated cuttings and with reasonable root development. FD4215 and Compass treatments also performed well.

These experiments were all carried out on Erica carnea cv. Robert Chapman.

APPENDIX I

Preliminary Experiment to assess efficacy of botrytis fungicides

Introduction:

Botrytis frequently attacks heather cuttings during propagation causing browning of the foliage and a reduction in the number and quality of cuttings rooted. This experiment was set up in March to investigate the efficacy of a number of fungicides on botrytis control, prior to carrying out a further experiment later in the season at the optimum time for taking cuttings.

Materials and Methods:

Site

The experiment was carried out within the glasshouse complex at the ADAS Regional Office, Coley Park, Reading.

Design

The experiment was of a randomized block design. Individual plots consisted of seed trays containing 100 cuttings. There were four replicates.

Husbandry

The cuttings were taken from stock plants of cv. Robert Chapman and stuck in

an ericacious peat based compost. Cuttings were inoculated with botrytis as described previously.

Fungicides

Table 1. Fungicides, active ingredients (a.i.) and dose rates

Fungicide	a.i.	Amount a.i. in product	Dose rate product/litre
Octave	manganese + prochloraz	50%	1 g
Elvaron	dichlofluanid	50%	2 g
Rovral Flo	iprodione	250 g/l	1 g
Repulse	chlorothalonil	500 g/l	2.2 ml
Compass	iprodione + thiophanate-methyl	167 g/l 167 g/l	2.5 ml
FD4215	experimental		7.5 g
hexaconazole Repulse	hexaconazole + chlorothalonil	500 g/l	2 ml 1 ml
Topas	penconazole	100 g/l	1 ml
Punch C	flusilazole carbendazim	250 g/l 125 g/l	1 ml

Application

Fungicides were applied to run off with a hand held pressurized sprayer. Sprays were applied on 8 March, 22 March, 5 April, 18 April, 3 May, 17 May and 1 June 1988.

Assessments

Cuttings were assessed for browning and at the end of the trial, cuttings were removed from the trays and excess peat washed off the root system and individual cuttings scored on the following scale:

5	=	Healthy vigorous top growth and good roots
4	=	Healthy moderate top growth
3	=	Browning of foliage and reduction in rooting
2	=	Some green foliage - not roots
1	=	Dead

A disease index was calculated using

$$\text{Disease index} = \frac{\begin{array}{c}(5 \times \text{No. in category 5}) + (4 \times \text{No. in category 4}) + \\ (3 \times \text{No. in category 3}) + (2 \times \text{No. in category 2}) + \\ (1 \times \text{No in category 1})\end{array}}{100}$$

Results:

Sporulating botrytis was observed on the cuttings 48 hours after inoculation but despite maintaining the cuttings under conditions of high humidity, affected tissue turned brown and botrytis became less apparent.

Cuttings were assessed for botrytis infection 15 days after inoculation (Table 2). There was little active sporulating botrytis on the cuttings but some of the cuttings were affected by browning of the foliage.

The numbers of cuttings affected by browning was highest in the untreated trays where only 52.5 per cent of the cuttings were healthy compared with

93.5 per cent of the cuttings in the trays treated with Elvaron. At this stage all fungicide treatments apart from Compass, FD4215 and hexaconazole Repulse significantly increased the number of healthy cuttings per Tray.

At a later assessment nine weeks after inoculation only 25.5 per cent of the cuttings were healthy in the untreated trays. (Table 3). Rovral and FD4215 treatments had the highest proportion of healthy cuttings with 49.25 and 49.75 per cent of the cuttings respectively being healthy and unaffected by browning.

Table 2. Botrytis infection 15 days after inoculation, 23 March '88

Treatment	% cuttings healthy	< 25% browning	25-50% browning	50-75% browning	>75% browning	Disease index
1 Untreated	52.50 a	32.5 b	0.75	1.5	12.75	4.1
2 Octave	82.75 b	15.5 ab	0.75	0	1.0	4.79
3 Elvaron	93.50 b	6.5 a	0	0	0	4.94
4 Rovral	78.75 b	15.75 ab	0.5	2.0	3.0	4.65
5 Repulse	90.25 b	9.25 a	0.25	0.25	0	4.89
6 Punch C	81.50 b	16.0 ab	1.0	0.5	1.0	4.76
7 Compass	72.75 ab	25.25 ab	0.75	2.0	0.25	4.71
8 Topas	87.00 b	10.75 ab	1.5	0.5	0	4.83
9 FD4215	73.75 ab	21.75 ab	0.75	2.25	1.5	4.64
10 hexaconazole Repulse	74.50 ab	22.00 ab	0.25	0	3.25	4.64
CV %	19.0	75.0				
SED	10.58	9.29				

Table 3. Botrytis infection 9 weeks after inoculation 18 May '88

Treatment	% cuttings healthy	< 25% browning	25-50% browning	> 50% browning	Disease index
1 Untreated	25.5 abcd	18.25 ab	5.25	50.75	1.81
2 Octave	39.5 cd	33.25 ab	0	27.25	1.15
3 Elvaron	38.5 cd	20.0 ab	0	40.25	1.41
4 Rovral	49.25 d	10.25 a	3.75	31.75	1.13
5 Repulse	27.0 abcd	12.0 ab	3.0	48.25	1.63
6 Punch C	6.25 a	41.75 b	0	52.0	1.98
7 Compass	36.75 bcd	15.0 ab	5.25	45.5	1.62
8 Topas	21.25 abc	27.25 ab	2.25	49.25	1.80
9 FD4215	49.75 d	12.5 ab	0.5	37.25	1.25
10 hexaconazole + Repulse	10.75 ab	28.0 ab	5.25	56.0	2.07
CV%	55.6	83.2	NS	NS	NS
SED	11.97	12.83			

Table 4. Final assessment of cuttings vigour and establishment 12 weeks post sticking.

Treatment	No cuttings in each of the following categories					Disease Index
	1	2	3	4	5	
1 Untreated	63.50	1.50	4.25	21.50	9.50	2.13
2 Octave	45.75	11.75	11.25	18.75	12.50	2.41
3 Elvaron	54.25	1.25	13.75	15.00	10.25	2.12
4 Rovral	52.50	3.50	9.00	18.00	17.00	2.44
5 Repulse	57.75	2.75	5.00	14.50	20.00	2.36
6 Punch C	63.25	1.25	26.25	3.75	0.00	1.79
7 Compass	63.00	0.25	6.25	19.00	10.50	2.11
8 Topas	56.75	1.25	6.25	26.50	9.25	2.30
9 FD4215	54.25	2.00	8.00	25.50	15.25	2.61
10 hexaconazole Repulse	71.75	1.25	10.25	16.75	5.00	1.89

Table 5. Effect of fungicide treatment on dry weight production

Treatment		Dry Weight g
1	Untreated	0.063 ab
2	Octave	0.063 ab
3	Elvaron	0.064 ab
4	Rovral	0.074 b
5	Repulse	0.065 ab
6	Punch C	0.043 a
7	Compass	0.072 b
8	Topas	0.056 ab
9	FD4215	0.072 b
10	hexaconazole + Repulse	0.061 ab
	CV %	21.18
	SED	0.0095

Cuttings in the trays treated with Punch C were affected by browning of the tips of the foliage and only 6.25 per cent of the cuttings appeared healthy. In addition cuttings treated with Punch C were a very dark green compared with the cuttings from the other treatments.

At the final assessment there were no significant differences between fungicide treatments and untreated trays in the disease index calculated (Table 4). Brown tipping of the foliage was observed on cuttings treated with Punch C, Topas, hexaconazole plus Repulse and Octave.

The effects of fungicide treatment on root initiation and development was difficult to assess because of problems associated with retrieving the root systems intact from the compost. The only noticeable affect of treatment was seen on cuttings treated with Rovral, where root production was limited to length of cutting immediately below the surface of the compost.

Total dry weight production was measured for all cuttings assessed in categories 3, 4 and 5 (Table 5). Cuttings treated with Rovral, Compass or FD4215 had the largest measurements for dry weight production although they were not significantly better than those for untreated cuttings. The dry weights of cuttings treated with Punch C or Topas were less than those for untreated cuttings.

Discussion

Three of the fungicides included in this trial Punch C, Topas and the mixture of hexaconazole plus Repulse although initially effective at controlling botrytis as seen in the assessment 15 days after inoculation are unsuitable for use during propagation since they caused browning of the shoot tips and in the case of Punch C also caused darkening of the foliage. Punch C and Topas also restricted growth as seen by the dry weight production. There were also indications that Octave also caused browning of the shoot tips although this was less obvious than in the previous three treatments.

Rovral and FD415 were the most effective fungicides when assessed on percentage of healthy cuttings, followed by Elvaron and Octave. Compass was interesting in that although there were slightly fewer healthy cuttings per tray than in the best treatments, the dry weight production of those cuttings was good. Cuttings treated with Rovral, Compass or FD4215 were noticeably bushier with more branding and shoot development than in other treatments.

This experiment was carried out using cutting material which was harder than that normally used by commercial growers but on the basis of this experiment it was decided that, at the rates used, Punch C, Topas and the mixture of hexaconazole plus Repulse were not suitable candidates for use on heathers during propagation and were not included in further work.

Acknowledgements

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