R & D Contract Report
Agricultural Development and Advisory Service

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CONTRACT REPORT

Fungicide Phytotoxicity Trial

HO/17b/87

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

Fungicides are widely used in heather production to control a range of diseases which can attack the plants from the propagation stage onwards. In addition to pythium, phytophthora and rhizoctonia which cause a root and stem base rot, heather plants are also susceptible to botrytis, pestalotiopsis and cylindrocarpon. To achieve broad-spectrum disease control many growers routinely use a range of fungicides. Previous work by the West of Scotland College of Agriculture indicated that some fungicides used during propagation inhibited root development and caused root browning. Fungicides used during growing on do not have label recommendations specifically for use on heathers and there is little information on the effects, if any, of these chemicals on crop growth.

Some cultivars of heaths and heathers are more difficult to grow than others, and they may vary in their tolerance to fungicides. To study the effects of fungicides on plant growth a number of heather cultivars must be included in the trials.

The main objective of the experiment was:

i) to assess the phytotoxicity of fungicides currently used in heather production.

ii) to assess the phytotoxicity of fungicides currently available on other crops which have potential for inclusion in disease control programmes on heathers.

iii) to examine the susceptibility of a range of heather cultivars to fungicide treatment.

Materials and Methods

Site

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

Design

The trial was of a split plot design. Fungicide treatment was the main plot treatment and cultivar type formed sub-plots. Main plots were fully randomized and there were five replicate blocks. Each sub plot consisted of two plants in 10 cm liners.

Husbandry

The plants were grown in a glasshouse at 17°C with additional lights and supplementary shading to prevent damage from direct sunlight.

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 material		7.5 g
hexaconazole + Repulse	hexaconazole chlorothalonil	500 g/l	2 ml 1 ml
Topas	penconazole	100 g/l	1.0 ml
Punch C	flusilazole carbendazim	250 g/l 125 g/l	1.0 ml

Table 2. Cultivars

Erica vagans	cv. Lyonesse
Erica cinerea	cv. C.D. Eason
Erica carnea	cv. King George
	cv. Pink Spangles
	cv. Silver Queen
Calluna vulgaris	cv. Elsie Purnell
	cv. Robert Chapman

Application

Fungicides were applied at 2-weekly intervals using a hand-held polypack pressurized sprayer. Fungicides were applied to run off.

Assessments

Individual plants were assessed visually throughout the period of the trial for development of browning and other visual effects of fungicide treatment. On completion of fungicide treatment, plants were harvested at soil level and oven dried at 110°C for 24 hrs. The dry weight production was measured.

Results

The seven cultivars in the trial had differing growth habits and response to fungicide treatment. The cultivars King George and Robert Chapman were slow growing and exhibited the earliest symptoms of foliar browning as shown in Table 3. The cultivar Silver Queen was also markedly affected by the second assessment on 18 April (Table 4).

The most noticeable phytotoxic effects were noted during the overall visual assessment on 16 May as a stunting of extension growth associated with browning of the shoot tip and a darkening of the foliage (Table 5). Plants treated with Topas and Punch C were the worst affected with symptoms being obvious at the recommended rate of treatment and being more marked at twice the recommended rate (Table 6). The mixture of hexaconazole plus Repulse was also phytotoxic producing symptoms of foliar browning particularly when applied at twice the recommended rate. Phytotoxic symptoms were also seen when Octave was applied at twice the recommended rate as a browning of the tip of the shoot, although this affect was not seen in plants treated with the recommended rate of Octave.

Visual symptoms were also expressed in dry weight production Table 7-10. At the recommended rate of fungicide treatment, Punch C was the only product to significantly reduce dry weight production overall compared with that of untreated plants. Compass and FD4215 treatments, in fact, significantly increased dry weight production.

When products were applied at twice the recommended rate Octave, Topas and hexaconazole plus Repulse significantly reduced dry weight production in addition to Punch C.

Table 3. Visual assessment of foliar browning and plant death, 31 March 88

Treatment	King George				Robert Chapman			
	% with browning		% dead		% with browning		% dead	
	x1	x2	x1	x2	x1	x2	x1	x2
1	25	0	12.5	0	75	37	25	12
2	10	37	0	0	50	50	20	0
3	20	30	0	20	70	70	20	20
4	30	20	0	0	40	50	60	0
5	40	10	0	0	40	80	50	10
6	20	50	0	0	70	60	10	10
7	0	10	0	0	70	60	20	0
8	10	0	20	20	60	50	20	0
9	0	30	20	0	50	10	40	20
10	10	10	0	0	50	50	0	10

Table 4. Visual assessment of foliar browning and plant death

Treatment	Silver Queen				King George				Robert Chapman			
	% with browning		% dead		% with browning		% dead		% with browning		% dead	
	x1	x2	x1	x2	x1	x2	x1	x2	x1	x2	x1	x2
1	20	30	0	0	20	20	20	0	70	30	30	30
2	30	10	0	0	30	20	10	0	60	50	30	10
3	40	10	0	0	30	20	20	20	60	60	30	20
4	60	20	0	0	30	20	20	10	40	20	60	40
5	10	10	0	0	10	30	40	0	20	60	60	20
6	30	80	0	10	10	70	20	10	70	60	10	10
7	0	30	0	0	20	0	0	10	40	10	50	10
8	20	80	0	0	30	0	22	10	70	90	20	0
9	30	50	0	0	30	40	20	0	50	30	40	20
10	60	20	0	0	20	10	0	0	60	60	10	0

Table 5. Visual assessment of foliage browning and plant death. Fungicide treatment at recommended rate, 16 May 88

Cultivar	Lyoness		C D Eason		King George		Pink Spangles		Silver Queen		Elsie Purnell		Robert Chapman	
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Treatment	Dead	Browning	Dead	Browning	Dead	Browning	Dead	Browning	Dead	Browning	Dead	Browning	Dead	Browning
1	20	20	0	0	30	40	0	0	0	40	10	10	30	60
2	0	50	0	0	10	10	0	10	0	50	0	0	30	40
3	0	10	0	10	30	50	0	0	0	30	0	50	30	50
4	0	30	0	0	30	30	0	10	0	50	0	20	60	40
5	0	10	0	0	40	20	0	10	10	40	0	30	60	10
6		40	10	30	30	0	0	0	0	20	0	60	10	90
7	0	10	0	0	0	40	10	0	0	40	10	20	50	80
8	0	10	0	0	30	40	10	0	0	40	10	20	50	40
9	0	0	0	0	40	20	10	0	0	40	0	30	40	50
10	10	20	0	20	20	20	0	0	0	70	0	20	10	80

Table 6. Visual assessment of foliage browning and plant death. Fungicide treatment at twice the recommended rate, 16 May 88

Cultivar	Lyoness		C D Eason		King George		Pink Spangles		Silver Queen		Elsie Purnell		Robert Chapman	
	%	%	%	%	%	%	%	%	%	%	%	%	%	%
Treatment	Dead	Browning	Dead	Browning	Dead	Browning	Dead	Browning	Dead	Browning	Dead	Browning	Dead	Browning
1	0	0	0	0	10	10	0	0	0	20	0	0	30	50
2	0	10	0	30	20	10	0	10	0	40	0	20	20	80
3	0	20	0	0	30	30	0	10	0	10	0	30	20	50
4	0	0	0	0	30	0	0	0	0	10	0	10	40	10
5	10	10	0	0	10	30	0	0	0	0	0	20	20	30
6	0	40	0	100	30	30	0	20	10	90	0	40	10	90
7	0	0	0	0	10	20	0	0	0	20	0	50	10	40
8	0	10	0	70	10	30	0	0	0	80	0	40	0	100
9	0	10	0	0	10	30	0	0	0	40	0	0	20	20
10	0	0	0	50	10	0	0	0	0	90	0	30	10	80

Table 7. Effect of fungicide treatment at the recommended rate on dry weight production, 23 August 88

	Vagaris	Cinerea	Carnea			Calluna	
Treatment	Lyonesse	C D Eason	King George	Pink Spangles	Silver Queen	Elsie Purnell	Robert Chapman
1 Untreated	2.86	5.30	1.11	6.31	4.96	5.53	2.53
2 Octave	3.07	5.52	1.81	7.27	4.10	6.94	2.32
3 Elvaron	3.03	3.84	0.94	5.95	4.76	6.80	3.04
4 Rovral	3.42	5.55	1.16	5.57	5.67	6.74	1.64
5 Repulse	2.89	5.41	1.59	3.59	5.37	6.32	2.33
6 Punch C	1.80	2.27	2.01	4.54	4.17	5.07	1.02
7 Compass	3.70	5.78	2.32	6.14	6.58	7.20	2.53
8 Topas	3.52	3.79	0.88	6.79	5.83	7.26	1.74
9 FD4215	3.20	4.37	2.10	6.59	5.18	7.09	4.18
10 hexaconazole + Repulse	3.22	5.08	1.99	4.66	3.73	6.14	2.43
CV %	34.1						
SED	0.894						

Table 8. Mean response of cultivars to fungicide treatment

Fungicide	Dry wt g/plant
Untreated	4.09
Octave	4.43
Elvaron	4.05
Rovral	4.25
Repulse	3.93
Punch C	2.98
Compass	4.88
Topas	4.26
FD4215	4.64
hexaconazole + Repulse	3.89
CV %	34.1
SED	0.338

Table 9. Effect of fungicide treatment at twice the recommended rate on dry weight production, 23 August 88

	Vagaris	Cinerea	Carnea			Calluna	
Treatment	Lyonesse	C D Eason	King George	Pink Spangles	Silver Queen	Elsie Purnell	Robert Chapman
1	2.98	3.89	1.74	3.76	5.02	3.61	2.92
2	2.33	2.53	1.00	3.37	3.41	5.08	0.91
3	2.66	3.33	1.17	3.84	5.32	5.08	2.51
4	3.24	4.14	1.35	4.29	4.94	6.43	3.06
5	3.04	3.77	1.73	4.17	5.79	5.65	3.38
6	0.36	0.57	0.34	1.83	1.93	3.54	0.54
7	3.27	3.33	1.84	4.69	4.91	4.07	4.00
8	1.77	1.47	0.71	2.65	1.74	2.32	0.64
9	2.46	3.64	1.15	3.20	4.50	5.89	3.67
10	1.78	2.50	1.26	3.88	2.22	3.04	0.88
CV %	39.1						
SED	0.738						

Table 10. Mean response of cultivars to fungicide treatment at twice the recommended rate

Fungicide	Dry wt g/plant
Untreated	3.42
Octave	2.66
Elvaron	3.42
Rovral	3.92
Repulse	3.93
Punch C	1.30
Compass	3.73
Topas	1.61
FD4215	3.50
hexaconazole + Repulse	2.22
CV %	39.3
SED	0.279

Discussion

Most of the newer fungicides included in this trial are unsuitable for use on heathers. Both Topas and Punch C caused stunting and browning of the laterals and overall reduction in dry weight production particularly when applied at twice the recommended rate. The mixture of hexaconazole plus Repulse also significantly reduced the growth rate when applied at twice the recommended rate. A similar affect was noticed with Octave which is a fungicide widely used currently in heather production. Apart from on the cultivar Silver Queen, Octave did not significantly reduce plant growth when applied at the recommended rate. The programme was very intensive, with a total of seven sprays being applied at two week intervals. In a commercial situation where Octave is one fungicide in a programme, there are unlikely to be any phytotoxicity problems.

The experimental fungicide FD4215 increased dry weight production in a number of cultivars at the recommended rate although at twice the recommended rate dry weight production decreased in certain cultivars. In comparison with other fungicides currently used on heathers, FD4215 was similar and could be a useful product when it becomes available.

The behaviour of the various cultivars to fungicide treatment was harder to assess. The cultivar Elsie Purnell had an overall positive response to fungicide treatment. This was very obvious at the recommended rate of treatment but was also noticeable when fungicides were applied at twice the recommended rate.

Fungicide treatment either did not affect dry weight production or significantly increased it in cultivars Lyonesse and King George when applied at the recommended rate but when applied at twice the recommended rate, the overall response of these two varieties to treatment was a reduction in dry weight production.

The cultivar C D Eason appeared most sensitive to fungicide treatment with a nil or negative effect on dry weight production when fungicide treatments were applied at either the recommended rate or at twice the rate.

The cultivars Pink Spangles, Robert Chapman and Silver Queen did not respond consistently to fungicide treatment. Some treatments significantly increased dry weight production in these cultivars whilst others significantly decreased it compared to that of the untreated plots but there was no overall consistent pattern.

The heather cultivars included in this experiment indicate that there is a range of sensitivity to fungicide treatment but that in general increasing the rate of fungicide to twice that recommended has an adverse effect on plant growth.

All the plant material used in this experiment was taken from a production system which included a broad-spectrum fungicide programme and there were no obvious disease problems within the crop. The overall response to fungicide treatment in cultivars Elsie Purnell, Lyonesse and King George raises the question of the presence of low levels of disease which although not causing obvious symptoms is reducing plant growth.

Conclusions

* Elvaron, Repulse, Rovral and Compass treatments did not produce any phytotoxic effects on established plants of the cultivars included in the experiment, even when applied in an intensive programme at twice the recommended rate of active ingredient.

* The experimental material FD4215 also showed no indications of phytotoxicity.

* Three triazole fungicides currently cleared for use on other crops Punch C, Topas and a mixture of hexaconazole plus Repulse were phytotoxic at the rates used and at these rates are unsuitable for use on heathers.

* There were indications that Octave caused a limited phytotoxic effect with browning of the shoot terminals. This was most marked when the product was used at twice the recommended rate. The number of sprays used was intensive and commercial growers would be advised to use Octave less frequently as part of a fungicide programme.

* There are differences between heather cultivars in sensitivity to fungicides and this should be considered when further work on heathers is instigated.

Acknowledgements

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MASTER – STAT. ANALYSES

HNS 176
Year 1

Statistical Analysis of HDC Fungicide Trial (Project HO/17/b/1988)

Design:

Two cultivars of each of two species were treated with five fungicide treatments in a split-plot arrangement with four replicates. The species/cultivar combinations were:

Calluna vulgaris cvs. Sister Anne & Robert Chapman and Erica carnea cvs. Pink Spangles & King George while the five fungicide treatments were: Topas 100, Compass, Rotation, Managed and No treatment, as detailed on the trial schedule. Fungicide treatments comprised main plots with species as sub-plots. Each sub-plot comprised 3 rows of 25 plants.

At the end of the trial plants were graded into three categories: (I) a top grade, suitable for sale, (II) a deferred grade, whose fate would be decided at a later date, and (III) a reject grade, to be disposed of.

Method of analysis:

A simple tabulation of the data was made, cross-classifying by species and treatment, for both counts and percentages in each grade. An analysis of variance was performed on each grade after arc-sine transformation (this was done to accommodate the wide range of percentage value across the data).

Analysis:

Although there are three grades of plants the important results can be gleaned from just the analysis of one of them, those in Grade I. The reason for this is that the only significant effect in Grade III is a difference in numbers between King George and the other three species. Consequently, for the most part, the analysis of Grades I and II will be effectively equivalent since %Grade II = 100 - %Grade I - %Grade III. However, for completeness all three analyses are given below.

Grade I - The analysis of variance shows significant effects for both main factors, and a significant interaction between them (all at $P < 0.001$). Examination of the subset of treatments excluding King George and Topas, shows that within a species there is very little difference between treatments in the percentage of plants falling in Grade I. Sister Anne has the greatest proportion and this is significantly different to the proportions for Pink Spangles and Robert Chapman the difference between which is not significant. There is no real evidence that any of treatments 2, 3 or 4 has an advantage over the no fungicide treatment! Note that Topas reduces the number of plants in Grade I for both Robert Chapman and Pink Spangles, but not Sister Anne. The data for King George showed marked differences between treatments but did not conform to any simple pattern. Further examination of the data revealed no untoward spatial patterns, but did demonstate a much greater degree of inter-plot variability for King George than for the other three species.

Grade II - Analysis of variance yields the same significant effects

and the table of means shows that the pattern of distribution is simply reversed: e.g. for Robert Chapman and Pink Spangles the number of plants in Grade II is now higher than for the other treatments, but that the numbers in the other treatments is roughly similar. Again, Sister Anne has fewer Grade II plants than these two species, exactly the mirror-image of the results for Grade I. As for Grade I, the results for King George are somewhat variable between treatments.

Grade III - As already alluded to, the analysis of Grade III plants reveals only a significant difference in numbers between King George (more waste plants) and the other three species.

J S Fenlon 11.11.88

***** Tables of counts & percentages *****

Variate: grade I plants

	species/cvars			
fungicide	Sister Anne count (%)	Robert Chapman count (%)	Pink Spangles count (%)	King George count (%)
Topas	218 (72.9)	23 (7.7)	96 (32.0)	49 (16.3)
Compass	227 (75.9)	147 (49.5)	198 (66.0)	196 (66.0)
Rotation	224 (74.9)	155 (51.7)	172 (57.3)	86 (28.7)
Managed	197 (65.7)	148 (49.5)	153 (51.0)	98 (32.8)
None	200 (66.7)	162 (54.0)	166 (55.5)	147 (49.0)

Variate: grade II plants

	species/cvars			
fungicide	Sister Anne count (%)	Robert Chapman count (%)	Pink Spangles count (%)	King George count (%)
Topas	72 (24.1)	263 (88.0)	190 (63.3)	228 (76.0)
Compass	66 (22.1)	138 (46.5)	94 (31.3)	76 (25.6)
Rotation	65 (21.7)	129 (43.0)	117 (39.0)	194 (64.7)
Managed	85 (28.3)	147 (49.2)	135 (45.0)	164 (54.8)
None	90 (30.0)	132 (44.0)	123 (41.1)	133 (44.3)

Variate: grade III plants

	species/cvars			
fungicide	Sister Anne count (%)	Robert Chapman count (%)	Pink Spangles count (%)	King George count (%)
Topas	9 (3.0)	13 (4.4)	14 (4.7)	23 (7.7)
Compass	6 (2.0)	12 (4.0)	8 (2.7)	25 (8.4)
Rotation	10 (3.3)	16 (5.3)	11 (3.7)	20 (6.7)
Managed	18 (6.0)	4 (1.3)	12 (4.0)	37 (12.4)
None	10 (3.3)	6 (2.0)	10 (3.3)	20 (6.7)

*****Analysis of variance*****

Variate: %grade I plants (angular transformed)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	3	63.13	21.04		
block.fungicide stratum					
fungicide	4	3920.65	980.16	20.86	< .001
Residual	12	563.90	46.99		
block.fungicide.cvar stratum					
cvar	3	5045.51	1681.84	43.62	< .001
fungicide.cvar	12	2563.94	213.66	5.54	< .001
Residual	45	1735.18	38.56		
Total	79	13892.31			

***** Tables of means *****

Variate: %grade I plants (angular transformed)

Grand mean 45.24

fungicide	Topas	Compass	Rotation	Managed	None
	32.50	53.52	46.61	44.83	48.72

cvar	SA	RC	PS	KG
	57.71	39.73	46.34	37.17

fungicide	cvar	SA	RC	PS	KG
Topas		58.68	15.82	34.34	21.15
Compass		60.65	44.70	54.37	54.34
Rotation		60.14	45.96	49.23	31.13
Managed		54.16	44.71	45.58	34.87
None		54.90	47.44	48.20	44.34

*** Standard errors of differences of means ***

Table	fungicide	cvar	fungicide cvar
rep.	16	20	4
s.e.d.	2.424	1.964	4.509
Except when comparing means with the same level(s) of fungicide			4.391

***** Analysis of variance *****

Variate: %grade II plans (angular transformed)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	3	42.41	14.14		
block.fungicide stratum					
fungicide	4	3329.00	832.25	22.30	<.001
Residual	12	447.79	37.32		
block.fungicide.cvar stratum					
cvar	3	4135.11	1378.37	45.80	<.001
fungicide.cvar	12	2285.48	190.46	6.33	<.001
Residual	45	1354.18	30.09		
Total	79	11593.96			

***** Tables of means *****

Variate: %grade II plants (angular transformed)

Grand mean 41.62

fungicide	Topas	Compass	Rotation	Managed	None
	53.38	33.82	40.28	41.63	38.97

cvar	SA	RC	PS	KG
	29.94	48.01	41.47	47.05

fungicide	cvar	SA	RC	PS	KG
Topas		29.27	70.24	52.81	61.22
Compass		27.98	42.95	33.96	30.39
Rotation		27.42	40.98	38.59	54.14
Managed		32.11	44.51	42.12	47.78
None		32.92	41.38	39.87	41.72

*** Standard errors of differences of means ***

Table	fungicide	cvar	fungicide cvar
rep.	16	20	4
s.e.d.	2.160	1.735	3.994
Except when comparing means with the same level(s) of fungicide			3.879

***** Analysis of variance *****

Variate: %grade III plants (angular transformed)

Source of variation	d.f.	s.s.	m.s.	v.r.	F pr.
block stratum	3	27.82	9.27		
block.fungicide stratum					
fungicide	4	63.28	15.82	0.76	0.568
Residual	12	248.40	20.70		
block.fungicide.cvar.stratum					
cvar	3	599.72	199.91	8.91	<.001
fungicide.cvar	12	318.53	26.54	1.18	0.324
Residual	45	1009.44	22.43		
Total	79	2267.19			

***** Tables of means *****

Variate: %grade III plants (angular transformed)

Grand mean 11.47

fungicide	Topas	Compass	Rotation	Managed	None
	11.50	10.91	11.98	12.78	10.18

cvar	SA	RC	PS	KG
	9.89	9.42	10.40	16.18

fungicide	cvar	SA	RC	PS	KG
Topas		8.46	10.42	11.99	15.14
Compass		6.90	11.07	9.08	16.59
Rotation		10.25	13.08	10.11	14.50
Managed		13.59	5.66	11.38	20.49
None		10.23	6.89	9.43	14.17

*** Standard errors of differences of means ***

Table	fungicide	cvar	fungicide cvar
rep	16	20	4
s.e.d.	1.609	1.498	3.317
Except when comparing means with the same level(s) of fungicide			3.349