WEST OF SCOTLAND COLLEGE

DEPARTMENT OF PLANT SCIENCES

AN INVESTIGATION INTO THE BIOLOGY AND CONTROL OF FUNGAL PATHOGENS OF *ERICA* AND *CALLUNA*

A project funded jointly by the Department of Agriculture for Scotland, the Highlands and Islands Development Board and the Horticultural Development Council.

Report for the period 1 October 1987 to 30 September 1988.

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INTRODUCTION

Work in the first year of the project has concentrated on the development of techniques for the culture and management of fungal pathogens, the culture and management of heathers and on ways of bringing the two together to produce diseased plants. With the ability to produce infection where and when desired, it is now possible to look at a range of topics concerning the biology and control of the pathogens which infect heathers.

At present, work is centred around **Rhizoctonia**, although similar experiments concerning **Pythium** are planned for the future.

In order to get a good picture of the genus as a whole, a number of strains from a wide geographical area are being used in the work. There is evidence that there can be great differences in pathogenicity and growth patterns between isolates. Several strains of **Rhizoctonia** have been obtained from nurseries in Holland and the U.K. Some of these are from **Calluna**, while others have been isolated from other nursery stock species. In the past it was thought that all isolates were **Rhizoctonia solani**, but in fact many of the strains isolated have only two nucleii and so do not belong to this species.

At present, several of the replicated experiments are being carried out on nurseries, as it is felt that a combination of nursery trials and trials at Auchincruive will provide the most reliable and relevant results. (In the past, differences between trials at Auchincruive and nursery trials have been found.)

This report has been split into two main sections. The pilot experiments are set out first, followed by the larger scale replicated experiments. The list of **Rhizoctonia** isolates currently held in store is present in the appendix, along with the list of cv's held.

INDEX TO PILOT EXPERIMENTS

When beginning research on a new topic, much groundwork requires to be done before large scale replicated experiments can be set up. In the early stages, much time would be wasted if important trials were set up before experimental practices and techniques were perfected. For this reason many pilot experiments are set up to try out techniques and test ideas. In this way problems can be sorted out before the techniques are applied in replicated experiments.

1. Observation of **Rhizoctonia** on heathers.

T1(a) To devise methods for inoculating plants and compost with **Rhizoctonia** and **Pythium**.

T1(b) To devise methods for isolating **Rhizoctonia** from plants.

T1(c) To determine whether **Rhizoctonia** will infect heather cuttings in inert media, (for the purposes of further investigation of infection mechanisms).

T1(d) To determine optimum conditions for infection and symptom expression.

T1(f) To determine whether infection of plants with **Rhizoctonia** I-A, (a relatively mild strain), will affect the long term health of heather plants.

2. Growth of **Rhizoctonia** in compost.

T2(a) To determine useful methods for isolating **Rhizoctonia** from compost and soil.

T2(b) To devise experimental techniques for investigating the growth of **Rhizoctonia** in compost.

T2(d) To see whether the fungicides, Basilex and Rovral have an effect on the growth of **Rhizoctonia** in compost.

7. Miscellaneous.

T7(a) to determine some of the physical and chemical properties of composts and compost constituents commonly used in experiments.

EXPERIMENT T1(a)

Aim:- To devise methods for inoculating plants and compost with *Rhizoctonia* and *Pythium*.

Several methods were used to inoculate compost with *Rhizoctonia* and *Pythium* and produce infection in cuttings present in the compost. The methods used and their problems/advantages are set out below.

1. Fungus grown on P.D.E.S. plates, chopped and mixed with compost.
   -Expensive and time consuming to produce in large quantities. Not as good as 5. for producing infected plants.

2. Fungus grown on sterile maize-meal and sand in glass flasks.
   -Difficult to get large quantities of fine sand. Mixture, when added to compost produces an undesireable reduction in air-filled porosity of the compost.

3. Fungus grown on plates in Potato dextrose broth. Mycelium was broken up in a blender prior to being mixed with compost.
   -Time consuming to produce and awkward to use. Not as good as 5. for producing infected plants.

4. Fungus grown on plain maize-meal or oat grains in glass flasks and mixed with compost.
   -More expensive than 5.

5. Fungus grown on chopped (3 to 10mm sections), autoclaved straw in glass flasks.
   -Time consuming to produce, but cheap and very effective at producing infection in cuttings.

Method 5. is now used for producing both *Pythium* and *Rhizoctonia* inoculum. Work has been carried out to determine the optimum amounts of distilled water to add to the straw prior to autoclaving. This is of extreme importance if good fungal growth is to be obtained.

Rhizoctonia is added to 12g straw + 36 mls water or
15g " + 40 " "

Pythium is added to 12g straw + 70mls water.

EXPERIMENT T1(b)

Aim:- To devise methods for isolating Rhizoctonia from plants. Several methods have been tried, the main conclusions are set out below.

If Rhizoctonia is present on the foliage, it can be isolated by wrapping the foliage in damp, (not wet) paper towels in a sealed chamber. The fungus will grow visibly on the foliage and the paper.

To check for Rhizoctonia on the fine feeder roots, the roots should be gently plucked from the plant and washed in flowing tap water. They are then placed in a petri dish filled with distilled water and incubated at room temperature for 24 hours. The fungus is easily identifiable under low power of a microscope.

It has been found that to give maximum likelihood of isolating Rhizoctonia from infected plants, several pieces of tissue should be removed from each of the 7 zones noted below.

Zone 1. Lower root zone - more than 3cm below soil level.
" 2. Upper root zone - soil level to 3cm below.
" 3. Stem base
" 4. Lowest foliage - 0 to 1cm above soil level.
" 5. Lower foliage - 1 to 2cm " " "
" 6. Mid foliage - 2 to 4cm " " "
" 7. Upper foliage - more than 4cm above soil.

The tissue pieces are then plated onto agar. The following sterilisation procedures have proved useful. If there is a shortage of plant material, methods A and B alone are used.

A. P.D.E.S. agar after surface sterilisation for 10s in 20% chloros.
B. P.D.E.S. agar after surface sterilisation for 20s in 20% chloros.
C. P.D.E.S. agar after surface sterilisation for 20s in 10% chloros.
D. W.A. agar after surface sterilisation for 10s in 10% chloros.
E. W.A. agar after surface sterilisation for 3 x 1/2 hour washes in sterile distilled water. Water is changed after each wash.

It has been found that the greatest % of infected pieces come from zones 3, 4, 5 and 6, not as was previously thought from lower root zones. Table 1 shows the number of infected pieces coming from each zone on a heavily infected plant. The results demonstrate that the infection is concentrated in the area 0 to

4cm above soil level. Plate 1 shows the plant from which these results were obtained.

Table 1. Location of infection in Rhizoctonia diseased plant

	Zone						
	1	2	3	4	5	6	7
No of infected pieces.	0	1	5	5	15	13	0
Total no of pieces	15	15	11	15	15	15	15
% of infected pieces	0	6.7	45.4	33.3	100	86.7	0

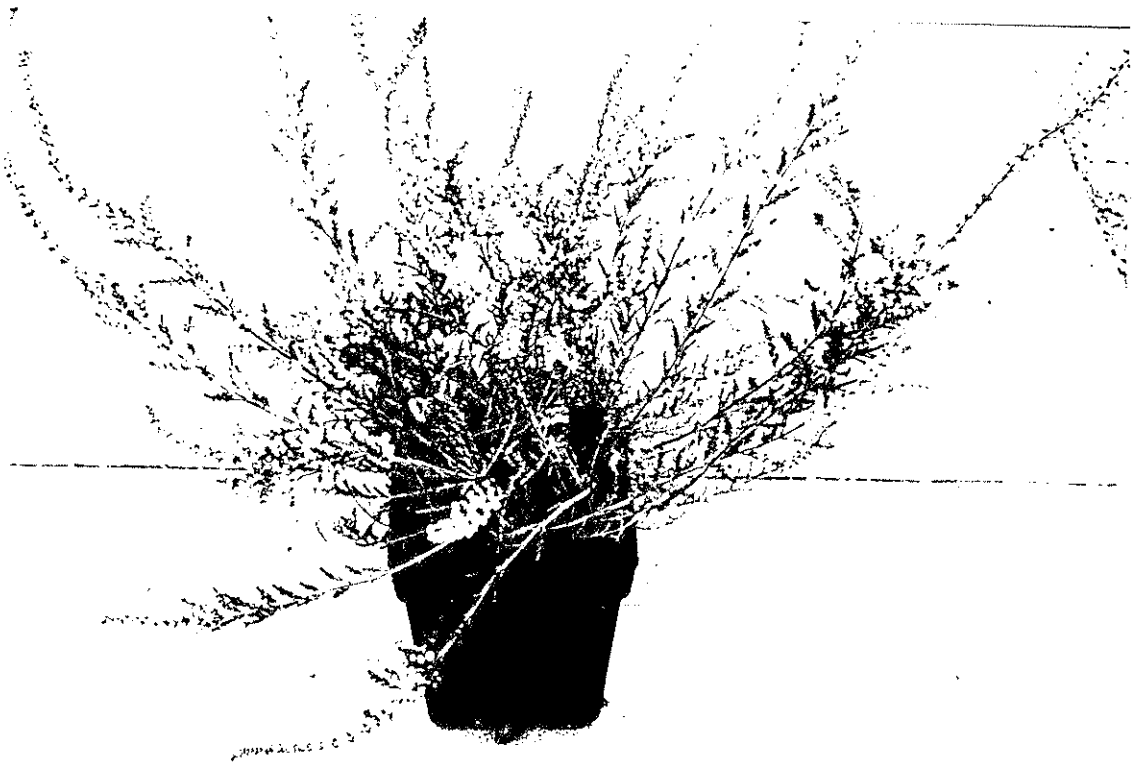


Plate 1. Calluna cv. My Dream infected with Rhizoctonia

EXPERIMENT T1(C)

Aim:- To determine whether **Rhizoctonia** will infect heather cuttings in inert media, (for the purposes of further investigation of infection mechanisms.)

It will be difficult to observe infection mechanisms when growing cuttings in compost, as compost particles adhere to the fine roots and tear parts of the plant away when they are removed. This experiment aims to devise ways of growing the cuttings so that **Rhizoctonia** can be observed more easily on the plants as they grow. Hopefully infection and colonisation can be observed as they happen, without the need to destroy plants. The main results obtained so far are noted below.

Medium	Comments
Fisons 'Clearcut'	**Rhizoctonia** grows slowly in this but heathers fail to root at all in the presence or absence of **Rhizoctonia**.
Methyl cellulose	A range of concentrations of this gel were tried, but neither heathers nor **Rhizoctonia** would grow in it.
Distilled water	Difficult to use for **Rhizoctonia** and cuttings would not root.
Nutrient solutions	As above.
Perlite.	The best so far. Heathers root well and **Rhizoctonia** grows well. However the perlite particles stick to the roots to a certain extent.

EXPERIMENT T1(d)

Aim:- To determine optimum conditions for infection and symptom expression.

This experiment was set up to give a brief idea of the conditions which created maximum symptom expression in cuutings struck into inoculated compost. It was not replicated. Uninoculated controls were included.

The treatments were as follows:-

Treatment no	Compost	Situation
1.	perlite	polythene tunnel
2.	50:50 peat + bark	" "
3.	25:75 fine sand + peat	" "
4.	perlite	cold frame under polythene
5.	50:50 peat + bark	" " "
6.	25:75 fine sand + peat	" " "
7.	perlite	glasshouse under polythene
8.	50:50 peat + bark	" " "
9.	25:75 fine sand + peat	" " "
10.	perlite	mist bench
11.	50:50 peat + bark	" "
12.	25:75 fine sand + peat	" "

-15 Calluna 'Cuprea' cuttings per tray were inserted.

-The foliage was assessed according to the following scale, three weeks after the start of the experiment.

FOLIAGE CONDITION SCALE

SCORE CONDITION

0 - No browning of foliage
1 - Bases or tips of a few branches brown
2 - " " " " " " " + 1 or 2 shoots totally brown.
3 - Extensive browning, but some green tissue.
4 - Totally brown foliage

Results

Table 2. Average foliage score of cuttings

	situation of trays			
compost	tunnel	cold frame	glasshouse	mist bench
peat + bark	3.5	4.0	2.1	1.3
peat + sand	3.8	4.0	1.9	0.4
perlite	3.1	2.5	1.9	0.4

All uninfected plants had a foliage score of 0

Table 2 and graph 1 show that symptom expression differs greatly between treatments. Cuttings in the frame and tunnel show more foliar browning than those in the glasshouse. Those on the mist bench are very much less brown than all other treatments.

Cuttings in the perlite show least browning, whereas those in the peat and sand show the most browning. The differences between treatments are obvious and well defined.

Plates 2 and 3 show some of the cuttings in the experiment, three weeks after striking. Plate 2 shows the effects of three different composts on the infection of heather cuttings by **Rhizoctonia**, and plate 3 compares the appearance of infected and uninfected cuttings growing in peat and sand compost.

The intention is now to examine a range of composts with different air filled porosities and a range of cutting bed temperatures, as the indications are that both these factors play a role in the severity of disease. [See expts R1(F) and R1(D)]

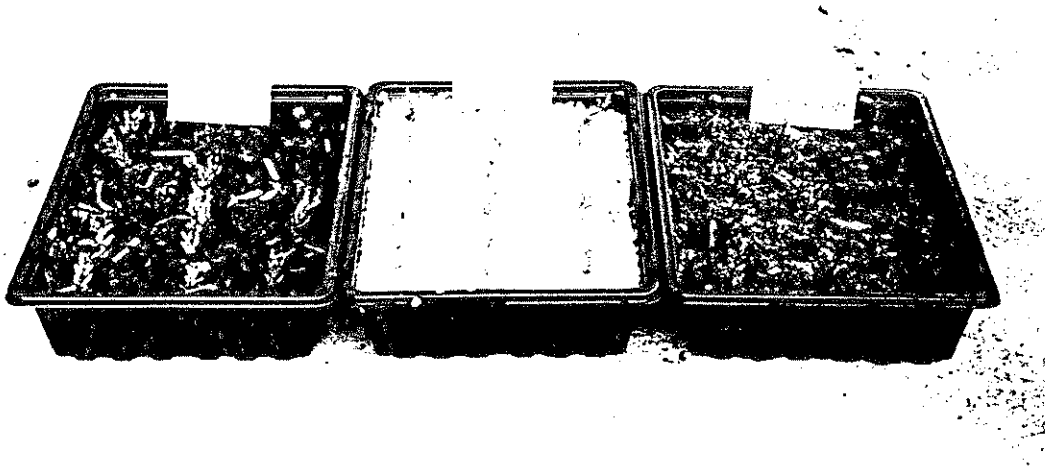


Plate 2. The effect of peat and bark, perlite and peat and sand on the infection of heather cuttings by **Rhizoctonia.**

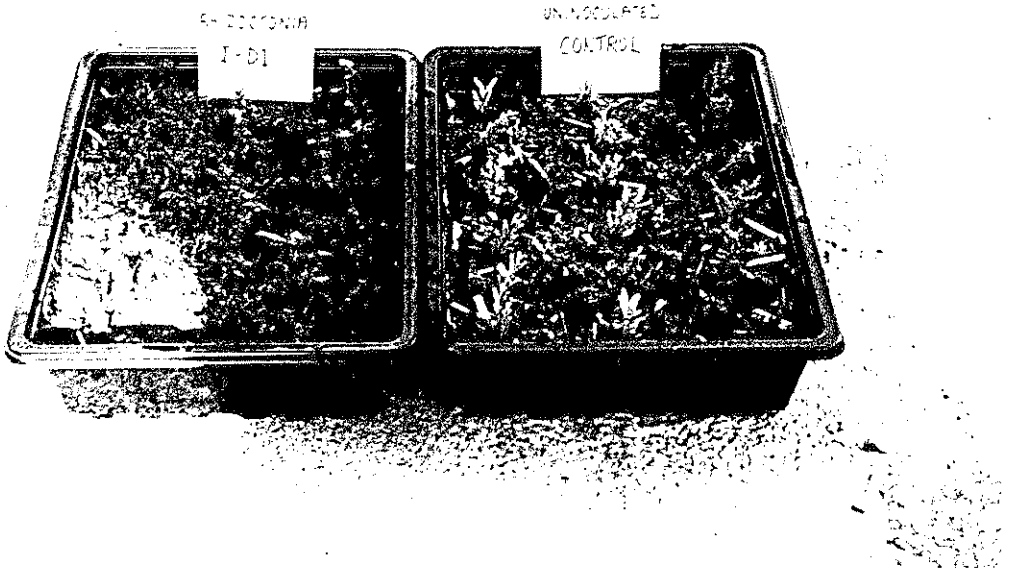


Plate 3. A comparison of infected and uninfected cutttings growing in peat and sand compost.

EXPERIMENT T1(f)

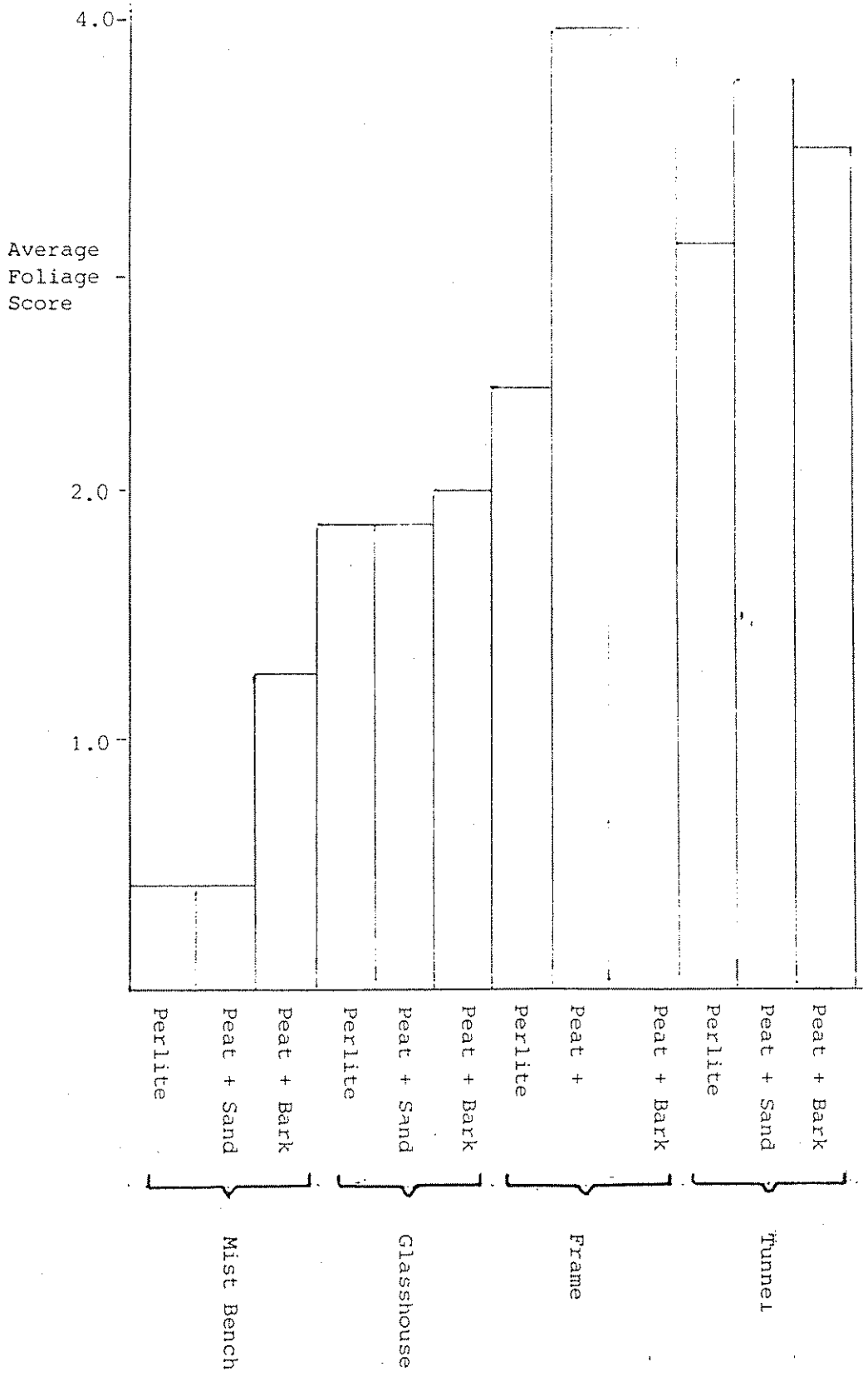
Aim:- To determine whether infection of plants with **Rhizoctonia** I-A, (a relatively mild strain), will affect the long term health of heather plants.

Evidence in the past, (prior to the start of this work), has suggested that most Rhizoctonia isolates are weak pathogens. This experiment , which was originally set up in Summer '87, is unreplicated and the plants are being observed as they grow and develop. The cuttings compost was inoculated and platings of stem and root sections showed that infection had taken place at an early stage.

The rooted cuttings, (of Calluna 'Mousehole', 'Crimson glory' and 'Silver knight') were potted and are being grown in 8cm optipots in a tunnel. Plate 4 shows some of the infected plants alongside the uninfected controls. There are few differences between the plants as yet, although the infected 'Crimson glory' plants are beginning to darken slightly.

A larger scale replicated experiment has recently been set up with a similar aim, see expt R1(B)

Plate 4. A comparison of plants, uninfected and infected with Rhizoctonia I-A.



Graph 1 Average foliage scores of cuttings in expt T1(d)

EXPERIMENT T2(a)

Aim:- To determine useful methods for isolating **Rhizoctonia** from field soil and compost.

Several methods have been tried for the above. The most successful include the following.

1. **Bait packets:** -Nylon net packets, (1cm x 1cm), enclosing either 5 radish seeds or 5 cabbage seeds and buried in soil or compost.

2. **Soil microbiology sampling tubes:** -5ml plastic vials filled with Richards agar, (a medium developed for isolating **Rhizoctonia** from soil), punctured with a red hot needle in 4 places, then buried in soil/compost.

3. **Slides covered in dried Richards agar and immersed in soil/compost.**

All three methods have succeeded in isolating **Rhizoctonia** from soil in a potato plot, soil in a heather garden and artificially inoculated compost.

EXPERIMENT T2(b)

Aim:- To devise experimental techniques for investigating the growth of **Rhizoctonia** in compost.

Difficulties occur from time to time when working with unfamiliar fungi. This group of experiments were set up to deal with these problems as they arise.

After several small trials, the following results were obtained.

1. If compost is very finely milled and completely sterile, the growth of **Rhizoctonia** is easily visible to the naked eye and can be measured using a ruler.

2. If working with unsterile compost, the following baits can be used to measure the growth of **Rhizoctonia** through the compost. Autoclaved straw sections, cotton stem segments, maize-meal pieces and segments of heather stems.

Of these, the straw has proved to be the best, as it can be easily examined microscopically and is not prone to colonisation by other saprophytic fungi. When measuring the growth of the fungus through the soil, bait pieces are placed in a line, or lines along the direction of travel of growth. Growth rate can be measured by examining the number of colonised bait pieces.

It is important that the bait pieces are sterile before use, (particularly in the case of the maize-meal), as saprophytic fungi already present on the bait may colonise the bait fully before the **Rhizoctonia** reaches it, preventing measurement of true **Rhizoctonia** growth rate.

EXPERIMENT T2(d)

Aim:- To see whether the fungicides, Basilex and Rovral have an effect on the growth of Rhizoctonia in compost.

A small experiment was set up to fulfill the above aim. The method used is set out in brief below.

1. One litre batches of finely milled compost were sterilised by autoclaving 3 times for 1 hour at 15lbs/in^2 at 24 hour intervals.

2. Prior to the 3rd autoclaving, fungicide was added to the batches as follows.

1 litre was left unamended
to 1 litre was added 0.08g of Basilex
" 1 " " " 0.4g " Rovral dust.

3. Six petri dishes were filled with each of the mixtures, and the dishes were inoculated with one piece of Rhizoctonia infested straw at the extreme edge. The dishes were incubated in sealed poly bags at 24°C, and were examined daily for evidence of growth.

Results

No growth took place in the compost containing Basilex, however Rhizoctonia grew in both the untreated and Rovral treated compost. It is thought that Rovral became inactive during autoclaving. In addition, contamination of the compost by other saprophytic fungi took place, making measurement of growth difficult.

This experiment is now being repeated on a larger scale, [see Experiment R2(A)], however unsterile compost and bait pieces are being used. In this way it is hoped that the problems so far encountered will be avoided.

EXPERIMENT T7(A)

Aim:- To determine some of the physical and chemical properties of composts and compost constituents commonly used in experiments.

The main results obtained so far are shown below.

Air-filled porosities of composts

Compost	A.F.P. (%)
Vapo peat	13.0
4:1 vapo peat and perlite	17.5
2:5:1 " " " "	15.5
1:1 " " " "	31.7
4:1 " " " Scotbark	13.2
1:1 " " " "	16.5
4:1 " " " fine sand	7.5
2:1 " " " " "	5.6
1:1 " " " " "	4.0
Scotbark	25.5
Cambark (fine)	22.0
4:1 peat and Cambark	15.0
1:1 peat and Cambark	18.4

-Vapo peat has a pH of between 3.9 and 4.5, depending on the sample.

-pH of compost samples was measured by taking 100mls of compost + 200mls of distilled water. The mixture was mechanically shaken for 1 hour before pH measurement.

-A good method of measuring the lime requirement of peat and compost mixtures involves the following procedures. 6 x litre bags of compost are limed with 0, 1, 2, 4, 6 and 8g/litre of dolodust. The bags are left for a week after which the pH values are measured. This gives a buffering curve from which the lime requirement can be calculated.

EXPERIMENT R1(A)i

Location:- Inverliever Nursery, Ford, Argyll

Date set up:- 10/6/88

Aim:- To determine whether Rhizoctonia isolate A has an effect on the rooting of Calluna cuttings.

Introduction

This experiment was started at a time when no pure isolates of Rhizoctonia had been obtained from heathers. The strain used, (namely Rhizoctonia I-A), was obtained from potatoes in 1986 and was proven to be pathogenic to cv's of Calluna during work done at the West College in 1987.

Materials

12 standard seed trays

2 x 15g bottles of autoclaved chopped straw, (3 to 5mm sections), inoculated with Rhizoctonia I-A.

2 x 15g lots of chopped straw, (3 to 5mm sections).

180 cuttings of Calluna vulgaris 'Silver Knight'

" " " " " 'Alba Praecox'

" " " " " 'C.W. Nix'

50:50 Irish peat and cambark cutting compost

polythene tunnel

white polythene covering

Method

Treatment 1. (control). Compost and uninoculated straw.
" 2. Compost and uninoculated straw + fungicide (Rovral dust @ 0.4g/l compost).
" 3. Compost and inoculated straw.
" 4. Compost " " " + fungicide (Rovral dust @ 0.4g/l compost)

Three replicates were used:-

1. Inoculum or plain chopped straw was mixed with compost, using 15g straw/inoculum per 10 litres of compost.

2. Fungicide was incorporated as indicated and was thoroughly mixed.

3. Seed trays were then filled with the compost mixtures.

4. 15 cuttings per cv. were struck into each tray giving a total of 45 cuttings per tray.

5. The trays were set out in a randomised block design, were covered with polythene and were looked after on the nursery along with other cuttings taken around the same date.

6. The cuttings were destructively assessed 26 days after the start of the experiment. Root systems were assessed using the scale noted below, and the foliage condition was noted. Pieces of foliage were incubated in damp chambers, pieces of stem base were plated out and floats were made to check for infection in 10 cuttings taken at random from each treatment.

ASSESSMENT SCALE, FOR ROOT DEVELOPMENT

1. = < 10 roots
2. = 11 to 15 roots
3. = 16 to 20 roots
4. = 21 to 30 roots
5. = 31 to 40 roots
6. = > 40 roots

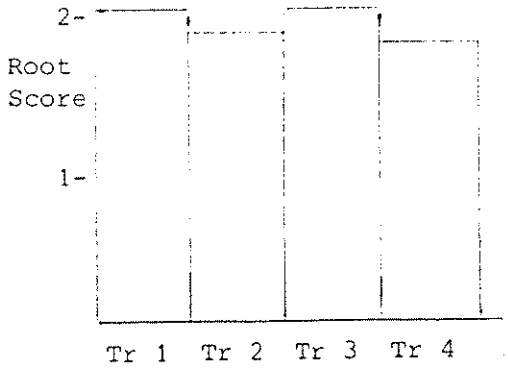
The length of the longest root on each cutting was also measured.

Results

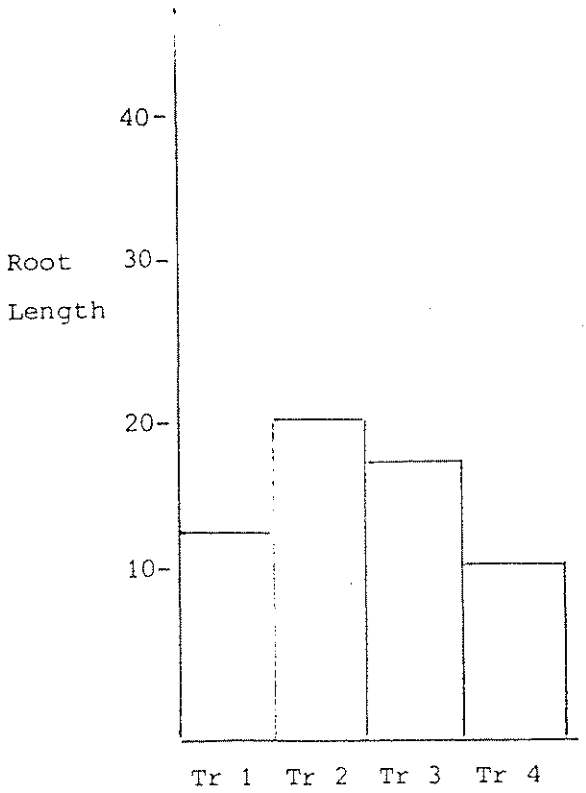
Table 3. % of tested cuttings infected with Rhizoctonia

	Treatment			
cv.	1.no rhiz no rovral	2.no rhiz + rovral	3.rhiz no rovral	4.rhiz + rovral
S.Q.	0	0	60.0	75.0
C.W.N.	0	0	77.0	60.0
A.P.	0	0	65.0	75.0

N.B. S.Q.= *Calluna vulgaris* 'Silver Queen'
C.W.N.= " " 'C.W. Nix'
A.P.= " " 'Alba praecox'



Graph 2 Mean root scores of cutting infected with Rhizoctonia I-A



Graph 3 Mean root lengths of cutting infected with Rhizoctonia I-A.

Table 4. Root scores of cuttings

	Treatment no.				
Cultivar	1	2	3	4	Mean
S.Q.	1.5	1.3	0.9	1.3	1.3
C.W.N.	2.2	2.0	2.7	2.0	3.0
A.P.	2.5	2.7	2.7	2.4	3.4
MEAN	2.1	2.0	2.1	1.9	

Table 5. Root lengths of cuttings

	Treatment no.				
Cultivar	1	2	3	4	MEAN
S.Q.	5.3	4.5	8.9	2.2	5.2
C.W.N.	18.1	18.3	24.7	13.7	18.7
A.P.	21.4	43.4	35.7	21.1	30.4
MEAN	14.0	22.1	19.8	12.3	

Table 3. shows that infection is taking place in both treatments where the compost is inoculated. There are no significant differences between the percentages of infected cuttings in treatments 3 and 4. Tables 4 and 5 and graphs 2 and 3 show that there is little difference in root development between treatments. No foliar browning was observed on any treatment at any stage during the experiment.

Discussion and conclusions

Rhizoctonia I-A was shown to have infected 60 to 77% of cuttings in treatments 3 and 4. However it has caused no damage to any of the cv's in any treatment in this experiment. This was surprising , since it proved pathogenic to several Calluna cv's in experiments carried out in 1987. It may be that repeated sub-culturing of the isolate on agar has caused it to lose its pathogenicity. All Rhizoctonia isolates are now stored on straw rather than agar. Experiments are now being carried out to test the pathogenicity of other Rhizoctonia isolates on various cv's. [See expts R1(C) and R1(G)].

EXPERIMENT R1(A)ii

Location:- Inverliever Nursery, Ford, Argyll

Date set up:- 16/8/88

Aim:- To determine whether Rhizoctonia isolates A and D1 have an effect on the rooting and development of Erica cuttings.

Introduction

Rhizoctonia isolate D1 was obtained from dying 1-year old Calluna 'My Dream' plants at Inverliever in Spring 1988. It appeared to be the primary cause of damage in this case. This experiment is one of the first in a series to determine the pathogenicity of this and other isolates towards Erica and Calluna cv's. Rhizoctonia I-A is also included for comparison, as all past work with deliberate infection of cuttings has involved this isolate.

Materials

9 optipot half trays

1 x 15g bottle of autoclaved, chopped straw, (3 to 10mm sections), inoculated with I-A.

1 x 15g bottle of above, inoculated with I-D1.

1 x 15g lot of chopped straw, (3 to 10mm sections).

45 cuttings of Erica cinerea

45 cuttings of Erica cinerea

45 cuttings of Erica cinerea

50:50 Irish peat and cambark compost

polythene tunnel

white polythene cover

Method

Treatment 1.(control) compost + uninoculated straw
" 2.compost + inoculated straw, (I-A)
" 3. " + " " , (I-D1)

Three replicates were used.

1. Inoculum or chopped straw was mixed with compost using 15g of straw/10 litres of compost.

2. Seed trays were filled with compost mixtures.

3. 5 cuttings/cv. were struck into each tray, giving a total of 15 cuttings/ tray

4. The trays were set out in a randomised block design, were covered with polythene and are being looked after on the nursery along with other cuttings taken at a similar date.

5. The cuttings will be destructively assessed for foliage condition and root development when the control plants have rooted successfully. (Normally 3 to 6 weeks after striking). This will be done using the scales noted in part i of this experiment.

6. At the same time, platings will be made from the cutting bases, floats will be made from the new roots, (where possible) and foliage will be incubated in D.C's to establish whether or not infection has taken place. One cutting/ cv / tray will be taken at random for the above.

Results

EXPERIMENT R1(B)

Location:- Inverliever Nursery, Ford, Argyll

Date set up:- 5/7/88

Aim:- To see whether Rhizoctonia I-A has an effect on the long term growth and development of Calluna plants.

Introduction

It has already been established that I-A is no longer as pathogenic towards Calluna cv's as it was in 1987. It has also been proven that although no symptoms are being observed on plants growing in inoculated compost, infection is taking place. This experiment aims to observe the growth and development of infected plants and to see whether disease symptoms become evident at any stage during the production of the plants, or after planting in a garden situation.

Materials

6 module trays (150 cell)

1 x 15g bottle of autoclaved, chopped straw, (3 to 10mm sections), inoculated with I-A.

1 x 15g lot of chopped straw, (3 to 10mm sections).

40 Calluna ' ' cuttings

40 Calluna ' ' "

40 Calluna ' ' "

50:50 Irish peat and cambark compost

polythene tunnel

white polythene cover

Method

Treatment 1.(control) compost + uninoculated straw
" 2.compost + inoculated (I-A) straw

This experiment was replicated three times.

1. Inoculum or plain chopped straw was mixed with compost, using 15g straw/inoculum per 10 litres of compost.

2. Seed trays were then filled with the compost mixtures.

3. 40 cuttings per cv were then struck into each tray, giving a total of 120 cuttings per tray.

4. The trays were set out in a randomised block design, were covered with polythene and are presently being looked after on the nursery along with other cuttings taken around the same time.

5. The cuttings are being liquid fed when necessary and will be potted on in the Autumn.

6. One cutting/ cv /tray is removed every 6 weeks to be destructively assessed. The foliage condition and root development are noted according to the scales used in experiment R1(A). Platings and root floats are made to check for infection and the foliage is incubated in D.C.'s.

7. The plants will be grown on until they are 1 year old, when they will be planted out in garden soil. They are being observed throughout their growth and development to check for differences between treatments. Assesment scales for foliage health, plant size etc, will be made up as the need arises.

Results

EXPERIMENT R1(C)i

Location:- West of Scotland College, Auchincruive

Date set up:- 17/8/88

Aim:- To test the pathogenicity of 11 Rhizoctonia isolates on Calluna cv's.

Introduction

Past work on agricultural crops and nursery stock has indicated that great differences can exist between isolates of **Rhizoctonia**. This experiment and the following one, [R1(C)ii], aim to examine whether differences in pathogenicity exist between the 19 isolates held at present. Some of the isolates were taken from **Calluna**, some from other nursery stock species and some are from potatoes. Four are known to be **Rhizoctonia solani** as the cells are multinucleate, whereas others are of unknown species.

Materials

26 polythene boxes, (12 x 12 x 8cm deep)

4 bottles of uninoculated chopped straw, (3 to 10mm sections)

11 isolates of **Rhizoctonia**, grown on autoclaved chopped straw in universal bottles. 2 bottles of each isolate.

104 cuttings of **Calluna vulgaris** 'Rosalind'

104 " " " " 'Darkness'

104 " " " " 'Alba praecox'

50:50 Irish peat and cambark compost

polythene tunnel

white polythene covering

Method

Treatment no.	isolate	Treatment no.	isolate
1. control	(2 boxes)	7.	A
2.	24B	8.	58
3.	48	9.	56
4.	B	10.	D1
5.	72	11.	64
6.	55	12.	52

The experiment was replicated twice.

1. Boxes were filled with compost and labelled.

2. One bottle of straw was emptied into each box and mixed with the top 4cm of compost with separate spatulas to avoid cross contamination.

3. Four cuttings/cv/tray were struck into each box, giving a total of 12 cuttings/ box.

4. The boxes were set out in a randomised block design in the tunnel under white polythene.

5. The cuttings were observed over a 6 week period and the foliage condition was noted after 2, 4 and 6 weeks according to the scale shown below. Rep 1 was destructively assessed after 4 weeks. The roots were scored according to the scale used in expt R1(A) and platings were made to check for the presence of infection. Rep 2 will be assessed in a similar way after 6 weeks.

Results

Table 6. Average foliage score (after 4 weeks) of **Calluna** cuttings infected with **Rhizoctonia** isolates.

	Cultivar			
Isolate no	Darkness	Rosalind	Alba praecox	mean score
control	0	0	0	0
58	0	0	0	0
52	3.3	2.3	3.3	3.0
A	0	0	0	0
B	0	0	0	0
48	4.0	1.0	3.0	2.7
64	3.0	2.0	3.8	2.9
24B	0.8	0	0	0.8
72	1.8	0.5	2.5	1.6
56	4.0	2.5	4.0	3.5
55	3.5	0.8	1.0	1.8
D1	2.0	1.0	2.3	1.4
mean score	1.9	0.8	1.7	

N.B. Foliage was scored according to the following scale:-

Score	condition
0	No browning of foliage
1	Bases or tips of a few branches brown
2	Bases or tips of a few branches brown + 1 or 2 shoots totally brown.
3	Extensive browning, but some green tissue
4	Totally brown foliage

Table 7. Average root score (after 4 weeks) of **Calluna** cuttings infected with **Rhizoctonia** isolates.

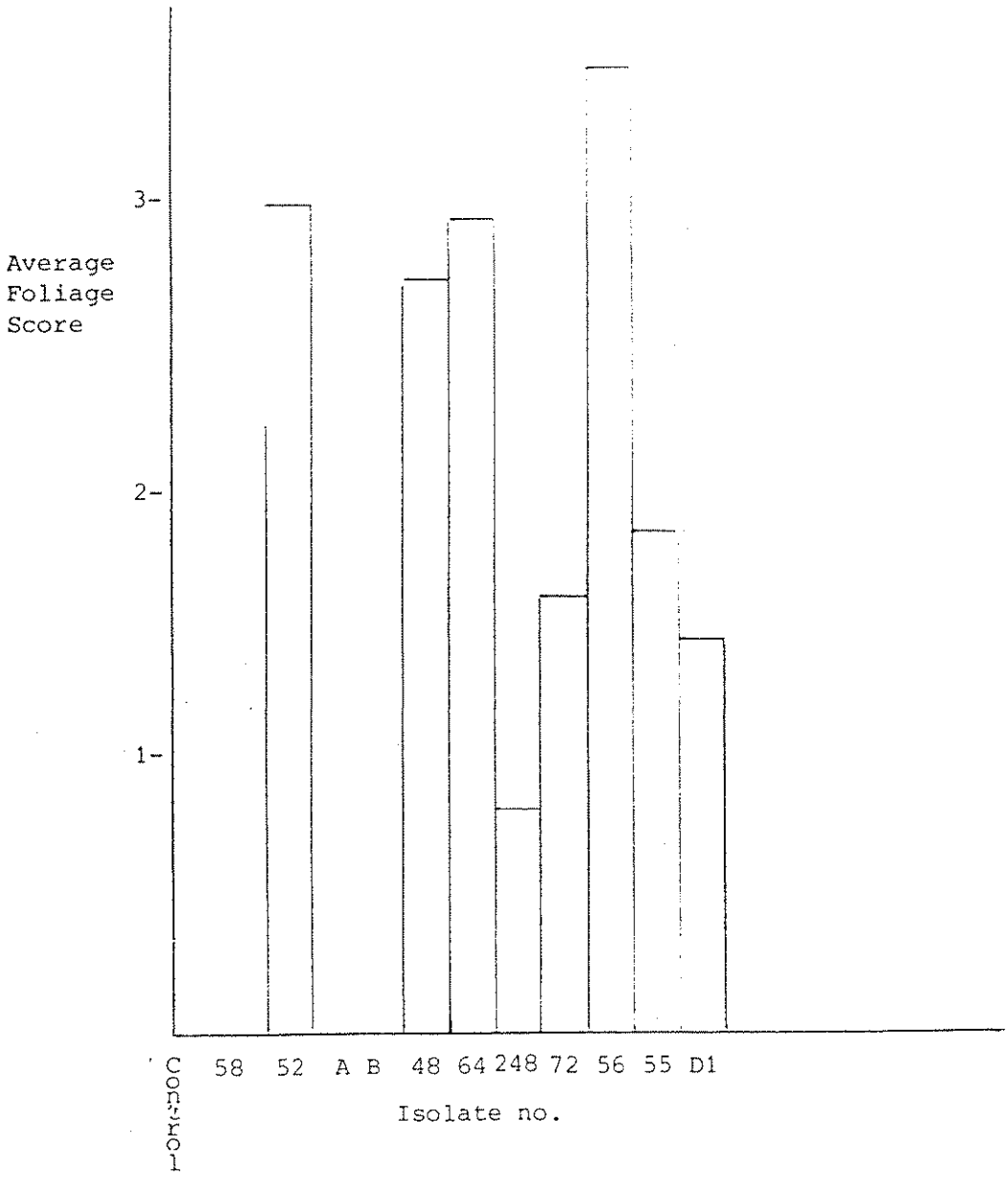
	Cultivar			
Isolate no.	Darkness	Rosalind	Alba praecox	mean score
control	6.0	6.0	6.0	6.0
58	6.0	5.8	6.0	5.9
52	2.3	4.3	1.5	2.7
A	3.8	4.5	5.8	4.7
B	6.0	5.8	5.5	5.8
48	5.8	2.8	2.3	3.6
64	5.5	5.5	3.8	4.9
24B	5.5	6.0	6.0	5.8
72	1.5	4.5	2.0	2.7
56	1.5	6.0	0.0	2.5
55	0.0	0.5	0.0	0.2
D1	1.5	2.5	2.3	2.1
mean score	3.8	4.5	3.4	

N.B. Roots were scored according to the following scale.

Score	Description
0	No roots
1	< 5 roots, all < 3mm in length
2	< 5 roots, some > 3mm in length
3	> 5 roots, but < 10, none > 5mm in length
4	> 5 roots, but < 10, some > 5mm in length
5	> 10 roots, mainly < 5mm in length
6	> 10 roots, mainly > 5mm in length

Infection had taken place with every isolate, as **Rhizoctonia** was isolated from cuttings in all treatments.

The control plants show no foliar browning and rooted in three weeks. Tables 6 and 7, and graph 4 demonstrate that there are



Graph 4 Average foliage score of cuttings infected with Rhizoctonia isolates.

obvious differences between the effects of the **Rhizoctonia** isolates used. Some isolates caused severe foliar browning, restriction of rooting and rotting of the cutting bases, (eg I-56 and I-48), whereas others caused no obvious damage, (eg I-A and I-B).

Plate 5 shows the differences in foliage condition between uninfected cuttings and those infected with isolates 56 and D1. Plate 6 shows uninfected cuttings and some of those from treatments infected with isolates D1 and 55, 3 weeks after the start of the experiment.

There are also differences in cultivar susceptibility. In general, 'Rosalind' is less susceptible to attack from **Rhizoctonia** than 'Alba praecox', which in turn is less susceptible than 'Darkness'.

Discussion and conclusions

Some of the differences in cultivar susceptibility may have been due to the type of cutting material used, (the cuttings were taken from plants in different tunnels). The 'Rosalind' cuttings were slightly harder than those of the other cv's. However this 'hardness' may be inherent in the growth habit of the cv, therefore forming part of the resistance to disease.

It is hoped to carry out a series of experiments to test the susceptibility of commonly grown cv's to attack from **Pythium** and **Rhizoctonia**. It may be the case that certain cv's are particularly prone to diseases in general. If this is true, growers may benefit from ceasing to grow the more disease prone cv's.

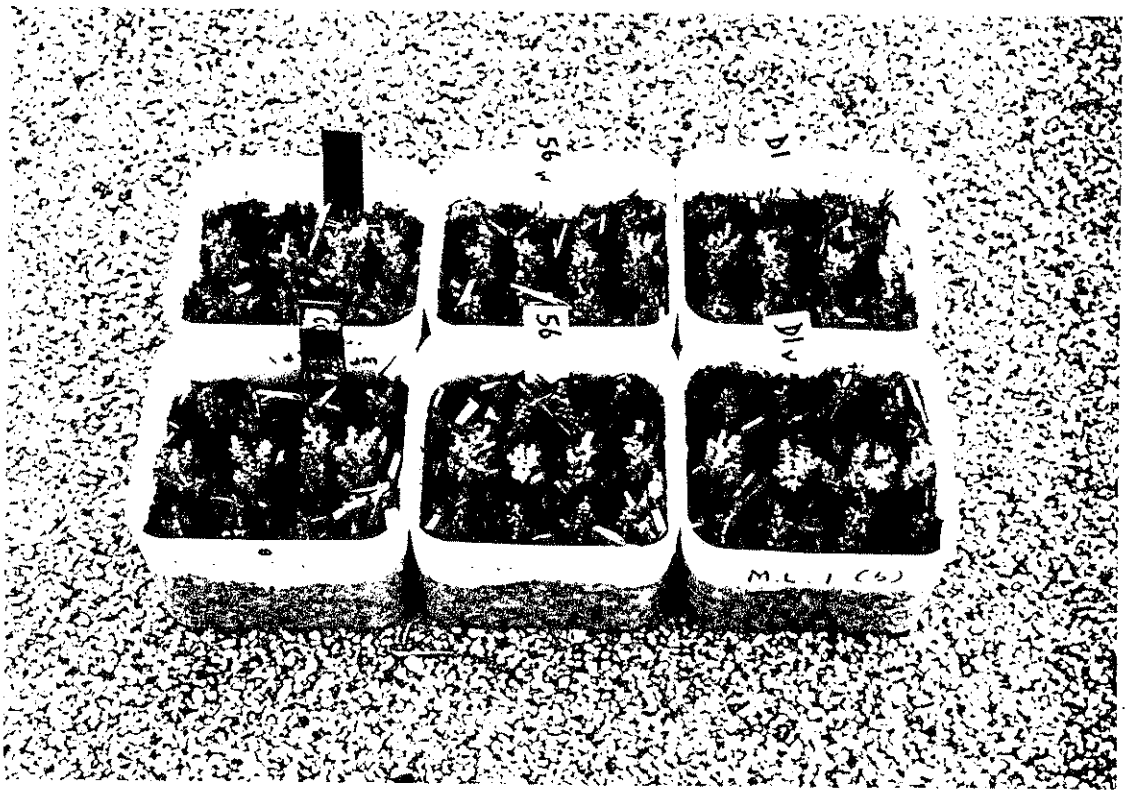


Plate 5. Differences in foliage condition between uninfected cuttings and those infected with Rhizoctonia isolates D1 and 56.

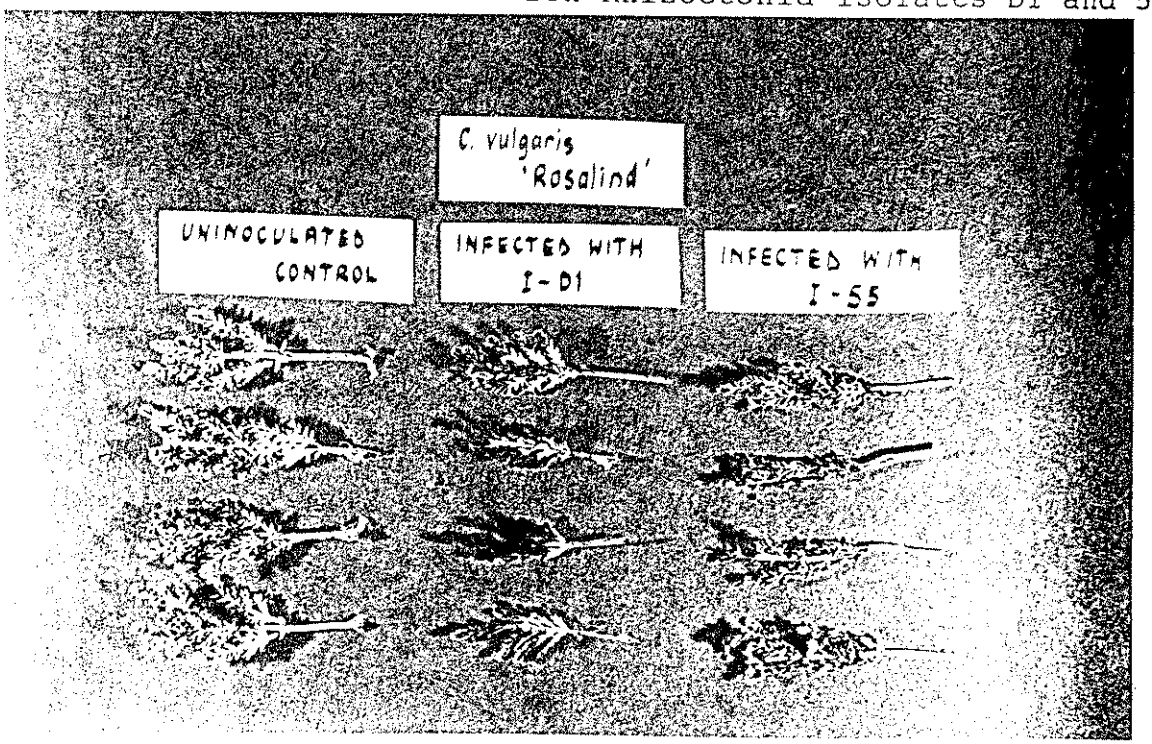


Plate 6. Uninfected cuttings compared with those infected with Rhizoctonia I-D1 and I-55, 3 weeks after the start of the experiment.

EXPERIMENT R1(C)ii

Location:- West of Scotland College, Auchincruive

Set up on:- 13/9/88

Aim:- As for R1(C)i

Materials

8 isolates of Rhizoctonia

otherwise as for R1(C)i

Methods

Treatment no.	Isolate
1. control (2 boxes/rep)	
2.	B1
3.	F
4.	Pr
5.	Pd
6.	57
7.	8
8.	10
9.	24A
10.	87-18

Results

EXPERIMENT R1(D)

Location:- Scotplants, Beith

Date set up:- 19/8/88

Aim:- To examine the importance of environment in the development of Rhizoctonia diseases.

Introduction:-

The environment in which cuttings are rooted differs greatly depending on the individual nursery, on the climate and on the time of year. Pilot experiments have suggested that the severity of disease incidence due to **Rhizoctonia** is dependent on the nature of the cutting environment. This experiment is the first of several which set out to examine the influence of environment on the development of **Rhizoctonia** disease. By studying the relationship between host and pathogen under different conditions, it is hoped that a better understanding of the situation will be gained. This may lead to the development of a cultural or integrated control system for the pathogen.

Materials

12 x half seed trays

2 x 12g bottles of autoclaved chopped straw, (3 to 10mm sections), inoculated with **Rhizoctonia** I-A.

2 x 12g lots of chopped straw, (3 to 10mm sections).

180 cuttings of **Calluna vulgaris** 'Golden feather'

180 " " " " 'Cuprea'

50:50 Irish peat and cambark compost

polythene tunnel

cold frame

white polythene covering

Method

Treatment 1. (Control), compost + uninoculated straw. Trays kept in tunnel after rooting.

Treatment 2. Compost + inoculated straw (I-D1). Trays kept in tunnel after rooting.

Treatment 3. (Control), compost + uninoculated straw. Trays kept in covered cold frame after rooting.

Treatment 4. Compost + inoculated straw (I-D1). Trays kept in covered cold frame after rooting.

This experiment was replicated three times.

1. Inoculum or plain chopped straw was mixed with the compost using 15g straw/inoculum per 10 litres of compost.

2. Seed trays were then filled with the compost mixtures.

3. 15 cuttings per cv were struck into each tray, giving a total of 45 cuttings per tray.

4. The trays were set out in a randomised block design in a polythene tunnel on the nursery, alongside other cuttings.

5. Following rooting, the polythene was removed from the trays in treatments 1 and 2, and the remaining trays were placed in a coldframe, where they will remain over the Winter.

6. The cuttings were observed throughout the rooting stage and the foliage of each cutting was assessed according to the scale used in expt R1(C), 3 weeks after the start of the experiment, (ie when the controls had rooted.

7. One cutting/cv/tray was removed at random at stage 6, and once every six weeks thereafter.

Results

EXPERIMENT R1(E)

Location:- West of Scotland College, Auchincruive

Date set up:- 13/9/88

Aim:- To examine the importance of cutting ripeness in the incidence and development or *Rhizoctonia* disease.

Introduction:-

Work with other crops has shown that the condition of the foliage, (ie. whether hard or soft), can affect the incidence of disease. On a commercial nursery, heather cuttings are taken at various times of year, and they can be taken from shoot tips or lower down the shoot. This experiment sets out to see whether the various types of cuttings differ in their susceptibility to disease attack.

Materials

18 optipot half trays

1 x 12g bottle of autoclaved, chopped straw, (3 to 10m sections), inoculated with Rhizoctonia I-D1

1 x 12g lot of chopped straw, (3 to 10mm sections)

60 basal cuttings from plants kept outdoors in soil

60 tip " " " " " " "

60 basal " " " " in pots in tunnel

60 tip " " " " " " " "

60 basal " " " " in glasshouse, (20 C)

60 tip " " " " " " , "

30 of each type were of Calluna vulgaris 'Silver Queen' and the remaining 30 were of Calluna 'Cuprea'

50:50 Irish peat and cambark compost

polythene tunnel

white polythene covering

Method

Tr 1.Basal cuttings from plants in soil , uninoculated.
Tr 2.Tip " " " " " , " .

Tr 3.Basal	"	"	"	"	"	, inoculated.
Tr 4.Tip	"	"	"	"	"	, " .
Tr 5.Basal	"	"	"	"	tunnel	, uninoculated.
Tr 6.Tip	"	"	"	"	"	, " .
Tr 7.Basal	"	"	"	"	"	, inoculated.
Tr 8.Tip	"	"	"	"	"	, " .
Tr 9.Basal	"	"	"	"	glasshouse	, uninoculated.
Tr10.Tip	"	"	"	"	"	, " .
Tr11.Basal	"	"	"	"	"	, inoculated.
Tr12 Tip	"	"	"	"	"	, " .

The experiment was replicated three times

1. Inoculum or plain chopped straw was mixed with compost, using 12g inoculunm/straw per 10 litres of compost.

2. Seed trays were then filled with the compost mixtures.

3. Five tip and five base cuttings/ cv were struck into each tray, giving a total of 20 cuttings per tray.

4. The trays were then set out in a randomised block design, were covered with polythene and placed in a polythene tunnel on gravel.

5. The cuttings will be observed throughout the rooting period and any relevant observations will be noted down. It is planned to destructively analyse the experiment one replicate at a time, at three weekly intervals commencing once the controls are well rooted. The foliage and root systems will be assessed and checks will be made for infection.

Results:-

The following results are from a foliage assessment carried out three weeks after the start of the experiment.

Table 8. The foliage condition of infected and uninfected cuttings taken from plants kept under different conditions

Treatment	Tip cuttings		Basal cuttings		Mean
	Silver Knight	Cuprea	Silver Knight	Cuprea	
Uninoculated					
Outdoor stock	1.5	0.1	1.0	0.0	0.65
Tunnel stock	0.0	0.0	0.0	0.0	0.00
Glasshouse stock	0.0	0.0	0.1	0.0	0.03
Inoculated (D1)					
Outdoor stock	3.2	2.8	3.7	2.6	3.08
Tunnel stock	3.2	2.8	3.3	1.9	2.80
Glasshouse stock	3.5	3.3	3.5	2.9	3.30
Mean	1.9	1.5	2.9	2.5	

NB. Foliage was assessed according to the following scale as shown on page 25.

Basal cuttings show more foliar browning than do tip cuttings after three weeks. Cuttings from glasshouse-kept stock show more browning than those taken from outdoor stock plants. Tunnel-kept stock plants yield the highest % of healthy cuttings.

Conclusions so far.

It appears that the type of cutting material used does have an effect on the incidence and development of **Rhizoctonia**. Further results are needed before more detailed conclusions can be reached.

EXPERIMENT R1(F)

Location:- West of Scotland College, Auchincruive

Date set up:- 13/9/88

Aim:- To find out the effect of temperature on the rooting and development of Calluna cuttings infected with **Rhizoctonia**.

Introduction:-

Pilot experiments have indicated that temperature may have an effect on the incidence and severity of **Rhizoctonia** infection. Since it is often possible to control the temperature in cuttings compost to some extent, a knowledge of the effects of temperature on the host/pathogen complex may be of use to the nurseryman. This experiment is the first in a series on this theme.

Materials

27 optipot half trays

1 x 12g bottle of autoclaved chopped straw, (3 to 10mm sections), inoculated with Rhizoctonia I-D1.

1 bottle of above, inoculated with I-56

135 cuttings of **Calluna** 'Cuprea'

135 " " "

135 " " "

50:50 Irish peat and cambark compost

polythene tunnel

glasshouse at ca. 12 to 20°C

uncovered cold frame

white polythene covering

Method

Tr 1. Uninoculated compost, cuttings in tunnel
Tr 2. I-D1 inoculated compost, cuttings in tunnel
Tr 3. I-56 " " " " "
Tr 4. uninoculated " " " glasshouse
Tr 5. I-D1 inoculated " " " "
Tr 6. I-56 " " " " "

Tr 7.	uninoculated	"	,	"	" coldframe
Tr 8.	I-D1 inoculated	"	,	"	" "
Tr 9.	I-56 "	"	,	"	" "

Three replicates were used

1. Inoculum or plain chopped straw was mixed with compost, using 15g of straw per 10 litres of compost.

2. Seed trays were then filled with compost mixtures.

3. Five cuttings /cv were struck into each tray, giving a total of 15 cuttings per tray.

4. The trays were set out in a randomised block design and were placed in their relevant locations, covered in polythene until rooting had taken place.

5. The cuttings will be observed throughout their development,and any relevant points will be noted. They will be destructively assessed one replicate at a time, every month, commencing after all the uninoculated plants have rooted. Foliage and root condition will be noted and cuttings will be checked for the presence or absence of infection.

Results

EXPERIMENT R1(G)

Location:- West of Scotland College, Auchincruive

Date set up:- 7/9/88

Aim:- To determine whether there are differences between cv susceptibility to Rhizoctonia.

Introduction:-

It is already known that great differences exist between cv's with respect to salt sensitivity and susceptibility to waterlogging, drought etc. It therefore follows that some cv's may be more susceptible to disease than others. If this is so, nurserymen may benefit from growing only those cv's which are more resistant to disease. This experiment is the first of a series which aims to look at the disease resistance/ susceptibility of a range of commonly grown cv's.

Materials:-

12 standard seed trays

1 x 12g bottle of Rhizoctonia I-D1, grown on autoclaved, chopped straw, (3 to 10mm sections).

1 x 12g bottle of Rhizoctonia I-56, grown as above.

1 x 12g lot of straw, chopped as above.

96 cuttings of Calluna vulgaris 'Salmon leap'

" " " " " 'Beoley Silver'

" " " " " 'Golden feather'

" " " " " 'Rosalind'

" " " " " 'My Dream'

" " " " " 'Cuprea'

" " " Erica cinerea 'Joseph Murray'

" " " " " 'Rockpool'

50:50 Irish peat and scotbark compost

polythene tunnel

white polythene covering

Method:-

Treatment 1. Uninoculated compost
" 2. Compost inoculated with Rhizoctonia I-D1
" 3. " " " " I-56

The experiment was replicated three times.

1. Seed trays were filled with compost.

2. Inoculum or plain chopped straw was spread evenly over the compost surface and was mixed with the top 2cm.

3. Eight cuttings per tray were struck into each tray giving a total of 64 cuttings per tray.

4. The trays were set out in a randomised block design under polythene in the tunnel, and the cuttings are being observed during development.

5. Foliage will be visually assessed 3 weeks after the start of the experiment. Reps 1 and 2 will be destructively assessed once the control cuttings have rooted. Foliage and roots will be assessed, and platings and incubations done to check for infection.

6. Reps 3 and 4 will be assessed two weeks later.

Results:-

Table 9. Foliage condition of cuttings 3 weeks after the start of the experiment.

	Treatment			
Cultivar	Control	Isolate D1	Isolate 56	Mean
My Dream	0	0.39	0.25	0.32
Cuprea	0	1.36	0.11	0.74
Rosalind	0	0.50	0.00	0.25
Bedley Silver	0	0.43	0.00	0.22
Serlei Aurea	0	0.29	0.14	0.22
Salmon Leap	0	0.18	0.00	0.09
Joseph Murray	0	0.04	0.00	0.02
Golden Feather	0	0.18	0.18	0.18
Rockpool	0	0.00	0.00	0.00
Mean	0	0.37	0.08	

NB. Foliage was assessed according to the following scale:-

0 - No browning of foliage
1 - etc. as on page 25
2 -
3 -
4 -
5 -

In general, isolate D1 causes more foliar browning than does I-56. No browning was observed on any of the uninfected cuttings. Differences were observed in the degree of browning on different cv's. Cuprea showed most browning, and Rockpool showed least browning.

Conclusions so far.

It appears that there are differences between cultivar susceptibility to **Rhizoctonia** infection. Further results are needed before firm conclusions can be reached.

EXPERIMENT R2(A)

Location:- West of Scotland College, Auchincruive

Date set up:- 16/9/88

Aim:- To find out whether the growth of Rhizoctonia in compost is affected by the presence of the fungicides 'Basilex' or 'Rovral'

Introduction

Pilot experiments have shown that the above fungicides do have an effect on Rhizoctonia growth in compost. Since fungicides are the only way of controlling Rhizoctonia in nursery stock at present, it is of great importance to be fully aware of the nature of the control which the available fungicides provide. This experiment is the first of several to investigate the effects of fungicides on Rhizoctonia.

Materials

24 petri dishes

Rhizoctonia I-56 }
} grown on autoclaved chopped straw.
" I-D1 } (3 to 10mm sections)

25% bark:75% peat compost

" : " " + 'Basilex' @ 0.08g/l

" : " " + 'Rovral' @ 0.4g/l

1 to 2mm pieces of autoclaved maize-meal, (as bait)

Method:-

Tr 1. Dishes filled with compost and inoculated with I-56
Tr 2. " " " " " " " I-D1
Tr 3. " " " " + 'Basilex' + in'c I-56
Tr 4. " " " " + ' " ' + " I-D1
Tr 5. " " " " + 'Rovral' + " I-56
Tr 6. " " " " + ' " ' + " I-D1

The experiment was replicated three times.

1. Dishes were filled with compost as indicated above.

2. Two pieces of straw, inoculated with the relevant isolate, were placed at the extreme edge of the dishes.

3. Maize-meal pieces were placed at 10mm intervals in a line from the inoculum to the other side of the dish, (ie. across the diameter.

4. Fungal growth was measured by examining the maize-meal pieces which become colonised as the fungus moves across the dish.

5. The dishes were kept at room temperature in sealed polythene bags.

Results:-

EXPERIMENT R2(B)

Location:- West of Scotland College, Auchincruive

Date set up:- 26/2/88

Aim:- To find out whether the growth of Rhizoctonia in compost is affected by pH.

Introduction:-

Pilot experiments have already shown that the growth of Rhizoctonia in vitro is affected by pH. This experiment aims to find out whether the same results apply to growth of the fungus in compost.

Materials

25% peat: 75% bark compost, autoclaved at 15lbs/in^2 for 1 hr, three times at 24 hr intervals.

magnesian lime, (dolodust)

incubator at 24^{o}C

24 x 85mm petri dishes

Rhizoctonia I-A, grown for two weeks on chopped, autoclaved straw.

Method

Treatment no.		Final pH value
Tr 1.	Unlimed compost	3.33
Tr 2.	Compost limed at 1g/l	4.34
Tr 3.	" " " 2g/l	4.85
Tr 4.	" " " 4g/l	5.32
Tr 5.	" " " 6g/l	5.48
Tr 6.	" " " 8g/l	5.56

The experiment was replicated three times.

1. The limed , autoclaved compost was placed in the dishes.

2. Each dish was inoculated with two pieces of colonised straw and was incubated in an incubator at 24 C.

3. The growth, which was visible to the naked eye, was measured every three days until the first dishes were fully colonised.

Results:-

Table 10. The effect of pH on the growth of Rhizoctonia I-A in compost.

	Growth (mm) from original inoculum					
	No. of g. of lime/litre compost					
No. of days after inoculation	0	2	4	6	8	10
3	0	0	1	1	3	3
6	0	0	3	7	10	14
9	0	U	12	23	25	30
12	0	U	30	34	45	49
15	0	U	52	57	54	U
18	0	U	68	71	U	U
22	0	U	80	80	U	U

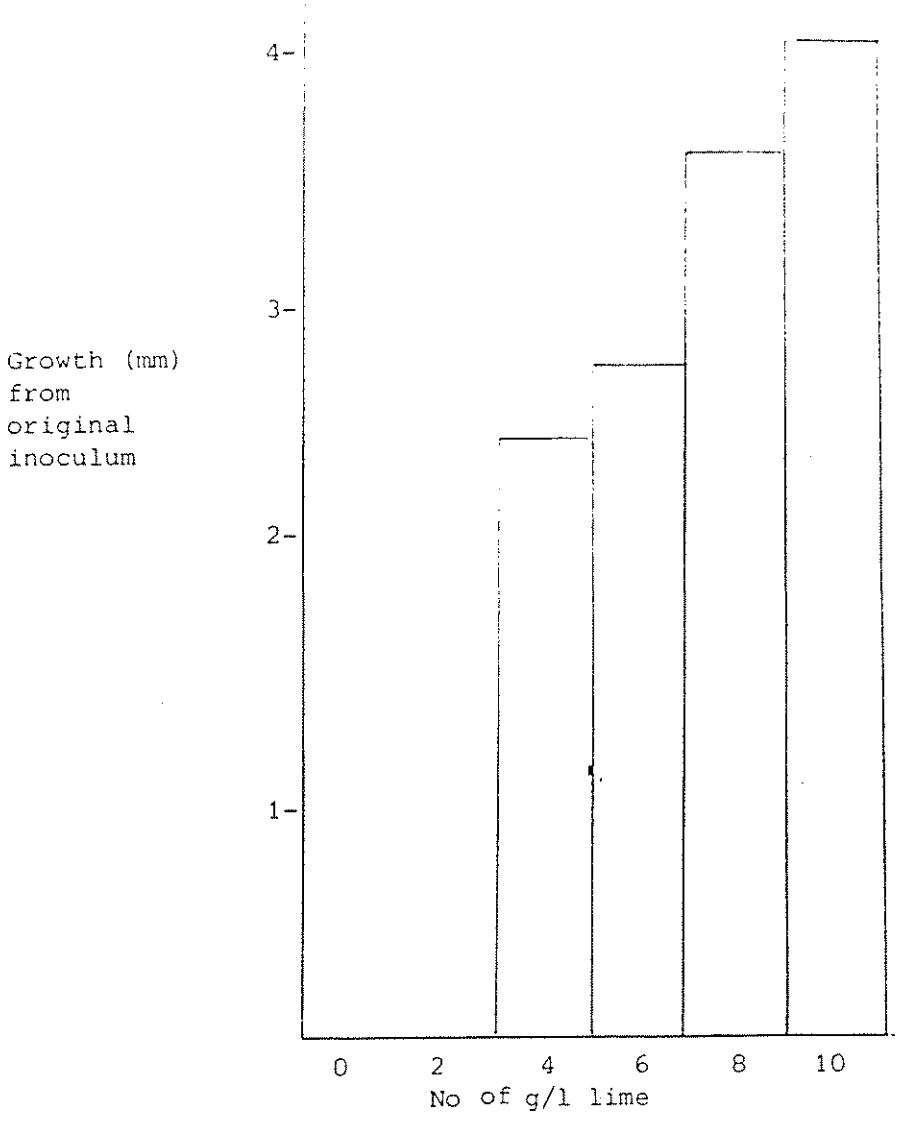
NB:- U = Unmeasurable

Table 10 and graph 5 show that Rhizoctonia isolate A grew fastest in the compost with 10g/l lime. The growth rate increased as the number of g/l lime increased from 0 to 10.

Discussion and conclusions

Difficulties with compost sterilisation were experienced throughout this experiment. It may be that the compost needs to be of a finer consistency, or requires longer sterilisation times. Several plates, (particularly those with higher quantities of lime), became heavily contaminated with other saprophytes, making measurement of Rhizoctonia growth impossible.

The fact that autoclaved compost has a significantly lower pH than non-autoclaved compost has meant that the addition of 10g/l dolodust to autoclaved compost only raises the pH to around 5.6. Although this experiment gives an idea of the growth rate of Rhizoctonia at pH values of 3 to 6, further work using a wider range of compost pH values, and properly sterilised compost would be needed to determine the optimum pH for growth.



Graph 5 The effect of PH on the growth of Rhizoctonia I-A in compost

EXPERIMENT R2(C)

Location:- West of Scotland College, Auchincruive

Date set up:- 16/6/88

Aim:- To determine the effects of temperature on the growth of Rhizoctonia in compost.

Introduction

Prior to carrying out experiments concerning the effects of temperature on the host/pathogen conmplex, it is important to know of the responses of **Rhizoctonia** to temperature when it is growing saprophytically in compost. This experiment is intended to fulfill that aim.

Materials

Rhizoctonia I-A, grown on chopped, autoclaved straw

Vapo peat, passed through a 1cm mesh griddle, moistened and autoclaved at 15lbs/in^2 for 1 hour 3 times at 24 hour intervals, then limed at 4g/l (dolodust). Eventual pH =

28 x 85mm petri dishes

incubators at 0, 5, 10, 15, 20, 25, 30, 35 and 40^{o}C.

Methods

The experiment was replicated 4 times.

1. Petri dishes were filled with compost, and one piece of inoculated straw was placed at the extreme edge of each dish.

2. Dishes were placed in each incubator inside sealed poly bags and the growth of **Rhizoctonia**, (which was easily visible to the naked eye,) was measured every 72 hours until the dishes in one incubator were fully colonised.

Results/

Results

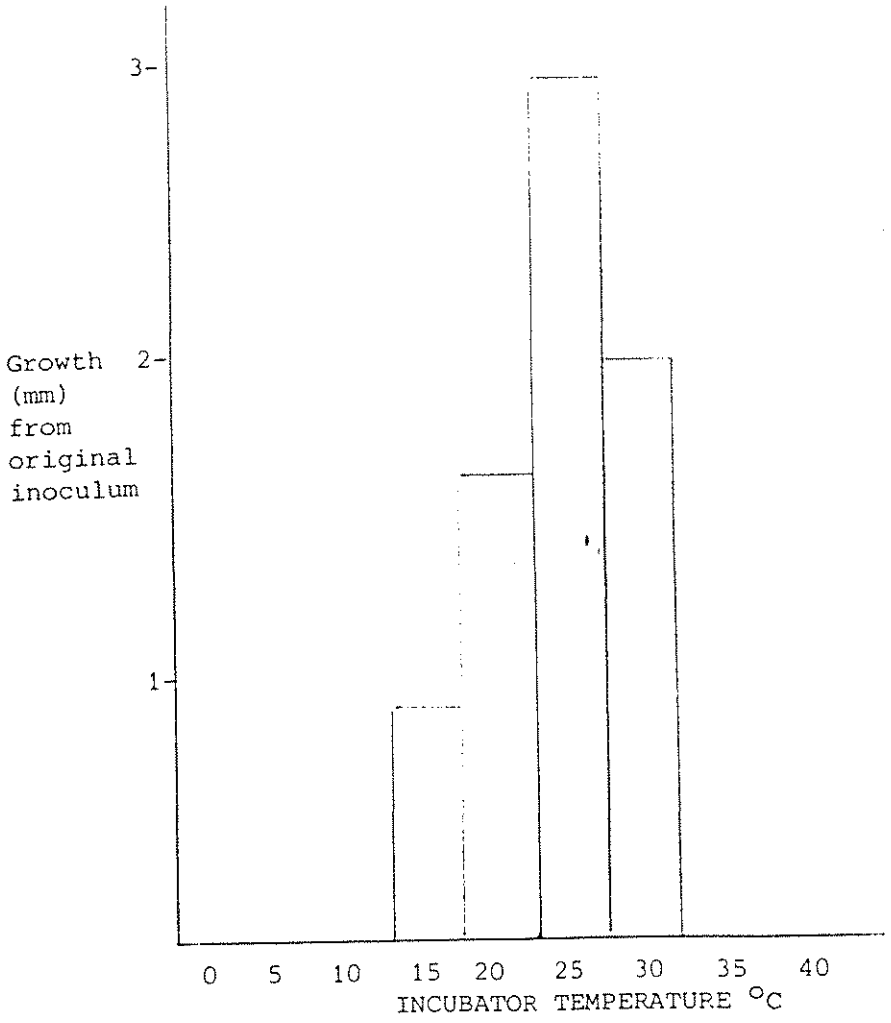
Table 11. Growth (mm) from original inoculum

No. of days after inoculation	Incubation temperature (°C)								
	0	5	10	15	20	25	30	35	40
3	0	5	0	1	2	3	2	0	0
6	0	0	0	4	5	16	9	0	0
9	0	0	0	7	7	27	21	0	0
12	0	0	0	8	13	38	25	1	0
15	0	0	0	12	24	59	30	1	0
18	0	0	1	15	36	75	U	U	0
21	0	0	1	U	U	U	U	U	0

Table 11 and graph 6 show that **Rhizoctonia** growth is fastest at 25°C and ceases at around 5°C and 35°C.

Discussion and conclusions

Although measurement of **Rhizoctonia** growth posed no problems during the first fortnight of the experiment, some of the plates became contaminated with saprophytes other than **Rhizoctonia** after this time. The contamination is again thought to be due to incomplete sterilisation of the compost. It is known that differences exist between strains of **Rhizoctonia**, therefore the growth rates of several isolates will have to be examined in this way before any conclusions can be made regarding the growth and behaviour of **Rhizoctonia** species in compost at different temperatures. Further work is planned along these lines.



Graph 6 The effect of temperature on the growth of Rhizoctonia in compost

EXPERIMENT R3(A)

Location:- West of Scotland College, Auchincruive

Date set up:- 21/3/88

Aim:- To find out the effect of pH on the growth of Rhizoctonia in vitro.

Introduction:-

It is well known that pH has an effect on the growth of not only heathers, but fungi as well. This experiment is intended to give an idea of the optimum pH for Rhizoctonia growth. It may well be that the best pH for growth in compost differs from that in vitro, however this experiment is intended merely as a guide. It is the first of many to examine the responses of the host/ pathogen complex to changes in pH.

Materials:-

Potato dextrose agar, amended with either lactic acid or sodium hydroxide to give pH values of 4.0, 4.8, 5.4, 5.9, 6.2, 7.4, and 8.8

42 petri dishes, (85mm diameter)

Rhizoctonia I-A

Rhizoctonia I-B

Rhizoctonia I-F

incubator at 24^{o}C

general lab facilities.

Method:-

The experiment was replicated three times.

1. Autoclaved P.D.A. was amended to give a range of pH values, the agar was then poured into plates and allowed to set.

2. An 11mm disc of agar from 2 week old Rhizoctonia cultures was placed in the centre of each petri dish. The growth of each of the three isolates was measured daily, beginning 24 hours following inoculation of the plates. The diameter of the colony was measured, ie the minimum measurement was 11mm. The growth rate (mm per day) was then calculated.

Results

Table 12 Growth rate of Rhizoctonia at different pH values

	pH							
Isolate	4.0	4.8	5.4	5.9.	6.2	7.4	8.8	mean
A	13.2	17.0	21.3	21.3	17.0	21.3	13.3	17.8
F	10.2	15.5	18.3	15.7	16.6	21.1	11.8	15.6
B	11.7	13.3	21.3	21.3	18.3	20.0	12.3	16.9
mean	11.7	15.3	20.3	19.4	17.3	20.8	12.4	

All three isolates grow fastest at around pH 5.4 to 5.9. The growth rates of the three isolates are similar , although there are slight differences in the growth rates at different pH values.

Conclusions

Although the three isolates show similar growth patterns, these responses may differ in compost. Other strains may grow at different rates. Further work is neccessary before firm conclusions on the responses of **Rhizoctonia** species, (as a whole) to pH changes can be made.

CONCLUSIONS SO FAR

The main conclusions to come out of the work so far are as follows.

1. Not all **Rhizoctonia** isolates cause immediate damage to heather cuttings when present in the compost, although infection has taken place in every isolate/cv combination tried so far.

2. There are great differences in pathogenicity between isolates.

3. There are differences between cultivar susceptibility.

4. Cutting environment, (ie temperature, compost air-filled porosity, pH etc) has an effect on the symptom expression of **Rhizoctonia** disease.

The intention is to carry on with the work along the lines mentioned in order to determine the cultural conditions which affect disease development. In this way, it is hoped that it will become possible to formulate control measures.

Appendix A

Rhizoctonia isolates held to date 14/9/88

Isolate	Source	No. of nucleii
A	Potato	?
B	Potato	?
F	Potato	?
Pr	Microbiota	2
Pd	Pyracantha	2
48	Juniperis	2
52	Calluna	2
55	Cotoneaster	many
56	Stephanandra	many
57	Calluna	2
58	Juniperis	2
64	Calluna	2
8	Tsuga canadensis	?
10	Juniperis	?
72	Astilbe	many
24A	Chamaecyparis	many
24B	Azalea	?
87-18	Cytisus	?
D1	Calluna 'My Dream'	?
B1	Calluna 'Boskoop'	?

Appendix B

LIST OF CULTIVARS HELD IN STOCK 14/9/88

Calluna vulgaris cv's

Beoley gold
Beoley silver
Bun
Crammond
Crimson glory
Cuprea
Darkness
Dart's gold
Drum-ra
Firefly
Flamingo
Gold Turret
H.E. Beale
Hirta
K11
K41
Kinlochruel
Loch Turret
Mousehole
Multicolour
My Dream
Oxabeck
Rosalind
Salmon leap
Serlei aurea
Silver knight
Silver queen
Sister Anne
Spring cream
Tricolourifolia
White lawn

Erica cinerea cv's

Alba major
Coccinea
Golden hue
Joseph Murray
Lilacina
Purple beauty
Rockpool
Violetta

Erica tetralix cv's

Con underwood

Erica carnea cv's

Foxhollow Fairy
King George
March seedling
Myretoun ruby
Pink spangles
Springwood white

Erica x darleyensis cv's

Furzey
Silberschmelze

Erica x praegeri

Irish Orange

Erica vagans cv's

Mrs D.F. Maxwell
Lionesse